R&S®RTP
High-Performance Oscilloscope
User Manual

1337995202

User Manual

Version 04

ROHDE&SCHWARZ

This manual describes the following R&S®RTP models with firmware version 4.15:

- R&S®RTP044 (1320.5007K04)
- R&S®RTP064 (1320.5007K06)
- R&S®RTP084 (1320.5007K08)

Mühldorfstr. 15, 81671 München, Germany
Phone: +49 89 41 29 - 0
Fax: +49 89 41 29 12 164
Email: info@rohde-schwarz.com
Internet: www.rohde-schwarz.com

1337.9952.02 | Version 04 | R&S®RTP

Throughout this manual, products from Rohde & Schwarz are indicated without the ® symbol , e.g. R&S®RTP is indicated as R&S RTP.

Contents

1 Preface

1.1 Safety Information

The R&S RTP oscilloscope is designed for measurements on circuits that are only indirectly connected to the mains or not connected at all. It is not rated for any measurement category.

The instrument is rated for pollution degree 2 - for indoor, dry location use where only non-conductive pollution occurs. Temporary conductivity caused by condensation is possible.

The instrument is intended for use in industrial areas. When used in residential areas, radio disturbances caused by the instrument can exceed given limits. Additional shielding can be required.

The instrument must be controlled by personnel familiar with the potential risks of measuring electrical quantities. Observe applicable local or national safety regulations and rules for the prevention of accidents.

Safety information is part of the product documentation. It warns you about the potential dangers and gives instructions how to prevent personal injury or damage caused by dangerous situations. Safety information is provided as follows:

- The "Basic Safety Instructions" in different languages are delivered as a printed brochure with the instrument.
- Throughout the documentation, safety instructions are provided when you need to take care during setup or operation.

WARNING

Risk of injury

Use the instrument in an appropriate manner to prevent electric shock, personal injury, or fire:

- Do not open the instrument casing.
- Do not use the instrument if you detect or suspect any damage of the instrument or accessories.
- Do not operate the instrument in wet, damp or explosive atmospheres.
- Make sure that the instrument is properly grounded.
- Do not use the instrument to ascertain volt-free state.

The instrument is heavy. Be careful when you lift or carry the instrument.

WARNING

Risk of injury

Do not exceed the voltage limits given in Chapter 2.2.1, "Front Panel", on page 38.

NOTICE

Risk of instrument damage due to inappropriate operating conditions

An unsuitable operating site or test setup can damage the instrument and connected devices. Before switching on the instrument, observe the information on appropriate operating conditions provided in the data sheet. In particular, ensure the following:

- All fan openings are unobstructed and the airflow perforations are unimpeded. A minimum distance of 10 cm to other objects is recommended.
- The instrument is dry and shows no sign of condensation.
- The instrument is positioned as described in the following sections.
- The ambient temperature does not exceed the range specified in the data sheet.
- Signal levels at the input connectors are all within the specified ranges.
- Signal outputs are connected correctly and are not overloaded.

1.2 Documentation Overview

This section provides an overview of the R&S RTP user documentation.

1.2.1 Manuals and Instrument Help

You find the manuals on the product page at:

www.rohde-schwarz.com/manual/rtp

Getting started manual

Introduces the R&S RTP and describes how to set up and start working with the instrument, and describes basic operations. A printed English version is included in the delivery. Editions in other languages are available on the product website.

Instrument help

The help offers quick, context-sensitive access to the complete information for the firmware basic functionality and applications.

User manual (Instrument)

Describes all instrument functions in detail. It also provides an introduction to remote control, a complete description of the remote control commands with programming examples, and information on maintenance and instrument interfaces. Includes the contents of the getting started manual.

The *online version* of the user manual provides the complete contents for immediate display on the internet.

Manuals for compliance test options

For compliance test options, extra test procedure manual are available. Test fixtures are described in printed manuals, which are delivered with the fixture.

- The following test procedure manuals are available:
  - USB 2.0 Compliance Tests for R&S RTP
  - Ethernet Compliance Tests for R&S RTP
  - MIPI D-PHY Compliance Tests for R&S RTP
  - DDR3 Compliance Tests for R&S RTP
  - ScopeSuite Automation
- The following test fixture manuals are available:
  - R&S RT-ZF1 USB 2.0 Compliance Test Fixture Set
  - R&S RT-ZF2 Ethernet Compliance Test Fixture Set
  - R&S RT-ZF3 Frequency Converter Board (100BASE-T1)
  - R&S RT-ZF4 10BASE-Te Test Fixture
  - R&S RT-ZF5 Ethernet Probing Fixture
  - R&S RT-ZF6 Frequency Converter Board (1000BASE-T1)

Basic safety instructions

Contains safety instructions, operating conditions and further important information. The printed document is delivered with the instrument.

Instrument security procedures manual

Deals with security issues when working with the R&S RTP in secure areas.

Service Manual

Describes the performance test for checking the rated specifications, module replacement, firmware update, troubleshooting and fault elimination, and contains mechanical drawings and spare part lists. The service manual is available for registered users on the global Rohde & Schwarz information system (GLORIS, https://gloris.rohde-schwarz.com).

1.2.2 Data Sheet and Brochure

The data sheet contains the technical specifications of the R&S RTP. It also lists the options with their order numbers and optional accessories. The brochure provides an overview of the instrument and deals with the specific characteristics.

See www.rohde-schwarz.com/brochure-datasheet/rtp

1.2.3 Release Notes, Open Source Acknowledgment

The release notes list new features, improvements and known issues of the current firmware version, and describe the firmware installation. The open source acknowledgment document provides verbatim license texts of the used open source software. It can also be read directly on the instrument.

See www.rohde-schwarz.com/firmware/rtp.

1.2.4 Application notes, Application cards, Videos

These documents deal with special applications or background information on particular topics.

See www.rohde-schwarz.com/application/rtp

1.3 Options Described in this Document

In addition to the base unit, the following options are described in this documentation:

Type	Designation	Order No.
R&S RTP-B1	MSO	1333.2424.02
R&S RTP-B6	Waveform and pattern generator	1333.2418.02
R&S RTP-B7	Pulse source	1333.2001.02
R&S RTP-K1	I²C and SPI serial triggering and decoding	1337.8604.02
R&S RTP-K2	UART/RS-232/RS-422/RS-485 serial triggering and decoding	1337.8610.02
R&S RTP-K3	CAN and LIN serial triggering and decoding	1337.8627.02
R&S RTP-K8	Ethernet serial triggering and decoding	1337.8633.02
R&S RTP-K9	CAN-FD serial triggering and decoding	1337.8640.02
R&S RTP-K12	Jitter analysis	1337.8656.02
R&S RTP-K17	High definition mode	1337.8856.02
R&S RTP-K19	Zone trigger	1337.8879.02
R&S RTP-K37	Spectrogram	1338.1110.02
R&S RTP-K40	MIPI RFFE serial triggering and decoding	1337.8733.02
R&S RTP-K42	MIPI D-PHY serial triggering and decoding	1337.8740.02
R&S RTP-K44	MIPI M-PHY serial triggering and decoding	1337.8756.02

Type	Designation	Order No.
R&S RTP-K50	Custom Manchester and NRZ serial triggering and decoding	1337.8762.02
R&S RTP-K52	8b10b serial triggering and decoding	1337.8779.02
R&S RTP-K55	MDIO serial triggering and decoding	1337.8785.02
R&S RTP-K57	100BASE-T1 serial triggering and decoding	1800.6548.02
R&S RTP-K61	USB 3.1 Gen 1 serial triggering and decoding	1337.8804.02
R&S RTP-K63	USB-PD serial triggering and decoding	1337.8810.02
R&S RTP-K64	USB SSIC serial triggering and decoding	1337.9117.02
R&S RTP-K72	PCI Express 1.x/2.x serial triggering and decoding	1337.8827.02
R&S RTP-K91	DDR3/DDR3L/LPDDR3 debug & compliance test. Decode and debug is described in this user manual. The compliance test is described in a separate manual.	1337.8840.02
R&S RTP-K121	Deembedding base option	1326.3064.02
R&S RTP-K122	Realtime deembedding extension	1326.3070.02

1.4 Conventions Used in the Documentation

1.4.1 Typographical Conventions

The following text markers are used throughout this documentation:

Convention	Description
"Graphical user interface elements"	All names of graphical user interface elements on the screen, such as dialog boxes, menus, options, buttons, and softkeys are enclosed by quotation marks.
[Keys]	Key and knob names are enclosed by square brackets.
`File names, commands, program code`	File names, commands, coding samples and screen output are distinguished by their font.
Input	Input to be entered by the user is displayed in italics.
Links	Links that you can click are displayed in blue font.
"References"	References to other parts of the documentation are enclosed by quotation marks.

1.4.2 Conventions for Procedure Descriptions

When operating the instrument, several alternative methods may be available to perform the same task. In this case, the procedure using the touchscreen is described. Any elements that can be activated by touching can also be clicked using an additionally connected mouse. The alternative procedure using the keys on the instrument or the on-screen keyboard is only described if it deviates from the standard operating procedures.

The term "select" may refer to any of the described methods, i.e. using a finger on the touchscreen, a mouse pointer in the display, or a key on the instrument or on a keyboard.

2 Getting Started

Note: the following chapters are identical to those in the R&S RTP Getting Started manual for R&S RTP instruments.

2.1 Preparing for Use

This section describes the basic steps to be taken when setting up the R&S RTP for the first time.

Observe the information on appropriate operating conditions provided in the data sheet and the general information given in "Risk of instrument damage due to inappropriate operating conditions" on page 26.

2.1.1 Unpacking and Checking the Instrument

To remove the instrument from its packaging and check the equipment for completeness, proceed as follows:

1. Pull off the polyethylene protection pads from the instrument's rear feet.
2. Carefully remove the pads from the instrument handles at the front.
3. Pull off the corrugated cardboard cover that protects the rear of the instrument.
4. Carefully unthread the corrugated cardboard cover at the front that protects the instrument handles and remove it.
5. Check the equipment for completeness using the delivery note and the accessory lists for the various items.
6. Check the instrument for any damage. If there is damage, immediately contact the carrier who delivered the instrument. Make sure not to discard the box and packing material.

Packing material

Retain the original packing material. If the instrument needs to be transported or shipped later, you can use the material to protect the control elements and connectors.

2.1.2 Positioning the Instrument

The instrument is designed for use under laboratory conditions. It can be used in standalone operation on a bench top or can be installed in a rack.

2.1.2.1 Bench Top Operation

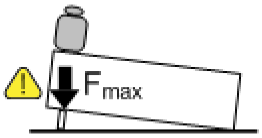
For standalone operation, place the instrument on a horizontal bench with even, flat surface. The instrument can be used in horizontal position, standing on its feet, or with the support feet on the bottom extended.

WARNING

Risk of injury if feet are folded out

The feet can fold in if they are not folded out completely or if the instrument is shifted. Collapsing feet can cause injury or damage the instrument.

- Fold the feet completely in or out to ensure stability of the instrument. Never shift the instrument when the feet are folded out.
- When the feet are folded out, do not work under the instrument or place anything underneath.
- The feet can break if they are overloaded. The overall load on the folded-out feet must not exceed 500 N.



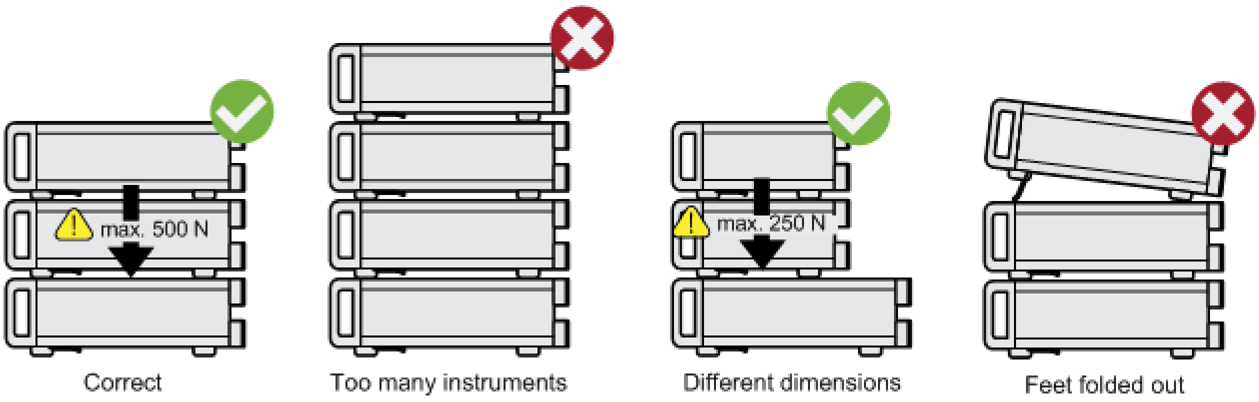
WARNING

Risk of injury when stacking instruments

A stack of instruments can tilt over and cause injury if not stacked correctly. Furthermore, the instruments at the bottom of the stack can be damaged due to the load imposed by the instruments on top.

Observe the following instructions when stacking instruments:

- Never stack more than three instruments. If you need to stack more than three instruments, install them in a rack.
- The overall load imposed on the lowest instrument must not exceed 500 N.
- It is best if all instruments have the same dimensions (width and length).
  If you need to stack smaller instruments on the top, the overall load imposed on the lowest instrument must not exceed 250 N.
- If the instruments have foldable feet, fold them in completely.



2.1.2.2 Rackmounting

The instrument can be installed in a rack using a rack adapter kit. The order number is given in the data sheet. The installation instructions are part of the adapter kit.

NOTICE

Risk of instrument damage due to insufficient airflow in a rack

If you mount several instruments in a rack, you need an efficient ventilation concept to ensure that the instruments do not overheat. Insufficient airflow for a longer period can disturb the operation and even cause damage.

2.1.3 Starting the Instrument

CAUTION

Risk of injury

Connect the oscilloscope to an outlet that has a ground contact.

If grounding is *not* ensured by the mains system, ground the oscilloscope using the protective earth conductor on the front panel and an appropriate cable.

Do not use an isolating transformer to connect the oscilloscope to the AC power supply.

2.1.3.1 Powering On and Off

The R&S RTP can be used with different AC power voltages and adapts itself automatically to it.

Refer to the data sheet for the requirements of voltage and frequency.

To power on

1. Connect the power cable to the AC power connector on the rear panel of the R&S RTP.
2. Connect the power cable to the socket outlet.
3. Switch the main power switch at the rear of the instrument to position I.

   The power key on the front panel lights up.

Before you start measurements, be sure to comply with the warm-up phase specified in the data sheet.

If you leave the main power switch on, the instrument is in standby mode. To disconnect from power supply, power off the instrument. Powering off is only required if the instrument must be disconnected from all power supplies.

To power off

1. If the instrument is running and the [Power] key is green, press the [Power] key on the front panel to shut down the instrument.
2. Switch the main power switch at the rear of the instrument to position 0.
3. Disconnect the AC power cable from the AC power supply.

NOTICE

Risk of losing data

If you switch off the running instrument using the rear panel switch or by disconnecting the power cord, the instrument loses its current settings. Furthermore, program data can be lost.

Press the Power key first to shut down the application properly.

2.1.3.2 Starting Up and Shutting Down

The [Power] key is located in the bottom left corner of the front panel.

To start up the instrument

1. Make sure that the R&S RTP is connected to the AC power supply and the main power switch on the rear panel is in position I.
2. Press the [Power] key on the front panel.

   The instrument performs a system check, boots the Windows operating system, and then starts the R&S RTP firmware.
   The [Power] key turns green and the illuminated keys on the front panel light up. If the previous session was terminated regularly, the oscilloscope uses the last settings.

To shut down the instrument

► Press the [Power] key on the front panel.

   All current settings are saved, and the software shuts down. The [Power] key turns orange. The standby power supplies only the power switch circuits.
   Now it is safe to power off the instrument.

The "Exit" function in the "File" menu shuts down only the firmware application. To shut down the instrument completely, also shut down the operating system in the "Start" menu, or use the [Power] key.

2.1.3.3 EMI Suppression

Electromagnetic Interference (EMI) may affect the measurement results.

To suppress generated Electromagnetic Interference:

- Use suitable shielded cables of high quality. For example use double-shielded RF and LAN cables.
- Always terminate open cable ends.
- Note the EMC classification in the data sheet.

2.1.4 Connecting External Devices

The following interfaces for external devices are provided:

- USB connectors at the front and rear panel of the instrument
- Monitor connectors DVI-D and DisplayPort at the rear panel of the instrument

2.1.4.1 Connecting USB Devices

The USB interfaces on the front and rear panels allow you to connect USB devices directly to the instrument. The number of USB connectors can be increased by using USB hubs. Due to the large number of available USB devices, there is almost no limit to the expansions that are possible with the R&S RTP.

The following USB devices can be useful, for example:

- USB flash drives to save screenshots and measurement results, and for easy installation of firmware applications
- Keyboard and/or mouse to simplify the operation and the entry of data, comments, filenames, etc.
- Printer to print measurement results and screenshots

You can connect or disconnect all USB devices during operation of the instrument.

Installing USB devices on R&S RTP is easy under the Windows operating system, because all USB devices are plug&play. After a device is connected to the USB interface, Windows automatically searches for a suitable device driver.

If the operating system does not find a suitable driver, it prompts you to specify a directory that contains the driver software. If the driver software is on a storage media, connect the appropriate drive to the instrument before proceeding. If the instrument is integrated in a network, you can also install driver data stored in a network directory.

When a USB device is disconnected from the R&S RTP, Windows immediately detects the change in hardware configuration and deactivates the corresponding driver.

The properties of external USB devices are configured in the operating system, not in the R&S RTP software. It is recommended that you use mouse and keyboard to access and modify the settings of the Windows operating system. To access Windows, press the Windows key on the external keyboard, or select "File" > "Minimize Application" on the R&S RTP menu.

Connecting a USB flash drive

If the installation of a USB flash drive is successful, Windows informs you that the device is ready to use. The device is made available as a new drive ("D:") and is displayed in Windows Explorer. The name of the drive depends on the manufacturer.

Connecting a keyboard

The keyboard is detected automatically when it is connected. The default input language is English – US.

To configure the keyboard properties:

1. Tap the "Find" icon (magnifier) on the Windows taskbar.
2. Type *keybord*.
3. Select "Edit language and keyboard options".

Connecting a mouse

The mouse is detected automatically when it is connected. To configure the mouse properties:

1. Tap the "Find" icon (magnifier) on the Windows taskbar.
2. Type *mouse*.
3. Select "Mouse settings".

Connecting a printer

When printing a file, the instrument checks whether a printer is connected and turned on, and whether the appropriate printer driver is installed. If necessary, printer driver installation is initiated by the Windows system. To install a printer driver:

1. Tap the "Find" icon (magnifier) on the Windows taskbar.
2. Type *printer*.
3. Select "Printers & scanners".
4. Select "Add a printer or scanner".

2.1.4.2 Connecting an External Monitor

You can connect an external monitor or projector to the R&S RTP. The following connectors are available:

- "DVI-D" on page 42
- "DisplayPort" on page 42

Before connecting an external monitor, ensure that the monitor and the R&S RTP are connected to a ground contact. Otherwise the instrument can be damaged.

After connecting an additional monitor or projector to the instrument, configure it for usage. The relevant settings are Windows settings but you can configure the displays directly in the instrument setup.

1. Check the input type of the monitor or projector. Make sure to select the correct cable. To use a VGA monitor, you need an active DVI-D to VGA adapter.
2. Press the [Setup] key.

3. Select the "System" tab.
4. Tap "Display / Monitors".
5. To show the instrument's display content only on the external monitor, select "Projector only".
   To show the instrument's display content on both the oscilloscope and the external monitor, select "Duplicate".

The touchscreen of the R&S RTP has a screen resolution of 1280 x 800 pixel. Most external monitors have a higher screen resolution. If the screen resolution of the monitor is set higher than the instrument's resolution, the application window uses a 1280 x 800 area of the monitor display. For full screen display, adjust the monitor's screen resolution using "Additional display settings".

2.2 Instrument Tour

This chapter describes the front and rear panels of the instrument including all function keys and connectors, and also the touchscreen with its control elements.

2.2.1 Front Panel

Figure 2-1 shows the front panel of the R&S RTP. The function keys are grouped in functional blocks to the left and the right of the touchscreen. Below the screen, various connectors are located.

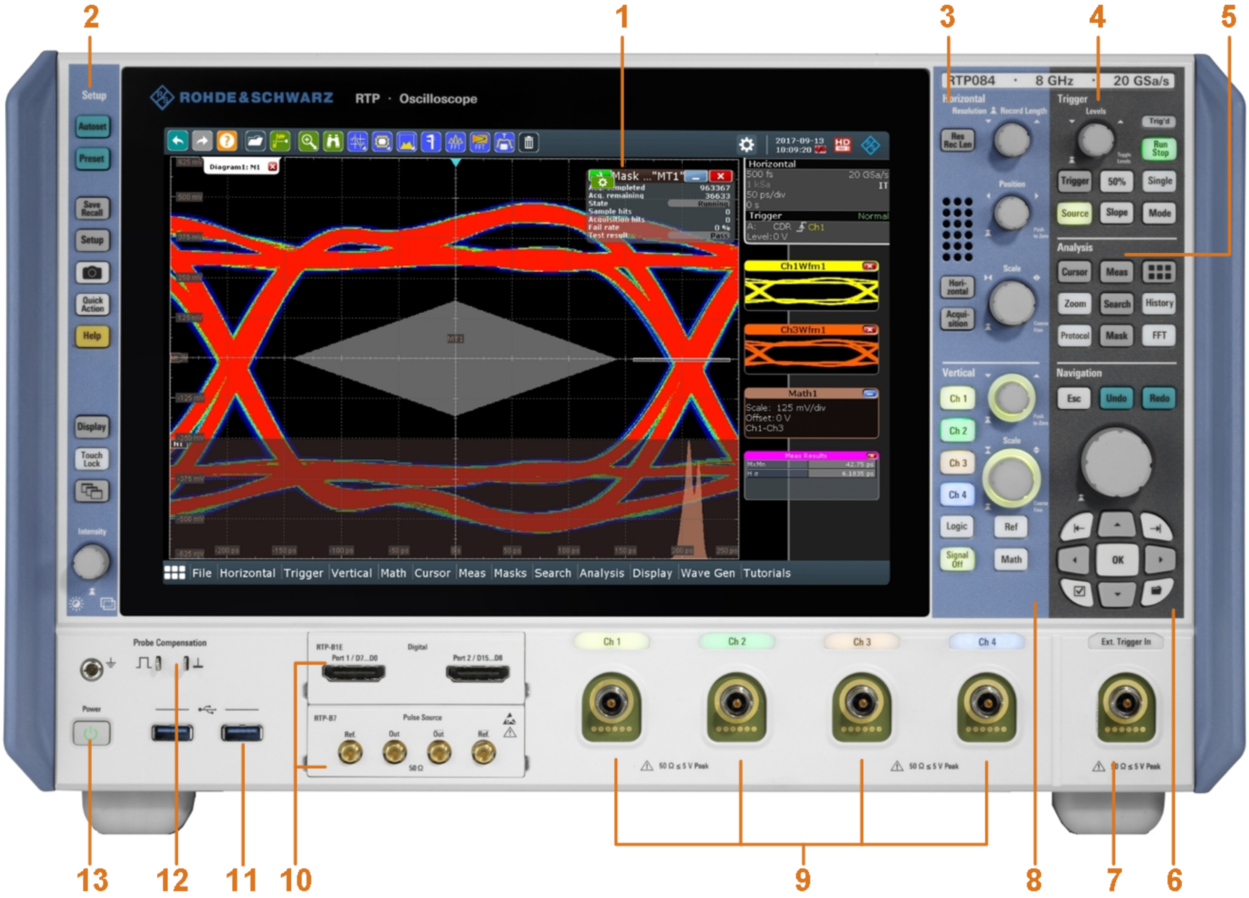


Figure 2-1: Front panel of R&S RTP

1 = Touchscreen
2 = Setup controls
3 = Horizontal controls
4 = Trigger controls
5 = Analysis keys
6 = Navigation controls
7 = External trigger input
8 = Vertical controls
9 = Input channels
10 = Two option slots for R&S RTP-B1 (MSO) or R&S RTP-B1E (for R&S RT-ZVC) , R&S RTP-B6 (waveform generator), R&S RTP-B7 (pulse source)
11 = USB connectors
12 = Connectors for probe compensation and grounding
13 = [Power] key

Channel inputs and external trigger input

The R&S RTP has four channel inputs to connect the input signals, and an external trigger input to control the measurement by an external signal.

The input connectors are provided with a special Rohde & Schwarz active probe interface, and they are BNC compatible. Thus, the instrument can automatically detect active probes that have the Rohde & Schwarz probe interface.

The input impedance of the inputs is 50 Ω.

NOTICE

Risk of instrument damage

The instrument is not rated for any measurement category.

Make sure that the input voltage on channel inputs and the external trigger input does not exceed 5 V RMS at 50 Ω input impedance.

The keys and controls are described in Chapter 2.2.3, "Keys and Controls", on page 43. The following connectors are available at the front panel:

Probe Compensation

Probe compensation terminal to support adjustment of passive probes to the oscilloscope channel.

⏚	Protective earth conductor for grounding the instrument.
⎍	Square wave signal for probe compensation, 1 kHz and 1 V_{pp}.
⊥	Ground connector for probes.

USB

Two USB type A connectors that comply with standard USB 3.0. They are used to connect devices like keyboard, mouse, printer and USB flash drive.

Note: Electromagnetic interference (EMI) can affect the measurement results. To avoid any impact, do not use USB connecting cables exceeding 1 m.

Mixed signal option R&S RTP-B1 / digital extension port R&S RTP-B1E

One of the front panel slots can be used to install the mixed signal option R&S RTP-B1 or the digital extension port R&S RTP-B1E for R&S RT-ZVC multi-channel power probe. The options provide connectors that can be used to connect two logical probes with 8 digital channels each (D0 to D7 and D8 to D15), or two flat interface cables to connect R&S RT-ZVC.

The maximum input voltage is 40 V peak at 100 kΩ input impedance. The maximum input frequency for a signal with the minimum input voltage swing of 500 mV (V_{pp}) is 400 MHz. For detailed specifications, refer to the data sheet.

Waveform generator option R&S RTP-B6

One of the front panel slots can be used to install the waveform generator option R&S RTP-B6. For detailed specifications, refer to the data sheet. The module provides the following connectors:

[Gen1, Gen2]	BNC connectors
[PattGen]	Connector for the pattern generator

Pulse source option R&S RTP-B7

One of the front panel slots can be used to install the pulse source option R&S RTP-B7. For detailed specifications, refer to the data sheet.

The module has four connectors.

- Out, $\overline{\text{Out}}$: 2.92 mm connectors (K type) for pulse signal output
- Ref, $\overline{\text{Ref}}$: 2.92 mm connectors (K type) for reference signal output

Note: Three of the mentioned options can be installed in one R&S RTP - two at the front panel, and one at the rear panel. Each option can be installed once only. To ensure correct installation and calibration, installation is done only at Rohde & Schwarz service centers. See also: "Option slot" on page 43.

2.2.2 Rear Panel

Figure 2-2 shows the rear panel of the R&S RTP.

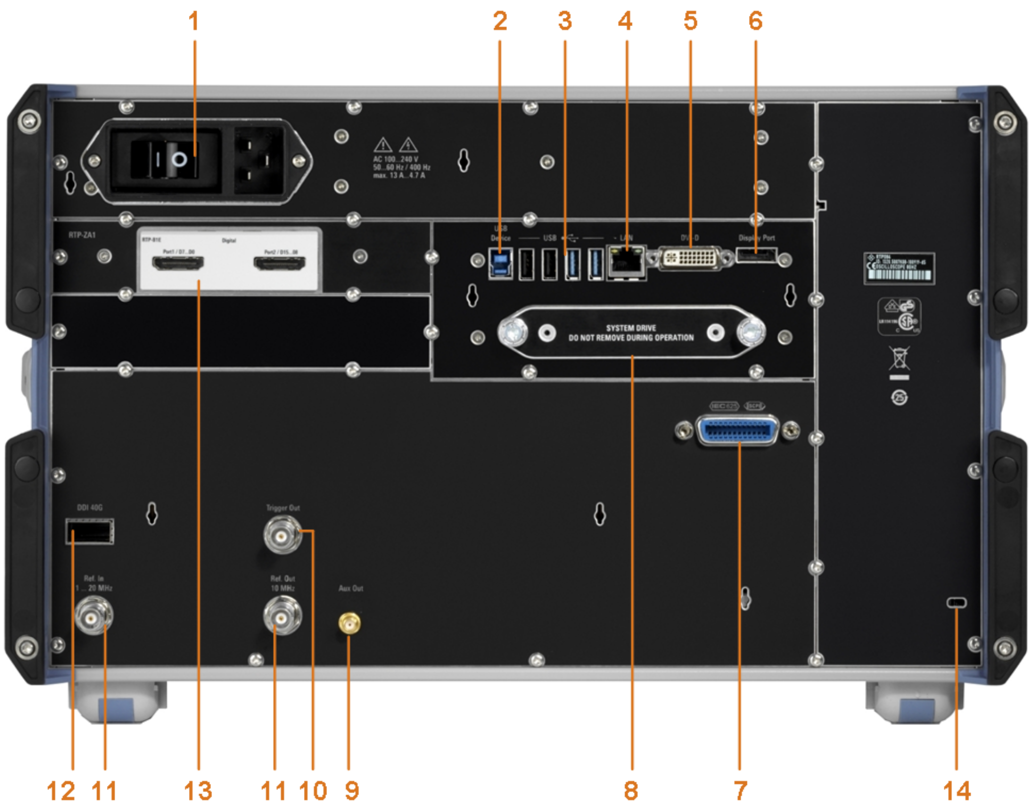


Figure 2-2: Rear panel of R&S RTP

1 = AC power supply connector and main power switch
2 = USB device connector, type B
3 = USB connectors, type A
4 = LAN connector
5 = DVI-D connector for external monitor
6 = DisplayPort connector
7 = GPIB connector

8 = Exchangeable solid state disk (SSD, option R&S RTP-B18)
9 = Aux Out connector
10 = External trigger output
11 = Ref In, Ref Out: reference input, and output of the OCXO reference signal
12 = Digital data interface (DDI, optional)
13 = Option slot
14 = Kensington lock slot to secure the instrument against theft

AC power supply connector and main power switch

Connection to the AC power line. The R&S RTP can be used with different AC power voltages and adapts itself automatically to it. The nominal voltage and frequency ranges are displayed on the rear panel and quoted in the data sheet.

If grounding is *not* ensured by the mains system, ground the oscilloscope using the protective earth conductor on the front panel and an appropriate cable.

The AC main power switch also interrupts the power supply of the OCXO.

When you power up the instrument, be sure to comply with the warm-up phase specified in the data sheet before you start measurements.

See also: Chapter 2.1.3, "Starting the Instrument", on page 34

USB Device

USB 3.0 interface of type B (device USB), to be used for remote control of the instrument.

USB

Four USB type A connectors. Two connectors comply with standard USB 3.0, and the other two with standard USB 2.0. They are used to connect devices like keyboard, mouse, printer, and flash drive to store and reload instrument settings and measurement data.

Note: Electromagnetic interference (EMI) can affect the measurement results. To avoid any impact, do not use USB connecting cables exceeding 1 m.

LAN

8-pin RJ-45 connector used to connect the instrument to a Local Area Network (LAN). It supports up to 1000 Mbit/s (10/100/1000BASE-T Ethernet).

DisplayPort

DisplayPort connector for an external monitor or projector. It supports DisplayPort version 1.1a.

DVI-D

Digital connector for an external monitor or projector. The monitor shows the complete content of the instrument's screen.

See also: Chapter 2.1.4.2, "Connecting an External Monitor", on page 37.

GBIP

Connector with GBIP interface. For detailed specifications, refer to the data sheet.

Aux Out
Output of the internal calibration signal, if the signal is configured to external destination.

Trigger Out
The BNC connector for external trigger output is used to provide the internal trigger signal of the oscilloscope to trigger other instruments for synchronized measurements.

When a trigger occurs, the R&S RTP creates a pulse of 5 V with a source impedance of 50 Ω and delivers it to the external trigger output. The instrument can also send the pulse on mask test violation or violation of measurement limits and margins.

If the connector is terminated with 50 Ω, the signal level is 2.5 V (50 mA). With 1 MΩ termination, the level is 5 V. A short-circuit of the connector to ground creates current of 100 mA.

To enable the trigger out signal, select "Trigger" menu > "Ctrl/Action". Here you also adjust polarity, delay, and length of the pulse. The default is a positive pulse of 100 ns. The minimum delay is 800 ns.

Ref In, Ref Out
BNC connectors for input of a reference signal, and for output of the OCXO reference signal.

The input frequency ranges from 1 MHz to 20 MHz in 1 MHz steps. The input impedance is 50 Ω.

The output frequency of the OCXO is 10 MHz, the impedance is 50 Ω. For detailed specifications, refer to the data sheet.

DDI 40G
Optional digital data interface for input and output of digital data.

Option slot
Slot to install one of the options R&S RTP-B1 (MSO) or R&S RTP-B1E (for R&S RT-ZVC) if both slots at the front panel are used for other options. To install the option, the R&S RTP-B21 slot adapter ist required. The options and their connectors are briefly described in Chapter 2.2.1, "Front Panel", on page 38.

2.2.3 Keys and Controls

2.2.3.1 Power Key

The [Power] key is located on the lower left corner of the front panel. It starts up and shuts down the instrument's software.

The light of the key shows the instrument state:

- Orange: standby, the main power switch is on, the software is shut down.
- Green: The instrument is ready for operation.

See also: Chapter 2.1.3, "Starting the Instrument", on page 34.

2.2.3.2 Setup Controls

Setup keys set the instrument to a defined state, change basic settings, and provide print and help functions. The intensity rotary knob adjusts the display contrast for several display elements.

[Autoset]
The instrument analyzes the enabled channel signals, and adjusts appropriate horizontal, vertical, and trigger settings to display stable waveforms.

[Preset]
Resets the instrument to a default state. All measurements, mask tests, zoom, and most individual settings are deleted, and all channels except for channel 1 are disabled. You can define preset configurations and save them to a file. The [Preset] key can be configured to set either factory defaults or a user-defined preset configuration.

[Save Recall]
Opens and closes the "File" dialog box, where you can:
- Save instrument settings (user settings)
- Load instrument settings which were saved before
- Save waveform data and measurement results
- Define a naming pattern for autonaming of files

[Setup]
Opens and closes the "Setup" dialog box, where you can:
- Access Windows configuration and install firmware updates
- Configure the touchscreen
- Check and install option keys for software options
- Check availability of hardware options
- Configure remote settings, LAN settings, and GPIB

Camera
Performs the action that is assigned to the key in "File" menu > "Frontpanel Setup" > "Hardkeys". By default, the key saves a screenshot of the waveform display.

See also: Chapter 3.3.2, "Hardkeys: Function Assignment", on page 85

[Help]
Opens the appropriate help topic for the active tab. If no dialog box is open, the contents page of the help appears.

[Touch Lock]
Locks the touchscreen to prevent unintended use. When the touchscreen is off, the key is illuminated. Press again to unlock the touchscreen.

[Display]
Opens and closes the "Display" dialog box to configure the appearance of the waveforms, the diagram layout, color tables, and the XY-diagram. You can also assign name labels to the waveforms.

[Intensity]
Adjusts the intensity of the waveforms on the screen, or the background transparency of dialog boxes, or the transparency of result boxes. If a dialog box is open, turning the knob changes the transparency of dialog boxes. If a result box is open, the transparency of result boxes is changed. Otherwise the waveform intensity is adjusted. Press the knob to toggle between the three settings. The controlled parameter and its value are shown in the input box in the lower right corner of the screen.

2.2.3.3 Horizontal Controls

The keys and rotary knobs in the Horizontal functional block adjust the acquisition settings and horizontal parameters. These settings are effective for all channel waveforms.

[Res Rec Len], [Horizontal]
Open and close the "Setup" tab in the "Horizontal" dialog box, where you can:
- Adjust the time scale, and acquisition time
- Adjust the horizontal position, and reference point
- Adjust the resolution and the record length
- Enable the roll mode

[Acquisition]
Opens and closes the "Acquisition" tab in the "Horizontal" dialog box, where you can define the acquisition processing (acquisition mode and waveform arithmetic).

[Resolution / Record Length]
The rotary knob changes the resolution or the record length. Press the knob to toggle the setting. The controlled parameter and its value are shown in the input box in the lower right corner of the screen.

For resolution, turn clockwise to increase the resolution: the time between two acquisition points gets shorter. Record length and sample rate increase while the acquisition time remains constant.

For record length, turn clockwise to increase the record length, and the resolution increases too - the time between to acquisition points gets shorter.

[Position]
The rotary knob changes the horizontal position of the waveform or the position of the reference point on the screen.

You can select if the knob changes the position or the reference point in "File" menu > "Frontpanel Setup" > "Knobs". To set the value to zero, press the knob. The current value is shown in the input box in the lower right corner of the screen.

"Horizontal position" defines the time distance of the reference point from the zero point of the diagram. Turn clockwise to move the waveform to the right.

"Reference point" defines the position of the reference point on the screen. Turn clockwise to move it to the right. The reference point marks the rescaling center of the time scale. It is indicated by a gray triangle outline at the top of the diagram. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.

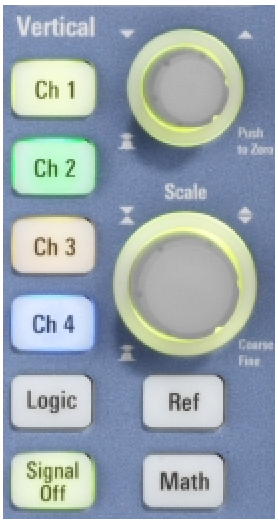
[Scale]
The rotary knob adjusts the time scale for all signals. The time scale is also known as timebase.

Turn clockwise to stretch the waveforms. Doing so, the scale value *time/div* decreases.

Press the knob to toggle between coarse and fine scale adjustment.

2.2.3.4 Vertical Controls

The keys and knobs in the Vertical functional block select a signal and adjust the vertical scale and position of the selected signal.



[Ch <n>]
Turns on, selects, and configures a channel. If the channel is active, the key lights up in the corresponding channel color .

The effect of the keypress depends on state of the channel:
- If channel is off: Pressing the key turns on the channel and selects it.
- If the channel is on, but not selected: Pressing the key selects the channel waveform.
- If the waveform is selected: Pressing the key opens the "Vertical" dialog box for the appropriate channel.

The vertical rotary knobs are focused on the selected waveform. They are illuminated in the color of the selected waveform.

[Logic]
Opens the dialog box for configuration of parallel buses and digital channels. The key lights up if you enable at least one parallel bus. You can switch off the selected bus using the [Signal Off] key.

[Ref]
Opens the "Reference" dialog box, where you can configure and display reference waveforms. Press the key repeatedly to switch the reference waveform.

If a reference waveform is selected, the vertical rotary knobs are illuminated in white or light gray (default colors), depending on the selected waveform.

[Math]
Opens the "Math" dialog box, where you can configure the calculation of mathematical waveforms using various mathematic operations on other waveforms. Press the key repeatedly to switch the math waveform.

If a math waveform is selected, the vertical rotary knobs are illuminated in brown (default color), the brightness of the color depends on the selected waveform.

[Position] (upper knob)
The upper rotary knob changes the vertical position or the offset of the selected waveform. The horizontal axis and the selected waveform are moved vertically. The knob lights up in the color of the selected waveform.

You can select if the knob changes the position or the offset in "File" menu > "Frontpanel Setup" > "Knobs". To set the value to zero, press the knob. Turn clockwise to move up the waveform. The current value is shown in the input box in the lower right corner of the screen.

- Position indicates the vertical location in divisions.
- Offset moves the vertical center of the selected channel to the offset value.

[Scale]
This rotary knob adjusts the vertical scale for the selected waveform. The knob lights up in the color of the selected waveform.

Turn clockwise to stretch the waveform. Doing so, the scale value V/div decreases.

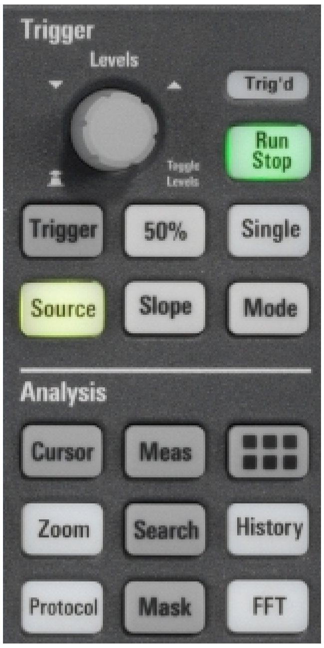
Press the knob to toggle between coarse and fine scale adjustment.

[Signal Off]
Turns off the selected signal and selects the next channel, math, or reference waveform.

The key is illuminated in the color of the selected signal and changes the color according to the new selection.

2.2.3.5 Trigger Controls

The keys and knob in the Trigger functional block adjust the trigger and start or stop acquisition.



[Trigger]
Opens and closes the "Trigger" dialog box, where you can:
- Select a trigger type and configure it.
- Set general trigger parameters and control the acquisition run.
- Qualify the trigger event with logic patterns.
- Configure a sequence of subsequent trigger events.
- Set up the zone trigger if option R&S RTP-K19 is installed.

[Levels]
The rotary knob sets the trigger level for all trigger types. Turn clockwise to move up the trigger level. If the selected trigger type requires two trigger levels - upper and lower level - press the knob to toggle between the two levels.

[Source]
Opens a dialog box where you can select the trigger source. Press the key again to switch the source. The key lights up in the color of the selected trigger source.

[Slope]
Toggles the trigger slope or trigger polarity, dependent on the trigger type. The current setting is shown on the trigger label, which is in the upper part of the sidebar.

[Mode]
Toggles the trigger mode between Auto and Normal. The current setting is shown on the trigger label.

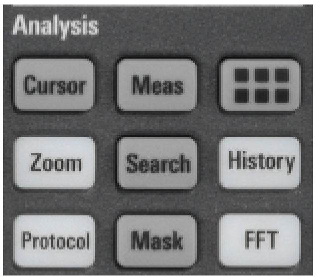
[Run Stop]
Starts and stops the continuous acquisition. A green light indicates a running acquisition. A red light shows that acquisition is stopped.

[Single]
Starts a defined number of acquisitions. A green light indicates a running acquisition. A red light shows that acquisition is stopped. Press the key again to stop running acquisitions.

To set the number of acquisitions, press the [Trigger] key, select the "Ctrl/Action" tab, and set "Average count (N-single count)".

2.2.3.6 Analysis Keys

The keys in the Analysis functional block provide direct access to measurement and analyzing functions. If you press [Cursor], [Zoom] or [Meas], the action starts on first keypress, and a second keypress opens the corresponding dialog box. If you press another function key, the dialog box opens.



[Cursor]
Displays vertical and horizontal cursors in the active diagram and opens the "Cursor Results" box.

Cursors are markers which are placed at points of interest on a waveform. The instrument measures the cursor positions and delta values between parallel cursors.

If you press the key while a cursor measurement is enabled, the "Cursors" dialog box opens.

In the "Cursors" dialog box, you can:
- Configure up to 4 cursor sets
- Define style and labels of the cursors
- Connect the cursor to the waveform and couple the cursors

[Meas]
Starts the default automatic measurement for the active waveform and opens the "Measurement" result box.

If you press the [Meas] key while a measurement is enabled, the "Measurements" dialog box is displayed, where you can:
- Configure amplitude and time measurements, eye, spectrum, and histogram measurements
- Configure gated measurement
- Configure long term and statistic measurements
- Configure actions to be executed if specified limits are exceeded

App Cockpit
Opens the "App Cockpit" dialog box, where you can start an application or analysis function directly, without knowing its position in the menu or toolbar.

The "App Cockpit" button on the left end of the menu has the same effect.

[Zoom]
Displays a zoom diagram for the active diagram. The key is illuminated if at least one zoom is active. If you press the key while the zoom function is on, the "Zoom" dialog box opens, where you can configure several zoom areas for detailed signal observation.

[Protocol]
Opens the "Protocol" dialog box which contains the configuration of serial buses and the settings for decoding the signals.

The key lights up if the decoding of a serial bus is active. You can switch off the decoded bus using the [Signal Off] key.

[Search]
Opens and closes the "Search" dialog box, where you can:
- Configure trigger events to be searched for
- Limit the search by gating
- Configure the presentation of search results

[Mask]
Opens and closes the "Masks" dialog box. Masks are used for error detection and compliance tests of digital signals.

You can:
- Configure masks and masks segments
- Define mask test parameters
- Configure actions triggered by mask violation
- Configure the mask display

[History]
The sample memory contains several stored acquisitions before the current one, which is shown in the display. Press the key to open the quick access "History" dialog box, where you can view the stored acquisitions and use them for further analysis. Press the key again to open the main "History" dialog box with more settings and information.

The key is illuminated as long as a history acquisition or replay is displayed.

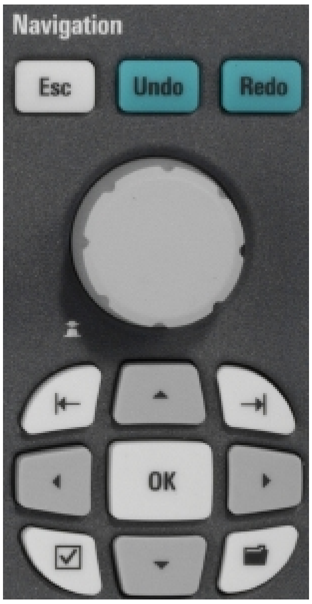
FFT
Opens and closes the FFT setup.

The key lights up if an FFT is active. You can switch off the FFT math waveform using the [Signal Off] key.

2.2.3.7 Navigation Controls

The rotary knob and the navigation keys provide an alternative way to navigate in dialog boxes and to enter numeric data.

See also: Chapter 2.3.7, "Using Dialog Boxes", on page 71



Navigation rotary knob
The navigation knob has various functions:

- In numeric entry fields: turn to increase or decrease the value.
- In tables: press to activate the edit mode, turn clockwise to increase the value or turn counterclockwise to decrease it, and press to enter the value and move to the next cell.
- To set cursor positions, histogram areas, and mask points in input boxes: press to toggle the parameter, turn clockwise to increase the value or turn counterclockwise to decrease it.
- To move zoom area, cursor line, or gate in diagrams: Turn to move the element that has the focus, and press to toggle the focus.

[Esc]
Closes a dialog box or input box.

[Undo]
Reverses the last setting actions step by step. Undo is not possible after load and recall actions, and after creating a reference waveform.

[Redo]
Recovers the undo steps in reverse order.

[OK]
The [OK] key has various functions:
- In dialog boxes and opened selection lists: the key applies the selected value.
- In tables: the key activates the edit mode. If the table cell is in edit mode, the key confirms the value, quits the edit mode and moves to the next cell.

Field left, Field right
In dialog boxes and tables, the keys move the focus.

In diagrams, they switch the focus between zoom areas, cursor lines, and gates.

Checkmark [☑]
The checkmark key [☑] has different functions depending on the focus:
- In usual dialog box: if the focus is on a selection list, the key opens the list and applies the selected value.
- In tables: activates the edit mode.

Tab
The tab key has various functions:

- In dialog boxes with only horizontal tabs, the key switches the horizontal tabs.
- In dialog boxes with horizontal and vertical tabs, the key switches the tabthat has the focus.
- In a table or diagram, the key moves the focus in the same way as the [▸] key.

Up arrow [▲], Down arrow [▼]
The up and down arrow keys have the following effects:
- In numeric edit fields: increase or decrease the parameter value.
- In tables: scroll vertically through the rows.
- In dialog boxes, for option buttons in a column: select an option. In an open selection list, the keys scroll the list.

Left arrow [◀], Right arrow [▶]
The left and right arrow keys have the following effects:
- In edit fields: move the cursor.
- In tables: scroll horizontally through the columns.
- In dialog boxes, for option buttons in a row: select an option.

2.3 Operating the Instrument

There are three ways to operate the R&S RTP.

Manual operation

Use the touchscreen, keys and rotary knobs, or an optional mouse and/or keyboard. The principles of manual operation are explained in this section.

Remote control

Create programs to automatize repeating settings, tests, and measurements. The instrument is connected to a computer that runs the program.

This way of operation is described in: Chapter 20, "Remote Control Commands", on page 949

Remote operation

The remote desktop connection of Windows can be used for instrument control and file transfer. Even on computers with non-Windows operating systems, a remote desktop connection is possible using RDP applications.

For details, refer to the User Manual, chapter "Remote Desktop Connection".

Remote monitoring and control of the instrument from a connected computer is also possible with a standard web browser and a LAN connection.

For details, refer to the User Manual, chapter "Web Control".

Alternatively, you can use Virtual Network Computing (VNC), which requires installation of the VNC server on the R&S RTP. Installation and configuration are described in the Application Note "Remote Monitoring and Control of the R&S RTP with a Web Browser", available on the Rohde & Schwarz Internet.

2.3.1 Means of Manual Interaction

The R&S RTP provides the following means of manual interaction, which you can use alternatively or complementary:

- Touchscreen:
  Using the touchscreen is the direct interaction way. Use your finger to place waveforms on the screen, mark areas for zoom and histograms, set parameters in dialog boxes, enter data, and much more. The control elements and actions on the screen are based on common concepts, and you will easily become familiar with the user interface.

  Tapping the screen works like clicking mouse buttons:
  - Tap = click: Selects a parameter or provokes an action.
  - Double-tap = double-click has the same effect as touch and hold = right-click: Opens the on-screen keyboard or keypad, or a specific editor if available

  Use gestures to scale the waveform:
  - Spread or pinch two fingers horizontally to change the horizontal scale (timebase).
  - Spread or pinch two fingers vertically to change the vertical scale of the active waveform.
- Function keys and rotary knobs:

The front panel provides nearly all functions and controls to operate the instrument in the classic ways, without touchscreen. As an exception, the sidebar cannot be used with front panel controls.

- Optional mouse and/or keyboard:
  These devices work conform to Windows standards. The navigation keys on the front panel correspond to the keys on the keyboard.

The usage of the touchscreen and navigation keys is described in detail in the following sections.

2.3.2 Touchscreen Display

2.3.2.1 Information on the Display

The touchscreen of the instrument shows the waveforms and measurement results, and also information and everything that you need to control the instrument. All waveform-related display elements are shown in Figure 2-3. An overview of control elements - like dialog box, toolbar - is given in Figure 2-6 .

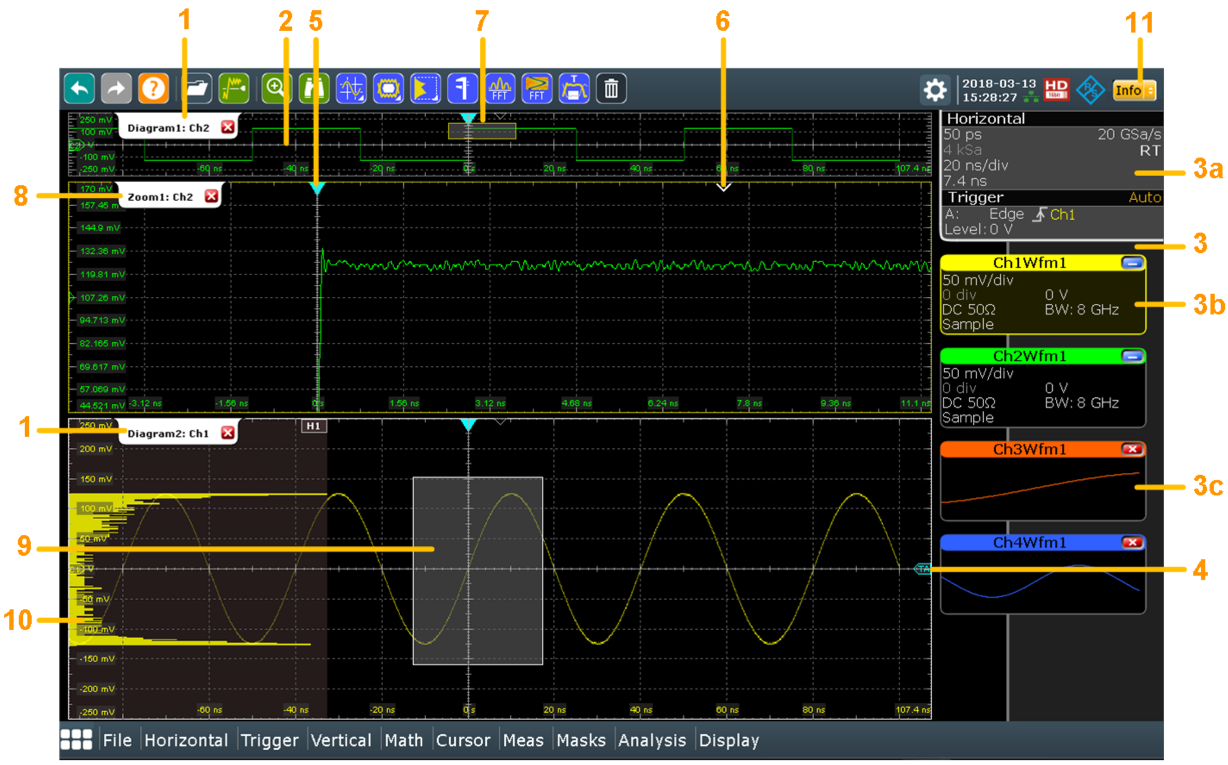


Figure 2-3: Display information

1 = Diagram
2 = Grid
3 = Sidebar with horizontal and trigger label (3a), signal icon with waveform settings (3b) and signal icon with minimized live waveform (3c)
4 = Trigger level

5 = Trigger position
6 = Reference point (distance from trigger position to reference point = horizontal position)
7 = Zoom area
8 = Zoom diagram
9 = Histogram area
10 = Histogram
11 = Messages

Diagram (1)

A diagram shows one or more waveforms: channel, reference, and math waveforms together with histograms, masks etc. Zoom details, XY-waveforms, spectra and other special waveforms are shown in separate diagrams.

By default, the diagram name contains the diagram number and the short names of the waveforms shown inside. To change the diagram name, touch and hold the tab name. The on-screen keyboard opens to enter the new name. Names must be unique.

To arrange the diagrams on the screen, the Rohde & Schwarz SmartGrid function helps you to find the target place simply and quickly. For details, see "To arrange a waveform using the SmartGrid" on page 61. You can also adjust the diagram size by dragging the diagram border.

Grid (2)

The grid shows the vertical and horizontal divisions. The division lines are labeled with the correspondent values. The grid labels have the color of the waveform to which they belong. If several waveforms are shown in one diagram, the grid has the color of the selected waveform.

Sidebar (3)

The sidebar is the control center for all enabled waveforms. On the top, the horizontal and trigger labels show the main timebase and trigger settings. If you tap a label, the relevant dialog box opens with the tab used at last.

Figure 2-4: Horizontal and trigger label on top of the sidebar

1 = Resolution
2 = Record length
3 = Timebase (horizontal scale)
4 = Horizontal position
5 = Sample rate
6 = RT - real time, IT - interpolated time

7 = Trigger mode
8 = Trigger type, slope or polarity, source for A-event and B-event
9 = Trigger level

Below, each waveform is represented by a signal icon. If the waveform is shown in a diagram, the signal icon displays its main vertical and acquisition settings. If you tap the "Minimize" icon on the signal icon, the waveform switches from the diagram area to the signal icon: the icon shows the real-time preview of the waveform. If you tap a signal icon, the dialog box with vertical settings for this waveform opens. See Chapter 2.3.4, "Working with Waveforms", on page 59 for a detailed description.

In Figure 2-3, the signal icons Ch1Wfm1 and Ch2Wfm1 show the main settings, and the waveforms are displayed in diagrams. All other waveforms are minimized and shown in the signal icon.

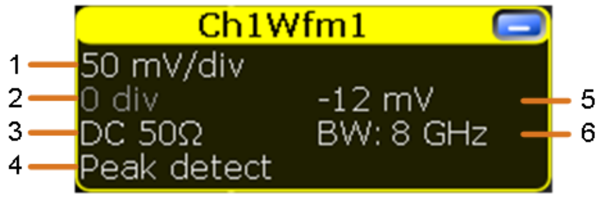


Figure 2-5: Signal label on the sidebar

1 = Vertical scale
2 = Vertical position
3 = Coupling and Termination
4 = Acquisition mode
5 = Offset
6 = Actual bandwidth, can be less than the instrument bandwidth depending on the number of active channels and other settings

If the sidebar contains many icons and not all icons are visible, touch one of the icons and move it up or down until the required icon appears.

You can also switch off the sidebar: "Display" menu > "Diagram Layout" > "Show signal bar" .

Trigger position and trigger level (4, 5)
The blue markers show the horizontal position of the trigger and the vertical trigger level. You can touch and move the trigger markers in the diagram to set the positions. The trigger point is the zero point of the diagram.

The trigger position can be moved outside the diagram. A red trigger position marker indicates that the trigger position is not visible.

Reference point (6)
The reference point marks the rescaling center. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.

You can define the position of the reference point (Horizontal), and its time distance from the trigger point of the diagram (Position).

Zoom diagram and zoom area (7, 8)
Zoomed waveforms are shown in separate zoom diagrams, in addition to the waveform diagrams. On the original waveform diagram, a rectangle indicates the zoomed section of the waveform - this is the zoom area. You can modify the zoom area by dragging the rectangle as a whole, and by dragging its edges. To toggle between these modes, tap the zoom area. You can also set exact positions.

The frames of the zoom area and of the associated zoom diagram have the same color, different zooms are marked with different colors. So it is easy to assign zoom area and zoom diagram.

As for waveform diagrams, you can change the name of the zoom diagram. A zoom in a zoom and coupled zooms are also possible.

For details, see Chapter 6.1, "Zoom", on page 226.

Histogram and histogram area (9, 10)
A histogram shows the frequency of occurrence of voltage or time values in a bar chart directly in the diagram. The rectangular histogram area indicates the part of the waveform that is considered in the histogram. The vertical histogram counts the voltage values, and the horizontal histogram counts time values. You can switch between vertical and horizontal mode, and modify the histogram area by dragging the rectangle as a whole, by dragging its edges, or by setting exact positions.

Messages (11)
A yellow or red button on the toolbar points to the status messages of the instrument. To open the message box, tap the button. See also: Chapter 2.3.9, "Messages", on page 74.

2.3.2.2 Control Elements on the Touchscreen

The touchscreen provides everything you need to control the instrument, to analyze waveforms, and to get measurement results. Figure 2-6 shows the control elements on a glance.

Figure 2-6: Control elements on the touchscreen

1 = Toolbar
2 = Sidebar, see "Sidebar (3)" on page 55
3 = Menu bar
4 = Dialog box
5 = Tab in a dialog box
6 = Result box
7 = Input box

Toolbar (1)

The icons on the toolbar provide quick and easy access to the most important functionality. For a detailed description, refer to Chapter 2.3.5, "Toolbar", on page 63.

Menu bar (3)

The menus provide access to the complete functionality of R&S RTP.

Dialog box (4, 5)

The tabs of the dialog boxes contain all task-oriented settings and operations, and black buttons for calling related tabs. The usage of dialog boxes is described in Chapter 2.3.7, "Using Dialog Boxes", on page 71.

Result box (6)

If you perform manual or automatic measurements, mask testing, or a search, the result box shows the results of the action. Similar to waveform diagrams, you can minimize the result box to a result icon on the sidebar, and display results in a separate diagram on the screen. The icon opens the corresponding dialog box to adjust the settings.

For details, see Chapter 2.3.6, "Displaying Results", on page 69.

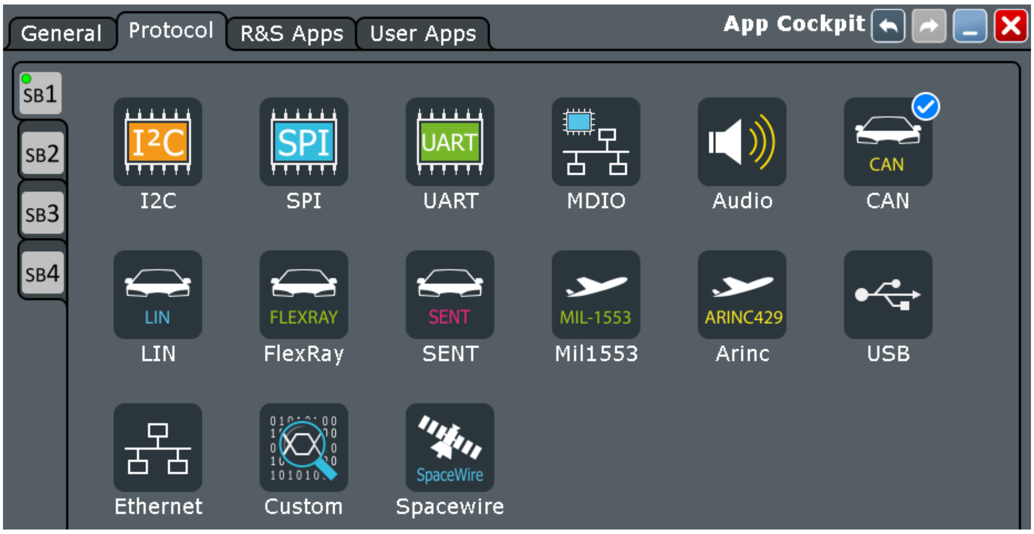
Input box (7)
The input box appears if you adjust a value using one of the rotary knobs, or if you drag an element on the screen, for example, a cursor line. The input box shows the current value of the modified parameter. You can enter the exact numerical value, change the step size, and - if available - autoset the value directly in the input box. The box title shows the name of the currently adjusted parameter. The input box is helpful when using the multi-function rotary knobs, for example, [Intensity], and [Resolution / Record Length].

See also: Chapter 2.3.8, "Entering Data", on page 72.

2.3.3 App Cockpit

The app cockpit provides fast access to all available applications.

► To open the app cockpit:
- Tap in the menu.
- Press the key in the [Analysis] section of the frontpanel.



2.3.4 Working with Waveforms

The R&S RTP can create and display several types of waveforms:
- Channel waveforms:
  Up to three waveforms per input channel can be shown. For a four-channel instrument, 12 channel waveforms are available.
- Reference waveforms:
  Four waveforms can be used as reference for comparison and analysis.
- Math waveforms:

Four mathematic waveforms can be created with mathematic operations performed on channel, reference, and other math waveforms.

- Zoom waveforms:
  Show the details of waveforms.
- XY-waveforms:
  Four XY-waveforms can be created. Each XY-waveform is built from the voltage values of two source waveforms.
- Digital waveforms:
  The Mixed Signal Option R&S RTP-B1 provides 16 digital channels grouped in two logic probes (pods) with 8 channels each.

Waveform handling

The R&S RTP can show and analyze many waveforms. To handle this multitude while keeping track of it, the R&S RTP provides intelligent support:

- The color system helps to distinguish the waveforms. The color of the vertical rotary knobs indicates the signal that is focused (selected). The color of each waveform can be changed, the color of its signal icon and of the illuminated keys is adjusted to the new color. Alternatively, a color table can be assigned to a waveform. Settings: [Display] > "Signal Colors / Persistence" tab.
- Waveforms can be minimized to signal icons showing a small real-time signal view. Thus, more space in the diagram area is available without switching off waveforms.
- Diagrams are displayed on tabs – you can arrange them side by side or one above the other. To change the diagram name, double-tap the tab name.
- The Rohde & Schwarz SmartGrid function helps to arrange the diagrams.

Waveform states

Depending on its place on the screen and the effect of settings, a waveform has one of the following states:

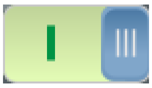
- Off
- Active:
  The waveform is shown in a diagram
- Selected:
  One of the active waveforms that has the focus. In each diagram, one of the assigned waveforms is selected – it appears "on top" in the diagram, and the grid labels have the color of the selected waveform. Some of the toolbar functions, like cursor and histogram measurements are performed on the selected waveform. All waveform-specific settings are applied to the selected waveform of the selected diagram. The vertical [Position] and [Scale] knobs, and the [Signal Off] key are illuminated with the color of the selected waveform.
  In Figure 2-3, "Ch1Wfm1" is the selected waveform: The frame of the diagram and the signal icon are highlighted.
- Minimized:
  The waveform is shown as real-time signal view in its signal icon.

To switch a waveform on

A channel waveform is activated as soon as you connect the probe. You can switch it on and off according to your needs.

► Choose one of the following ways:

- Press the channel key.
- In the "Vertical" dialog box, select the channel and tap the "Show channel" button.

The waveform is now active, selected, and is shown in the diagram.

To select a waveform

► Choose one of the following ways:

- Tap the waveform in the waveform diagram.
- To select a channel, reference, or math waveform, press the corresponding key.
- Tap the signal icon.

Note: Zoom waveforms in zoom diagrams cannot be selected.

To minimize a waveform

► Choose on of the following ways:

- Tap the "Minimize" icon in the upper right corner of the waveform's signal label in the sidebar.
- Drag the waveform from the diagram to the sidebar.

The waveform disappears from the diagram and the minimized signal view is shown in the signal icon.

Tip: To set the waveform back to its previous diagram immediately, use "Undo".

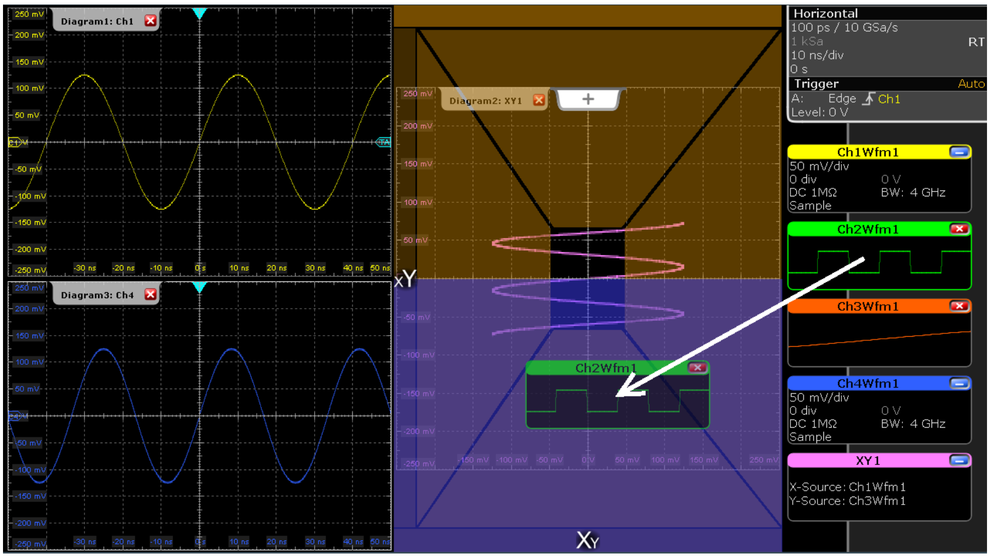
To arrange a waveform using the SmartGrid

You can arrange waveforms in one of the existing diagrams, or in a new diagram.

The usage of the SmartGrid is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > SmartGrid".

1. Drag the signal icon to the diagram area, and move it around.
   The Rohde & Schwarz SmartGrid appears and a blue area shows where the waveform will be placed.

2. Drop the waveform in the target area.
   The waveform appears in an existing or in a new diagram, and it is selected for further actions.



3. To change the size of the new diagram, drag its edge to the required position.

The diagram layout depends on the position where you drop the signal view, in relation to an existing diagram.

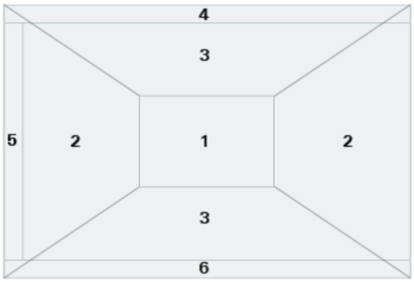


Figure 2-7: SmartGrid positions

1 = In the existing diagram, overlay of signal
2 = New diagram on the left or right
3 = New diagram above or below
4 = New diagram on top of the existing diagram
5 = XY-diagram
6 = YX-diagram

To switch off a waveform

► Do one of the following:

- Select the waveform, and then press the [Signal Off] key.
- To switch off a minimized waveform, tap the "Close" icon in the upper right corner of the minimized signal view.
- Disable "Show channel" in the "Vertical" > "Channels" tab.
- Tap the "Delete" icon (Recycle bin) in the toolbar, and then the waveform.

If several waveforms overlap or lie close together, the upper (selected) waveform is switched off.

2.3.5 Toolbar

The toolbar provides direct access to important control and measurement functions. It shows current date and time, and a message button. The selected function is highlighted.

By default, the toolbar shows the most frequently used functions. You can configure the content of the toolbar and hide the date/time display, see Chapter 2.3.5.2, "Configuring the Toolbar", on page 64.

2.3.5.1 Using the Toolbar

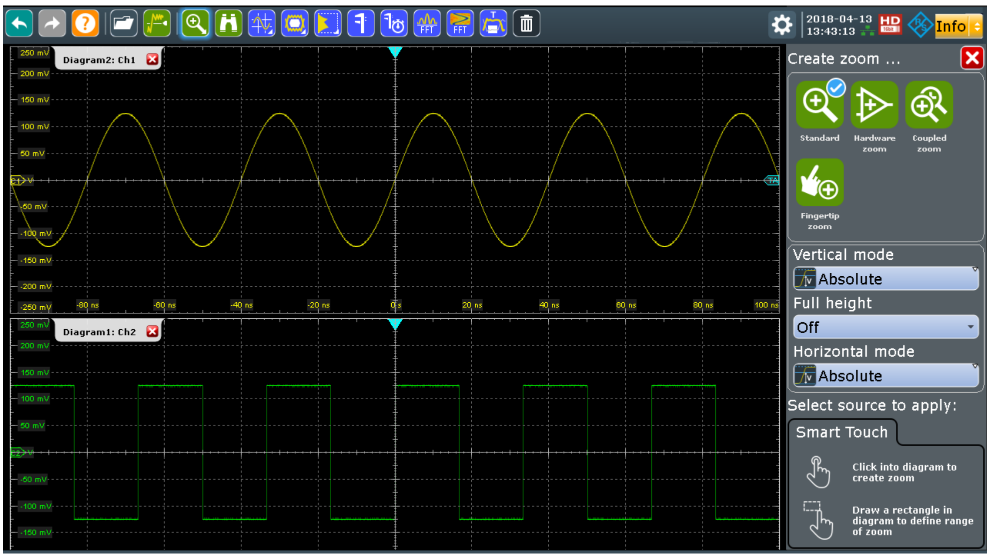
Using the toolbar is easy and straightforward.

Some of the toolbar functions are one-click actions. These actions are performed immediately when you tap the icon.

Other toolbar functions are analyzing functions. These actions are interactive actions.

To use analyzing functions (interactive actions)

1. If several waveforms are shown in the diagram, select the waveform that you want to analyze.
   See: "To select a waveform" on page 61
2. Tap the icon of the function in the toolbar.
3. Check and adjust the settings in the sidebar on the right.



4. To define the analyzed area, do one of the following:
   - Tap the required diagram.
   - Drag a rectangle on the diagram.

The toolbar handling is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Toolbar".

2.3.5.2 Configuring the Toolbar

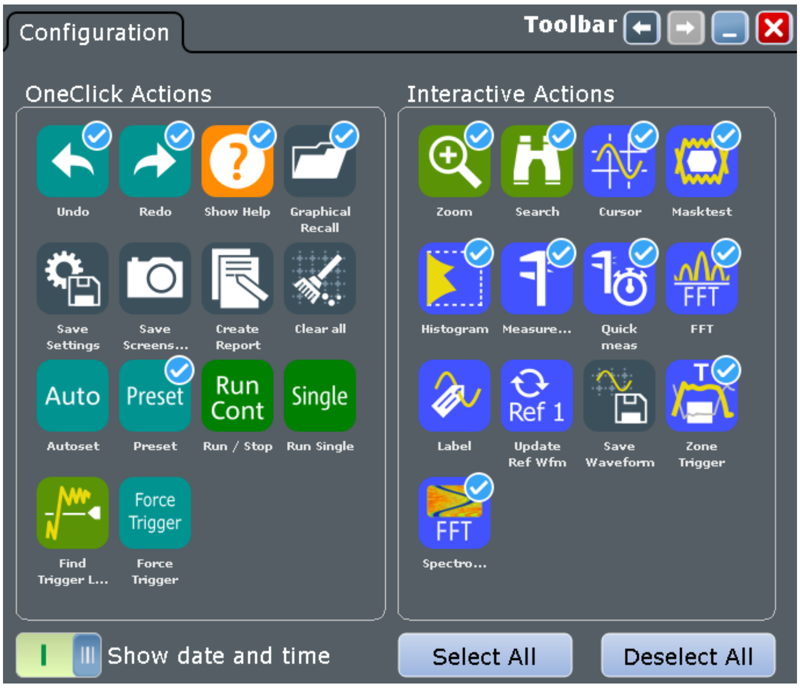
You can configure the contents of the toolbar so that only the required functions are displayed. Furthermore, date and time can be hidden. The toolbar configuration is part of the user preferences. It is retained when you switch off and on the instrument, and you can save it in the user preferences and user-defined preset.

1. To open the toolbar configuration, choose one of the following ways:
   - Tap the icon in the toolbar:
     
   - On the "Display" menu, select "Toolbar".
2. Select the required toolbar functions:
   - Disable the functions that you do not need.
     Enable the functions that you want to add to the toolbar.
   - To display all available toolbar icons, tap "Show All".
   - To hide all toolbar icons, tap "Hide All".
3. To hide the current date and time on the toolbar, disable "Show date and time".

A detailed description of the toolbar functions is given in Chapter 2.3.5.3, "Toolbar Functions", on page 64.

2.3.5.3 Toolbar Functions

This chapter describes all toolbar functions in detail.



One-click actions	Interactive actions
Undo	Zoom
Redo	Search
Show Help	Cursor
Graphical Recall (load saveset)	Masktest
Save Settings	Histogram
Save Screenshot	Measurement
Create Report	Quick meas
Clear all	FFT
Autoset and Preset	Delete
Run / Stop and Run Single	Label
Find Trigger Level	Update Ref Waveform
Force Trigger	Save Waveform
	Spectrogram (option R&S RTP-K37)
	Zone trigger (option R&S RTP-K19)

You can configure the content of the toolbar and hide the date/time display, see Chapter 2.3.5.2, "Configuring the Toolbar", on page 64.

The following list describes at first the default toolbar functions and then the additional functions.

Undo
Undoes the last setting actions step by step. Some actions cannot be revoked: locking the touchscreen with [Touch Lock], and saving data. The undo stack is deleted during the following actions: Reloading settings from file, and reference waveform actions (save, load and preset with active reference waveform).

Redo
Recovers the undo steps in reverse order.

Show Help
Enables the tooltip display. A short description appears when you tap a parameter in a dialog or result box. To open the corresponding help topic, tap the "Show Help" button in the lower right corner of the tooltip. See also: Chapter 2.3.10, "Getting Information and Help", on page 75.

Graphical Recall (load saveset)
Opens a window to select and load instrument settings that were previously stored in a saveset. A graphical preview helps you to find the required settings.

Zoom
The zoom icon on the toolbar shows the last selected zoom type. A short tap on the icon activates the selected zoom.

To use another zoom type, select it in the sidebar.

Standard zoom ← Zoom
Displays a magnified section of the diagram in an additional zoom diagram. It is a display zoom, instrument settings are not changed.

Touch and hold the zoom area to open the "Zoom" dialog box.

Remote command:
`LAYout:ZOOM:ADD` on page 1097

Hardware zoom ← Zoom
Changes the instrument settings - horizontal and vertical scales as well as trigger level and offset - to display a part of the diagram in greater detail.

Coupled zoom ← Zoom
Creates a coupled zoom area and its related zoom diagram. If you change the size of one zoom area, the size of all coupled zoom areas is changed as well.

Remote command:
`LAYout:ZOOM:ADDCoupled` on page 1098

Fingertip zoom ← Zoom
Magnifies the waveforms around your fingertip.

Tap the icon and put your finger on the waveform. The touched part of the waveform is displayed in a magnifier. Drag your finger on the screen to move the magnifier. You can change the zoom factor using the Navigation knob.

Search
Performs a search. Tap the icon and adjust the settings in the sidebar. Tap the diagram with the waveform to be searched, or drag a rectangle to define a search gate. The search is performed on the selected waveform.

Cursor
The cursor icon shows the last selected cursor type. A short tap on the icon activates the selected cursor.

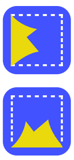
To use another cursor type, select it in the sidebar, and adjust the settings.

Tap the diagram where you want to set the cursors, or draw a rectangle in the diagram to position the cursor lines. The resulting cursor lines measure the selected waveform. The results appear in the "Cursor Results" box. You can adjust the cursor source, type and position in the result box. Move the cursor lines by dragging them in the diagram, or by turning the navigation knob. Pressing the knob switches the parameter to be changed.

Masktest
Starts the on-screen mask definition and the testing against the defined mask.

Tap the icon and then tap the points that build the mask. Double-tap the last point to finish mask definition. To create a rectangular mask, draw a rectangle on the screen. You can move the mask on the screen.

To configure the mask test settings, tap the icon in the "Mask" result box.



Histogram
The histogram icon on the toolbar shows the last selected histogram type. A short tap on the icon activates the selected histogram.

To use another histogram type, select it in the sidebar, and adjust the settings.

Tap the icon and then drag a rectangle on the diagram to mark the histogram area. The histogram for the selected waveform appears.

Touch and hold the histogram area to open the "Histogram" dialog box.

Measurement
Starts an automatic measurement.

You can run up to 8 automatic measurement groups in parallel. The "Automatic meas-urment" icon starts the measurement groups one after the other.

A measurement group consists of minimum one measurement, and can consist of many measurements of the same category. Tap the icon and select the measurements in the sidebar. Tap the diagram with the waveform to be measured. To define a mea-surement gate, draw a rectangle on the screen.

To modify the measurement, tap the icon in the "Measurement" result box.

Quick meas
Performs a set of measurements on the selected waveform. You can configure up to 8 measurement to be included in quick measurement.

Tap the icon and then tap the diagram with the waveform to be measured.

FFT
Transforms a waveform to the frequency spectrum by fast Fourier transform (FFT). The FFT trace is shown in a new diagram.

Tap the icon and adjust the settings in the sidebar. Tap diagram with the waveform to be transformed. The FFT diagram is created from the selected waveform.

To adjust FFT settings, double-tap the FFT diagram.

Delete
Removes zoom and histogram areas and their diagrams; measurement areas and their associated results; and mask segments. The icon also switches off a waveform.

Tap the icon and then tap the area or diagram to be deleted, or the waveform to be switched off.

Save Settings
Saves the current instrument settings in a saveset. The filename is created according to the autonaming pattern. You can reload the saveset using the "Load saveset (Graphical recall)" toolbar icon, or using [Save Recall] > "Save/Recall" > "Settings".

Save Screenshot
Saves a screenshot of the current display using the settings defined in "File" menu > "Print Setup".

Create Report
Creates a report of the current measurement settings and results using the settings defined in "File" menu > "Report Setup".

Clear all
Deletes all measurement results including long term measurement and statistics, all waveforms, and the history.

Autoset and Preset
Performs an autoset, or a preset to a default state. The icons have the same functionality as the corresponding keys on the front panel. They are useful when you control the instrument remotely.

Run / Stop and Run Single
Starts and stops the continuous acquisition, or starts a defined number of acquisition cycles. The icons have the same functionality as the corresponding keys on the front panel. They are useful when you control the instrument remotely.

Find Trigger Level
Analyses the signal and sets the trigger level to the middle of the signal peaks.

Force Trigger
Starts an immediate single acquisition. If the acquisition is running in normal mode and no valid trigger occurs, use "Force Trigger" to confirm that a signal is available. Then you can use the displayed waveform to determine how to trigger on it.

Label
Defines a waveform label that names or explains the waveform. Tap the icon and then tap the waveform to be labeled. If you tap the display background, the label is assigned to the selected waveform. Enter the label text using the onscreen keyboard. The text is shown in the same color as the waveform. You can drag the label to another position.

Update Ref Waveform
Copies the selected source waveform with all its settings to the reference waveform. If the acquisition is running, the reference waveform is a snapshot. You can configure up to four reference waveforms.

Select the required reference waveform (R1 to R4) in the sidebar.

Save Waveform
Exports the waveform data to file using the settings defined in [Save Recall] > "Waveforms / Results" > "Waveforms". The filename is created according to the autonaming pattern.

Tap the icon and then tap the waveform to be exported. If you tap the display background, the selected waveform is exported, or a multichannel export is performed if configured.

Spectrogram (option R&S RTP-K37)
Starts an FFT and the spectrogram. The FFT trace and the spectrogram are shown in separate diagrams.

Tap the icon. Select the source in the sidebar, or tap diagram with the waveform to be transformed. The diagrams are created from the selected waveform.

Zone trigger (option R&S RTP-K19)
Defines a zone trigger, which combines the trigger condition with the intersection or non-intersection of one or more zones or masks.

Tap the icon and then tap the corner points of the zone on the screen.

2.3.6 Displaying Results

The results of automatic and cursor measurements, mask tests, and searches are displayed immediately in a result box.

There are several places to display the results:

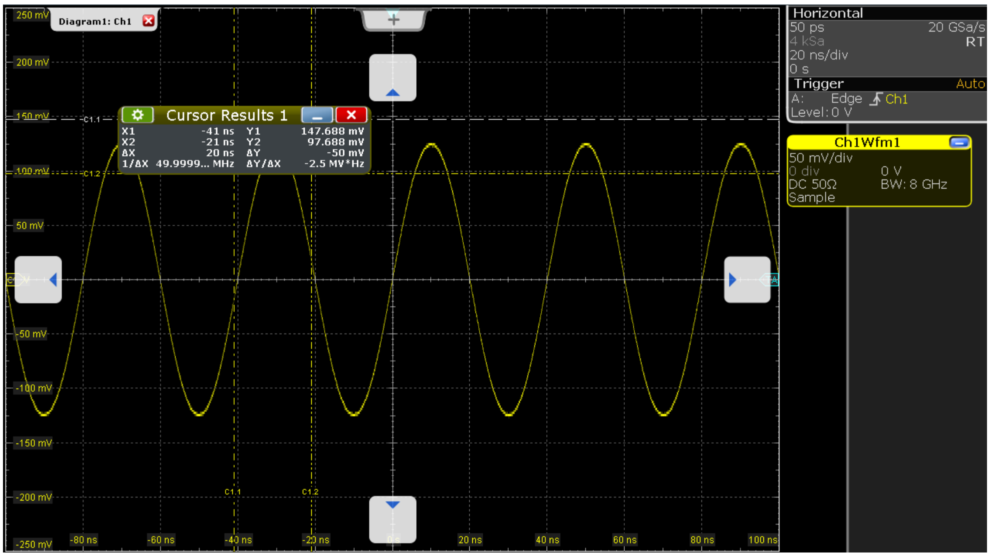
- In a floating result box in front of the diagrams, which you can move on the display
- In a minimized view (result icon) on the sidebar
- In a separate tab
- For results of automatic measurements: in a docked tab below the diagram

The default position and the font size can be adjusted.

To arrange a result box on the display

► Touch the title of the result box and drag the box on the screen. The SmartGrid indicates where the result box will be placed.

- If you drop the box on one of the buttons, the results are shown in a separate tab besides, above, or below the diagram.
- If you drop the box on the sidebar, a result icon is created.
- If you drop the box somewhere else, a floating result box is created.



1 = Floating result box
2 = Table in a tab on the left or right
3 = Table in a tab above or below
4 = New tab

To open the corresponding setup dialog box

1. In the result box, tap the icon. Alternatively, double-tap the results.
2. If the sidebar opens, tap "Advanced Settings" in the sidebar.

   The dialog box with corresponding settings opens.

To define the default position of results

1. Press the [Display] key on the front panel.
2. In the "Display" dialog box, select the "Diagram Layout" tab.
3. Under "Result box", select the "Default position":
   - "Preview": result icon on the sidebar
   - "Floating": floating result box in front of the diagrams
4. For result boxes of automatic measurements, the docked position is the default. In docked position, the result table is placed below the diagram. To change the default position of measurement results, select "Meas" menu > "Gate/Display" > "Default" position.

To adjust the font size in result boxes

1. Press the [Setup] key.

2. Select the "Screen" tab.
3. Set the "Result dialog font size".

2.3.7 Using Dialog Boxes

All functionality is provided in dialog boxes as known from computer programs. You can control the instrument intuitively with the touchscreen. This section provides an overview of the accessing methods and describes how to use the dialog boxes.

Each dialog box has four icons in the upper right corner:

	Go back: opens the previously opened dialog box.
	Go forward: opens the next dialog box.
	Minimizes the dialog box to a small box that only contains the last selected function.
	Closes the dialog box.

For direct access to important control and measurement functions use the toolbar, see Chapter 2.3.5, "Toolbar", on page 63.

To open a dialog box

► Perform one of the following actions:
- Tap the required menu, and then the menu entry.
- Press the function key on the front panel.
- If a results box is open, tap the icon to open the corresponding dialog box.
- To open the "Vertical" dialog box of a waveform, tap its signal icon. For XY-waveforms, the "XY Diagram" tab opens.
- Tap the horizontal or trigger label to open the "Horizontal" or "Trigger" dialog box, respectively.

To minimize a dialog box

If you want to change only one setting during analysis, and you need to change it often, you can display a small box that only contains the required setting.

1. Tap the function that you need to modify.
2. Tap the "Minimize" icon in the upper right corner of the dialog box.

The dialog box turns into a small box that contains only the "Wfm Arithmetic" setting.

3. To restore the complete dialog box, tap the "Maximize" icon in the small box.

To close a dialog box

► Tap the "Close" icon in the upper right corner.
Or:
Press the [Esc] key on the front panel.

To select an option in a dialog box

► Tap the required option.
Or:
Press the [⇤] and [⇥] keys to navigate to the required option. Then press the [☑] key.

To select an option in a list

If many options are available - for example, for the trigger type - the options are provided in a list. The current selection is shown on the list button.

► Tap the list button. Then tap the required option.
Or:
Use the front panel keys:
a) Press the [⇤] and [⇥] keys to navigate to the list button.
b) Press the [☑] key to open the list.
c) Press the [▲] and [▼] keys to navigate to the required option in the list.
d) Press the [☑] key to select the marked option.

2.3.8 Entering Data

Most important parameters have their own rotary knobs on the front panel. When you turn a knob, the input box appears the lower right corner of the screen, showing the parameter name and current value.

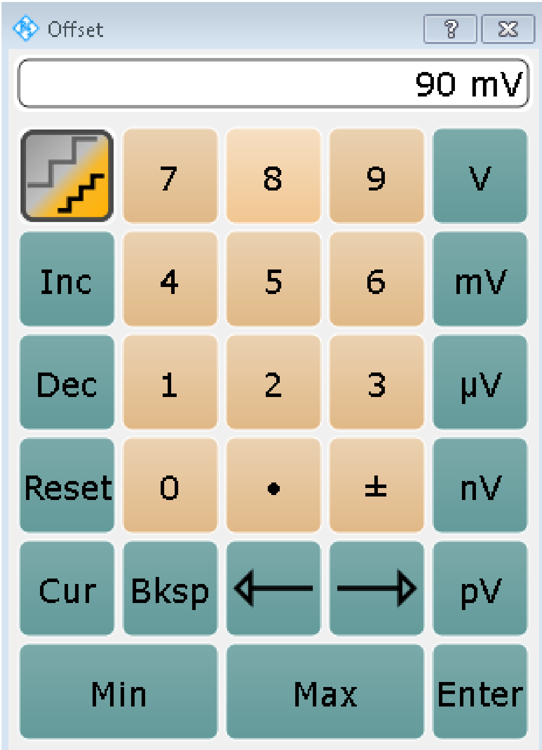
Using rotary knobs

1. Turn the knob to change the value.
2. To toggle the increment, tap the "Steps" icon in the input box.
3. To set the parameter to the autoset value (if available), tap the "RESET" icon.

For data input in dialog boxes, the touchscreen provides an on-screen keypad to enter numeric values and units. For text input, the on-screen keyboard with English key layout is used.

To enter values with the on-screen keypad

1. Double-tap the entry field.
   The on-screen keypad opens.



2. Enter the numeric value using the following methods:
   - To use the default value, tap "Reset" (if available).
   - To use the minimum or maximum value, tap "Min" or "Max", respectively.
   - To increase the displayed value in fixed steps, tap "Inc".
     To decrease the value in fixed steps, tap "Dec".
     To toggle between small steps and large steps, tap the "Steps" icon.
     
   - To get the value that was used before the keypad was displayed, tap "Cur".
   - To enter a user-defined value, tap the numbers and complete the entry by tapping the unit button.
     – The arrow buttons move the cursor left or right.
     – "Bksp" deletes the last character before the cursor.
     – "±" changes the sign of the value.

To enter data with the on-screen keyboard

1. Double-tap the entry field to open the on-screen keyboard.
   If available, you can also tap the keyboard icon on the right of the entry field.

2. Enter the text as you would on a normal keyboard.
   - To enter a series of capital characters, tap "Caps".
     To enter one capital character, tap "Shift".
   - To use the currently defined value, tap "Cur". This is the value that was used before the keyboard was displayed.
   - The arrow buttons move the cursor left or right.
   - "Bksp" deletes the last character before the cursor.
3. Tap "Enter" to complete the entry.

To enter numeric data in a dialog box with navigation controls

1. To navigate to the entry field, press the [⇤] and [⇥] keys.
2. To change the value with a small step size, turn the rotary knob.
   Alternatively, press the [▲] and [▼] keys for a larger step size.

If you edit numeric data in tables, the entry field must be in edit mode. To activate the edit mode, press ENTER, or the [☑] key, or the navigation rotary knob.

2.3.9 Messages

Status messages of the instrument are displayed for a few seconds. Then they are saved in a message box in the upper right corner of the screen. By default, the message box is closed. You can open it to read the messages and to delete them.

► To open and close the message box, tap the "Info" button.

If no messages are available, the "Info" button is hidden.

Important messages are indicated by a red "Info" button. These messages cannot be deleted, they remain until the problem is solved.

2.3.10 Getting Information and Help

In many dialog boxes, graphics are included to explain the way a setting works. For further information, you can use the following sources:

- Tutorials demonstrate the general usage of the R&S RTP, for example, how to use the SmartGrid.
- Tooltips give a short description of the parameter.
- The context help provides functional description on a setting, and the corresponding remote command.
- The general help explains a dialog box, provides instructions, and general information.

2.3.10.1 Displaying Tutorials

Tutorials are silent movies, which are available directly on the instrument, and on the Internet. They show basic usage aspects.

To see a tutorial on the instrument

1. On the menu, tap "File".
2. Tap "Tutorials".
3. Tap the tutorial that you want to see.

2.3.10.2 Displaying Help

To display tooltips and context help

1. Enable the "Tooltip" icon on the toolbar.

2. Tap the parameter for which you need information.

   The tooltip opens.

3. To open the corresponding help topic, tap the "Show Help" button in the lower right corner of the tooltip.

   The "Help" window opens and displays the comprehensive description and the corresponding remote command. You can browse the help for further information.

   Note: The tooltip icon disables automatically when you tap a parameter. To show another tooltip, tap the tooltip icon again.

To open general help

► Press the yellow [Help] button on the left side of the screen.

   If a dialog box is open, the help topic for the current tab is shown. Otherwise the "Contents" page appears.

2.3.10.3 Using the Help Window

The Help window contains several tabs:

- "View" - shows the selected help topic
- "Contents" - contains a table of help contents
- "Index" - contains index entries to search for help topics
- "Search" - provides text search

The Help toolbar provides some buttons:

- To browse the topics in the order of the table of contents: Up arrow = previous topic, Down arrow = next topic
- To browse the topics visited before: Left arrow = back, Right arrow = forward
- To increase or decrease the font

To navigate the Help, use the touchscreen. Alternatively, you can also use the navigation keys on the front panel.

To search for a topic in the index

The index is sorted alphabetically. You can browse the list, or search for entries in the list.

1. Switch to the "Index" tab.
2. Select the "Keyboard" icon besides the entry field.
3. Enter the first characters of the keyword you are interested in.

   The entries containing these characters are displayed.
4. Double-tap the suitable index entry.

   The "View" tab with the corresponding help topic is displayed.

To search topics for a text string

1. Switch to the "Search" tab.
2. Select the "Keyboard" icon besides the entry field.
3. Enter the string you want to find.
   If you enter several strings with blanks between, topics containing all words are found (same as AND operator).

   For advanced search, consider the following:
   - To find a defined string of several words, enclose it in quotation marks. For example, a search for *"trigger qualification"* finds all topics with exactly *"trigger qualification"*. A search for *trigger qualification* finds all topics that contain the words *trigger* and *qualification*.
   - Use "Match whole word" and "Match case" to refine the search.
   - Use operators AND, OR, and NOT.

To close the Help window

► Select the "Close" icon in the upper right corner of the help window.
Or: Press the [Esc] key.

3 Instrument Setup

You can adapt various instrument settings to your requirements, such as language, display appearance, and assign functions to some keys.

The chapter describes also the handling of software options.

The following setup procedures are described in other chapters of the documentation:

- Chapter 2.1.4, "Connecting External Devices", on page 36
- Chapter 19.3, "Web Interface", on page 935
- Chapter 19.6, "Remote Settings", on page 946
- The firmware update is described in the release notes.

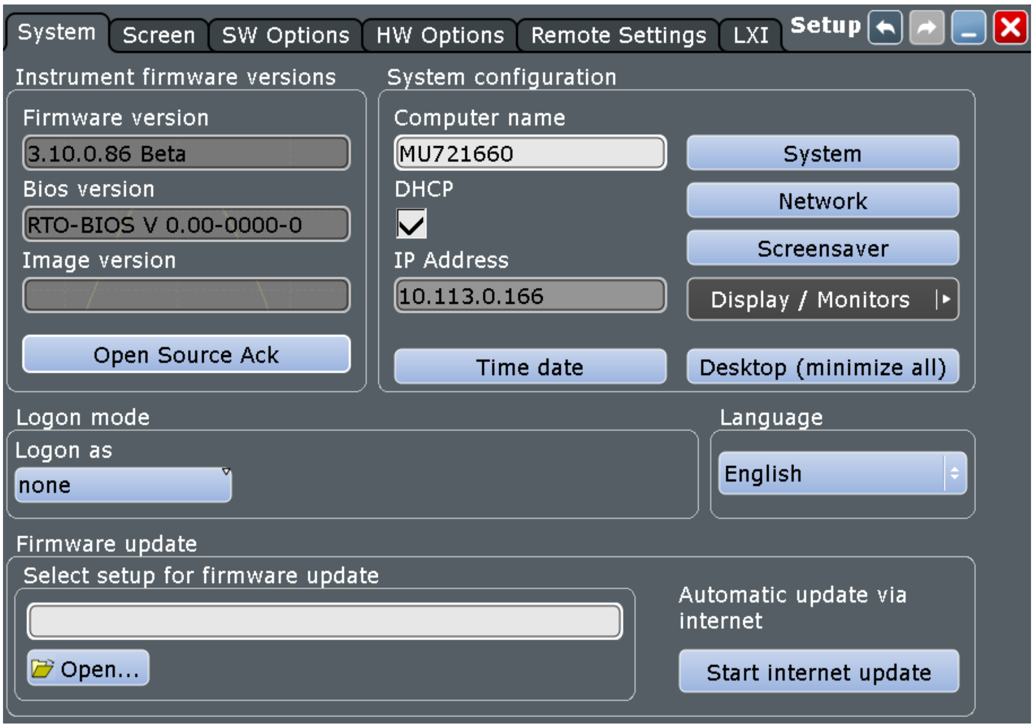
The following settings and procedures are described in the current chapter:

3.1 System Setup

3.1.1 System Settings

Access: [Setup] > "System" tab

The settings on this tab are related to the basic instrument and system configuration.



Firmware version
Indicates the firmware version currently installed on the instrument.

Remote command:
`DIAGnostic:SERVice:FWVersion?` on page 982

Bios version
Indicates the BIOS version currently installed on the instrument.

Image version
Indicates the image version currently installed on the instrument.

Desktop (minimize all)

Minimizes all displayed application windows on the instrument, so that the desktop becomes visible on the screen to access the Windows functionality.

This function is also available from the "File" menu.

Computer name, IP Address, DHCP

Indicates the currently defined computer name, the defined IP address and DHCP address enabling. These values are required to configure the instrument for work in a network.

NOTICE! Risk of network problems. All parameters can be edited here; however, beware that changing the computer name has major effects in a network. For details, see Chapter 19.2, "Setting Up a Network (LAN) Connection", on page 930.

Remote command:

`DIAGnostic:SERVice:COMPutername` on page 982

System

Opens the standard Windows "System Properties" dialog box to configure system settings. Only users with administrator rights can fulfill this task.

Network

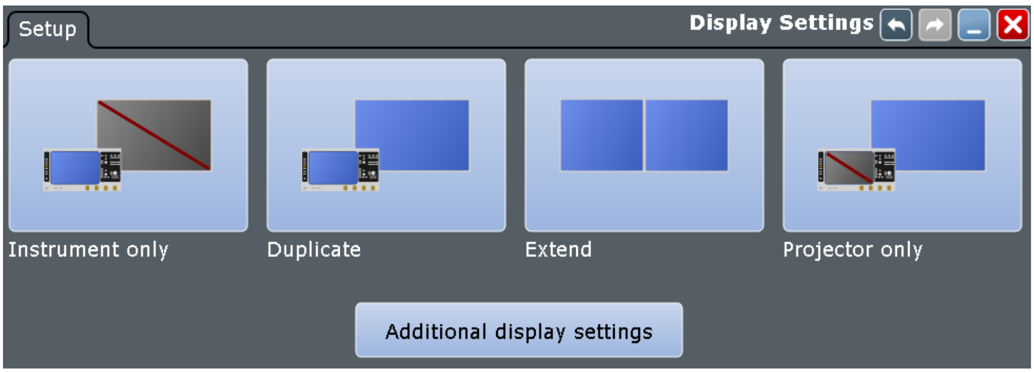
Opens the standard Windows "Network Connections" dialog box to configure a network connection. Only users with administrator rights can fulfill this task.

Screensaver

Opens the standard Windows "Display Properties" dialog box to configure a screen saver.

Display / Monitors: Display Settings

The "Display / Monitors" button opens the "Display Settings" dialog box, where you can extend or duplicate the instrument display to a second monitor or projector (external display).



"Instrument only"	The instrument display is on, the external display is off.
"Duplicate"	The external display shows the same content as the instrument display.

"Extend"	The instrument display and the external display show different content.
"Projector only"	The instrument's user interface is only shown on the external display, the instrument display is off.
"Additional display settings"	Opens the Windows configuration for display settings.

Time, date
Opens the standard Windows "Date and Time Properties" dialog box to set the correct date and time. Only users with administrator rights can fulfill this task.

Note: Usually date and time are set correctly. To adjust your regional time, select the correct time zone rather than changing the time.

Remote command:
`SYSTem:DATE` on page 981
`SYSTem:TIME?` on page 982

Log on as
Sets the user that is automatically logged on during the startup process of the instrument. The change of this setting takes effect at the next instrument startup.

See Chapter 19.1.3, "Logon", on page 928 for restrictions of the standard user and how to change the auto-logon.

"User autologon"	Auto-logon as standard user with limited access. Enter the "User name": *NormalUser* and the "Password" of the standard user.
"Admin autologon"	Auto-logon with unrestricted access to the instrument and network. The setting is only available for administrators. Enter the "User name": *Instrumen* and the administrator's "Password" to enable the auto-logon.
"None"	No auto-logon, user name and password are requested at instrument startup.

Language
Selects the language in which the dialog boxes, result boxes and other screen information is displayed.

Select setup for firmware update
Your instrument is delivered with the latest firmware version. Firmware updates are provided on the internet at:

www.rohde-schwarz.com/firmware/rtp.

The "Release Notes" describe the improvements and modifications of all firmware versions ans also how to update the firmware. They are available along with the firmware on the same web page.

Only users with administrator rights can fulfill this task.

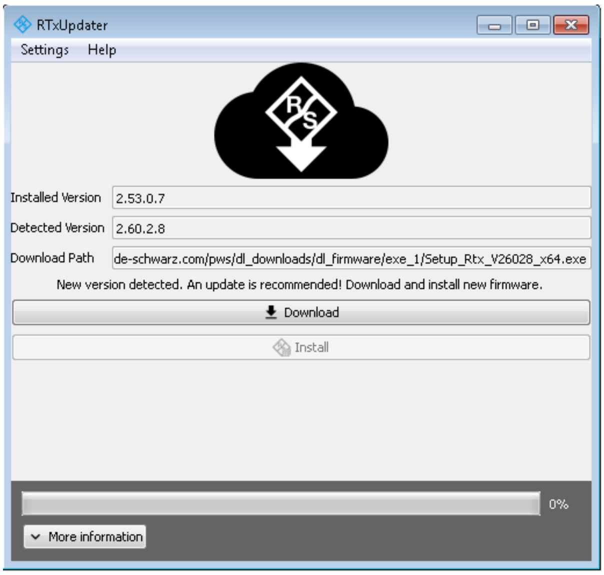
"Load"	Loads the specified file.
"Open"	Opens a file selection dialog box and loads the selected file.

"Explore" Opens the Windows file explorer where you can navigate and search for files and folders as usual.

Start internet update

Starts the "RTxUpdater", which connects to the internet, checks for newer versions, downloads the firmware file, and installs the firmware. Only users with administrator rights can fulfill this task.

Make sure that your device is connected to the Internet. If your corporate network uses a proxy server, enter the proxy settings in "Settings" menu > "Proxy Settings". Ask your administrator for correct proxy settings.



A short instruction is available under "Help" > "Help".

3.1.2 Setting the Display Language

You can change the language in which the dialog boxes, result boxes and other screen information is displayed. A reboot of the instrument is not necessary.

1. Press the [Setup] key.
2. Select the "System" tab.
3. Tap the "Language" button. The button shows the current language.
4. Select the required language.

   The instrument changes the language after a few seconds.

3.2 Screen Setup

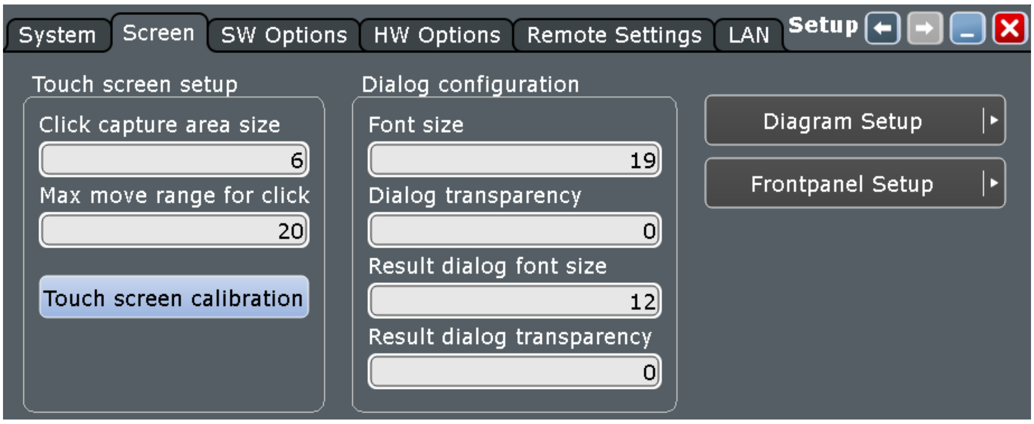
3.2.1 Screen Settings

Access: [Setup] > "Screen" tab

The settings on this tab are related to the screen display.

Note for "Dialog configuration", "Front panel setup" and "Navigation rotary knob" settings:

These settings are user-specific, they are *not* reset by [Preset] and `*RST`. You can reset them to default values using [Save Recall] > "Save/Recall > User defined preset > Factory defaults" or using the `SYSTem:PRESet` command.



Click capture area size
Defines the number of pixels around each element (e.g. button, icon, data point) that create a capture area. If you tap your finger or click the mouse pointer within this capture area, this element is considered to be selected. If you tap or click outside this area, a different or no element is selected.

The larger the area, the easier is it to select an element. However, when selecting data points, for example, a large frame does not allow you to select precisely.

Max move range for click
Defines the maximum number of pixels around an element (e.g. data point) within which your pointing device must stay to "click" the element. When you tap or click a specific element and move your finger or the mouse outside this range, it is considered to be a "moving" or "dragging" operation.

Touchscreen calibration
Opens the touchscreen calibration application, see Chapter 3.2.2, "Aligning the Touchscreen", on page 84. Only users with administrator rights can fulfill this task.

Font size
Defines the font size of the text in dialog boxes.

Dialog transparency
Defines the transparency of the dialog box background. For high transparency values, you can see the waveform display in the background, and possibly check the effect of the changed setting. For lower transparency values, readability in the dialog box improves.

Result dialog font size
Defines the font size of the text in result boxes. The size of the result box is adapted to the font size.

Result dialog transparency
Defines the transparency of the measurement result boxes in the same way as Dialog transparency.

3.2.2 Aligning the Touchscreen

When the device is delivered, the touchscreen is initially calibrated. However, to ensure that the touchscreen responds to the finger contact correctly, a touchscreen alignment is required. Only users with administrator rights can fulfill this task.

Alignment of the touchscreen is useful:

- At first use
- If the position of the instrument has been changed, and you cannot look straight on the screen
- If another person operates the instrument
- If you notice, that touching a specific point on the screen does not achieve the correct response

1. Press the [Setup] key.
2. Select the "Screen" tab.
3. Tap "Touchscreen Calibration".

   A blinking cross appears in the lower left corner of the screen.
4. Touch and hold the cross until "OK" is shown.

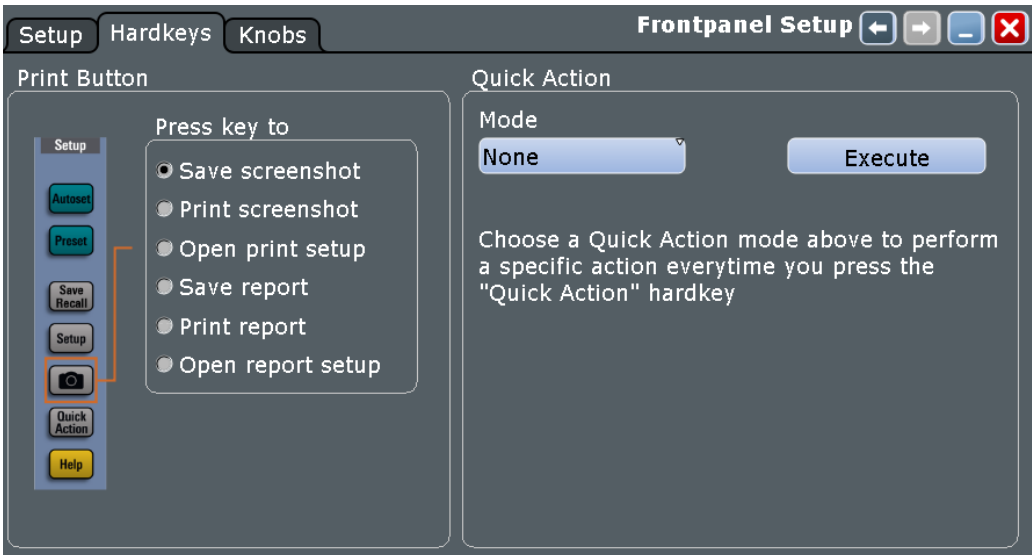
5. Repeat this action for the crosses in the other corners.
6. Tap the R&S logo button in the task bar to display the instrument's user interface.

3.3 Frontpanel Setup

In the "Frontpanel Setup" dialog box, you can adjust the luminosity of the screen and luminous keys, assign functions to keys and knobs, and adjust the Navigation knob.

3.3.1 Setup: Luminosity Settings

Access: "File" menu > "Frontpanel Setup" > "Setup"



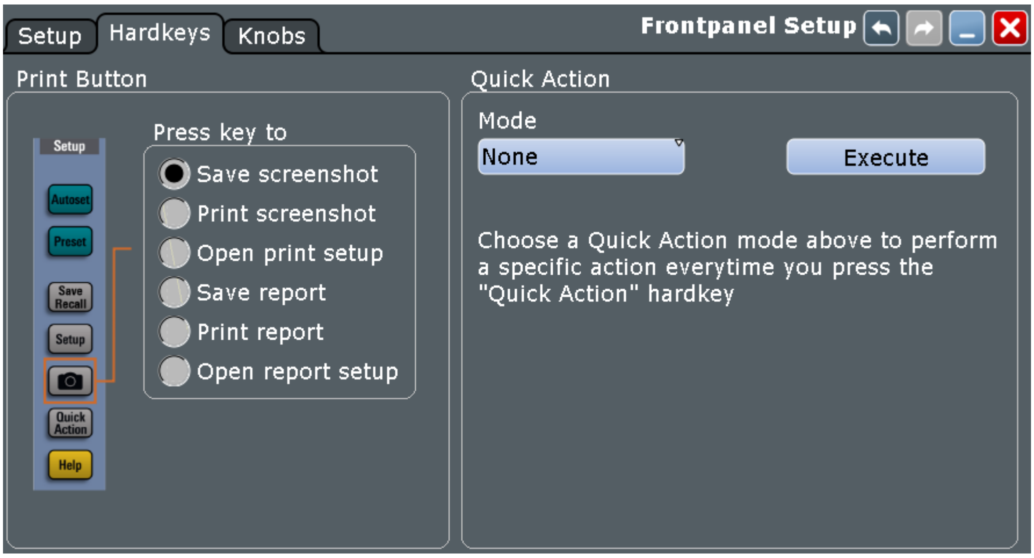
LCD Intensity
Changes the background luminosity of the touchscreen.

LED Intensity
Defines the luminosity of illuminated front panel keys and rotary knobs.

3.3.2 Hardkeys: Function Assignment

Access: "File" menu > "Frontpanel Setup" > "Hardkeys"

You can configure the function of some controls on the front panel to your needs.



Print Button

The Camera key on the left side of the display is a shortcut key that initiates an associated action.

You can assign one of the following actions to the Camera key:
- Save a screenshot
- Print a screenshot
- Open print setup
- Save a report
- Print a report
- Open report setup

Configure the settings for the selected action.
- Screenshots: "File" menu > "Print Setup", see Chapter 11.3.1, "Screenshot Settings", on page 449.
- Report: "File" menu > "Report Setup", see Chapter 11.4.1, "Report Settings", on page 455.

Quick Action

The Quick Action key on the left side of the display is a shortcut key that initiates an associated action. To test the setup, tap "Execute".

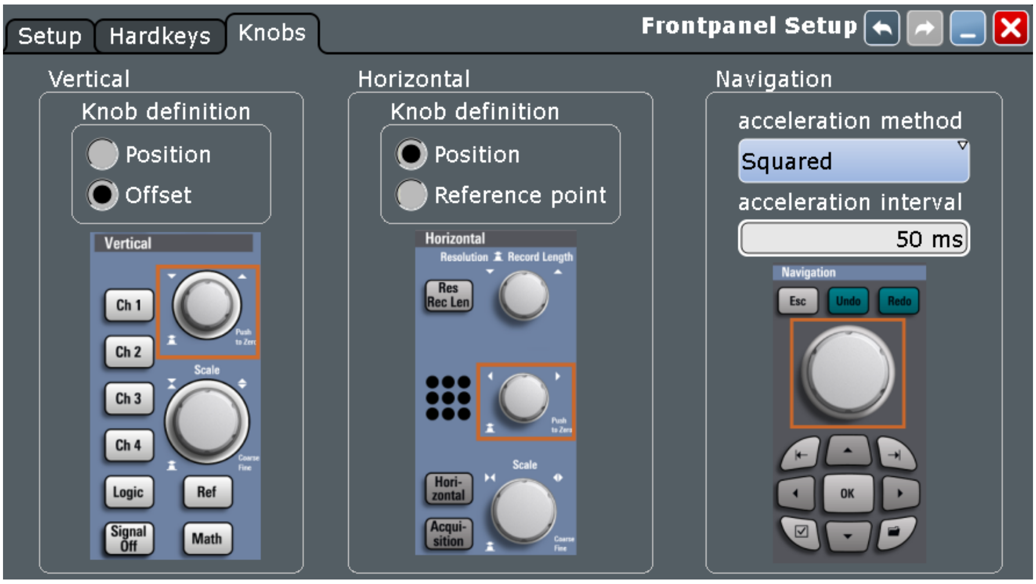
You can assign one of the following actions to the Quick Action key:

"Application"	Starts an external application. Select the path of the application executable, additional parameters, and the working directory as in a Windows shortcut definition.
"Graphical Recall"	Opens the "Load saveset" window to select and load instrument settings that were previously stored in a saveset. See also: "Graphical Recall (load saveset)" on page 66.
"Clear all"	Deletes the all measurement results, waveforms, and the history. See also: "Clear all" on page 68

Remote command:
`QACTion:MODE` on page 985
`QACTion:EXECute` on page 986
To run an application:
`QACTion:PATH` on page 986
`QACTion:PARameters` on page 986
`QACTion:WDIRectory` on page 986

3.3.3 Knobs

Access: "File" menu > "Frontpanel Setup" > "Knobs"



Vertical
The vertical Position knob can change the waveform position or the offset of the selected waveform. Select the action that you want to perform.

See also: Chapter 2.2.3.4, "Vertical Controls", on page 46.

Horizontal
The horizontalPosition knob can change the horizontal position or the reference point. Select the action that you want to perform.

See also: Chapter 2.2.3.3, "Horizontal Controls", on page 45.

Rotary knob acceleration method
Selects a method to accelerate the movement of the element on the screen compared to the actual movement of the rotary knob. Acceleration is useful if you need to move from one end of the screen to the other, for example. Without acceleration, you have to turn the knob quite a while to reach the other end. On the other hand, acceleration can make precise selection difficult, since a small movement of the knob causes a relatively large movement on the screen.

"None"	No acceleration method used.
"Squared"	Moderate acceleration method used.
"Exponential"	Strong acceleration method used.

Rotary knob acceleration interval
Defines the delay time during which the movement of the rotary knob is analyzed before acceleration is applied. For short intervals, acceleration sets in quickly, but is not as effective. For long intervals, acceleration is more effective. However, it takes longer until the instrument reacts on the knob's input. Furthermore, when you turn the knob slowly during fine-tuning, subsequent movements that occur during the same interval are accelerated, making precise selection difficult.

3.4 Display Configuration

3.4.1 Adjustable Display Elements

You can customize the various elements on the screen according to your needs:

Toolbar

The toolbar contains icons that start frequently used functions. You can define which tools are displayed on the toolbar.

Diagrams

The basic diagram elements can be shown or hidden: grid, crosshair, label, and tab titles. You can also enter user-defined diagram names.

Waveforms

For waveforms, you can adjust the persistence, the waveform style, and color. You can also annotate the waveforms by adding screen texts.

To set the color, you can select it from a color palette or assign color tables defining the color of waveform pixels depending on the cumulative occurrence of the associated values. You can assign a different color or color table to each waveform.

The following default color tables are provided:

- "False colors"
- "M-Hot"
- "M-Hsv"
- "M-Jet"
- "Spectrum"
- "Single Event"
- "Temperature"

Dialog boxes and result boxes

You can configure the font size, contrast and transparency in dialog and result boxes. Thus, you can optimize readability or keep track of the waveforms while changing settings in dialog boxes.

Clear results

To delete all results, statistics, waveforms, and also the history, select "Display" menu > "Clear all".

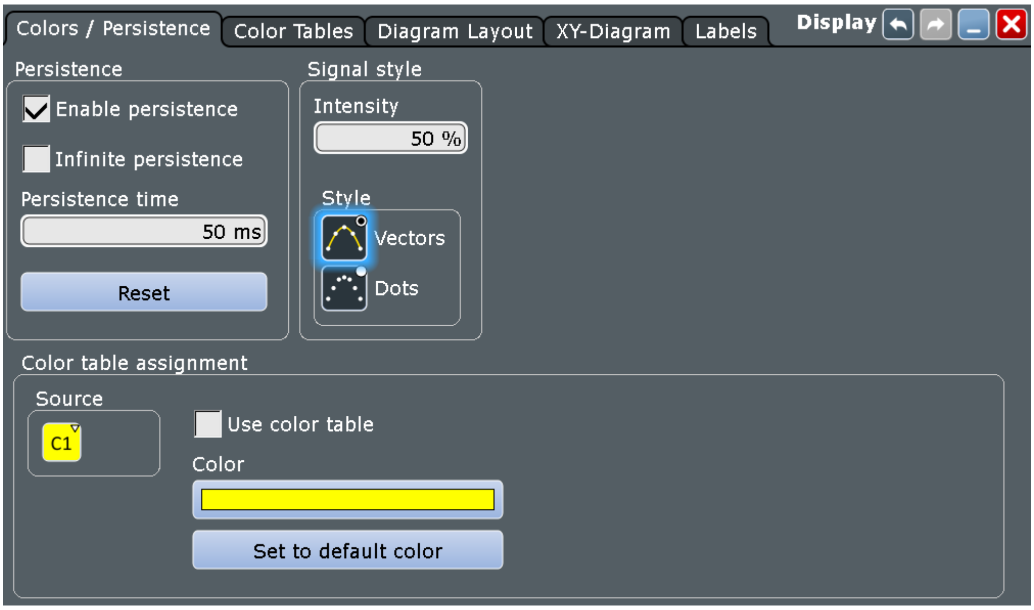
3.4.2 Display Settings

Display settings are configured in the "Display" dialog box, which is opened when you press the [Display] key or select an item from the "Display" menu.

3.4.2.1 Colors / Persistence

Access: [Display] > "Colors / Persistence" tab

The "Colors / Persistence" tab contains settings for the general display of waveform data.



Enable persistence

If enabled, each new data point in the diagram area remains on the screen for the duration that is defined using Persistence time, or as long as Infinite persistence is selected.

If disabled, the waveform points are displayed only for the current acquisition.

Remote command:
`DISPlay:PERSistence[:STATe]` on page 987

Infinite persistence

If infinite persistence is enabled, each new waveform point remains on the screen until this option is disabled. Use infinite persistence to display rare events in the signal.

Remote command:
`DISPlay:PERSistence:INFinite` on page 987

Persistence time

Sets a time factor that controls how long the waveforms points fade away from the display. Thus, the R&S RTP emulates the persistence of analog phosphor screens.

Remote command:
`DISPlay:PERSistence:TIME` on page 987

Reset
Resets the display, removing persistent all waveform points.

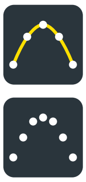
Remote command:
`DISPlay:PERSistence:RESet` on page 987

Intensity
This value determines the strength of the waveform line in the diagram. Enter a percentage between 0 (not visible) and 100% (strong). The default value is 50%.

You can also use the [Intensity] knob on the left side of the screen to adjust the waveform intensity directly.

Note: Use of color tables. The exact mapping of the cumulative value occurrences according to the assigned color table is guaranteed only if the intensity is set to 50%. All other intensity values falsify the mapping but may improve the visibility of the signal. See also: Chapter 3.4.3.2, "Changing Waveform Colors", on page 99.

Remote command:
`DISPlay:INTensity` on page 987



Style
Select the style in which the waveform is displayed:

"Vectors" The individual waveform points are connected by a line.
Define the strength of the line using the [Intensity] knob on the left side of the screen.

"Dots" Only the individual waveform points are displayed. Waveform sample points are the ADC sample points and additional interpolated points if "Interpolated time" is used for resolution enhancement. To see the dots of one waveform, perform one acquisition with [Single] and N=1 ("Average count" = 1). During continuous acquisition, or a [Single] acquisition with N > 1, the dots of multiple subsequent waveforms are displayed on the screen. Thus, the waveform on the screen might look like a line.
Consider also the "Interpolation" on page 127.

Remote command:
`DISPlay:DIAGram:STYLe` on page 988

Color
Shows the current color of the selected waveform. To change the color, tap the button and select a color. The color of the waveform, its signal icon, channel icon, and of the illuminated keys is adjusted to the new color.

Remote command:
`DISPlay:COLor:SIGNal<m>:COLor` on page 988

Set to default color
Resets the color of the selected waveform to the factory default.

Use color table

If enabled, the selected waveform is displayed according to its assigned color table.

If this option is disabled, the selected color is displayed, and the intensity of the specific signal color varies according to the cumulative occurrence of the values.

Remote command:
`DISPlay:COLor:SIGNal<m>:USE` on page 989

Source

Selects the waveform to which the color table and the labels are assigned.

A spectrogram (option R&S RTP-K37) always has the same color as the math (spectrum) waveform from which it is created.

Assigned color table

Adjust the waveform colors to suit your preferences. For each of the following waveform types you can assign a suitable color table:
- Analog and digital channels
- Reference waveforms
- Results of a mathematical function, also for FFT and derived spectrogram.
- Measurements and tracks
- XY-traces
- Serial buses if a protocol option is activated
- Parallel buses if MSO option is installed

See also: Chapter 3.4.2.2, "Color Tables", on page 92.

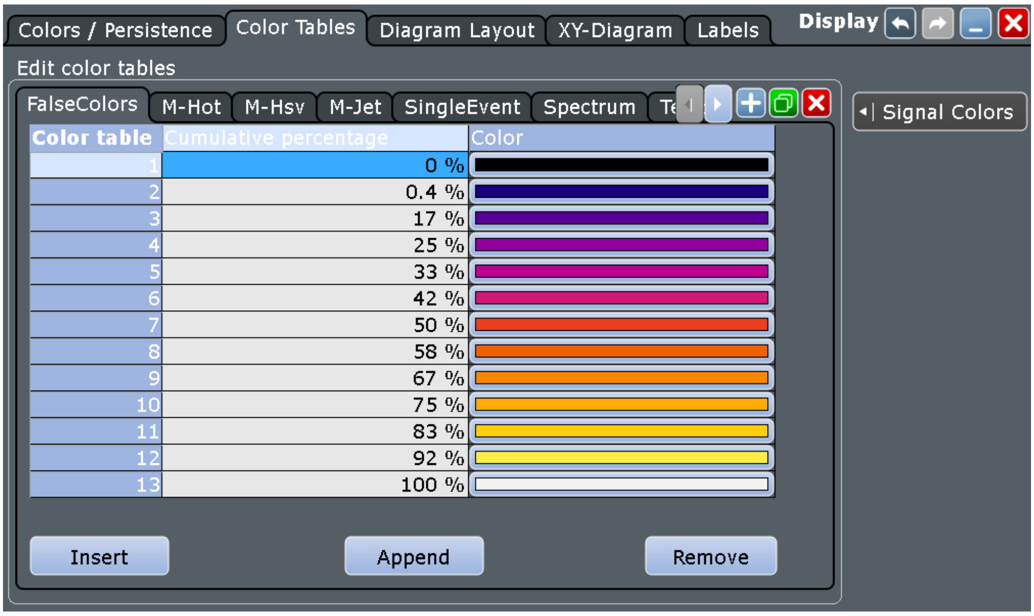
Remote command:
`DISPlay:COLor:SIGNal<m>:ASSign` on page 988

3.4.2.2 Color Tables

Access: [Display] > "Color Tables" tab

Color tables define the color of the waveform pixels depending on the cumulative occurrence of the associated values. By default, the intensity of the specific waveform color varies according to the cumulative occurrence of the values. The more often a value occurs, the darker the color of the data point is displayed.

The following default color tables are provided:
- "False colors"
- "M-Hot"
- "M-Hsv"
- "M-Jet"
- "Spectrum"
- "Single Event"
- "Temperature"



The editing table allows you to edit existing color tables or add new ones that can then be assigned to the waveforms. To assign a color table to a waveform, use the "Signal colors / Persistence" tab.

See also:

- Chapter 3.4.3.2, "Changing Waveform Colors", on page 99
- Assigned color table

Remote commands

The following remote commands are used to configure color tables:

`DISPlay:COLor:PALette:COUNt?` on page 989

`DISPlay:COLor:PALette:ADD` on page 989

`DISPlay:COLor:PALette:REMove` on page 989

`DISPlay:COLor:PALette:POINt:INSert` on page 990

`DISPlay:COLor:PALette:POINt:ADD` on page 990

`DISPlay:COLor:PALette:POINt[:VALue]` on page 990

`DISPlay:COLor:PALette:POINt:COUNt?` on page 991

`DISPlay:COLor:PALette:POINt:REMove` on page 990

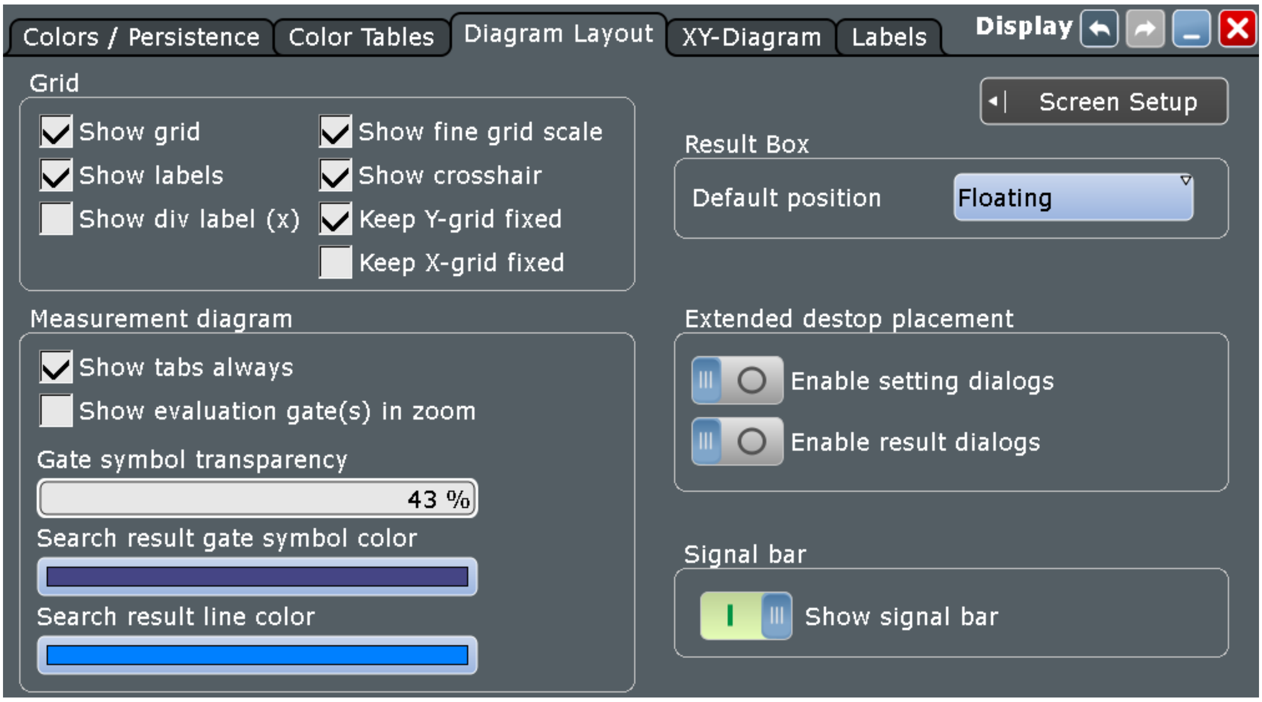
`DISPlay:COLor:PALette:COUNt?` on page 989

3.4.2.3 Diagram Layout

Access: [Display] > "Diagram Layout" tab

On the "Diagram Layout" tab, you define the basic diagram layout and the position of result boxes.

These settings are user-specific, they are *not* reset by [Preset] and `*RST`. You can reset them to default values using [Save Recall] > "Save/Recall > User defined preset > Factory defaults" or using the `SYSTem:PRESet` command.



Show grid

If selected, a grid is displayed in the diagram area. A grid helps you associate a specific data point to its exact value on the x- or y-axis.

Remote command:

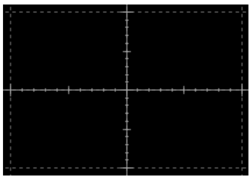
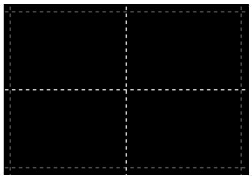
`DISPlay:DIAGram:GRID` on page 991

Show labels
If selected, labels mark values on the x- and y-axes in specified intervals in the diagram.

Remote command:
`DISPlay:DIAGram:LABels` on page 992

Show div label (x)
If selected, the time scale value is shown at the diagram bottom instead of the horizontal grid labels. For example, 10 ns/div is shown instead of the values 0, 10, 20, 30... ns.

Show fine grid scale
If selected, the crosshair is displayed as a ruler with scale markers. If disabled, the crosshair is shown as dashed lines.

Remote command:
`DISPlay:DIAGram:FINegrid` on page 992

Show crosshair
If selected, a crosshair is displayed in the diagram area. A crosshair allows you to select a specific data point by its co-ordinates.

Remote command:
`DISPlay:DIAGram:CROSshair` on page 991

Keep Y-grid fixed
If enabled, the horizontal grid lines remain in their position when the position of the curve is changed. Only the values at the grid lines are adapted. Fixed horizontal grid lines correspond to the behavior of traditional oscilloscopes.

Remote command:
`DISPlay:DIAGram:YFIXed` on page 992

Keep X-grid fixed
If enabled, the vertical grid lines remain in their position when the horizontal position is changed. Only the values at the grid lines are adapted.

Show tabs always
If selected, the tab titles of all diagrams are displayed: "Diagram1", "Diagram2" ...

If cleared, the tab titles are not shown except for titles in a tabbed diagram. In tabbed diagrams, the tab titles are required to change the tabs.

Remote command:
`DISPlay:DIAGram:TITLe` on page 992

Show evaluation gate(s) in zoom
If enabled, the available histogram areas, masks, and measurement gates are shown in the zoom diagrams. If the evaluation gate is within the zoom area, the display helps to move or modify the evaluation gates in the zoom window.

Make sure that the option is disabled if the zoom area and the evaluation gate are of nearly the same size to avoid conflicts in operation.

Gate symbol transparency
Sets the transparency of the area that is defined as measurement or search gate. The setting only takes effect if "Show gate" is enabled.

Remote command:
`DISPlay:GATE:TRANsparency` on page 992

Search result gate symbol color
Sets the color of the search zoom area. The search zoom area is displayed if "Show search zoom windows" is enabled. See also: "Search zoom window" on page 416.

Search result line color
Sets the color of the search result markers. The markers are displayed if "Show search zoom windows" is enabled.

Result Box: Default position
Defines where a new result box opens.

"Floating" The result box opens as a box similar to a dialog box in front of the diagrams. It can be moved and shows all results.

"Preview" The result box opens as a minimized result icon on the sidebar. It shows only two columns and a few rows of the results.

Remote command:
`DISPlay:RESultboxes:DEFaultpos` on page 993

Extended desktop placement
If an external monitor is connected to the instrument, you can enable these settings to display dialog boxes and/or result boxes on the external monitor. Thus, the boxes do not cover the waveforms on the instrument display.

Show signal bar
If enabled, the sidebar is displayed on the right of the diagram area.

The sidebar contains signal icons that display either real-time views of minimized waveforms, or the main settings of displayed waveforms. On the top of the bar, the timebase label and trigger label provide general information for all displayed channels.

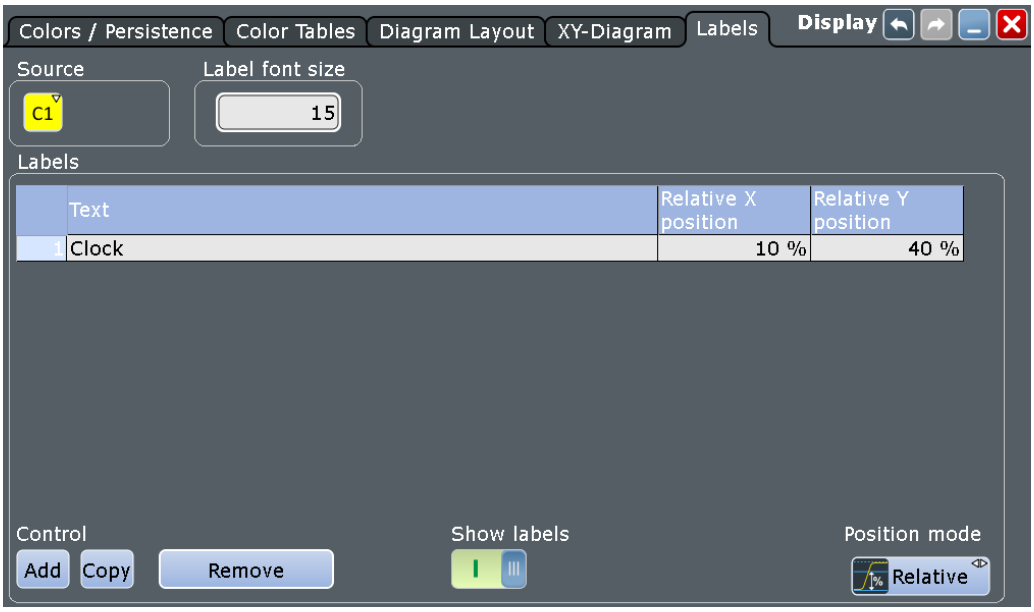
Remote command:
`DISPlay:SIGBar[:STATe]` on page 995

3.4.2.4 Waveform Labels

Access: [Display] > "Labels" tab

Using labels, you can annotate the waveforms to name or explain each waveform. The text is shown in the same color as the assigned waveform. Each label has its individual position. You can enter exact positions in the dialog box, or drag the labels on the screen to the required position. The position can be a fixed one (relative to the screen), or a flexible position (absolute, assigned to the axes).

To add labels quickly, you can add the "Label" icon to the toolbar and use it.



Make sure that the correct waveform tab is selected before you enter the labels.

Labels

For each waveform, the "Labels" table shows the assigned texts and their positions. Enter the label text and the horizontal and vertical positions for each label.

"Add" Adds a line at the end of the list.

"Copy" Copies the selected line in a new line.

"Remove" Deletes the selected line. Only single lines can be removed.
You can also delete a label by using the toolbar: Tap the "Delete" icon and then the label.

Remote command:
DISPlay:SIGNal:LABel:ADD on page 996
DISPlay:SIGNal:LABel:REMove on page 997
DISPlay:SIGNal:LABel:TEXT on page 997
DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition on page 998
DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition on page 998
DISPlay:SIGNal:LABel:HORizontal:RELative:POSition on page 999
DISPlay:SIGNal:LABel:VERTical:RELative:POSition on page 999

Show labels
Enables or disables the label display.

Position mode
Defines the label position either relative to the diagram or with absolute values according to the units of the waveform. Relative positions are fixed, whereas absolute positions move with the waveform display when the scales, the vertical position or offset, or the reference point are changed.

The position mode applies to all labels of the selected waveform. For different waveforms, different position modes can be selected.

"Relative" Sets a fixed position in percent of the screen counting from the upper left corner.

"Absolute" Sets the position in time and voltage values, or in other units depending on the waveform character.

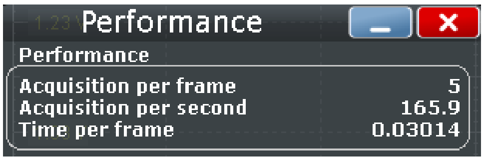
Remote command:
`DISPlay:SIGNal:LABel:POSMode` on page 998

Label font size
Defines the size of the labels in the diagram.

3.4.2.5 Performance

Access: "Display" menu > "Show Performance"

The "Performance" result box shows information on the current acquisition performance values of the R&S RTP.



The instrument groups acquired waveforms together in a frame, and displays the frame content. The maximum number of frames displayed per second is about 30. The current number of frames per second is indicated as reciprocal "Time per frame". If the time scale decreases, and thus the number of acquisitions per second also decreases, the number of acquisitions per frame can drop to 1.

3.4.2.6 Clear Results

"Display" menu > "Clear all"

"Clear all" resets all results in all measurement result boxes including long-term measurement and statistic results, and deletes all waveforms and the history. If you need this function frequently, you can add the corresponding icon to the toolbar, see Chapter 2.3.5.2, "Configuring the Toolbar", on page 64.

3.4.3 Adjusting the Display

You can adjust the appearance of several display elements:

- Diagram name, see Chapter 3.4.3.1, "Changing the Diagram Name", on page 99.
- Waveform colors, see Chapter 3.4.3.2, "Changing Waveform Colors", on page 99.
- Icons on the toolbar, see Chapter 2.3.5.2, "Configuring the Toolbar", on page 64.
- Font size and transparency of dialog boxes and result boxes, see Chapter 3.4.3.3, "Configuring the Appearance of Dialog and Result Boxes", on page 101.

3.4.3.1 Changing the Diagram Name

► Double-tap the diagram tab name. The on-screen keyboard opens to enter the new name.

3.4.3.2 Changing Waveform Colors

For each waveform, you can set a waveform color, or you define a color table that specifies which waveform points are displayed in which color. You can use one of the default color tables, or define your own table according to your needs. You can also edit the default color tables.

After you define a color table, you must assign it to the waveform it is to be used for, and enable its use.

The exact mapping of the cumulative value occurrences according to the assigned color table is guaranteed only if the intensity is set to 50%. All other intensity values falsify the mapping but may improve the visibility of the signal.

See also: "Intensity" on page 91.

For details on signal color settings, see Chapter 3.4.2.2, "Color Tables", on page 92.

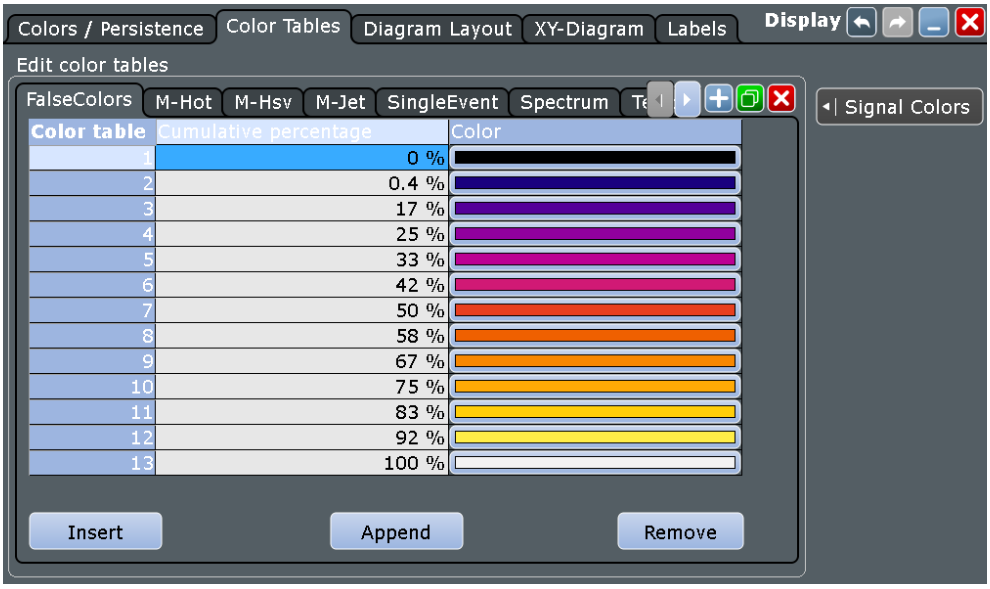
To change a waveform color

1. On the "Display" menu, tap "Signal Colors / Persistence".
2. Under "Color table assignment", select the waveform for which you want to change the color.
3. Tap the "Color" button.
4. In the "Adjust Colors" dialog box, select a predefined color, or define any other RGB color with "User defined Colors".

To edit a color table

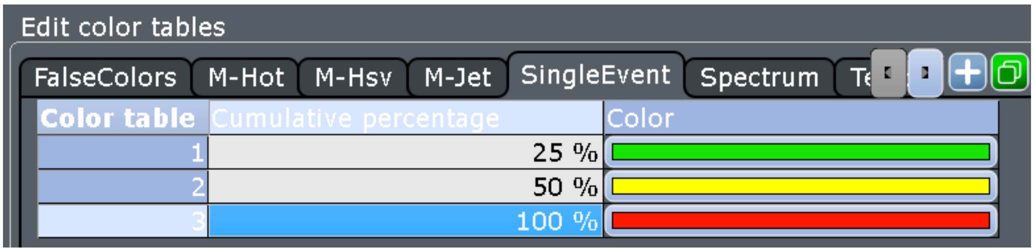
1. On the "Display" menu, tap "Color Tables".

2. Under "Edit Color Tables", select the color table you want to edit.



3. For each range of cumulative occurrence of the values, insert an entry in the color table:
   - To insert an entry at the end of the color table, tap "Append".
   - To insert an entry before an existing entry, tap the existing row. Then tap "Insert".
   - To remove an entry, tap the entry. Then tap "Remove".
4. Assign a color to each entry: Tap the "Color" cell.
   Select a predefined color, or define your own color.

Example:



In this example, values with a cumulative occurrence under 25% (very short or rare display) are displayed green. Values with an occurrence of 40% are yellow-green. Values with an occurrence of 90% (displayed almost for the entire duration of the signal) are a deep shade of orange.

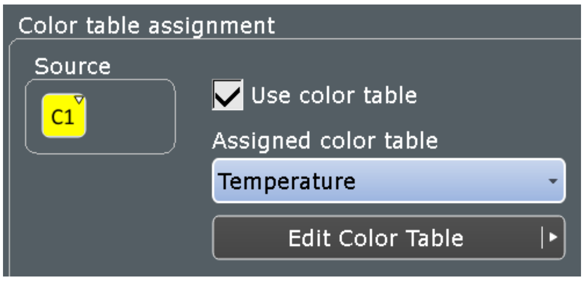
To create a color table

1. On the "Display" menu, tap "Signal Colors".
2. **To create an empty color table:** tap the "Add" button and enter a name for the new color table using the on-screen keyboard.

To copy an existing color table: select the color table you want to copy, and tap the "Copy" button. Enter a name for the new color table using the on-screen keyboard.

To assign the color table and enable its use

1. Open the "Signal Colors/ Persistence" tab of the "Display" dialog box.
2. Under "Color Table Assignment", select the "Source" for the waveform.
3. Enable "Use Color table".



4. Under "Assign color table", select the color table you want to assign to the waveform.

   The waveform colors are displayed according to the definition in the color table.

3.4.3.3 Configuring the Appearance of Dialog and Result Boxes

You can optimize the display of dialog and result boxes so they do not interfere with the waveform display and you can still analyze the results and settings.

To change the font size in dialog and result boxes

1. Press [Setup].
2. Select the "Screen" tab.
3. To set the font size in points for text in all dialog boxes, change "Font size". Most dialog boxes are optimized for a font size of 19 pt.
4. To set the font size in points for result boxes, change "Result dialog font size". The default is 12 pt.

To change the transparency of dialog boxes and result boxes

The transparency of the dialog box background lets you see the waveforms behind the box. You can configure the transparency separately for dialog boxes and result boxes.

1. Press [Setup].
2. In the "Screen" tab, in the "Dialog box transparency" field, enter the transparency value for dialog boxes.

For high transparency values, you can see the waveform display in the background, and possibly check the effect of the changed setting. For lower transparency values, readability in the dialog box improves.

3. In the "Result box transparency" field, enter the transparency value for result boxes.

Alternatively, you can press the [Intensity] knob until the required parameter is shown in the data input box, and then turn the knob to set the transparency.

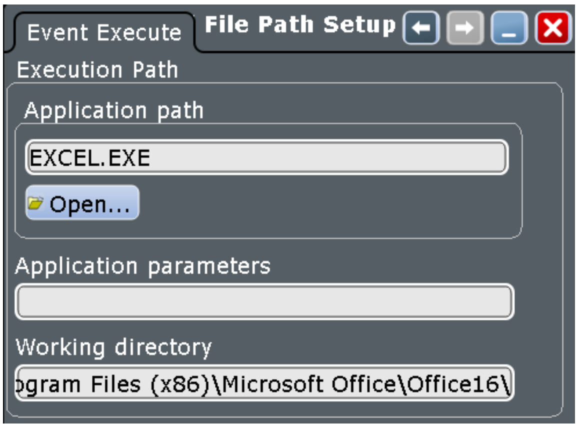
3.5 External Application

Access: "File" menu > "External Setup"

The R&S RTP can start an external application on the instrument or in the network (if connected) when an event occurs.

The following events can start an application:

- Trigger event
- Mask violation
- Successful completion of mask test
- Limit or margin violation of measurements
- Successful completion of limit and margin tests



Set the path of the application executable, optional parameters, and the working directory as in a Windows shortcut definition. The setup is valid for all events.

Remote commands:

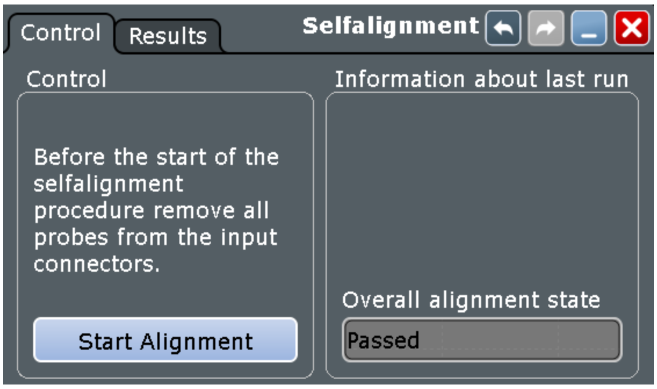
- EXECutable:NAME on page 999
- EXECutable:PARameter on page 1000
- EXECutable:WDIRectory on page 1000

3.6 Self-alignment

When data from several input channels is displayed at the same time, it may be necessary to align the data vertically or horizontally to synchronize the time bases or amplitudes and positions. This is the case, for example, when strong temperature changes occur (> 5°).

3.6.1 Control

Access: "File" menu > "Selfalignment"



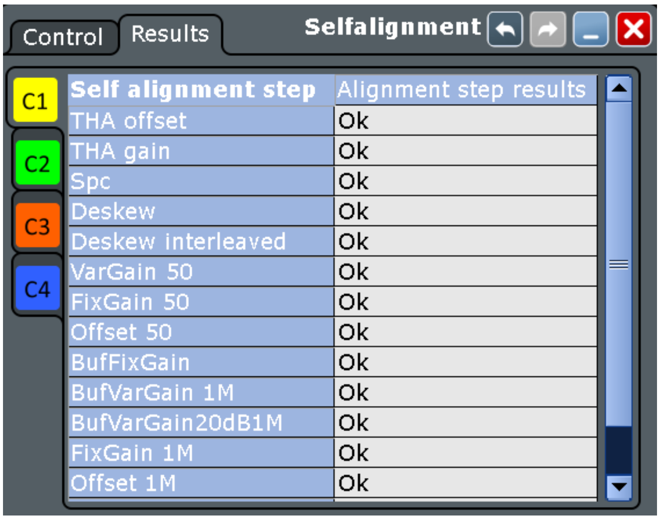
Start Alignment
Starts the self-alignment procedure for all channels.

Remote command:
`*CAL?` on page 973

Date / Time / Overall alignment state
Show the date and the summary result of the self-alignment process: Passed or Failed. Detailed results are provided on the "Results" tab.

3.6.2 Results

For each channel, the results of the individual alignment steps are shown for all technical channel component. In case you require support, you may be asked to provide this information.



3.6.3 Performing a Self-alignment

The self-alignment aligns the data from several input channels vertically and horizontally to synchronize the timebases, amplitudes and positions. The self-alignment process includes a basic hardware check.

Recommendation on performing the self-alignment:

- When putting the instrument into operation for the first time
- After a firmware update
- Once a week
- When major temperature changes occur (> 5°)

NOTICE

Warm-up and prepare the instrument

Make sure that the instrument has been running and warming up before you start the self-alignment. The minimum warm-up time is indicated in the data sheet.

Remove the probes from the input connectors.

1. On the "File" menu, select "Selfalignment".
2. On the "Control" tab, tap "Start Alignment".

   The alignment is performed, the process might take several minutes. A message box informs you about the running process, wait until this message box closes. The overall pass/fail result is shown in the "Overall alignment state" field. The results of the individual alignment steps for each input channel are indicated in the "Results" tab. This information is required if problems arise.

3.7 Firmware Update

Your instrument is delivered with the latest firmware version. Firmware updates are provided on the internet at:

www.rohde-schwarz.com/firmware/rtp.

The "Release Notes" describe the improvements and modifications of all firmware versions ans also how to update the firmware. They are available along with the firmware on the same web page.

3.8 Options

Additional options for the R&S RTP can be enabled using a license key. To obtain the license key, consult your sales representative.

The license type defines the duration of applicability and the portability of a license. The following license types are provided: evaluation, permanent, portable, quantified, timed with duration of 1, 3, 6 or 12 months. A license can also be in the states deactivated and expired.

Unregistered licenses

Unregistered licenses are not assigned to a particular instrument. The instrument accepts only registered licenses. If your license is delivered unregistered, use the online tool R&S License Manager to register the license for your instrument. The registration of a permanent license is irreversible, so ensure that you register it for the correct instrument. The address of the tool is https://extranet.rohde-schwarz.com/service.

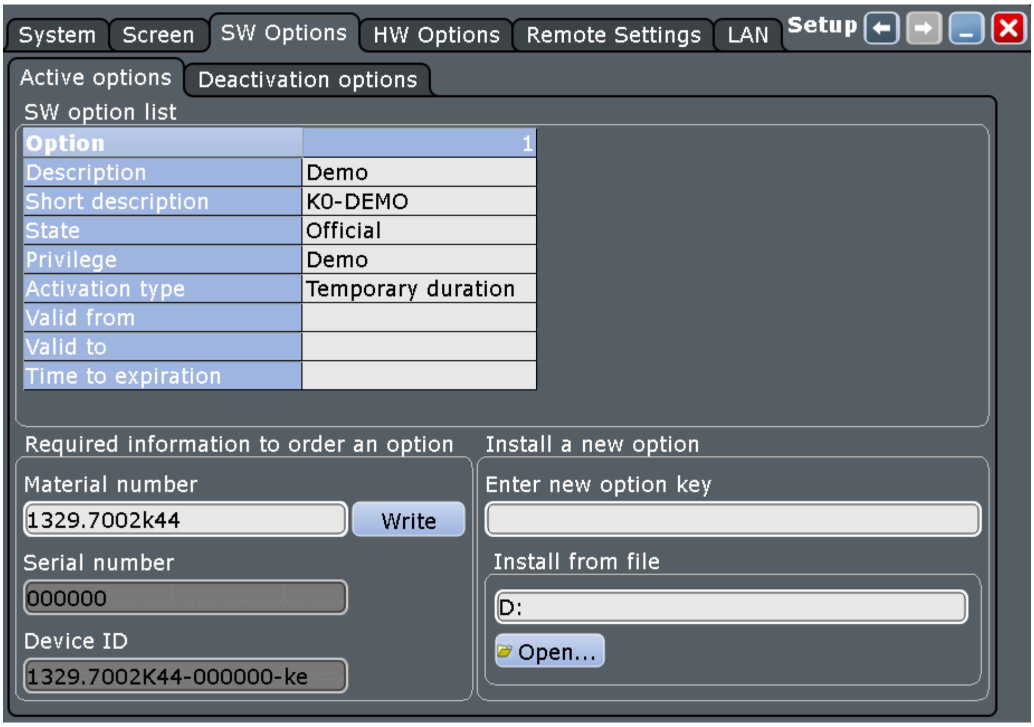
The R&S License Manager also allows you to move a portable license to another instrument.

3.8.1 SW Options

3.8.1.1 Active Options Settings

Access: [Setup] > "SW Options" tab > "Active options" subtab

The "Active options" tab provides information on installed software options. Here you can install new options or deactivate existing options using license keys.



SW option list

Shows the activated options. This information provided for administration and trouble-shooting purposes. If you need support for an option, provide this information to the service representative.

The "State" of the option indicates whether the installed option is a normal or a beta-release version. Beta-release versions must be activated explicitly in the "Mode" dialog box (see Chapter 3.8.5, "Options in Beta State", on page 109).

Material number, Serial number, Device ID

Indicates the material number, serial number and the device identification string (device ID) of your instrument. These numbers, in particular the device ID, are required to order a new option, or to move a portable option.

Remote command:

`DIAGnostic:SERVice:PARTnumber` on page 983

`DIAGnostic:SERVice:SERialnumber?` on page 983

`SYSTem:DEVice:ID?` on page 982

Enter new option key

Enter the license key here to activate the option. For license keys delivered as a file, use Install from file. Only users with administrator rights can activate options.

Install from file

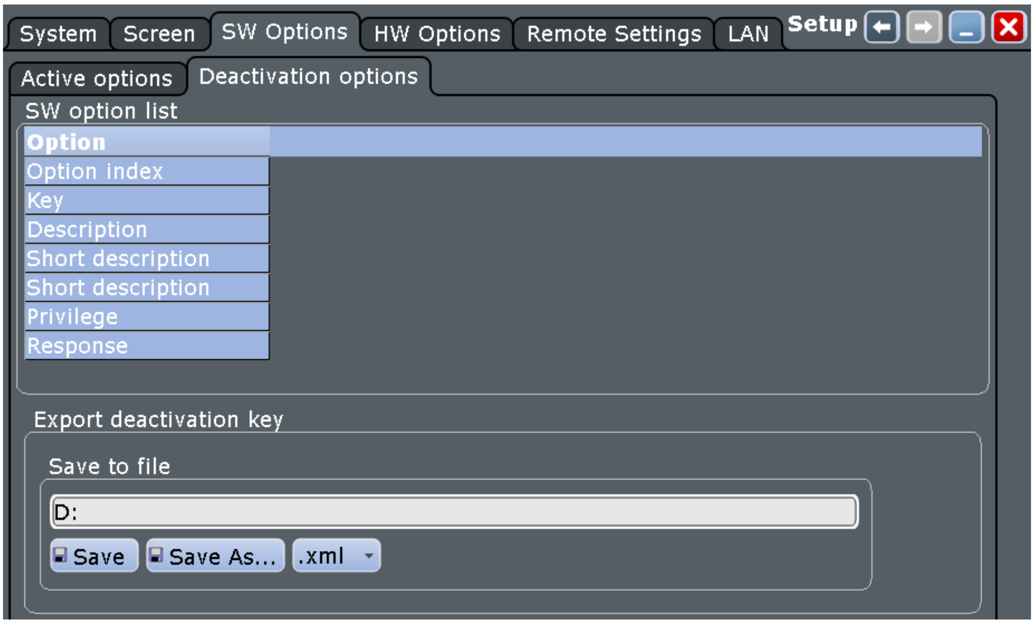
If you got a license file, install the license here. Tap "Open" to open the file selection dialog, or enter the complete path and filename. For details, see Chapter 11.7, "File Selection Dialog", on page 461. Only users with administrator rights can activate options.

When you move a portable license, use this function to import the deactivation key that is generated by the "R&S License Manager". See also Chapter 3.8.4, "Moving a Portable License", on page 108.

3.8.1.2 Deactivation Options

Access: [Setup] > "SW Options" tab > "Deactivation options" subtab

The "Deactivation options" tab shows all deactivated options and provides a function to export the deactivation response.



Export deactivation key
When you move a portable license, or deactivate an option, you have to note the response key, or to save the response to a file. The "R&S License Manager" needs the response key.

See also Chapter 3.8.4, "Moving a Portable License", on page 108.

3.8.2 HW Options

This tab informs about the availability of hardware options.

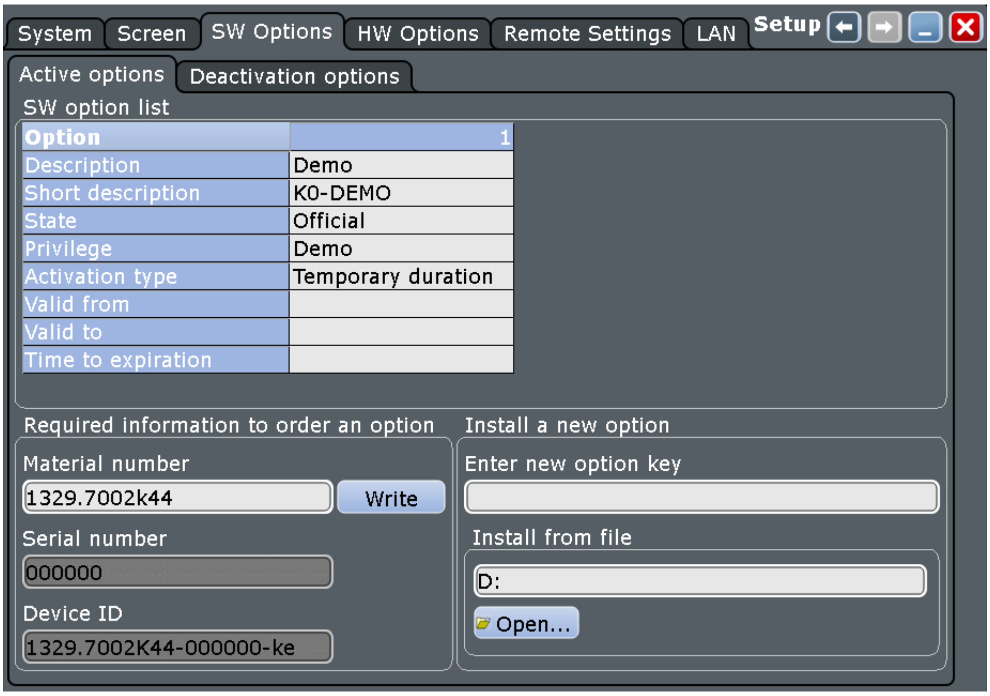
3.8.3 Activating Options

Options are activated by license keys. No additional installation is required. Consult your sales representative and provide the material number and serial number (or the device ID) of your instrument to get a license key. The license key is provided in written form or in a file. Unregistered licenses must be registered in the R&S License Manager before they can be activated on the instrument.

If the option has a portable license, keep the license file or option key at a save place. You need the license to move it to another instrument.

Only users with administrator rights can activate options.

1. Press the [Setup] key and select the "SW options" tab.



2. If you received a key in written form, enter the key in the "Enter new option key" field.
   If you received a key in digital form as a file, tap "Open", navigate to the directory that contains the file, and select the option key file.
3. If you want to activate several options, repeat step 3 for each option.
4. Restart the instrument or the firmware.

See also: Chapter 3.8.1, "SW Options", on page 105

3.8.4 Moving a Portable License

The following procedure describes how to move an active portable license to another instrument. Each instrument is identified by its individual device ID.

The procedure involves the transfer of files between the R&S License Manager web tool and the instruments (source and target). For file transfer, you can use a USB flash drive, or store the files in a LAN directory that can be accessed by both instruments and by the device that runs the R&S License Manager.

1. Make sure that the license file or written option key that is installed on the source instrument is available.
2. On the source and target instruments:
   Select [Setup] > "SW Options" tab > "Active options" subtab and note the device IDs of both instruments.
3. In the R&S License Manager:
   a) Open the R&S License Manager: https://extranet.rohde-schwarz.com/service.
   b) Select "Move Portable License".
   c) Enter the device identifications of the source and target instruments.
4. In the R&S License Manager:
   a) Open the portable license file of the source instrument, or enter the license key (option key).
   b) Generate the deactivation key and store it to a file.
5. On the source instrument:
   a) On the "Active options" subtab, use "Install from file" to install the deactivation key file generated in the previous step.
   b) Select the "Deactivation options" subtab and note the "Response" key.
6. In the R&S License Manager:
   a) Enter the deactivation response key generated in the previous step.
      As a result, a portable license file registered for the target is generated.
   b) Store the new license file.
7. On the target instrument:
   On the "Active options" subtab, use "Install from file" to install the license generated in the previous step.
8. Reboot the source and the target instruments.

   The portable license is now active on the target instrument, and it is not any more available an the source instrument.

3.8.5 Options in Beta State

Options may be released in beta state. These options require a license key and an additional activation.

To activate a beta option:

1. On the "File" menu, select "Mode".
2. Select the "Operation Mode" tab.
3. Enable "Enable options in beta state".

The activation is effective immediately until the next shut-down of the firmware.


Acquisition
Operation Mode
Mode
Enable options in beta state

4 Acquisition and Waveform Setup

This chapter describes the horizontal and vertical settings as well as the acquisition and probe setup.

4.1 Basics

This chapter provides background information on the essential settings in the vertical and horizontal systems, on acquisition setup and probing.

4.1.1 Vertical System

The controls and parameters of the vertical system are used to scale and position the waveform vertically.

4.1.1.1 Input Coupling

The input coupling influences the signal path between input connector and the following internal signal stage. The coupling can be set to DC or ground.

- DC coupling shows all parts of an input signal. DC coupling is the default for 50 Ω input impedance.
- Ground coupling disconnects the input signal from the vertical system to see the ground level (zero volts) on the screen. Ground coupling is useful for reference purposes.

4.1.1.2 Vertical Scale and Position

Vertical scale and vertical position directly affect the resolution of the waveform amplitude. The vertical scale corresponds to the ADC input range. To get the full resolution of the ADC, set up the waveforms to cover most of the height of the diagram.

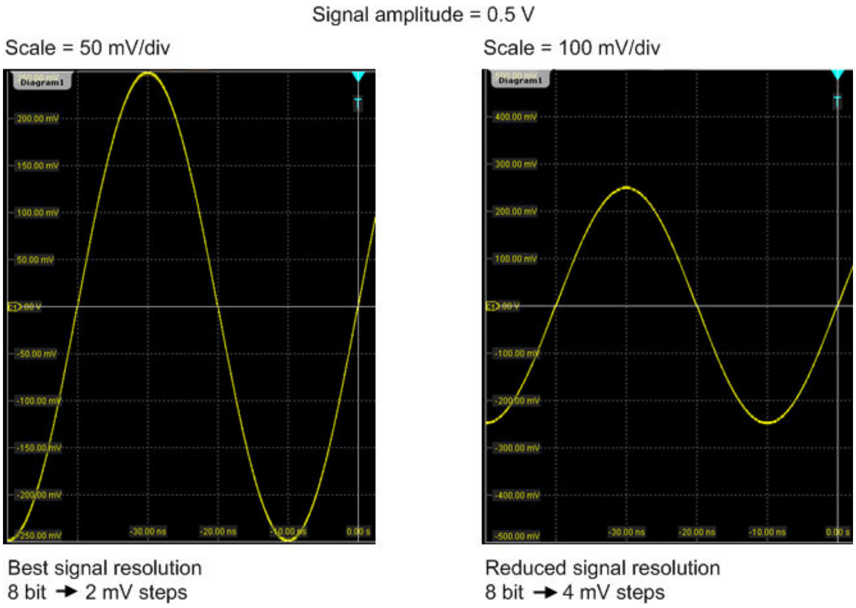


Figure 4-1: Input range and resolution of the ADC

With R&S RTP, you can work with multiple diagrams, and each diagram obtains the full vertical resolution, no matter where the diagram is placed. Therefore, use a separate diagram for each waveform instead of the traditional setup that arranges the waveforms side by side in one diagram.

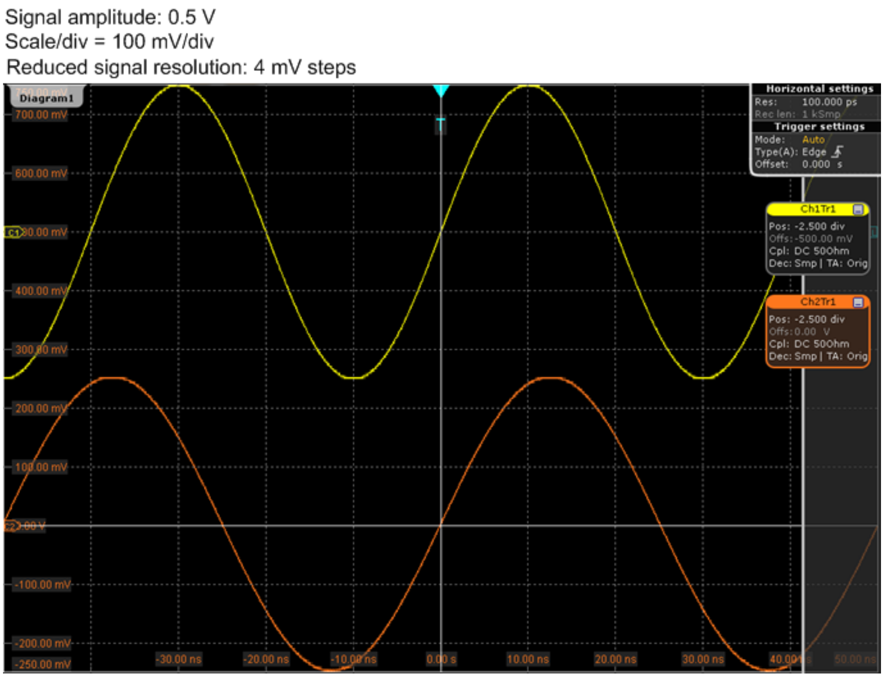


Figure 4-2: Traditional setup of multiple waveforms in one diagram: reduced resolution

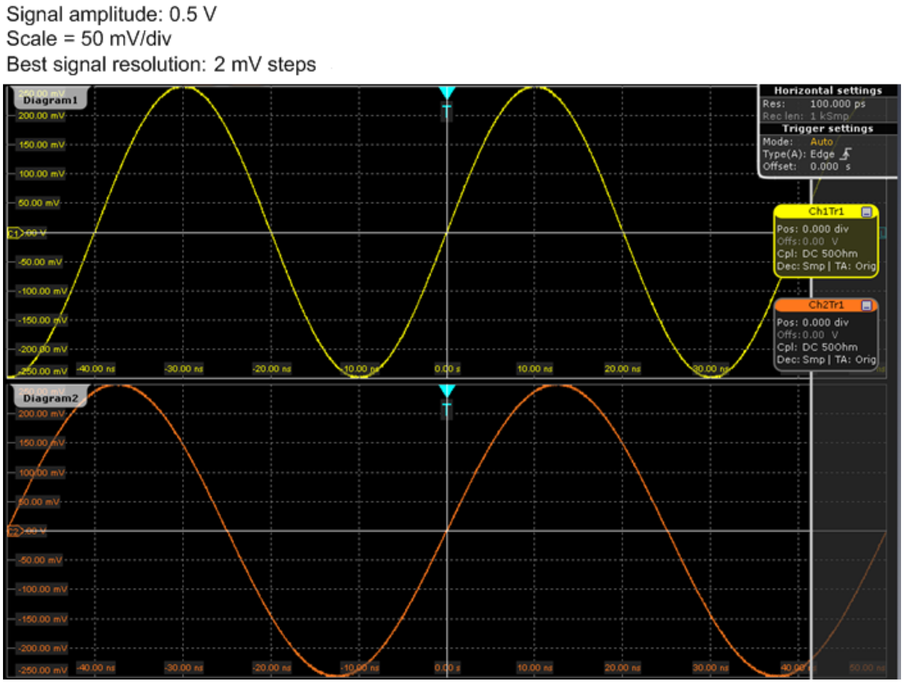


Figure 4-3: R&S RTP setup of multiple waveforms in separate diagrams: best resolution

4.1.1.3 Bandwidth

For analog applications, the highest signal frequency determines the required oscilloscope bandwidth. The oscilloscope bandwidth should be slightly higher than the maximum frequency included in the analog test signal to measure the amplitude with very little measurement error.

Most test signals are more complex than a simple sine wave and include several spectral components. A digital signal, for example, is built up of several odd harmonics. As a rule, for digital signals the oscilloscope bandwidth should be 5 times higher than the clock frequency to be measured.

The oscilloscope is not a stand-alone system. You need a probe to measure the signal of interest, and the probe has a limited bandwidth, too. The combination of oscilloscope and probe creates a *system bandwidth*. To reduce the effect of the probe on the system bandwidth, the probe bandwidth must exceed the bandwidth of the oscilloscope, the recommended factor is 1.5 x oscilloscope bandwidth.

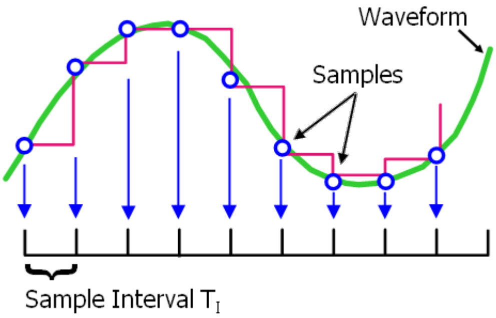
See also: Chapter 4.1.4.1, "Voltage Probes", on page 118

4.1.2 Sampling and Acquisition

The vertical system of a digital oscilloscope conditions the test signal in a way that the following A/D Converter (ADC) can transform the measured voltage into digital data.

4.1.2.1 Sampling and Processing

The A/D converter samples the continuous signal under test at specific points in time and delivers digital values called **ADC samples**. The rate at which the converter is working is the **ADC sample rate**, a constant value specified in GHz: $f_{ADC} = 1 / T_I$



The digital ADC samples are processed according to the acquisition settings. The result is a waveform record that contains **waveform samples** and is stored in the **waveform memory**. The waveform samples are displayed on the screen and build up the waveform.

The number of waveform samples in one waveform record is called **record length**. The rate of recording waveform samples - the number of waveform samples per second - is the **sample rate**. The higher the sample rate, the better the resolution is and the more details of the waveform are visible.

A sufficient resolution is essential for correct reconstruction of the waveform. If the signal is undersampled, aliasing occurs - a false waveform is displayed. To avoid aliasing and accurately reconstruct a signal, Nyquist theorem postulates that the sample rate must be at least twice as fast as the highest frequency component of the signal. However, the theorem assumes ideal conditions, so the Nyquist sample rate is usually not sufficient.

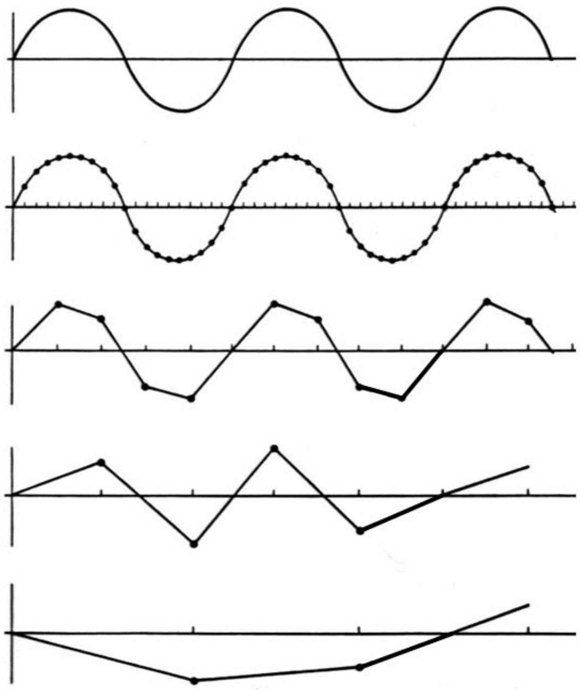


Figure 4-4: Waveforms acquired with different sample rates

To avoid aliasing, the sample rate must be set to a value 3 to 5 times the fastest frequency component of the signal. A higher sample rate increases signal fidelity, increases the chance to capture glitches and other signal anomalies, and improves the zoom-in capabilities.

4.1.2.2 Acquisition Settings

The sample rate can be the same as the constant ADC sample rate, or higher, or lower. To get a higher sample rate, interpolation as method of **resolution enhancement** is used. To reduce the sample rate, **decimation** methods help: sample,peak detect, high resolution and RMS.

As digital waveform data is stored in the memory, and the memory can save many waveform records, further **waveform arithmetic** processing is possible: average and envelope waveforms are resulting waveforms, created from a composite of sample points taken from multiple acquisitions.

4.1.2.3 Acquisition Control

You can run the R&S RTP in two ways:

- Run Stop: the instrument acquires data until you stop it manually.
- Single: the instrument samples and processes a specified number of acquisitions.

The determining point of an acquisition is the trigger. The instrument acquires continuously and keeps the sample points to fill the pre-trigger part of the waveform record. When the trigger occurs, the instrument continues acquisition until the post-trigger part of the waveform record is filled. Then it stops acquiring and waits for the next trigger. When a trigger is recognized, the instrument does not accept another trigger until the acquisition is complete.

The trigger modes define how the instrument triggers:

- Normal: The instrument acquires a waveform only if a real trigger occurs, that is, if all trigger conditions are fulfilled.
- Auto: The instrument triggers repeatedly after a fixed time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. If the real trigger is faster than the auto trigger, both modes are virtually the same.

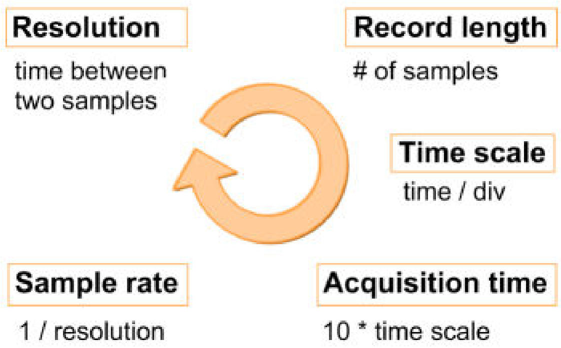
In practice, both trigger modes are useful: The auto mode lets you see the signal with little adjustment, while the normal mode selects the interesting part of the waveform. If you want to acquire a specified number of waveforms, make sure to select the normal trigger mode. Thus you get only the required number of interesting acquisitions.

See also: Chapter 5, "Triggers", on page 180

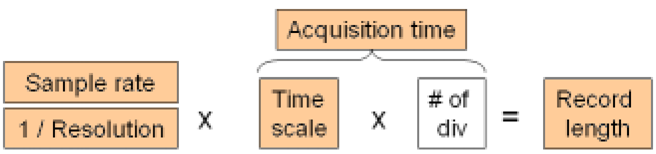
4.1.3 Horizontal System

4.1.3.1 Parameters of the Horizontal System

The control parameters of the horizontal system are tightly connected. Thus, changing one parameter affects the other parameters as well.



The mathematical dependencies can be summarized as follows:



The number of divisions is 10, which is the only constant parameter.

When you set up horizontal parameters, you can choose whether the record length or the resolution remains constant.

- With constant resolution, increasing the time scale also increases the record length, and vice versa. You can limit the record length to a maximum value.

- With constant record length, increasing the time scale coarsens the resolution, that is, the time between two waveform samples gets longer.

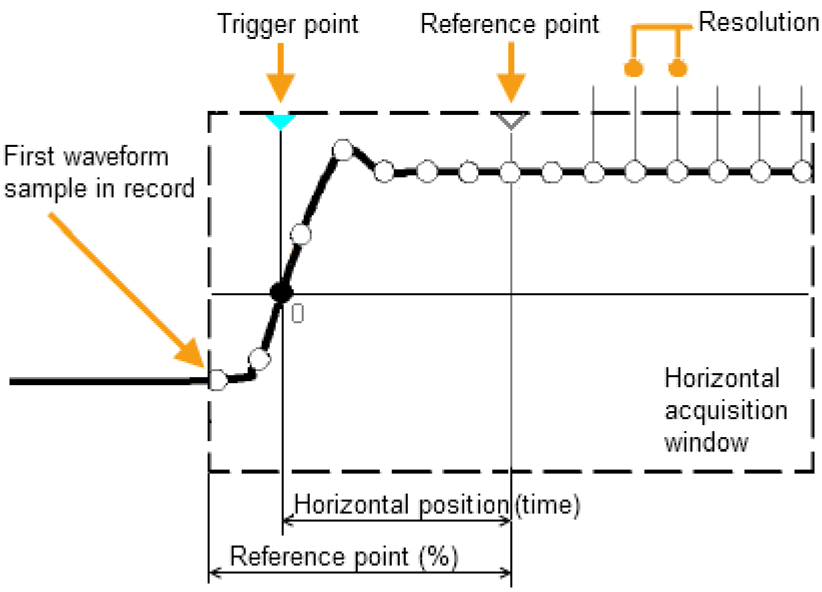
For both settings, the "Auto adjustment" ensures a sufficient resolution to prevent undersampling.

4.1.3.2 Horizontal Position

As described before in Chapter 4.1.2.3, "Acquisition Control", on page 115, the trigger is the determining point of the waveform record.

In many scenarios, you want to analyze the waveform some time before or after the trigger. To adjust the horizontal acquisition window to the waveform section of interest, you can use the following parameters:

- The **horizontal position** defines the time distance from the trigger point (the zero point of the diagram) to the reference point. Changing the horizontal position, you can move the trigger point, even outside the screen.
- The **reference point** is the rescaling center of the time scale on the screen. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.



4.1.4 Probes

A probe connects the signal source (DUT) to the oscilloscope, and delivers the signal to be measured. It is the essential first link in the measurement chain.

An ideal probe fulfills the following requirements:

- Safe and reliable contacts
- Infinite bandwidth
- The probe should not load the signal source and thus impact the circuit operation.

- The connection should not introduce or suppress signal components (hum, noise, filter) and thus degrade or distort the transferred signal.

In reality, the probe can never be an ideal one, it always affects the signal transmission and the signal source, and thus the measured signal. It depends on the frequency to be measured and on the signal source to determine the acceptable loading, and to determine which kind of probe delivers good results.

The solution depends on the quantity to be measured regarding:

- Signal type: voltage, current, power, pressure, optical, etc.
- Signal amplitude: The oscilloscope itself can only display voltages in a limited range. Most probes can adjust the dynamic range to amplitudes from a few mV to 10 V. Smaller or much larger signals require specialized equipment.
- Signal frequency: High frequencies require advanced equipment to get correct results.
- Source characteristic: The source impedance is the decisive factor when choosing the suitable connection.

4.1.4.1 Voltage Probes

The following table provides an overview on common voltage probes and their usage.

Table 4-1: Voltage probes overview

Probe type	Attenuation	Typical bandwidth range	Oscilloscope input	Usage
Passive, high impedance	1:1	10 MHz	1 MΩ	Low-speed signals, low-level signals
Passive, high impedance	10:1	500 MHz	1 MΩ	General purpose
Passive, low impedance	10:1	up to 10 GHz	50 Ω	High frequency
Active, single-ended	10:1	up to 10 GHz	50 Ω	High speed
Active, differential	10:1		50 Ω	Floating

For a list of recommended probes, refer to the R&S RTP product brochure.

Besides the possible input voltage range, two factors are important when selecting a voltage probe: Bandwidth and impedance over frequency.

- **Bandwidth:**
  The combination of probe and oscilloscope builds up a system. The resulting system bandwidth is approximately determined with:

$$\frac{1}{BW_{system}} = \sqrt{\left(\frac{1}{BW_{probe}}\right)^2 + \left(\frac{1}{BW_{scope}}\right)^2}$$

  To measure the signal with low measurement error, the system bandwidth should be higher than the highest frequency component of the signal. The probe bandwidth must be even higher than the system bandwidth.

- **Impedance:**
  A minimum impedance is required to keep the circuit loading low. Over frequency, the impedance decreases, in particular with passive probes. The probe impedance should be approximately 10 times the impedance of the circuit test point at the highest signal frequency.

Active Voltage Probes - General

Active probes require operating power from the instrument and have a proprietary interface to the instrument. Their main qualities are:

- Low loading on signal source
- The probe is automatically recognized by the instrument, no adjustment is required.
- Adjustable DC offset at probe tip allows for high resolution on small AC signals which are superimposed on DC levels.
- Connections should be as short as possible to keep the usable bandwidth high.
- Observe the operating voltage range.
- The probe impedance depends on the signal frequency.

RT-ZS single-ended active probes and RT-ZD differential active probes provide special features for easier use and precise measurements. These special features are not available on RT-ZSxxE probes.

- The micro button on the probe head remotely controls important functions on the instrument, like running and stopping the acquisition, autoset, AutoZero and setting the offset to mean value.
- The R&S ProbeMeter measures DC voltages between the probe tip and the ground connection with very high precision. The result is displayed on the instrument's screen. So you can check DC voltages with different levels without having to adjust the measurement range of the oscilloscope. The R&S ProbeMeter also measures the zero error of the probe to optimize measurement results at small signal levels.

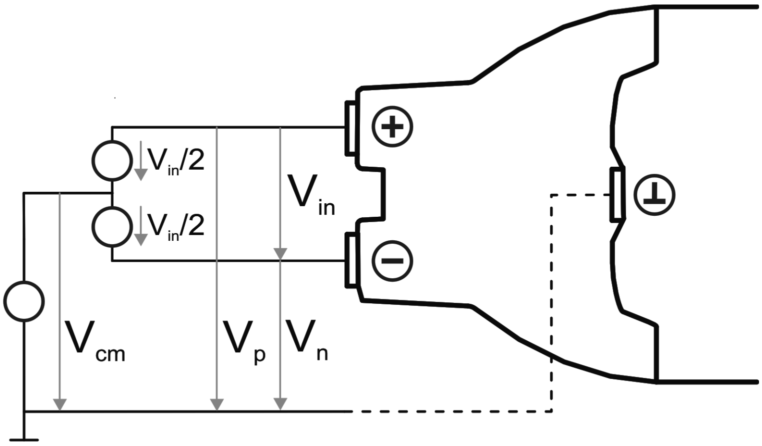
When you connect an R&S RT-ZSxx active probe to a channel input of the R&S RTP, the oscilloscope recognizes the probe. It reads the identification and calibration data from the probe box and shows the result in the "Setup" and "Probe Attributes" tabs. This data together with the deskew time for a given channel is stored and processed by the R&S RTP. If you connect the probe the next time to the same channel, the information is fetched and used.

Differential Active Probes

Differential active probes are designed to measure signals that are referenced against each other, and voltages that are not references to ground, for example twisted-pair signal lines. The R&S RT-ZD probes are differential probes with high input impedance, they can be used to measure voltages between any two test points.

Compared with two-channel measurement setup with single-ended probes, the measurement with differential probes is symmetric due to the same amplification and cable length on both paths. It is also immune to interference and noise and occupies only one input channel.

A differential probe has three sockets: the positive signal socket (+), the negative signal socket (-), and the ground socket.



Multiple input voltages can be defined for a differential probe:

- Differential mode input voltage (V_{in}, V_{dm})
  Voltage between the positive and negative signal sockets
- Positive single-ended input voltage (V_p)
  Voltage between the positive signal socket and the ground socket
- Negative single-ended input voltage (V_n)
  Voltage between the negative signal socket and the ground socket
- Common mode input voltage (V_{cm})
  Mean voltage of positive and negative signal sockets referred to the ground socket, respectively

Two of these voltages are independent values, the other two can be calculated:

$$V_{in} = V_p - V_n$$

$$V_{cm} = \frac{V_p + V_n}{2}$$

R&S RT-ZD probes detect only differential input voltages and provide it to the oscilloscope. Common mode signals are suppressed by the probe. This characteristic is described by the Common Mode Rejection Ratio (CMRR):

$$CMRR = \frac{DifferentialGain}{CommonMode\,Gain}$$

In addition, the R&S ProbeMeter of R&S RT-ZD differential probes can measure differential and common mode DC voltages. The measurement result is displayed on the oscilloscope's screen. The common mode measurement of the R&S ProbeMeter allows you to check the input voltage relative to ground. Thus, the CM measurement is a convenient way to detect breaches of the operating voltage window, and the reason of unwanted clippings.

4.2 Horizontal Settings

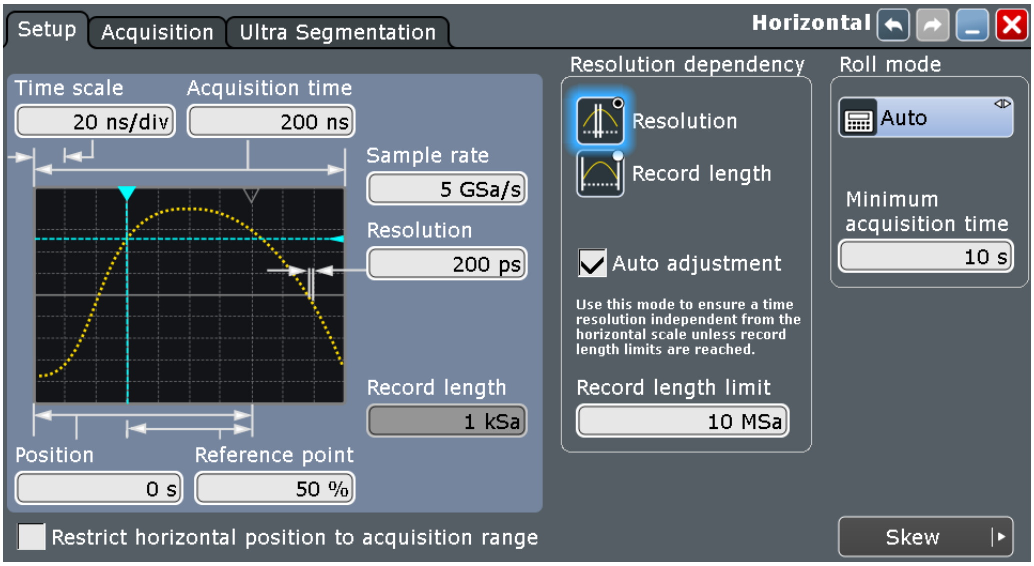
The "Horizontal" menu provides the time base and acquisition configuration for channel and spectrum waveforms:

4.2.1 Setup

Access: Horizontal key

The "Setup" tab in the "Horizontal" dialog box provides the settings for the time axis and the roll mode.

For background information, see Chapter 4.1.3, "Horizontal System", on page 116.



Time scale
Sets the horizontal scale for all channel and math waveforms in seconds per division. Increase the scale to see a longer time interval of the waveform. Decrease the scale to see it in more detail. The scale has a point that remains fixed on the screen when the scale value is changing - the reference point.

Remote command:
`TIMebase:SCALe` on page 1001

Acquisition time
Shows the time of one acquisition, that is the time across the 10 divisions of the diagram:

Acquisition time = Time scale * 10 divisions

Changing the acquisition time changes the time scale too.

Remote command:
`TIMebase:RANGe` on page 1002

Position
Defines the time distance between the reference point and the trigger point (the zero point of the diagram). If you want to see a section of the waveform some time before or after the trigger, enter this time as horizontal position. The requested waveform section is shown around the reference point. Use positive values to see waveform sections after the trigger - the waveform and the diagram origin move to the left.

See also "Reference point" on page 122.

Remote command:
`TIMebase:HORizontal:POSition` on page 1002

Reference point
Sets the position of the reference point in % of the screen. The reference point marks the rescaling center of the time scale. It is indicated by a grey triangle outline at the top of the diagram. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compressed to both sides of the reference point.

Remote command:
`TIMebase:REFerence` on page 1002

Restrict horizontal position to acquisition range
If enabled, the horizontal position cannot be set outside the visible waveform diagram.

Remote command:
`TRIGger<m>:OFFSet:LIMited` on page 1003

Sample rate
Sets the number of captured waveform points per second. It considers the samples of the ADC, and the reduction of waveform points by decimation.

If interpolation is not active, the sample rate is the reciprocal value of the resolution and thus also depends on the acquisition time and the record length.

If interpolation is active, the sample rate is limited to the ADC sample rate.

See also:
- Chapter 4.1.2, "Sampling and Acquisition", on page 113
- Chapter 4.1.3, "Horizontal System", on page 116

Remote command:
`ACQuire:SRReal` on page 1005

Resolution
Sets the time between two waveform samples. A fine resolution with low values produces a more precise waveform record.

Remote command:
`ACQuire:RESolution` on page 1005

Record length
Indicates the number of waveform samples that build the waveform across the acquisition time.

Remote command:
`ACQuire:POINts[:VALue]` on page 1005

ZVC Resolution
Available only, if a R&S RT-ZVC multi-channel power probe probe is connected to the instrument.

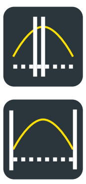
Displays the current resolution, the time between two waveform samples, of the R&S RT-ZVC multi-channel power probe channel.

Remote command:
`ACQuire:ZRESolution?` on page 1048

ZVC Record length
Available only, if a R&S RT-ZVC multi-channel power probe probe is connected to the instrument.

Indicates the number of waveform samples that build the channel's waveform across the acquisition time.

Remote command:
`ACQuire:POINts:ZVALue?` on page 1048



Resolution / Record length (Resolution dependency)
You can choose to keep constant either the resolution or the record length when you adjust the time scale or acquisition time.
- With constant resolution, increasing the time scale also increases the record length, and vice versa. You can limit the record length to a maximum value.
- With constant record length, increasing the time scale coarsens the resolution, that is, the time between two waveform samples gets longer.

Remote command:
`ACQuire:POINts:AUTO` on page 1003

Auto adjustment (Resolution dependency)
Prevents undersampling and ensures a sufficient resolution to acquire the correct waveform if the time scale is changed. The setting takes effect if the changed parameter - resolution or record length - reaches a limit. The instrument automatically keeps this parameter constant at its limit, and changes the other parameter regardless of the "Resolution / Record length" setting.

See also: Resolution / Record length (Resolution dependency)

Remote command:
`ACQuire:POINts:AADJust` on page 1004

Record length limit (Resolution dependency)
Sets a limit for the record length to prevent very large records. This value is only available if "Auto adjustment" is on and a constant resolution is selected. If you increase the time scale, the resolution remains constant and the record length increases until the limit is reached. Further increase of the time scale changes the resolution and keeps the record length limit.

See also:
- Resolution / Record length (Resolution dependency)
- Auto adjustment (Resolution dependency)

Remote command:
`ACQuire:POINts:MAXimum` on page 1004

Roll mode
In roll mode, the instrument shows the waveforms immediately, without waiting for the complete acquisition of the waveform record. If the time base is slow - at long time scale values - the roll mode saves waiting for the waveform display. The instrument displays newly acquired waveform points at the right edge of the display and moves the waveform to the left.

The roll mode has following restrictions:
- Roll mode disables persistence
- History is not available

The instrument activates the roll mode automatically if the following conditions are fulfilled:

- Acquisition time exceeds the defined "Minimum acquisition time"
- Waveform arithmetic is disabled ("Off")
- Only one waveform per channel is active
- All channel waveforms are set to the same decimation mode, and only to one of these values: "Sample", "Peak detect", or "High res"
- All mask tests are disabled
- Fast segmentation is disabled
- FFT is disabled
- All serial buses are disabled
- All digital channels are disabled (MSO option R&S RTP-B1)
- No CDR jitter data is acquired
- No zone trigger is active

The roll mode depends also on sample rate and record length. In roll mode, the sample rate limit is 2 MSa/s. At 50 s, the resulting record length limit is 100 MSa.

If the acquisition time is >50 s, the record length limit is effective, and the maximum sample rate depends on the acquisition time:

Sample rate ≤ 100 MSa / Acquisition time.

If the acquisition time is <50 s, the maximum sample rate in roll mode depends on the number of active channels:

Sample rate = 2 MSa/s / Number of active wfms.

The corresponding maximum record length is:

*Record length ≤ 2 MSa/s * Acquisition time / Number of active wfms*.

Thus, the roll mode switches off, or it does not activate automatically if:

- The record length exceeds the limit at acquisition times >50 s.
- The sample rate exceeds the limit.
- Too many waveforms are active.

Remote command:
`TIMebase:ROLL:ENABle` on page 1005
`TIMebase:ROLL:STATe?` on page 1006

Minimum acquisition time ← Roll mode
The instrument can activate the roll mode automatically if the Acquisition time exceeds the value given here.

Remote command:
`TIMebase:ROLL:MTIMe` on page 1006

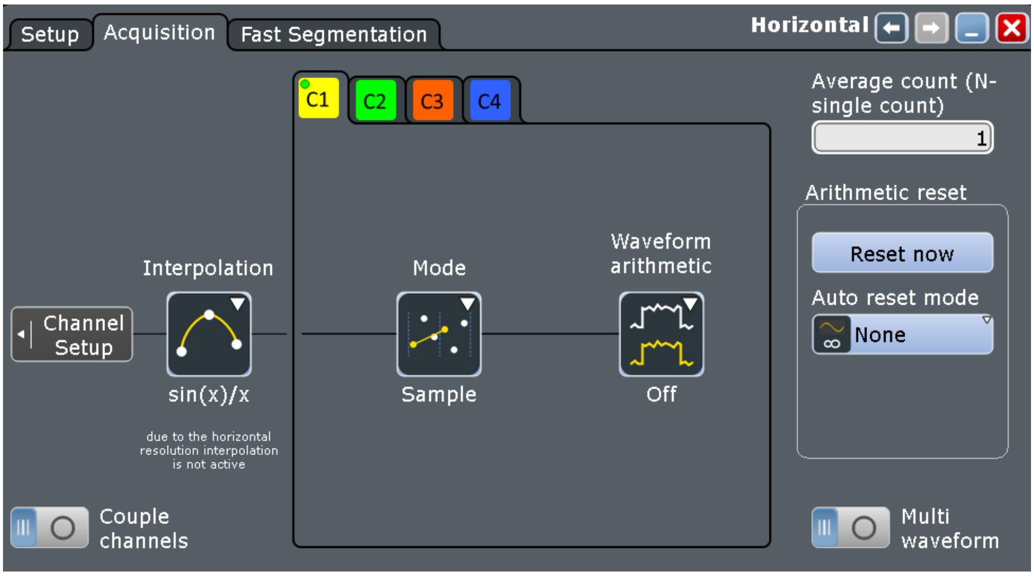
4.2.2 Acquisition

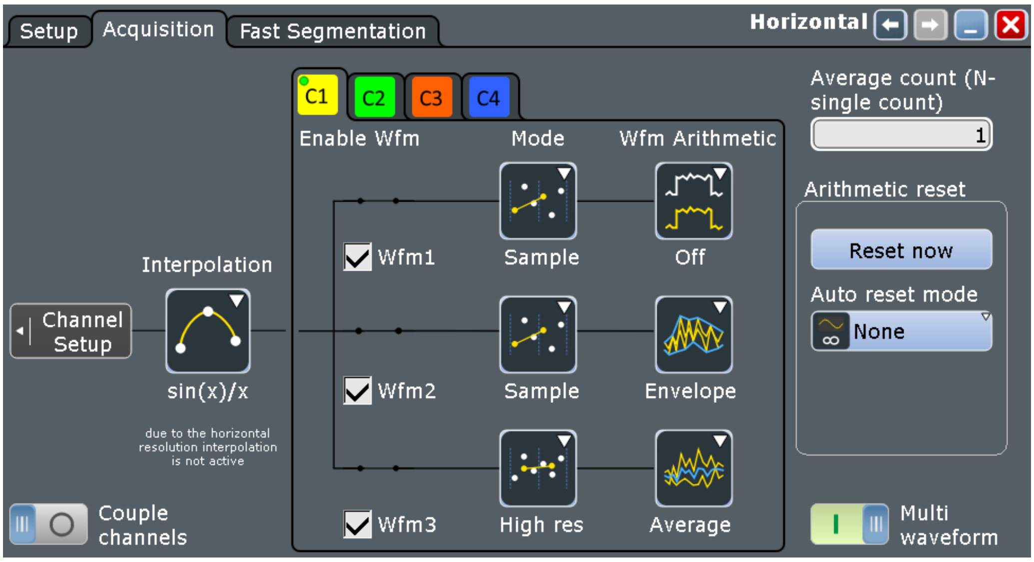
Access: [Acquisition] key

Acquisition settings control how the waveform is built from the captured samples.

You can display up to three waveforms from one input signal and apply different decimation and arithmetic to each waveform.

For background information, see Chapter 4.1.2, "Sampling and Acquisition", on page 113.





The acquisition "Mode" and "Waveform arithmetic" are specific for each waveform. Make sure to select the channel tab first, then set up the waveforms.

Interpolation

Selects the interpolation method. If the defined "Sample rate" is higher than the ADC sample rate, interpolation adds points between the captured samples of the waveform by various mathematic methods.

"Linear" Two adjacent ADC sample points are connected by a straight line, the interpolated points are located on the line. You see a polygonal waveform similar to the real signal, and also the ADC sample points as vertexes.

"sin (x)/x" Two adjacent ADC sample points are connected by a sin(x)/x curve, and also the adjoining sample points are considered by this curve. The interpolated points are located on the resulting curve. This interpolation method is precise and shows the best signal curve.

"Sample/Hold" The ADC sample points are displayed like a histogram. For each sample interval, the voltage is taken from the sample point and considered as constant, and the intervals are connected with vertical lines. Thus, you see the discrete values of the ADC - the measured samples.

Remote command:
`ACQuire:INTerpolate` on page 1006

Couple channels

Sets the acquisition mode and the waveform arithmetic of all channels to the last set value.

If the acquisition settings are coupled, "Multi waveform" is not available, only one waveform per channel can be used.

Remote command:
`ACQuire:CDTA` on page 1007

Multi waveform

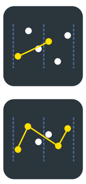
For each channel, up to three waveforms can be shown and analyzed. The decimation mode and the waveform arithmetic are specific for each waveform. So you can analyze several aspects of the signal: For example, waveform1 shows the peaks, and waveform2 shows the average of the signal.

Remote command:
`ACQuire:MUWaveform` on page 1007

Enable Wfm

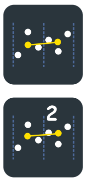
Activates or deactivates the individual waveforms of the selected channel.

Remote command:
`CHANnel<m>[:WAVeform<n>][:STATe]` on page 1007



Mode

Selects the decimation mode. Decimation reduces the data stream of the ADC to a stream of waveform points with lower sample rate and a less precise time resolution. The R&S RTP uses decimation, if the waveform "Sample rate" is less than the ADC sample rate. In this case, interpolation is not possible.



The decimation mode is waveform-specific, you can select another mode for each waveform.

There are different methods to define the recorded waveform point out of n sample points:

"Sample" One of n samples in a sample interval of the ADC is recorded as waveform point, the other samples are discarded. The time between the two adjacent waveform points is exactly the resolution. Very short glitches might remain undiscovered by this method.

"Peak detect" The minimum and the maximum of n samples in a sample interval are recorded as waveform points, the other samples are discarded.

"High res" The average of n sample points is recorded as one waveform sample. Averaging reduces the noise, the result is a more precise waveform with higher vertical resolution.

"RMS" The waveform point is the root mean square of n sample values. Thus, the RMS value reflects the instantaneous power. This arithmetic mode is used to average a measured power waveform. Linear averaging of power signals causes an error dependent on the noise of the signal to be averaged.

Remote command:
`CHANnel<m>[:WAVeform<n>]:TYPE` on page 1008

Wfm Arithmetic

Waveform arithmetic builds the resulting waveform from several consecutive acquisitions of the signal. The arithmetic works with interpolated and decimated waveforms.

This setting is waveform-specific.

The methods are:

"Off" The data of only one acquisition is recorded according to the decimation settings. In effect, no waveform arithmetic is processed.

"Envelope" Detects the minimum and maximum values in a sample interval over several acquisitions. Each acquisition is done in the "Peak detect" decimation mode, and the most extreme values for all acquisitions build the envelope. The resulting diagram shows two envelope waveforms: the minimums (floor) and maximums (roof).
The envelope is built until the restart criterion is reached, see "Auto reset mode / Reset mode" on page 129.

Note: If you change from "Envelope" to "Off", make sure to set also the "Mode" to the required value.

"Average" The average is calculated from the data of the current acquisition and several acquisitions before. The method reduces random noise and other heterodyne signals. It requires a stable, triggered and periodic signal for correct function.
The number of acquisitions for average calculation is defined with "Average count"
The "Auto reset mode" defines the restart condition.

Remote command:
`CHANnel<m>[:WAVeform<n>]:ARIThmetics` on page 1008

Acquisition/average count

Access:
- Trigger > "Control" tab > "Average count (N-single count)"
- [Acquisition] > "Average count"
- [Horizontal] > "Fast Segmentation" tab > disable "Acquire maximum" > "Required"
- [Math] > "Setup" tab > "Average count"

The acquisition and average count has several effects:
- It sets the number of waveforms acquired with [Single]
- It defines the number of waveforms used to calculate the average waveform. Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the value is, the better the noise is reduced.
- It sets the number of acquisitions to be acquired in a fast segmentation acquisition series. Thus, you can acquire exactly one fast segmentation acquisition series with [Single].
  If fast segmentation is enabled and configured to acquire the maximum number of acquisitions, the acquisition count is set to that maximum number and cannot be changed. See also: "Number of acquisitions" on page 131.
- It is the "Finished" criteria for the state of a mask test.

Remote command:
`ACQuire:COUNt` on page 1009

Reset now

Forces the immediate restart of the envelope and average calculation for all waveforms.

Remote command:
`ACQuire:ARESet:IMMediate` on page 1009

Auto reset mode / Reset mode

Defines when the envelope and average evaluation restarts.

"None"	No restart, the number of acquisitions considered by the waveform arithmetics is not limited.
"Time"	Restarts the envelope and average calculation after the time defined in "Reset time".
"Waveforms"	Restarts the envelope and average calculation after a number of acquired waveforms defined in "Reset count".

Remote command:
`ACQuire:ARESet:MODE` on page 1009
`ACQuire:ARESet:TIME` on page 1010
`ACQuire:ARESet:COUNt` on page 1010

4.2.3 Fast Segmentation

In normal acquisition mode, only a short time is used for sampling; processing and display take most of the time. The processing and display time is blind time causing a gap in the recorded signal. The normal acquisition mode may miss very short-time and infrequent events occurring during the dead time.

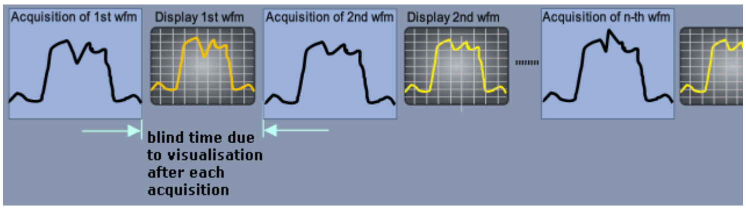


Figure 4-5: Normal acquisition with blind time

With fast segmentation, several triggered acquisitions are captured fast, with hardly any dead time between the acquisitions. The data is processed and the waveforms are displayed when the acquisition of the series has been completed.

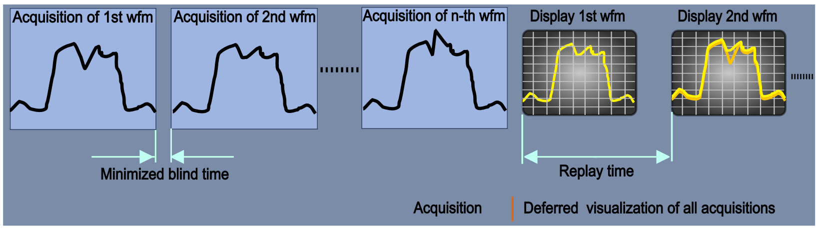


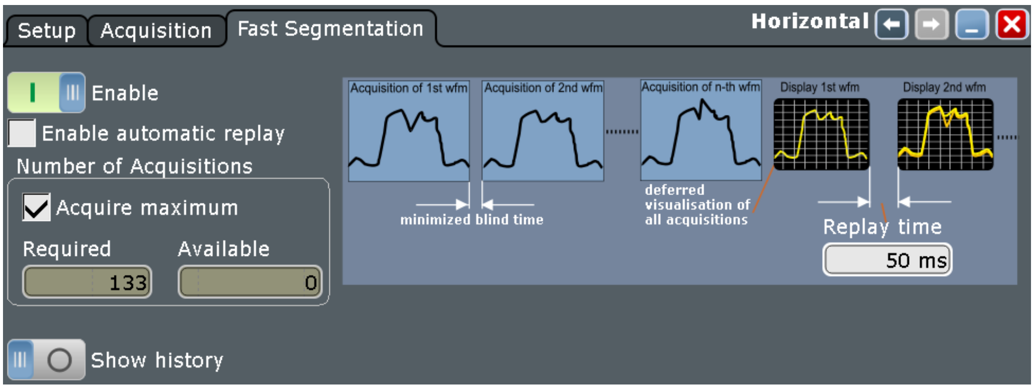
Figure 4-6: Fast segmentation with deferred processing and display

Fast segmentation and history

The acquisition series is written in the sample memory, thus the memory size limits the number of acquisitions in a series. This memory is the memory that is accessed by the history, thus the history function is used to read out the contents of the sample memory.

To use the history functionality, enable "Show history" in the "Fast Segmentation" tab. The history viewer settings are displayed directly in the "Fast Segmentation" tab.

See also: Chapter 6.4, "History", on page 259.



Enable fast segmentation
Switches the fast segmentation mode on and off.

Remote command:
`ACQuire:SEGMented:STATe` on page 1010

Enable automatic replay
If enabled, the instrument starts processing and displaying the data when the acquisition series is captured completely. Depending on the number of acquisitions, it can take some time until the acquisition series is displayed. If the setting is disabled, the instrument only captures the data and stores it in the sample memory.

Remote command:
`ACQuire:SEGMented:AUToreplay` on page 1011

Number of acquisitions
You can define the number of acquisitions to be stored in a fast segmentation acquisition series:
- Acquire the maximum number of acquisitions that can be stored in the sample memory.
  To acquire the maximum number, enable "Acquire maximum". The maximum number of acquisitions is shown in the "Required" field.
- Acquire a given number of acquisitions.
  Enter the number in the "Required" field.

The acquisition count (Acquisition/average count) is always set to the required number of acquisitions. Thus you can acquire exactly one fast segmentation acquisition series with [Single]. The [Run Stop] key works in the same way as [Single], it stops acquisition when the series is completed.

You can stop the running acquisition before the series is completed.

The number of acquired waveforms is shown in "Available" and can be displayed with "Show history".

Remote command:
`ACQuire:SEGMented:MAX` on page 1011

Replay time
Defines the display speed of the fast segmentation acquisition series. Display starts after the series has been captured completely.

See also: "Replay time per acq." on page 262

Show history
Enables the history mode and displays the history viewing functions in the "Fast Segmentation" tab.

See also: Chapter 6.4.2.1, "Viewer", on page 260.

4.3 Vertical Settings

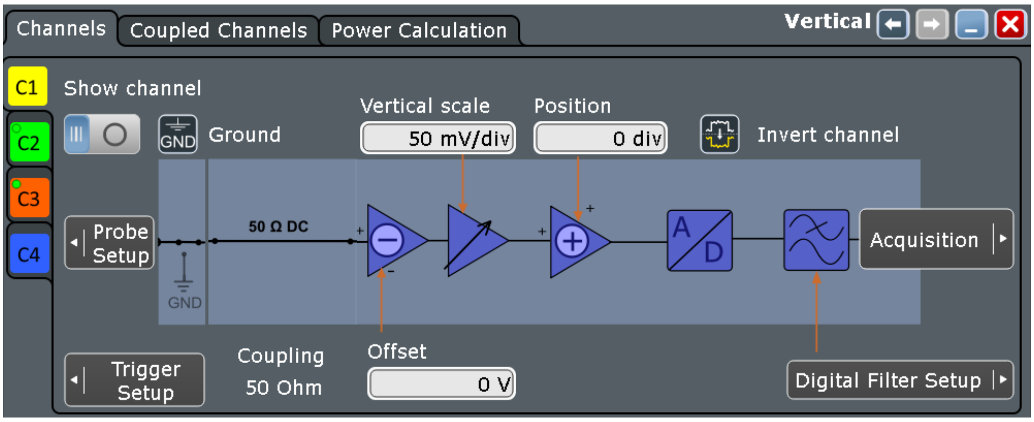
The "Vertical" menu contains all channel-dependent settings and information.

4.3.1 Channels

Access: "Vertical" menu > "Channels"

The "Channels" tab provides all basic vertical settings. The channels are listed in vertical tabs at the left side of the dialog box.

You can also filter the signal for high frequency rejection, see Chapter 4.7, "Digital Filter Setup", on page 171.



Make sure that the correct channel tab is selected. The vertical rotary knobs are illuminated in the color of the selected channel.

Show channel

Switches the channel signal on or off. The signal icon appears on the sidebar. The waveform of the last acquisition is displayed in the diagram.

Remote command:

`CHANnel<m>:STATe` on page 1011

Ground

Connects the input to the ground.

Remote command:

`CHANnel<m>:GND` on page 1012

Vertical scale

Defines the vertical scale in Volts per division. Increasing the scale compresses the display of the signal.

Remote command:
CHANnel<m>:SCALe on page 1012

Position

Moves the selected signal up or down in the diagram. The visual effect is the same as for Offset but the waveform is adjusted later in the signal flow. While the offset sets a voltage, position is a graphical setting given in divisions.

By default, the horizontal grid axis remains in the center when the offset is changed. To shift the axis together with the waveform, disable Keep Y-grid fixed in "Display > Diagram Layout".

Remote command:
CHANnel<m>:POSition on page 1013

Invert channel

Turns the inversion of the signal amplitude on or off. To invert means to reflect the voltage values of all signal components against the ground level. If the inverted channel is the trigger source, the instrument triggers on the inverted signal.

You can use inversion, for example, to switch the polarity of a differential signal without changing the probe connections.

Remote command:
CHANnel<m>:INVert on page 1014

Coupling

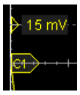
Shows the termination of the channel input signal: 50 Ω. Both DC and AC components of the signal are passed.

Remote command:
CHANnel<m>:COUPling on page 1012

Offset

The offset voltage is subtracted to correct an offset-affected signal. The vertical center of the selected channel is shifted by the offset value and the signal is repositioned within the diagram area. Negative offset values move up the waveform, positive values move it down.

The offset of a signal is determined and set by the autoset procedure. The current value is shown in the waveform label, and it is marked by a small triangle in the grid.



If a Rohde & Schwarz differential probe is connected, the offset is the differential offset.

If a Rohde & Schwarz modular probe is connected, the offset of the selected probe mode is used. For example, in CM mode, the offset is the common mode offset.

By default, the horizontal grid axis remains in the center when the offset is changed. To shift the axis together with the waveform, disable Keep Y-grid fixed in "Display > Diagram Layout".

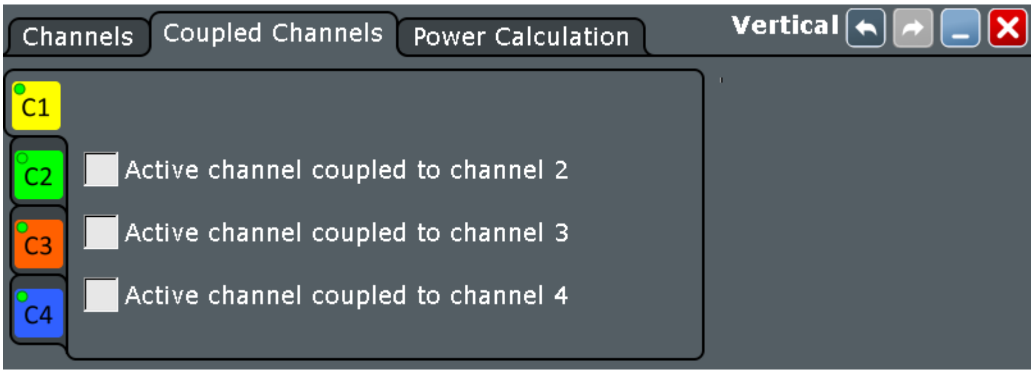
Remote command:
CHANnel<m>:OFFSet on page 1013

4.3.2 Coupled Channels

Access: "Vertical" menu > "Coupled Channels"

Channel coupling sets the vertical settings of the coupled channels to the values of the active channel. If you want to have the same vertical settings for two or more channels , you can set them at once by coupling these channels.

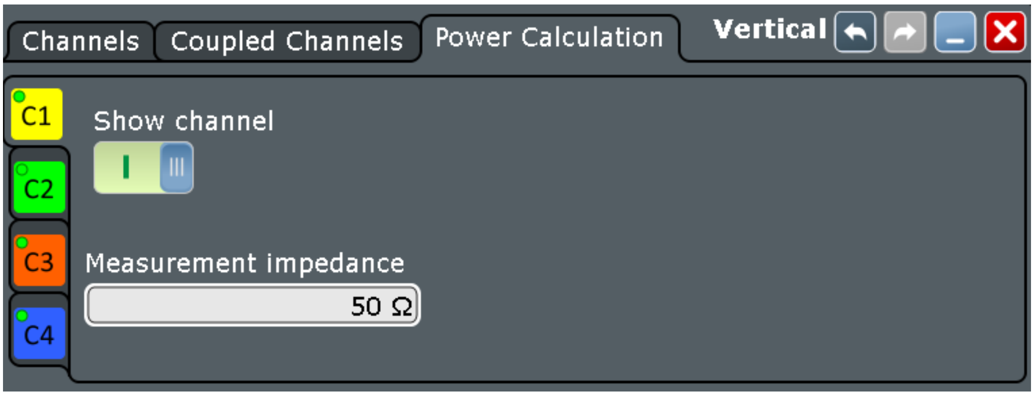
Channel coupling affects all vertical settings that are adjusted in the "Channels" tab: vertical scale, position, offset, bandwidth, coupling, and ground.



4.3.3 Power Calculation

Access: "Vertical" menu > "Power Calculation"

Make sure that the correct channel tab is selected.



Show channel
Switches the channel signal on or off. The signal icon appears on the sidebar. The waveform of the last acquisition is displayed in the diagram.

Remote command:
`CHANnel<m>:STATe` on page 1011

Measurement impedance
Sets the impedance of the channel for power calculations and measurements.

Remote command:
`CHANnel<m>:IMPedance` on page 1014

4.4 High Definition Mode (Option R&S RTP-K17)

The high definition mode offers up to 16 bits of vertical resolution. Higher vertical resolution reduces quantization noise and acquires waveforms of higher accuracy with finer details of the signal to be seen.

The number of vertical resolution bits defines the number of vertical levels that the acquisition samples are mapped to (quantization). 16 bits of resolution represent 65536 voltage quantization levels, while 8 bits of resolution represent only 256 voltage levels. The waveform values are recorded with 16 bit word length, except for peak detect decimation.

The higher vertical resolution is achieved by applying a digital low pass filter (DSP filter) to the output of the ADC, which reduces the bandwidth of the signal. Increasing the bandwidth reduces the resulting digital resolution. The high definition is also applied to the digital trigger, thus the R&S RTP can trigger with the same high resolution with which they can display signals.

High definition can be used, for example, to measure slow pulses with high accuracy, or to analyze AM signals with very low modilation index, as used in radar.

See also:
- Chapter 4.1.1, "Vertical System", on page 111
- Chapter 4.1.2, "Sampling and Acquisition", on page 113

4.4.1 High Definition Settings

Access: "App Cockpit" menu > "HD"

High definition is a special acquisition mode of the oscilloscope. This mode has only one setting - the filter bandwidth.

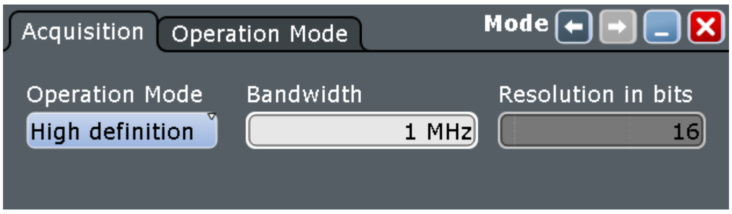


Figure 4-7: Setting the instrument into high definition mode

Operation mode
Sets the operation mode of the instrument.

"Normal"	Usual oscilloscope mode
"High definition"	Mode with higher digital resolution, up to 16 bit. Requires option R&S RTP-K17.

Remote command:
`HDEFinition:STATe` on page 1051

Bandwidth
Sets the filter bandwidth for the high definition mode.

The maximum filter bandwidth is 2GHz.

Remote command:
`HDEFinition:BWIDth` on page 1051

Resolution in bits
Shows the resulting vertical resolution in high definition mode. The higher the filter bandwidth, the lower the resolution. For details, refer to the R&S RTP Specifications.

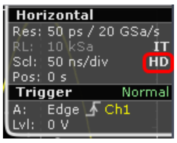
Remote command:
`HDEFinition:RESolution?` on page 1052

4.4.2 Effects of the High Definition Mode

The high definition mode has several effects:

Acquisition

The active high definition mode is indicated by "HD" in the horizontal label.



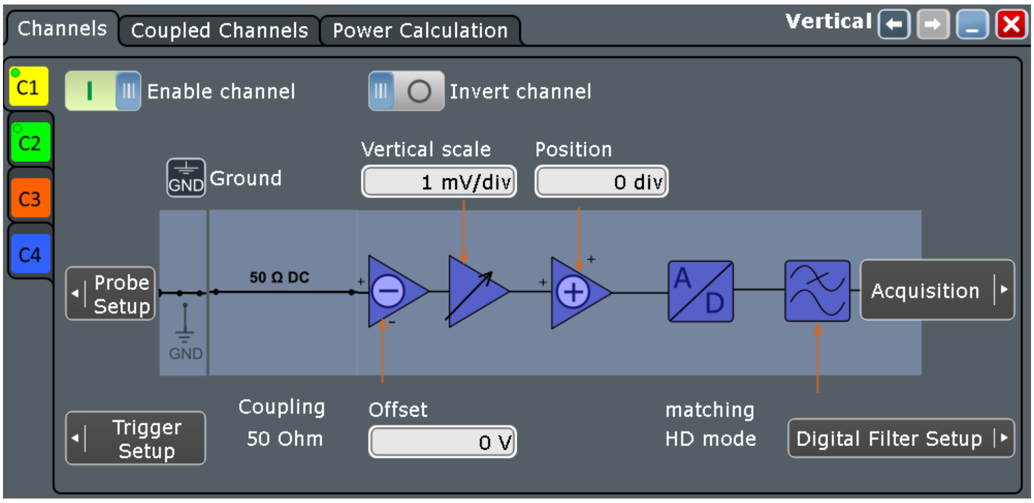
The high definition mode works with half the realtime sample rate. For FFT, the instrument halves this sample rate again.

The waveform values are recorded with 16-bit word length, except for peak detect decimation (2 values with 8 bit).

Vertical system

The current bandwidth is shown in the channel label.

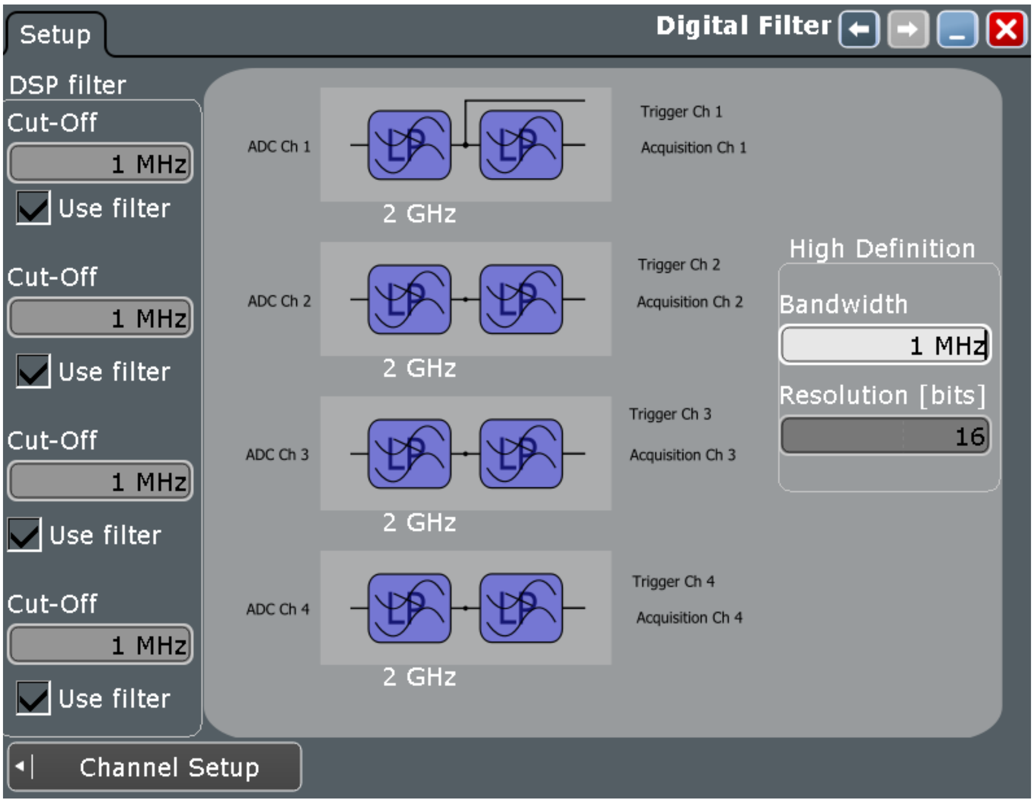
In the "Channels" dialog box (CH<x>), the "Bandwidth" setting is not available because the bandwidth is set by the high definition filter.



The minimum vertical scale is 500 µV/div instead of 1 mV in normal mode.

Digital filter

The digital filter settings are set automatically. You can change the high definition "Bandwidth" in the "Digital Filter Setup".



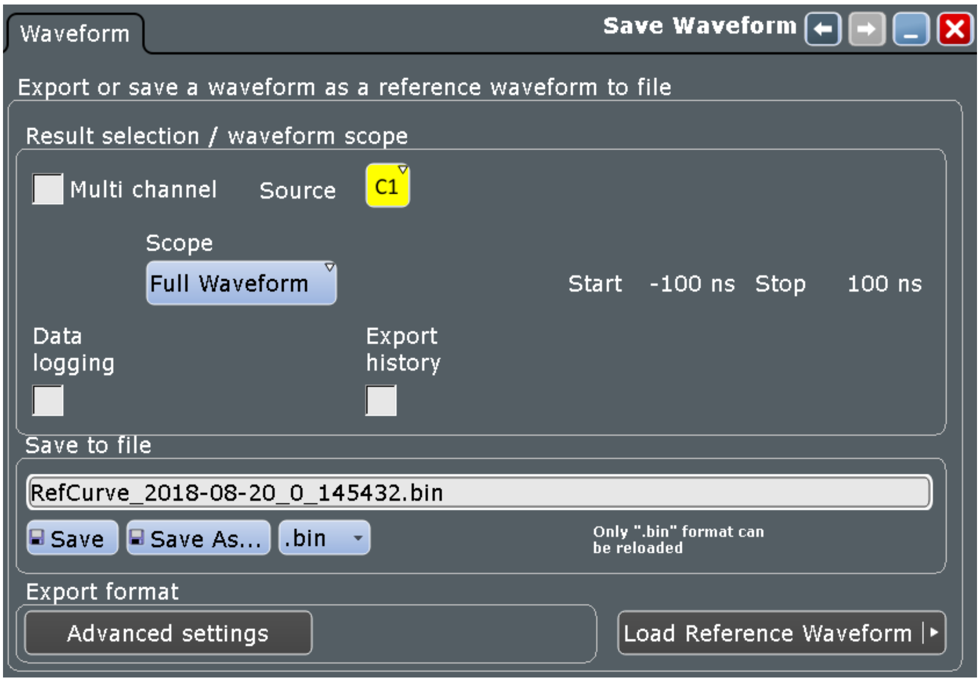
History

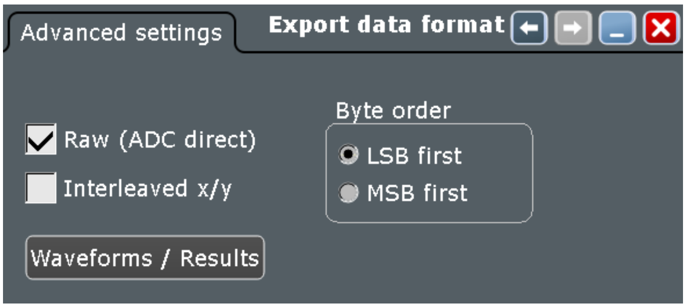
Due to the 16-bit word length, the history depth is reduced, less waveforms are saved than in normal mode.

Export

In high definition mode, waveform data in raw format is exported to file with 16-bit word length, except for peak detect decimation (2 values with 8 bit). In addition, you can define the byte order of the data words.

To define additional export settings, tap "Advanced Settings" in [Save Recall] > "Waveform".





See:

- "Raw (ADC direct)" on page 439
- "Interleaved x/y" on page 439
- "Byte order" on page 440

If you use remote control commands to transfer data to a controlling computer, set the data format to `INT,16` to transfer the complete data words (see `FORMat[:DATA]` on page 977).

4.5 Probes

With R&S RTP digital oscilloscopes, you can use various probe types. Mostly these probes are passive and active voltage probes. The "Probes" dialog box provides all probe-relevant information.

The instrument can detect many probes and read out the probe-specific parameters, for example, bandwidth and attenuation.

In the "Setup" tab, you find all settings that are relevant for the connected probe.

Access: "Vertical" menu > "Probe Setup"

The functionality on the "Setup" tab changes according to the type of the attached probe. Probes with Rohde & Schwarz probe interface (probe box), and also many other passive voltage probes, are recognized by the instrument. The R&S RTP reads out the main characteristics of the probe and displays them. Other probes cannot be detected, but their characteristics are known to the instrument. These known probes are called "Predefined probes". Probes that are not recognized automatically and not predefined are unknown probes, they require manual setting of measurement unit and attenuation.

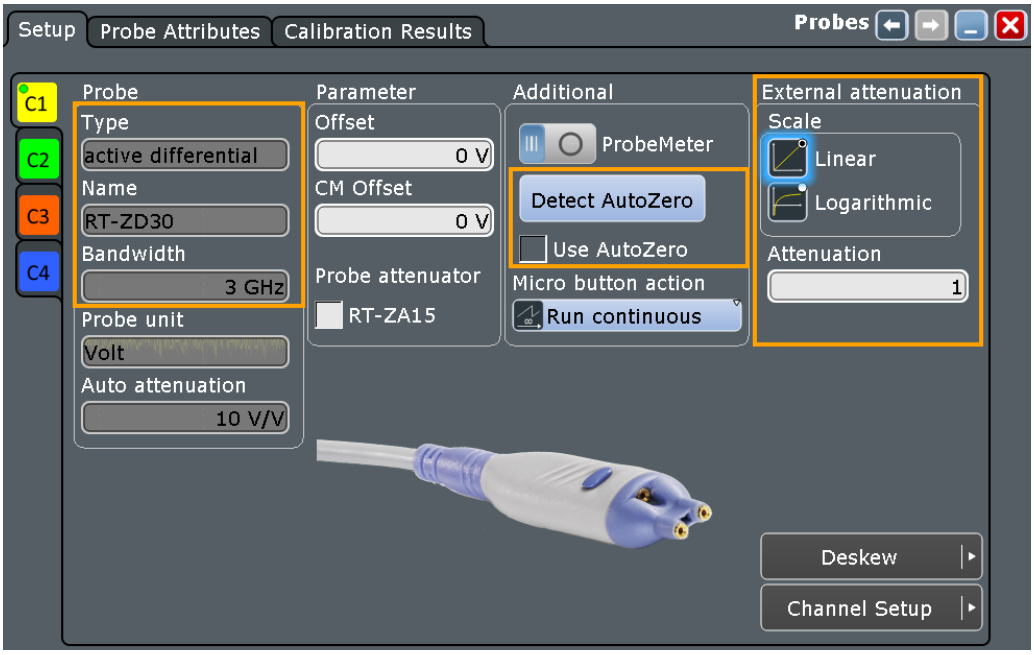
Before you adjust the settings, select the correct channel tab on the left.

Additional information is given in the "Probe Attributes" and "Calibration Results" tabs. For background information, see Chapter 4.1.4, "Probes", on page 117.

This chapter has the following sections:

4.5.1 Shared Probe Settings

Some of the settings in the "Pobes Setup" tab are available for all probes.



The shared probe settings are:

Type, Name, Bandwidth

The fields show the characteristics of a recognized or predefined probe for information. If the instrument cannot recognize the probe, and the probe is not known, the "Type" is "None", and the other fields are empty.

Remote command:

`PROBe<m>:SETup:TYPE?` on page 1018

`PROBe<m>:SETup:NAME?` on page 1018

`PROBe<m>:SETup:BANDwidth?` on page 1018

Detect AutoZero, Use AutoZero

Differences in DUT and oscilloscope ground levels can cause larger zero errors, which affect the waveform. If the DUT is ground-referenced, the AutoZero function corrects the zero error of the probe to optimize measurement results at small signal levels. The validation limit depends on the probe attenuation because probes with high attenuation often have to compensate high offsets. AutoZero detects offset values even when the signal is out of the current measurement range.

To correct the zero error of voltage probes, short the signal pin and the ground pin together and connect them to the ground of the DUT. Then tap "Detect AutoZero". While the alignment is running, the instrument switches to DC coupling to display the waveform correctly.

To include the measured offset in measurement results, enable "Use AutoZero".

If a current probe is connected, the function demagnetizes the probe's sensor head and sets the waveform to zero position. See "Detect AutoZero" on page 160.

Remote command:
PROBe<m>:SETup:OFFSet:AZERo on page 1019
PROBe<m>:SETup:OFFSet:USEautozero on page 1019

External attenuation: Scale, Attenuation
Consider a voltage divider that is part of the DUT before the measuring point. The external attenuation is included in the measurement, and the instrument shows the results that would be measured before the divider. External attenuation can be used with all probes.

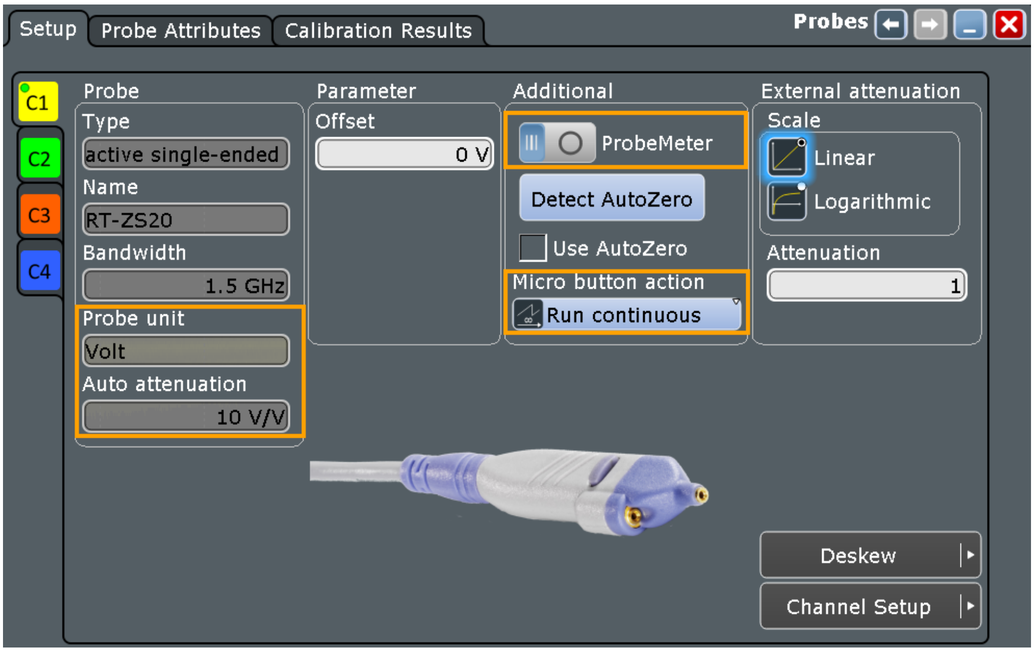
"Scale" Select linear or logarithmic attenuation scale.

"Attenuation" Enter the attenuation of the voltage divider according to the selected scale. The conversion from linear to logarithmic values depends on the "Vertical unit" of the probe:
For voltage-based unit (V and A):
*attenuation (dB) = 20 * log_{10}(attenuation factor)*
For power-based unit (W):
*attenuation (dB) = 10 * log_{10}(attenuation factor)*

Remote command:
CHANnel<m>:EATScale on page 1020
CHANnel<m>:EATTenuation on page 1020

4.5.2 Settings for the R&S Probe Interface (Voltage Probes)

Active voltage probes with Rohde & Schwarz probe interface provide special features: the micro button and the ProbeMeter. Furthermore, the R&S RTP can read out the attenuation of the probe.



The settings for active voltage probes with Rohde & Schwarz probe interface are:

Probe unit, Auto attenuation

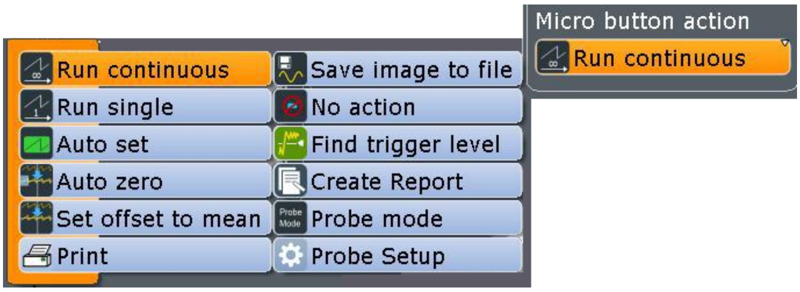
If the probe is recognized by the R&S RTP, the instrument reads the attenuation unit and value from the probe an displays them.

Remote command:

`PROBe<m>:SETup:ATTenuation[:AUTO]?` on page 1019

Micro button action

Active voltage probes with Rohde & Schwarz probe interface have a configurable micro button on the probe head. Pressing this button, you start an action on the instrument directly from the probe. The button is disabled during internal automatic processes, for example, during self-alignment, autoset, and find level.



Select the action that you want to start from the probe:

"Run Continuous"
Is the default assignment. Starts or stops the acquisition (same as Run Stop key).

"Run single"
Starts a defined number of acquisitions (same as [Single] key).

"Auto set"
Starts the autoset procedure (same as Autoset key).

"AutoZero"
Starts an auto zero measurement, see "Detect AutoZero, Use AutoZero" on page 140.

"Set offset to mean"
Performs an automatic compensation for a DC component of the input signal using the result of a background mean measurement. See: "Offset to mean" on page 158.

"Print"
Prints the current display according to the "Printer control" settings in the "Print" dialog box. Depending on the selected printer, you can print to a local or network driver, or save to a file. See also: Chapter 11.3, "Screenshots", on page 448.

"Save image to file"
Saves the current display as image according to the image settings in the "Print" dialog box. See also Chapter 11.3, "Screenshots", on page 448.

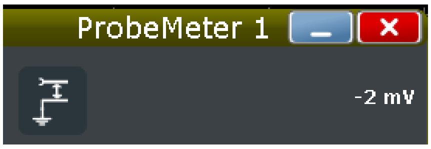
"No action"
Select this option to prevent unwanted actions due to unintended usage of the micro button.

"Find trigger level"	Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*.
"Create report"	Creates and saves a report using the settings defined in "File" menu > "Report Setup".
"Probe mode"	Only available if a R&S RT-ZM modular probe is connected. Sets the measurement mode of the modular probe. See also "Probe Mode" on page 151.
"Probe Setup"	Opens the "Probes Setup" dialog box.

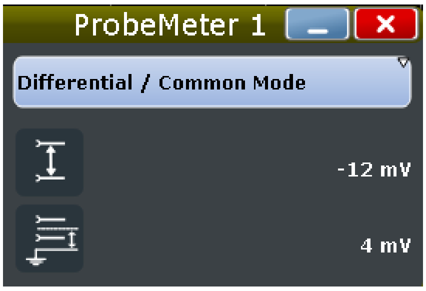
Remote command:
`PROBe<m>:SETup:MODE` on page 1020

ProbeMeter
The integrated R&S ProbeMeter of active voltage probes with Rohde & Schwarz probe interface is a voltmeter. It measures DC voltages between the probe tip and ground connection or between the probe tips with very high precision. The R&S ProbeMeter enables ground-referenced measurements of voltages. The measurement is performed continuously and in parallel to the measurements of the oscilloscope.

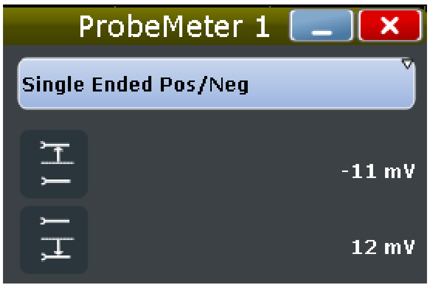
- **"Probemeter"**
  Select "Probemeter" to activate the integrated R&S ProbeMeter of active R&S probes. The measured voltages are displayed in the "ProbeMeter" result box on the screen.
- **ProbeMeter measurement results of single-ended active R&S probes**
  Measures the voltage between the probe tip and the ground.



- **ProbeMeter measurement results of differential and modular R&S probes**
  You can select the voltage to be measured by the differential active probe:
  – "Differential / Common Mode":
    Differential voltage is the voltage between the positive and negative signal sockets.
    Common mode voltage is the mean voltage between the signal sockets and the ground socket. It measures the voltage level relative to ground, for example, to check the operating voltage window.



  – "Single Ended Pos/Neg": Measures the voltage between the positive/negative signal socket and the ground.



The ProbeMeter always measures the common mode and differential voltages. Single-ended voltages are calculated values:
$V_p = V_{cm} + 0.5 * V_{in}$ and $V_n = V_{cm} - 0.5 * V_{in}$

Remote command:
`PROBe<m>:PMETer:VISibility` on page 1022
`PROBe<m>:SETup:DISPlaydiff` on page 1022
`PROBe<m>:PMETer:RESults:SINGle?` on page 1022
`PROBe<m>:PMETer:RESults:POSitive?` on page 1024
`PROBe<m>:PMETer:RESults:NEGative?` on page 1023
`PROBe<m>:PMETer:RESults:DIFFerential?` on page 1023
`PROBe<m>:PMETer:RESults:COMMon?` on page 1023

4.5.3 Setup for Passive Probes

Passive probes are the most widely used probes for oscilloscope measurements. Passive probes require compensation.

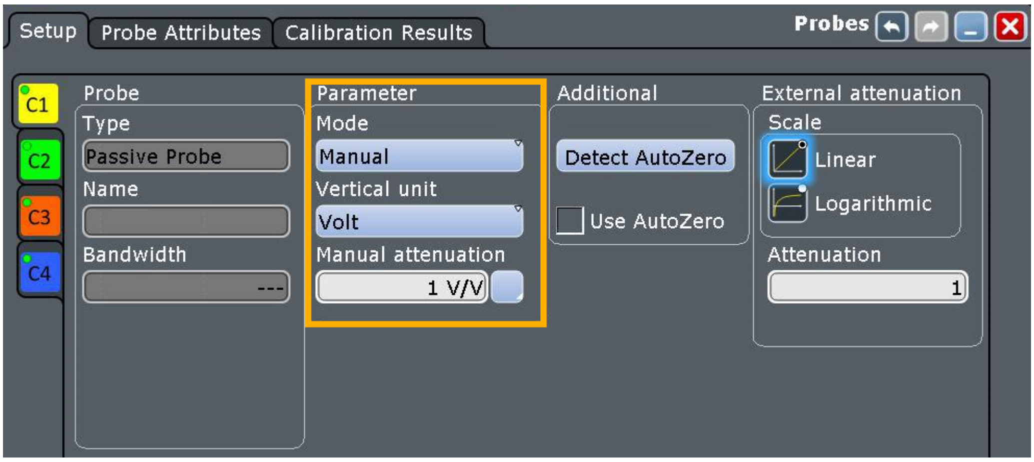


Figure 4-8: Probe setup for passive probe R&S RT-ZP10

The following shared probe settings are available:
- "Type, Name, Bandwidth" on page 140
- "Detect AutoZero, Use AutoZero" on page 140
- "External attenuation: Scale, Attenuation" on page 141

If a passive probe is connected, the probe attenuation is read out and shown in the "Setup" tab:

- "Probe unit, Auto attenuation" on page 142

If you need to change the unit or attenuation, change the "Mode" to "Manual" and enter the correct values.

Mode

Defines how the attenuation of a passive probe is set.

"Auto" The instrument uses the values that are read out from the probe.

"Manual" You can define the attenuation unit and value.
See: "Vertical unit, Attenuation, Gain" on page 145

Remote command:
`PROBe<m>:SETup:ATTenuation:MODE` on page 1024

Vertical unit, Attenuation, Gain

If a predefined probe is connected and selected, the attenuation or gain values are shown.

For unknown probes and passive probes in manual mode, you can set user-defined values for unit, gain and attenuation.

Remote command:
`PROBe<m>:SETup:ATTenuation:UNIT` on page 1025
`PROBe<m>:SETup:ATTenuation:MANual` on page 1025
`PROBe<m>:SETup:GAIN:MANual` on page 1025

4.5.4 Setup for Active Voltage Probes

Active voltage probes with Rohde & Schwarz probe interface have an integrated data memory that contains identification data and individual probe correction parameters. The R&S RTP can detect these probes and read out the data. Furthermore, these probes have a micro button and a ProbeMeter.

Active voltage probes that are offered by Rohde & Schwarz but not equipped with a Rohde & Schwarz probe interface are known to the R&S RTP as predefined probes, see Chapter 4.5.6, "Setup for Predefined Probes", on page 156.

The following shared probe settings are available:

- "Type, Name, Bandwidth" on page 140
- "Detect AutoZero, Use AutoZero" on page 140
- "External attenuation: Scale, Attenuation" on page 141

Special features of the Rohde & Schwarz probe interface are described in these sections:

- "Probe unit, Auto attenuation" on page 142
- "Micro button action" on page 142
- "ProbeMeter" on page 143

The specific settings of Rohde & Schwarz active probes are described in the following chapters:

4.5.4.1 R&S RT-ZS Single-Ended Probes

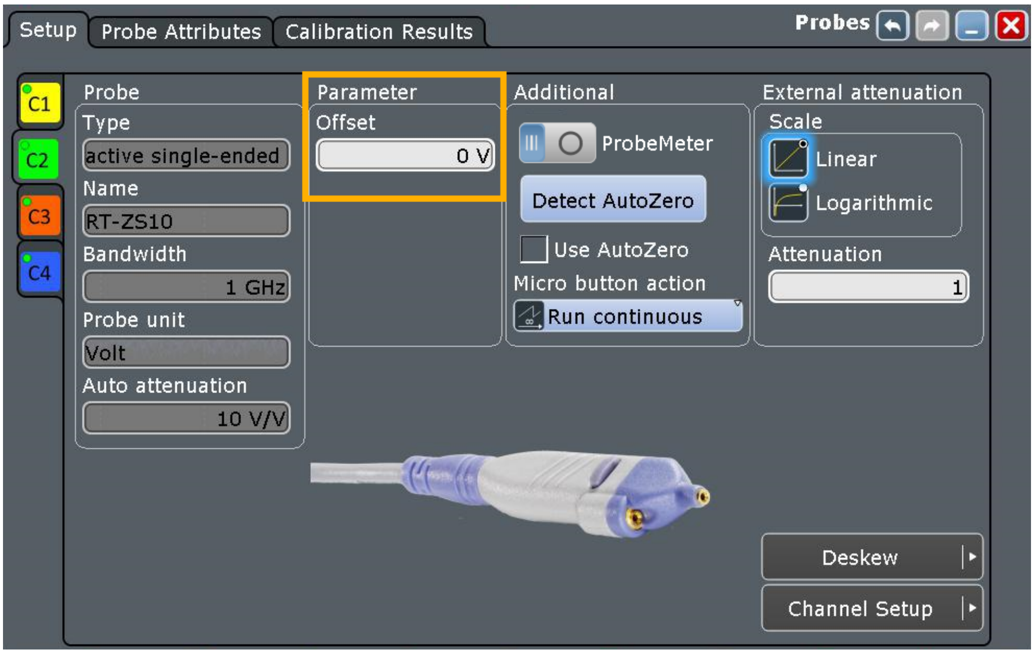


Figure 4-9: Probe setup for active single-ended probe R&S RT-ZS10

The only setting for R&S RT-ZS probes is the channel offset. See "Offset" on page 133.

4.5.4.2 R&S RT-ZD Differential Probes

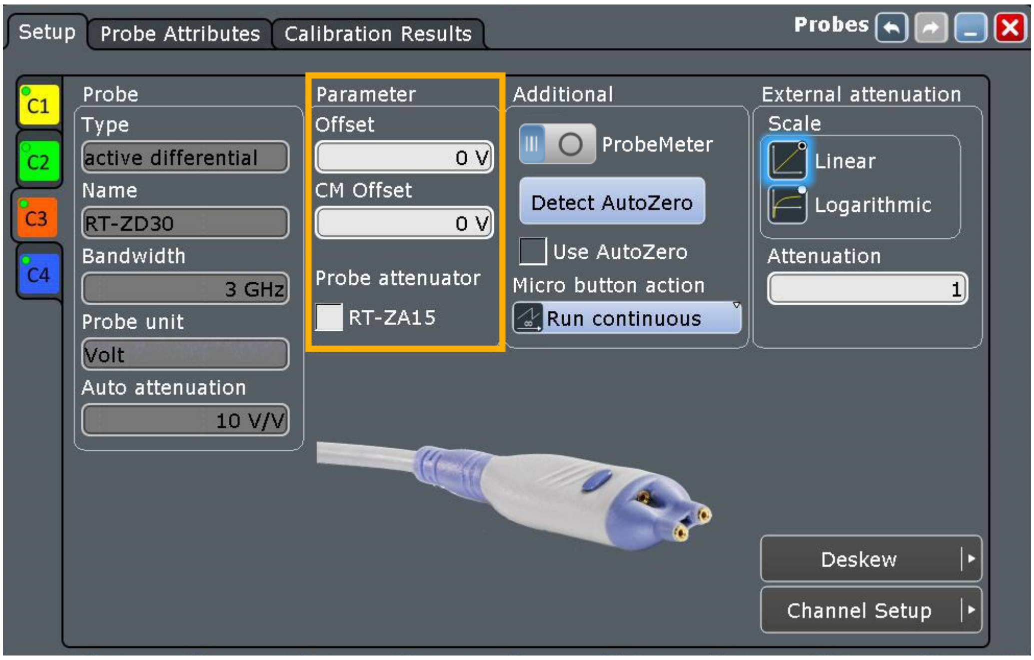


Figure 4-10: Probe setup for active differential probe R&S RT-ZD30

The offset is the differential offset. See "Offset" on page 133.

Specific settings for R&S RT-ZD probes are the following:

CM offset

Sets the common-mode offset to compensate for a common DC voltage applied to both input sockets (referenced to the ground socket). Offset compensation is particularly helpful for measurements on differential signals with high common mode levels, for example, current measurements using a shunt resistor. You can measure the common mode input voltage using the R&S ProbeMeter.

The setting is available for Rohde & Schwarz differential probes, and for modular probes in DM or CM mode (see "DM Offset, CM Offset, P Offset, N Offset" on page 152).

Remote command:
`PROBe<m>:SETup:CMOFfset` on page 1026

Probe attenuator RT-ZA15

If you use the external attenuator R&S RT-ZA15 together with one of the differential active probes R&S RT-ZD, enable RT-ZA15 to include the external attenuation in the measurements.

Remote command:
`PROBe<m>:SETup:ZAXV` on page 1026

4.5.4.3 R&S RT-ZPR Power Rail Probes

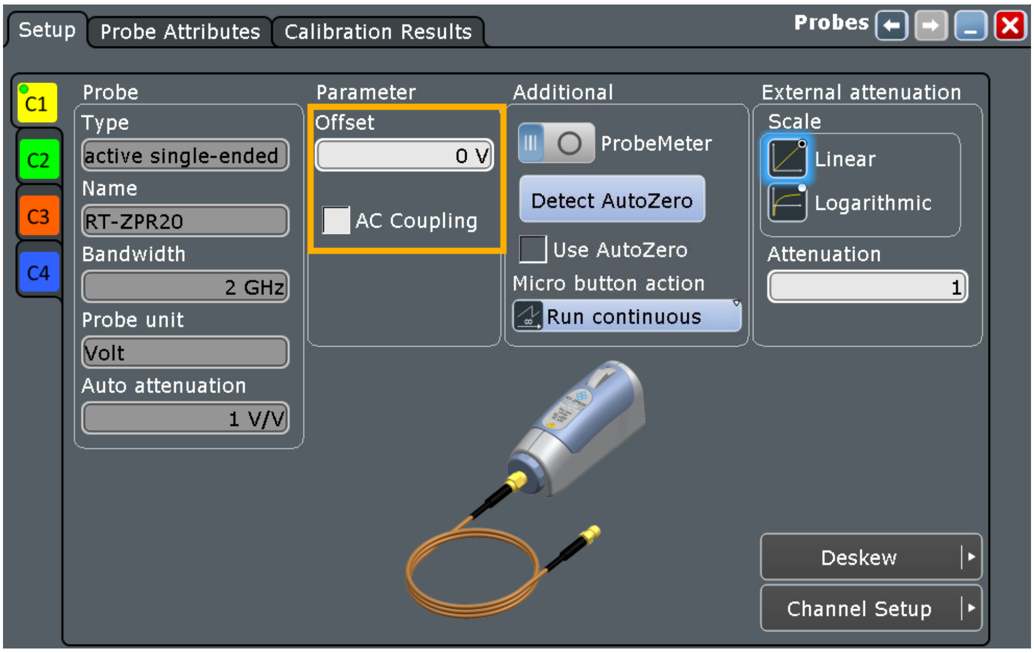


Figure 4-11: Probe setup for power rail probe R&S RT-ZPR

The offset is the channel offset. See "Offset" on page 133.

If the ProbeMeter is active, an additional function is provided in the "ProbeMeter" result box:

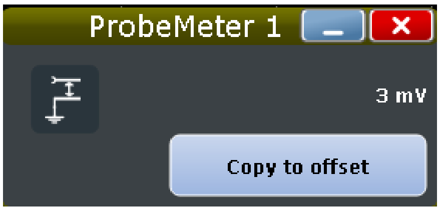


Figure 4-12: ProbeMeter result box for

Specific settings for R&S RT-ZPR probes are the following:

AC Coupling
Enables AC coupling in the R&S RT-ZPR power rail probes, which removes DC and very low-frequency components. The R&S RT-ZPR probe requires 50 Ω input termination, for which the channel AC coupling is not available. The probe setting allows AC coupling also at 50 Ω inputs.

Remote command:
`PROBe<m>:SETup:ACCoupling` on page 1026

Copy to offset
Sets the measured ProbeMeter value as offset. Thus, the value is considered in measurements.

Remote command:
PROBe<m>:SETup:ADVanced:PMToffset on page 1027

4.5.4.4 R&S RT-ZHD High-Voltage Differential Probes

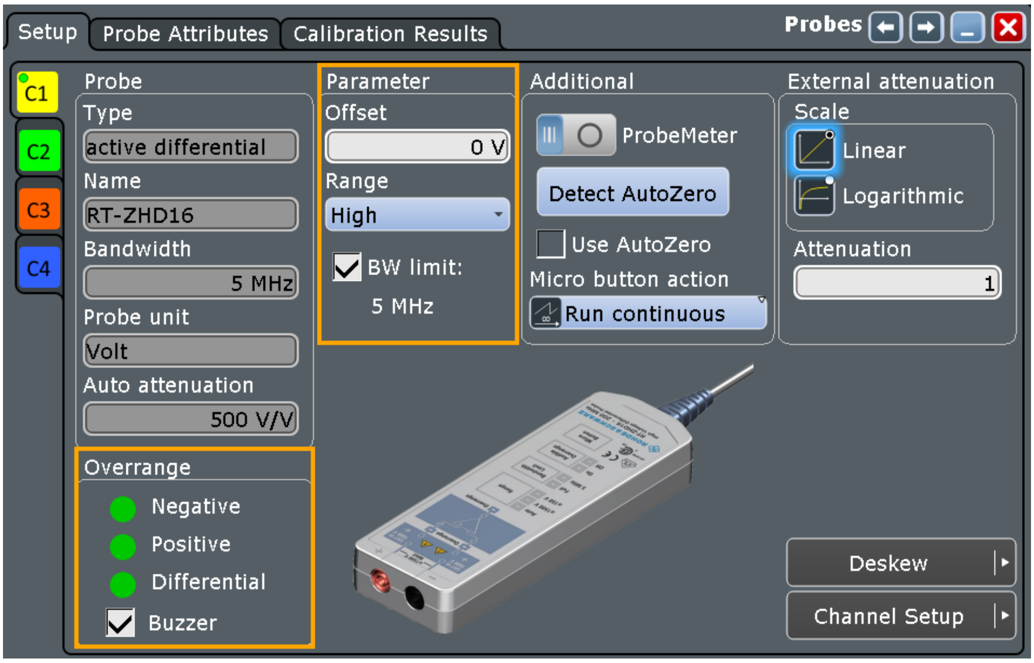


Figure 4-13: Probe setup for R&S RT-ZHD probes

The offset is the differential offset. See "Offset" on page 133.

Specific settings for R&S RT-ZHD probes are the following:

Range
Sets the voltage range of a R&S RT-ZHD probe. You can set the range on the probe control box or at the oscilloscope.

"Auto"	The voltage range is set only at the oscilloscope with "Vertical scale".
"Low"	Sets the lower voltage range of the connected probe. The selected value is shown in "Auto Attenuation".
"High"	Sets the higher voltage range of the connected probe. The selected value is shown in "Auto Attenuation".

Remote command:
PROBe<m>:SETup:ADVanced:RANGe on page 1027

BW limit
Activates the lowpass filter in the probe control box and displays the used limit. You can also set the filter directly on the probe control box.

Remote command:
PROBe<m>:SETup:ADVanced:FILTer on page 1027

Buzzer
Activates the acoustic overrange warning in the probe control box. You can also activate the sound directly on the probe control box.

Remote command:
`PROBe<m>:SETup:ADVanced:AUDioverload` on page 1028

Negative, Positive, Differential Overrange
The color turns red if the voltage exceeds the probe range. The indicators are also available on the probe control box.

4.5.5 Modular Probes

The probes of the R&S RT-ZM family are modular probes. They have a probe head and a probe amplifier connected by a cable, and various probe tip modules and tip cables for different applications. R&S RT-ZM probes are equipped with Rohde & Schwarz probe interface, and provide special features: ProbeMeter, micro button, and a wide offset compensation range.

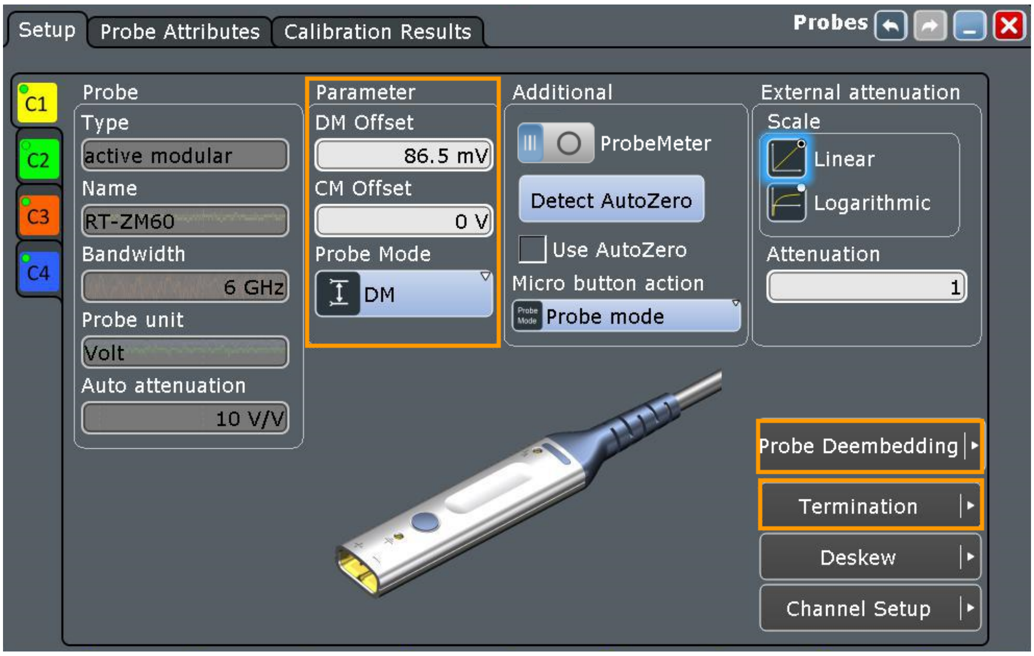
If you connect the R&S RT-ZM probe to the external trigger input, you can adjust only the trigger level and the probe mode. The instrument sets the trigger level to the probe offset value (DM, CM, P or N, depending on the probe mode).

The following shared probe settings are available:

- "Type, Name, Bandwidth" on page 140
- "Detect AutoZero, Use AutoZero" on page 140
- "External attenuation: Scale, Attenuation" on page 141

Special features of the Rohde & Schwarz probe interface are described in these sections:

- "Probe unit, Auto attenuation" on page 142
- "Micro button action" on page 142
- "ProbeMeter" on page 143



4.5.5.1 Setup Parameters of Modular Probes

The basic setup parameters of all modular probes are the measurement mode and the offset settings.

Access: "Vertical" menu > "Probe Setup"

Make sure to adjust also the deembedding settings under "Probe Deembedding" (see Chapter 4.5.5.2, "Deembedding for Modular Probes", on page 152).

Probe Mode
Sets the measurement mode of modular probes.

The modular probes of the R&S RT-ZM family have a multi-mode function. You can switch between single-ended, differential and common mode measurements without reconnecting or resoldering the probe. You can set the probe mode in the dialog box, and you can assign the probe mode setting to the micro button.

If you use the R&S RT-ZMA30 browser module, only DM measurements are possible because this module has no ground connector.

The measurement modes are:

"DM" Differential mode input voltage (V_{dm}), the voltage between the positive and negative input terminal.

$$V_{dm} = V_p - V_n$$

"CM" Common mode input voltage (V_{cm}), the mean voltage between the positive and negative input terminal vs. ground.

$$V_{cm} = \frac{V_p + V_n}{2}$$

"P" Positive single-ended input voltage (V_p). The voltage between the positive input terminal and ground.

"N" Negative single-ended input voltage (V_N). The voltage between the negative input terminal and ground.

Remote command:
PROBe<m>:SETup:PRMode on page 1028

DM Offset, CM Offset, P Offset, N Offset
Compensate offset voltages. Available offsets depend on the selected probe mode.

The offset of the selected probe mode is used as channel offset and considered automatically for correction. For example, in CM mode, the common mode offset is used as channel offset. See also: "Offset" on page 133.

"DM Offset" Compensates a DC voltage applied between the positive (V_p) and the negative (V_n) input terminal at the probe tip.

"CM Offset" Compensates a DC voltage applied to both input terminals referenced to ground. See also: "CM offset" on page 147.

"P Offset" Compensates a DC voltage applied to the positive input terminal (V_p) referenced to ground.

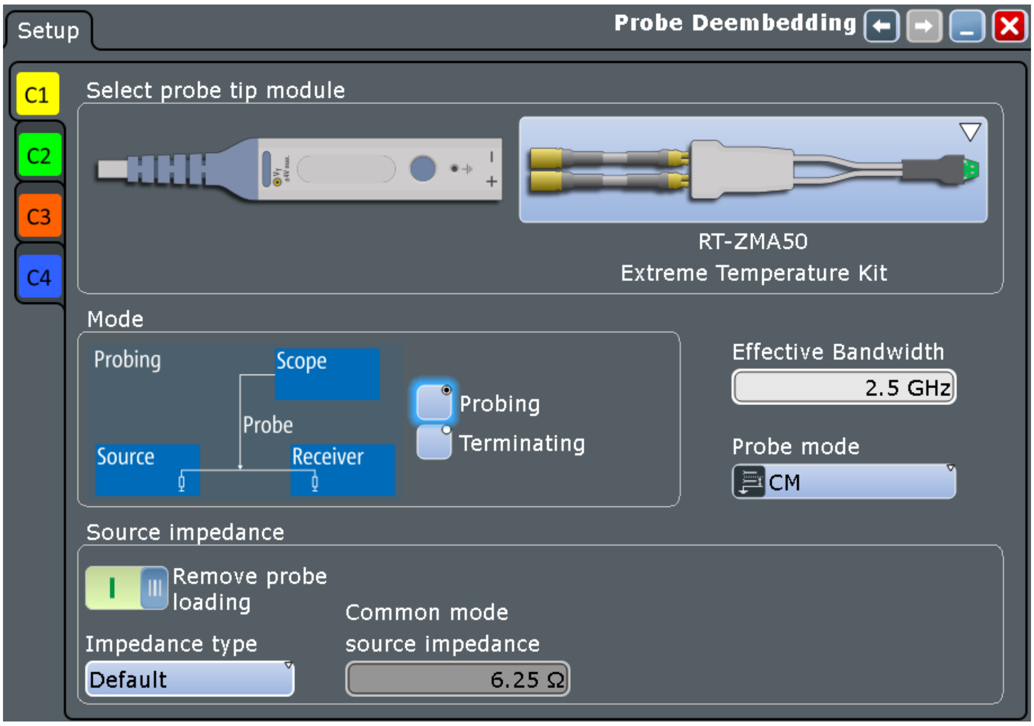
"N Offset" Compensates a DC voltage applied to the negative input terminal (V_n) referenced to ground.

Remote command:
PROBe<m>:SETup:DMOFfset on page 1029
PROBe<m>:SETup:CMOFfset on page 1026
PROBe<m>:SETup:NOFFset on page 1029
PROBe<m>:SETup:POFFset on page 1030

4.5.5.2 Deembedding for Modular Probes

Deembedding removes the parasitic effects of the measurement setup from the measured signal. These effects are typically increasing when signal frequency increases. Thus, deembedding is useful or even necessary when measuring signals of 4 GHz frequency or higher.

Access: "Vertical" menu > "Probe Setup" > "Probe Deembedding"



Select probe tip module, Pin spacing

Selects the tip module that is used for measurement.

If R&S RT-ZMA40 is selected, choose also the used submodule: semi-rigid cables or none.

For the browser module R&S RT-ZMA30, measure the space between the pins, and select the appropriate value.

Remote command:
`PROBe<m>:DEEMbedding:TIPModule[:SELect]` on page 1031
`PROBe<m>:DEEMbedding:TIPModule:ZMA<n>:SUBModule` on page 1032

Probing, Terminating

Sets the probing mode.

Select "Probing" if you use a high-ohmic probe and measure on an existing line in parallel to the load.

Select "Terminating" if the measuring equipment is the load of the line.

Remote command:
`PROBe<m>:DEEMbedding:MODE` on page 1032
`DEEMbedding<m>:COMPonent<n>:MODE` on page 1840

Effective bandwidth

Sets the maximum bandwidth for probe deembedding until which the signal is corrected. This maximum value is the minimum bandwidth value of the probe bandwidth, tip module bandwidth, and oscilloscope bandwidth. It cannot be higher than the highest frequency in a used S-parameter file.

Consider that most tip modules support the full bandwidth of the probe, but some tip modules have limited bandwidth.

If deembedding option R&S RTP-K121 is active, the instrument uses the effective bandwidth that is set in the "Deembedding" > "Setup" dialog box.

Remote command:
`PROBe<m>:DEEMbedding:BANDwidth` on page 1032

Probe mode

See "Probe Mode" on page 151.

Remove probe loading

If "Probing" is selected, you can remove the loading of the probe.

If the probe loading is removed, you see the signal that would be at the measurement point if the probe's input impedance is ideal (infinite impedance).

Without removing the loading, you see the real signal at the measurement point, including the probe loading.

Remote command:
`PROBe<m>:DEEMbedding:REMProbeload` on page 1033
`DEEMbedding<m>:COMPonent<n>:LOAD:REMProbeload` on page 1841

Impedance type

Sets the impedance type of the DUT.

"Default" The default value depends on the selected probing mode and the measurement mode of the probe. The impedance is a constant value over frequency. If the default value does not match to the DUT, select "Constant" or "Touchstone".

"Constant" The source impedance is a constant value over frequency. Enter the value in Source impedance.

"Touchstone" Use this setting if the DUT impedance depends on the frequency. The impedance of the DUT over frequency is described by S-parameters, which are saved in a Touchstone file. S-parameters can be listed as complex numbers (real and imaginary parts), or as magnitude and phase in the order of increasing frequency. The phase unit has to be degree (°). Load the file to import the S-parameters.
Depending on the measurement setup, you need a `*.s2p` or `*.s1p` file. If the complete measurement setup is a 2-port (1 input and 1 output), you need a `*.s1p` file. This file contains 1 S-parameter, which describes the source impedance.
If the complete measurement setup is a 3-port (2 inputs and 1 output), you need a `*.s2p` file. The measurement setup is a 3-port if it includes a modular probe R&S RT-ZM or differential probe R&S RT-ZD. The `*.s2p` file contains 4 S-parameters, assuming that port 1 is connected to the p-input of the probe, and port 2 to the n-input. The file describes the impedance matching at the ports and the coupling between the ports.

Remote command:
PROBe<m>:DEEMbedding:LOAD[:TYPE] on page 1033
DEEMbedding<m>:COMPonent<n>:LOAD[:TYPE] on page 1841
PROBe<m>:DEEMbedding:LOAD:FILE on page 1034
DEEMbedding<m>:COMPonent<n>:LOAD:FILE on page 1842

Source impedance
Impedance of the DUT. Shows the default source impedance or sets the user-defined constant impedance value. If an R&S RT-ZM probe is connected, the value depends on the selected probe mode: common mode, differential, or single-ended measurement.

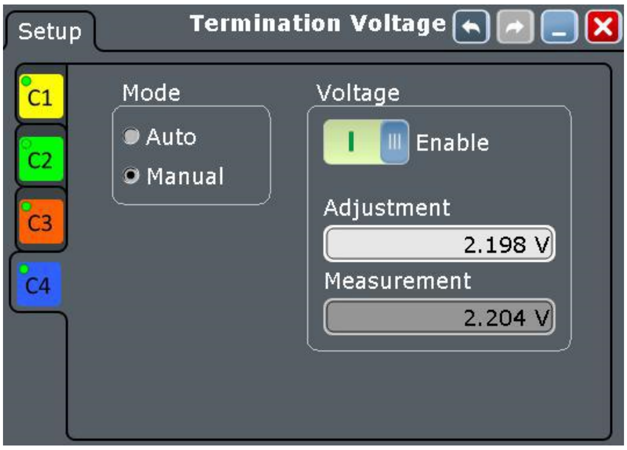
Remote command:
DEEMbedding<m>:COMPonent<n>:LOAD:IMPedance on page 1842
PROBe<m>:DEEMbedding:LOAD:IMPedance on page 1034

4.5.5.3 Termination Voltage (Only with R&S RT-ZMA40 SMA Module)

Termination voltage is relevant if you use the R&S RT-ZMA40 SMA module. The SMA module applies a termination voltage (±4 V) to the DUT to enable measurements against a common mode DC voltage instead of ground. This measurement is required for many digital signal standards.

The termination voltage can be controlled by the oscilloscope. Therefore, connect the V_T terminal of the R&S RT-ZM probe amplifier to the V_T terminal of the R&S RT-ZMA40 SMA module using the red DC lead (see R&S RT-ZMUser Manual). The required termination voltage is measured and adjusted automatically, but can also be set manually.

Access: "Vertical" menu > "Probe Setup" > "Termination"



Mode
In "Auto" mode, the instrument uses the measured common mode voltage for termination.

In "Manual" mode, you can enter the voltage to be used for termination. Use the manual mode if you know the common mode voltage of the DUT.

Remote command:
`PROBe<m>:SETup:TERM:MODE` on page 1030

EnableTermination Voltage
Activates control of the termination voltage.

Remote command:
`PROBe<m>:SETup:TERM:STATe` on page 1030

Adjustment
Sets the voltage to be used for termination to DC voltage.

Remote command:
`PROBe<m>:SETup:TERM:ADJust` on page 1031

Measurement
Shows the measured common mode voltage.

Remote command:
`PROBe<m>:SETup:TERM:MEASure?` on page 1030

4.5.6 Setup for Predefined Probes

Probes that cannot be detected, but their characteristics are known to the R&S RTP are called "Predefined probes".

The following shared probe settings are available:

- "Type, Name, Bandwidth" on page 140
- "Detect AutoZero, Use AutoZero" on page 140
- "External attenuation: Scale, Attenuation" on page 141

The probe attenuation of the selected probe is also shown in the "Setup" tab:

- "Probe unit, Auto attenuation" on page 142

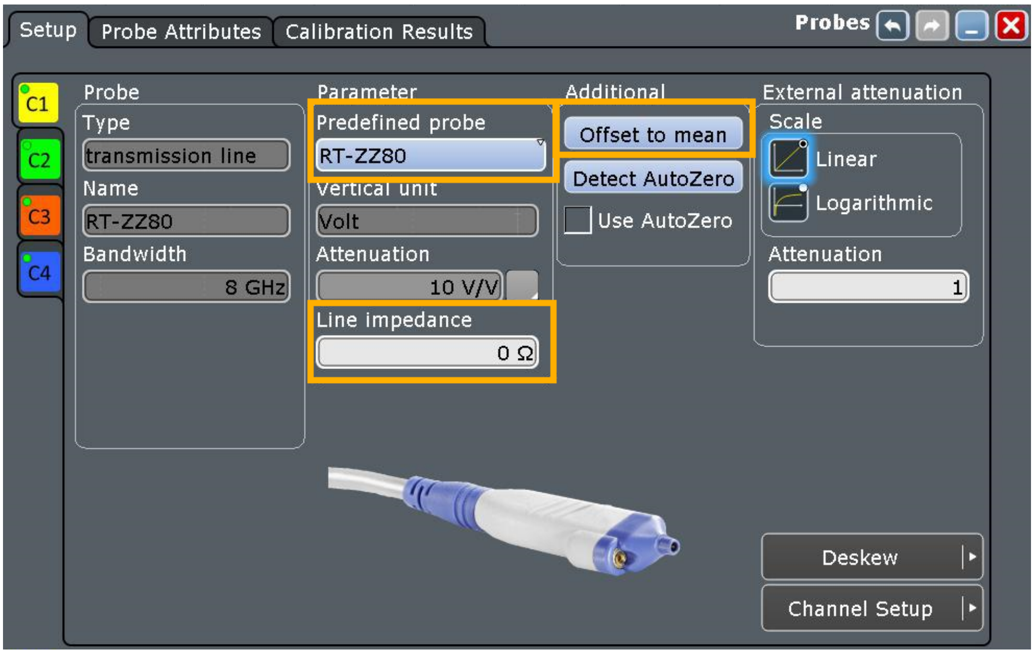


Figure 4-14: Probe setup for transmission line probe R&S RT-ZZ80

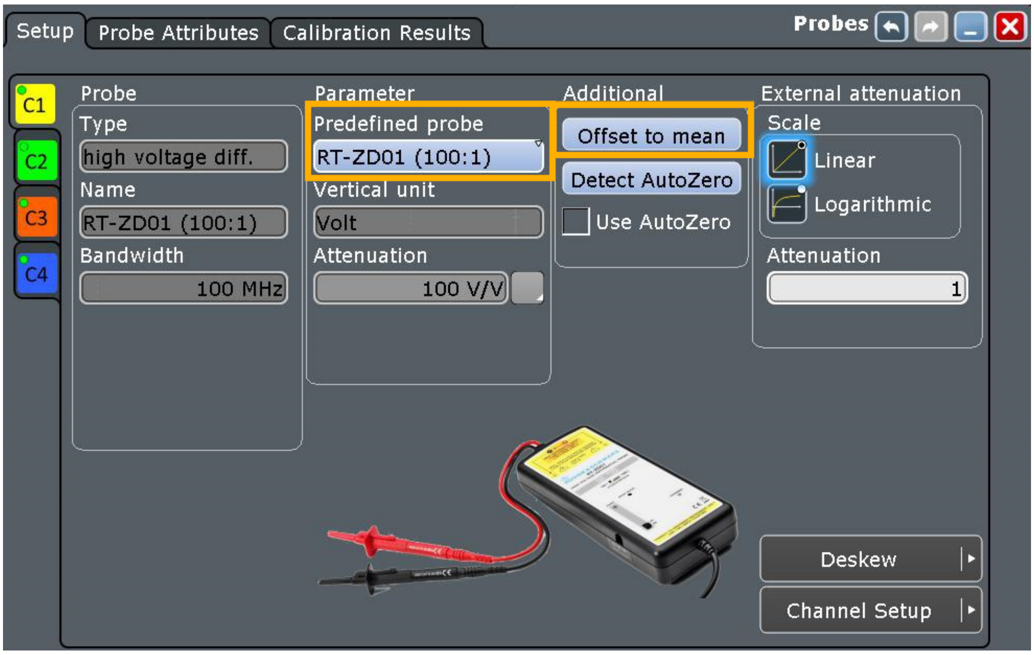


Figure 4-15: Probe setup for R&S RT-ZD01

Specific settings for predefined probes are the following:

Predefined probe

List of probes that are known to the instrument. The instrument lists only probes that match the instrument coupling and, if connected, also the used adapter.

Select the used probe on the list. The corresponding "Vertical unit" and the "Attenuation" or "Gain" are shown.

All other unrecognized probes that are not listed, are unknown probes. For these probes, set "Predefined probe" to "None". See Chapter 4.5.8, "Setup for Unknown Probes", on page 161.

Remote command:
`PROBe<m>:SETup:ATTenuation:DEFProbe` on page 1035

Offset to mean

Performs an automatic compensation for a DC component of the input signal using the result of a background mean measurement. The result is shown in "Offset". The function is probe-independent and supports quick and convenient measurements of input signals with different DC offsets. It detects offset values even when the signal is out of the current measurement range. It also sets the zero level to the determined DC offset in the middle of the screen and thus prevents clipping of the waveform.

Remote command:
`PROBe<m>:SETup:OFFSet:TOMean` on page 1035

Line impedance

If the transmission line probe R&S RT-ZZ80 is selected, enter the impedance of the measured line.

The actual attenuation of the transmission line probe depends on the impedance of the line Z_0:

$$Attenuation = 10 + Z_0 / 100$$

The instrument uses the actual attenuation to determine the measurement values.

4.5.7 Setup for Current Probes

The setup and adjustment of current probes depends on the output connector of the probe: BNC or Rohde & Schwarz probe box.

The following shared probe settings are available:

- "Type, Name, Bandwidth" on page 140
- "Detect AutoZero, Use AutoZero" on page 140
- "External attenuation: Scale, Attenuation" on page 141

Current probes R&S RT-ZCxx

The current probes **R&S RT-ZCxx** have BNC connectors. They are known to the R&S RTP as predefined probes, see Chapter 4.5.6, "Setup for Predefined Probes", on page 156. Demagnetizing and zero adjustment is done on the probe, see the probe's User Manual for details. Make sure to demagnetize and adjust the probe before taking measurements.

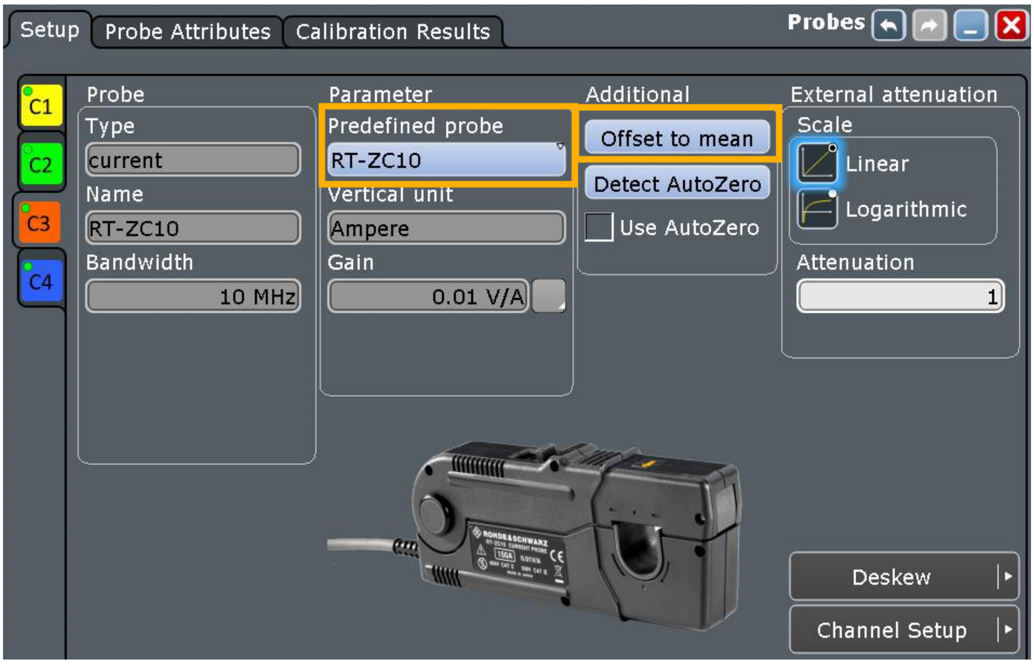


Figure 4-16: Probe setup for current probes R&S RT-ZC10

Current probes R&S RT-ZCxxB

Current probes **R&S RT-ZCxxB** have a Rohde & Schwarz probe interface; they are powered and remotely controlled by the oscilloscope.

When the probe is connected, demagnetization is performed automatically.

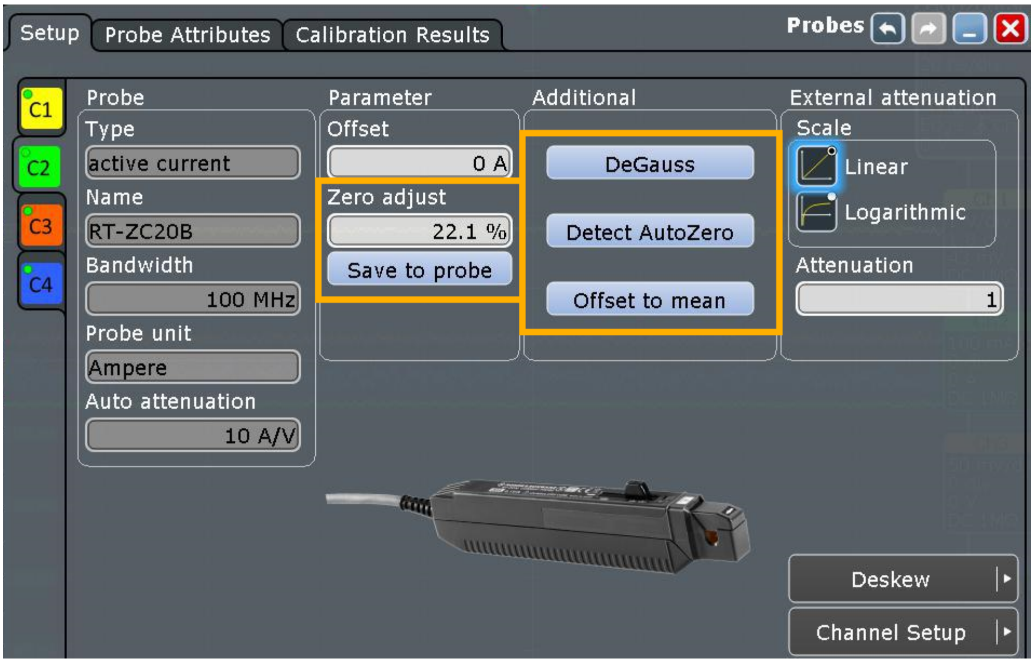


Figure 4-17: Probe setup for current probes R&S RT-ZC20B

For all current probes, attenuation or gain is shown in the "Setup" tab, and you can set the offset to mean:

- "Probe unit, Auto attenuation" on page 142
- "Offset to mean" on page 158

Current probes R&S RT-ZCxxB are adjusted by the following functions:

DeGauss

Demagnetizes the core if it has been magnetized by switching the power on and off, or by an excessive input. Always carry out demagnetizing before measurement.

The demagnetizing process takes about one second. During demagnetizing, a demagnetizing waveform is displayed.

Demagnetizing is done automatically when R&S RT-ZCxxB is connected to the oscilloscope, or when "Detect AutoZero" is performed.

Remote command:
`PROBe<m>:SETup:DEGauss` on page 1036

Detect AutoZero

If a current probe is connected, the function demagnetizes the probe's sensor head and sets the waveform to zero position to correct the error offset. Thus, it compensates for the remanence and offset caused by temperature drift.

For R&S RT-ZCxxB probes, the determined "Zero adjust" value is displayed and can be saved in the probe head.

See also "Detect AutoZero, Use AutoZero" on page 140.

Remote command:
`PROBe<m>:SETup:OFFSet:AZERo` on page 1019

Zero adjust

Zero adjust corrects the effect of an offset caused by temperature drift, and compensates for the remanence. The setting is only available if DC coupling is set.

To set the waveform to zero level by the instrument, use "Detect AutoZero". The detected value is displayed.

Alternatively, you can adjust the value manually until the waveform is set to zero level. Make sure to demagnetize the probe before zero adjustment.

The value is given in percent of the maximum range, which is internally defined. The actual setup range depends on the temperature drift, the measured current and other variables, and it can change over time. If you measure high currents, the probe core magnetizes, which impairs the measurement results. Therefore, repeat "Detect AutoZero" before the measurement.

Remote command:
`PROBe<m>:SETup:OFFSet:ZADJust` on page 1036

Save to probe
Saves the "Zero adjust" value in the probe box. If you connect the probe to another channel or to another R&S RTx oscilloscope, the value is read out again, and you can use the probe without further adjustment.

Remote command:
`PROBe<m>:SETup:OFFSet:STPRobe` on page 1036

4.5.8 Setup for Unknown Probes

If the R&S RTP cannot detect the probe, and the probe is not a predefined one, you can set the probe parameters manually.

The following shared probe settings are available:
- "Type, Name, Bandwidth" on page 140
- "Detect AutoZero, Use AutoZero" on page 140
- "External attenuation: Scale, Attenuation" on page 141

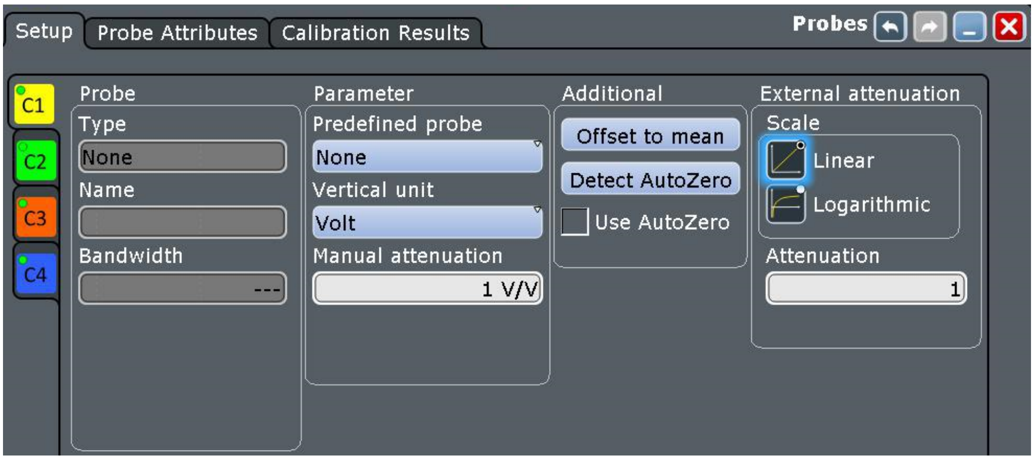


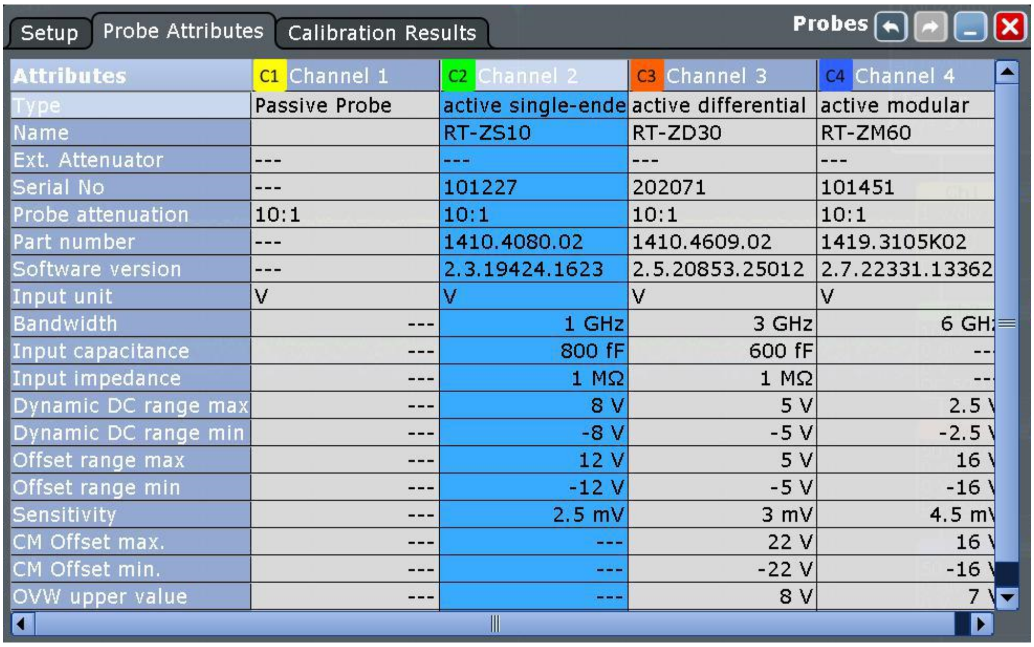
Figure 4-18: Probe setup for an unknown probe

Set the unit and the attenuation or gain of the probe: "Vertical unit, Attenuation, Gain" on page 145.

4.5.9 Probe Attributes

The "Probe Attributes" tab provides an overview of all R&S probes connected to an input channel.

For a specification of the probe parameters, refer to the data sheet.



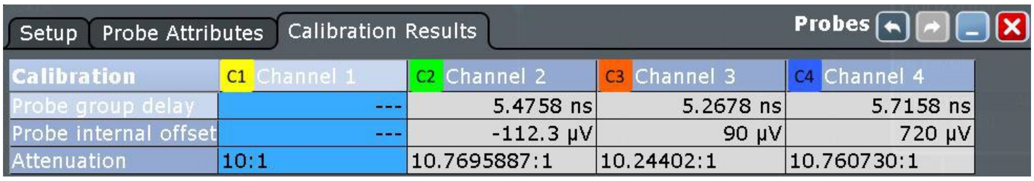
Attributes	C1 Channel 1	C2 Channel 2	C3 Channel 3	C4 Channel 4
Type	Passive Probe	active single-ende	active differential	active modular
Name		RT-ZS10	RT-ZD30	RT-ZM60
Ext. Attenuator	---	---	---	---
Serial No	---	101227	202071	101451
Probe attenuation	10:1	10:1	10:1	10:1
Part number	---	1410.4080.02	1410.4609.02	1419.3105K02
Software version	---	2.3.19424.1623	2.5.20853.25012	2.7.22331.13362
Input unit	V	V	V	V
Bandwidth	---	1 GHz	3 GHz	6 GH
Input capacitance	---	800 fF	600 fF	--
Input impedance	---	1 MΩ	1 MΩ	--
Dynamic DC range max	---	8 V	5 V	2.5 V
Dynamic DC range min	---	-8 V	-5 V	-2.5 V
Offset range max	---	12 V	5 V	16 V
Offset range min	---	-12 V	-5 V	-16 V
Sensitivity	---	2.5 mV	3 mV	4.5 mV
CM Offset max.	---	---	22 V	16 V
CM Offset min.	---	---	-22 V	-16 V
OVW upper value	---	---	8 V	7 V

Remote commands:

- PROBe<m>:ID:SWVersion? on page 1037
- PROBe<m>:ID:PRDate? on page 1037
- PROBe<m>:ID:PARTnumber? on page 1037
- PROBe<m>:ID:SRNumber? on page 1038
- PROBe<m>:SETup:CAPacitance? on page 1038
- PROBe<m>:SETup:IMPedance? on page 1038

4.5.10 Calibration Results

The "Calibration Results" tab provides the calibration data stored in the probe for all R&S probes connected to an input channel.



Calibration	C1 Channel 1	C2 Channel 2	C3 Channel 3	C4 Channel 4
Probe group delay	---	5.4758 ns	5.2678 ns	5.7158 ns
Probe internal offset	---	-112.3 µV	90 µV	720 µV
Attenuation	10:1	10.7695887:1	10.24402:1	10.760730:1

4.6 R&S RT-ZVC Probe

With the R&S RTP and option R&S RTP-B1E, you can use the R&S RT-ZVC multi-channel power probe. It has an integrated 2- or 4-channel amperemeter and 2- or 4-channel voltmeter. The probe provides parallel measurements of analog or digital, voltage/current signals with excellent 18-bit resolution.

For more information on the R&S RT-ZVC probe, see also its user manual.

Source Channels

You can simultaneously connect a R&S RT-ZVC and a R&S RT-ZL04 to the R&S RTP, but no parallel operation on screen is possible.

You can acquire and measure the R&S RT-ZVC or R&S RT-ZL04 together with the analog input channels. They are running on the same horizontal scale.

If an amperemeter or voltmeter channel is activated, it can be displayed on the screen and used as a source for:

- Waveform measurements
- Mask testing
- Waveform math
- Search and mark function
- Display characteristics

Also, if a R&S RT-ZVC probe is connected, its amperemeter and voltmeter channels can be used as a source for Trigger type "Edge".

Data export

You can save the data of the amperemeter and voltmeter channels to an XML, CSV, or BIN file. One channel per file can be saved. Files in BIN format can be reloaded to the R&S RTP as reference waveforms.

See also:

- Chapter 11.2.6, "Saving and Loading Waveform Data", on page 446
- Chapter 11.2.2, "Waveforms - Export Settings", on page 435

Remote commands for export to file:

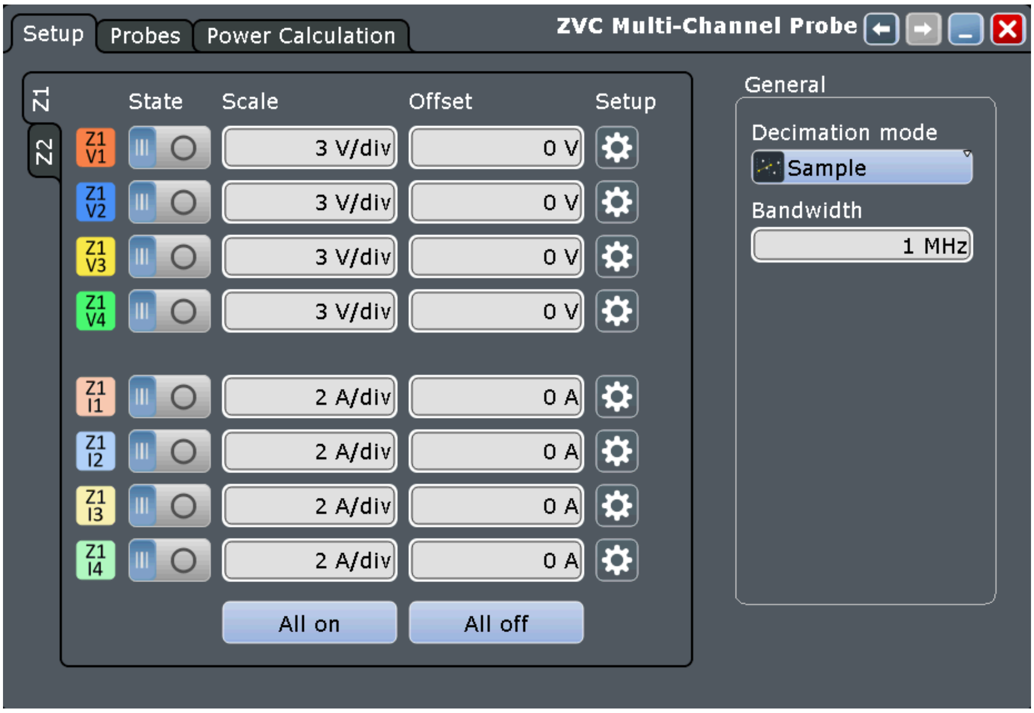
- `EXPort:WAVeform:SOURce` on page 1281
- `EXPort:WAVeform:NAME` on page 1282
- `EXPort:WAVeform:SAVE` on page 1282

4.6.1 R&S RT-ZVC Overview

4.6.1.1 Setup

Access: "Vertical" menu > "ZVC Multi-Channel Probe" > "Setup" tab

Make sure that the tab of the correct probe is selected on the left side.



State

Enables the corresponding channel of the probe. The number of available channels depend on the characteristics of your multi-channel power probe.

Remote command:
`ZVC:Z<m>:V<n>[:STATe]` on page 1047
`ZVC:Z<m>:I<n>[:STATe]` on page 1044

Vertical Scale

Defines the vertical scale for the channel in Volts per division. Increasing the scale compresses the display of the signal. Within a given operation range, modifying the scale is equivalent to scaling a display range.

For the voltmeter channels, the Vertical Scale, the Offset and the "Position" specify the operating range of the voltmeter.

Remote command:
`ZVC:Z<m>:V<n>:SCALe` on page 1046
`ZVC:Z<m>:I<n>:SCALe` on page 1042

Offset

The vertical center of the selected channel is shifted by the offset value and the signal is repositioned within the diagram area. Negative offset values move up the waveform, positive values move it down.

Within a given operation range, modifying the offset is equivalent to moving vertically the display range. The offset can only be modified such that the display range reaches at most the limits of the operation range.

For the voltmeter channels, the Vertical Scale, the Offset and the "Position" specify the operating range of the voltmeter.

Remote command:
`ZVC:Z<m>:V<n>:OFFSet` on page 1045
`ZVC:Z<m>:I<n>:OFFSet` on page 1041

All on
Enables all available channels.

All off
Disables all available channels.

Decimation mode
Selects the decimation mode for all R&S RT-ZVC probes. Decimation reduces the data stream of the ADC to a stream of waveform points with lower sample rate and a less precise time resolution.

"Sample"	One of n samples in a sample interval of the ADC is recorded as waveform point, the other samples are discarded. The time between the two adjacent waveform points is exactly the resolution. Very short glitches might remain undiscovered by this method.
"Peak detect"	The minimum and the maximum of n samples in a sample interval are recorded as waveform points, the other samples are discarded.
"High res"	The average of n sample points is recorded as one waveform sample. Averaging reduces the noise, the result is a more precise waveform with higher vertical resolution. The high measurement resolution is suitable for high accuracy measurements of instantaneous values.

Remote command:
`ZVC:TYPE` on page 1040

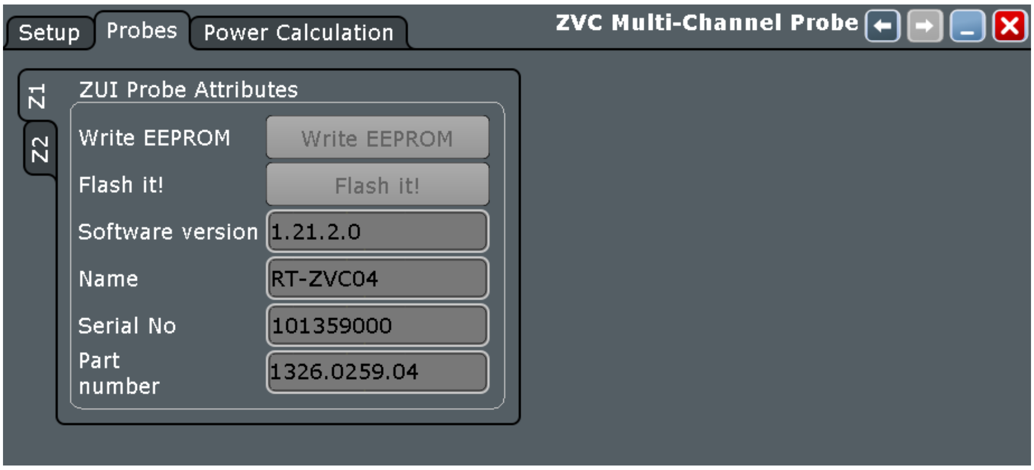
Bandwidth
Sets the bandwidth limit of all R&S RT-ZVC probes. The bandwidth specifies the maximum frequency at which a purely sinusoidal signal is still transferred at 89 % (0.1 dB) of its amplitude.

The bandwidth of some current channels is restricted to 300 KHz due to their vertical settings.

Remote command:
`ZVC:BANDwidth` on page 1039

4.6.1.2 Probes

Access: "Vertical" menu > "ZVC Multi-Channel Probe"> "Probes" tab



Software version

Displays the software version of the probe.

Remote command:

`ZVC:Z<m>:ID:SWVersion?` on page 1048

Name

Displays the name of the probe.

Remote command:

`ZVC:Z<m>:ID:NAME?` on page 1047

Serial no

Displays the serial number of the probe.

Remote command:

`ZVC:Z<m>:ID:SRNumber?` on page 1047

Part number

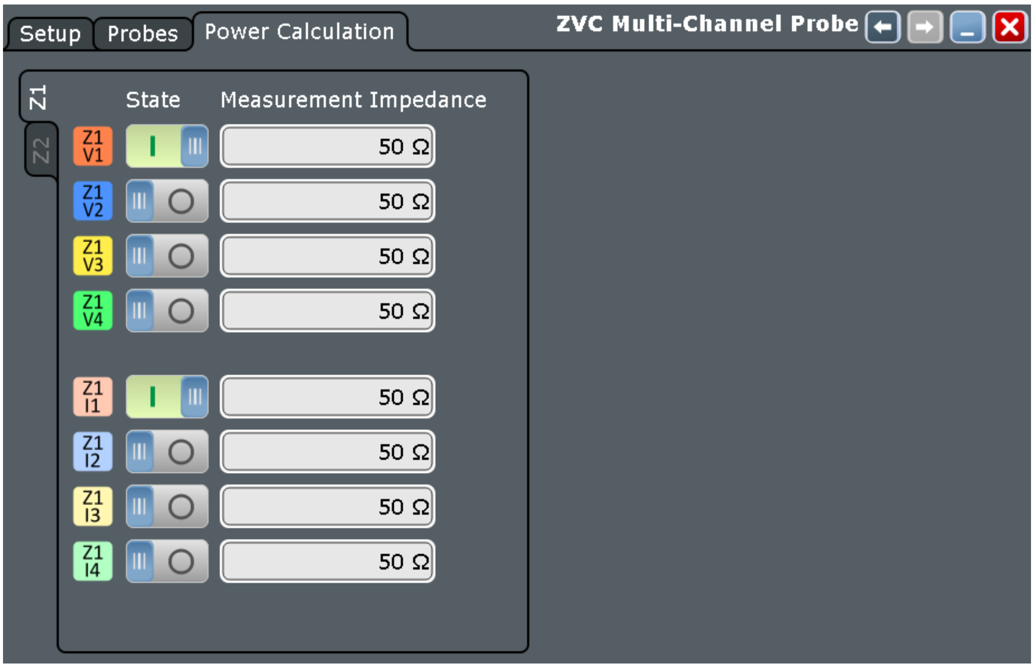
Displays the part number of the probe.

Remote command:

`ZVC:Z<m>:ID:PARTnumber?` on page 1047

4.6.1.3 Power Calculation

Access: "Vertical" menu > "ZVC Multi-Channel Probe"> "Power Calculation" tab



State

Enables the corresponding channel of the probe. The number of available channels depend on the characteristics of your multi-channel power probe.

Remote command:
`ZVC:Z<m>:V<n>[:STATe]` on page 1047
`ZVC:Z<m>:I<n>[:STATe]` on page 1044

Measurement Impedance

Sets the impedance of the probe channel for power calculations and measurements.

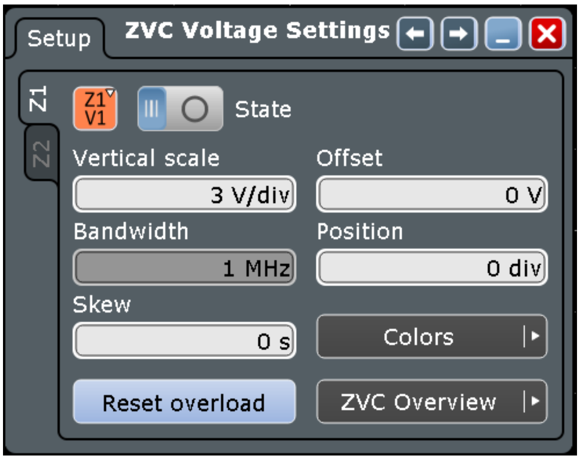
Remote command:
`ZVC:Z<m>:V<n>:IMPedance` on page 1045
`ZVC:Z<m>:I<n>:IMPedance` on page 1040

4.6.2 ZVC Voltage Setup Settings

Access: "Vertical" menu > "ZVC Multi-Channel Probe" > "Setup" dialog > "Setup" of voltage channel

See also:

- Vertical Scale
- Offset



Channel
Selects the voltmeter channel to be configured.

State
Enables the corresponding voltage channel of the probe. The number of available channels depend on the characteristics of your multi-channel power probe.

Remote command:
`ZVC:Z<m>:V<n>[:STATe]` on page 1047

Bandwidth
Displays the bandwidth of the current channel. You can set the probe bandwidth in the "Setup" dialog.

Remote command:
`ZVC:Z<m>:V<n>:BANDwidth?` on page 1044

Position
Moves the selected signal up or down in the diagram. The visual effect is the same as for Offset. While the offset sets a voltage, position is a graphical setting given in divisions. Within a given operation range, modifying the position is equivalent to moving vertically the display range. The position can only be modified such that the display range reaches at most the limits of the operation range.

For the voltmeter channels, the Vertical Scale, the Offset and the "Position" specify the operating range of the voltmeter.

Remote command:
`ZVC:Z<m>:V<n>:POSition` on page 1046

Skew
Sets the skew, a delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically.

Remote command:
`ZVC:Z<m>:V<n>:SKEW` on page 1046

Reset Overload
Resets the overload indication at the probe.

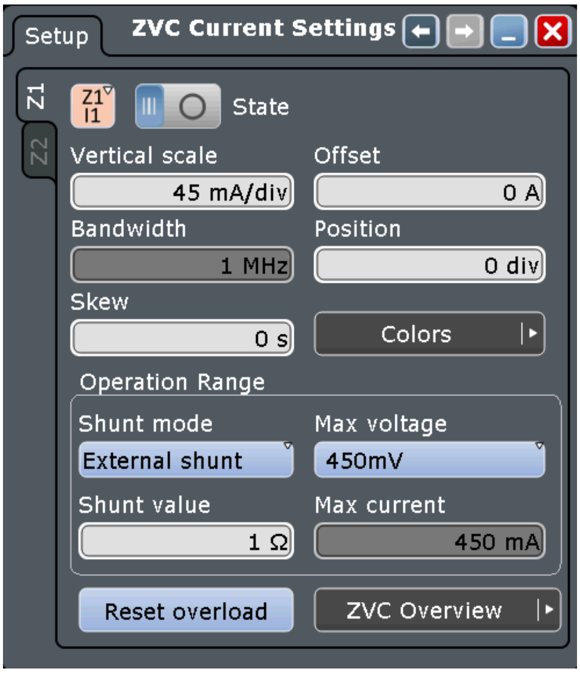
Remote command:
`ZVC:Z<m>:V<n>:OVERload:RSTO` on page 1045

4.6.3 ZVC Current Setup Settings

Access: "Vertical" menu > "ZVC Multi-Channel Probe" > "Setup" dialog > "Setup" of current channel

See also:

- Vertical Scale
- Offset



Channel
Selects the amperemeter channel to be configured.

State
Enables the corresponding current channel of the probe. The number of available channels depend on the characteristics of your multi-channel power probe.

Remote command:
`ZVC:Z<m>:I<n>[:STATe]` on page 1044

Bandwidth
Displays the bandwidth of the current channel. You can set the probe bandwidth in the "Setup" dialog.

Remote command:
`ZVC:Z<m>:I<n>:BANDwidth?` on page 1040

Position
Moves the selected signal up or down in the diagram. The visual effect is the same as for Offset. While the offset sets a current, position is a graphical setting given in divisions. Within a given operation range, modifying the position is equivalent to moving vertically the display range. The position can only be modified such that the display range reaches at most the limits of the operation range.

Remote command:
ZVC:Z<m>:I<n>:POSition on page 1042

Skew
Sets the skew, a delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically.

Remote command:
ZVC:Z<m>:I<n>:SKEW on page 1044

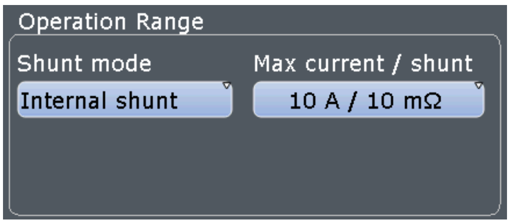
Shunt mode
Selects the internal or external shunt mode.

Regarding the shunt selection, i.e. the burden voltage level, there is a trade-off between the burden of the circuit under test and the SNR at the front-end input. The burden voltage is the DUT circuit loading caused by leads, connectors and the amperemeter circuit.

From the DUT perspective, the burden voltage has to be kept low not to distort the device operation. In contrast, from the probe's view the voltage has to be as large as possible to obtain a good SNR. For that reason, the external shunt can be applied to get the best compromise of both for a specific measurement range.

Remote command:
ZVC:Z<m>:I<n>:SHUNt:MODE on page 1043

Internal Shunt Mode
If Shunt mode is set to "Internal shunt", includes the settings for the internal shunt mode.



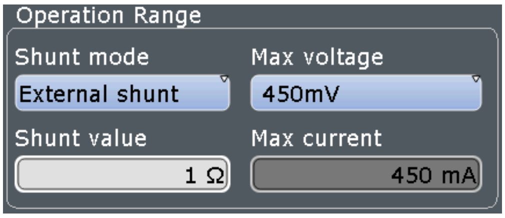
Max current / shunt ← Internal Shunt Mode
Selects the maximum current and the internal shunt value.

With the maximum current and the internal shunt selection, the operating range of the amperemeter is specified. At the same time, the burden voltage at the amperemeter input can be estimated. For values of the total round-trip resistance that can be seen at the test lead ends, consider the data sheet.

For using internal shunts, the circuit under test needs to be interrupted so that the current can flow through the probe.

Remote command:
ZVC:Z<m>:I<n>:SHUNt:MAXCurrent on page 1043

External shunt mode
If Shunt mode is set to "External shunt", includes the settings for the external shunt mode.



Maximum voltage ← External shunt mode
Selects the maximum voltage at the external shunt.

Remote command:
ZVC:Z<m>:I<n>:SHUNt:MAXVoltage on page 1044

Shunt value ← External shunt mode
Sets the shunt value of the external shunt resistor.

Remote command:
ZVC:Z<m>:I<n>:SHUNt:EVALue on page 1042

Max current ← External shunt mode
Displays the maximum current.

Remote command:
ZVC:Z<m>:I<n>:SHUNt:MXCValue? on page 1043

Reset Overload ← External shunt mode
Resets the overload indication at the probe.

Remote command:
ZVC:Z<m>:I<n>:OVERload:RSTO on page 1041

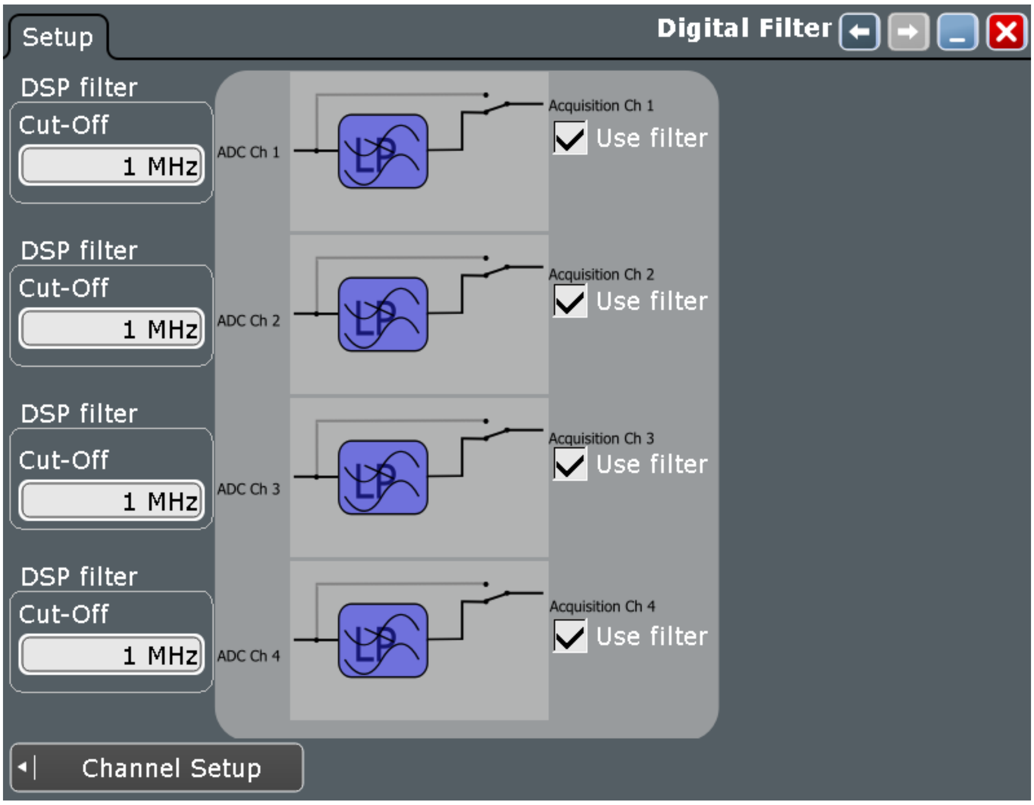
4.7 Digital Filter Setup

Access: "Vertical" menu > "Digital Filter"

After processing by the A/D converter, the channel and trigger signals are digitized signals. These digitized signals can be filtered to reject high frequency - also known as Digital Signal Processing (DSP). You can filter the acquisition channels.

One filter is applied to a channel.

If High Definition mode (option R&S RTP-K17) is installed, digital filter settings are enabled automatically. You can change the high definition bandwidth in the "Digital Filter Setup", which is applied to the channels.



Use filter

Enables the DSP filter for the correspondig input channel.

Remote command:

`CHANnel<m>:DIGFilter:STATe` on page 1049

Cut-off

Sets the limit frequency of the lowpass filter for input channels.

Remote command:

`CHANnel<m>:DIGFilter:CUToff` on page 1049

4.8 Horizontal Accuracy

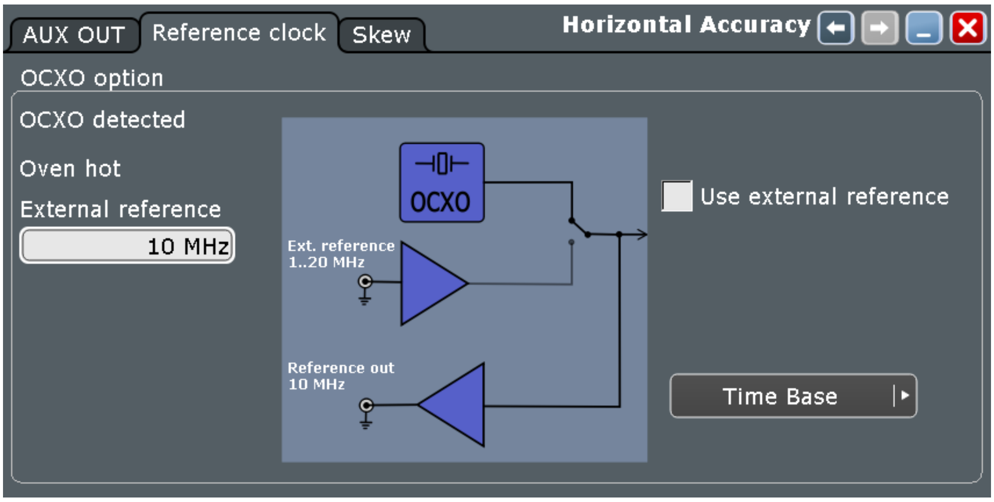
Access: "Horizontal" menu > "Skew".

The "Horizontal Accuracy" dialog box contains standard and optional settings to improve measurement and analysis accuracy and to reduce jitter effects.

4.8.1 Reference Clock (OCXO)

Access: "Horizontal" menu > "Skew" > "Reference clock" tab.

The oven-controlled crystal oscillator (OCXO) produces a 10 MHz internal reference signal with precise and stable frequency. With OCXO, you can also use an external reference signal. The input and output connectors for the external reference signal are on the rear panel alongside the external trigger input.



Detected

Indicates if the OCXO is detected by the instrument.

Oven hot

Indicates when the oven has reached its nominal temperature and is operating with the specified accuracy.

External reference

Sets the frequency of an external reference input signal that is connected to the external reference input on the rear panel of R&S RTP. A frequency range from 1 MHz to 20 MHz is supported.

Remote command:
`SENSe[:ROSCillator]:EXTernal:FREQuency` on page 1052

Use external reference

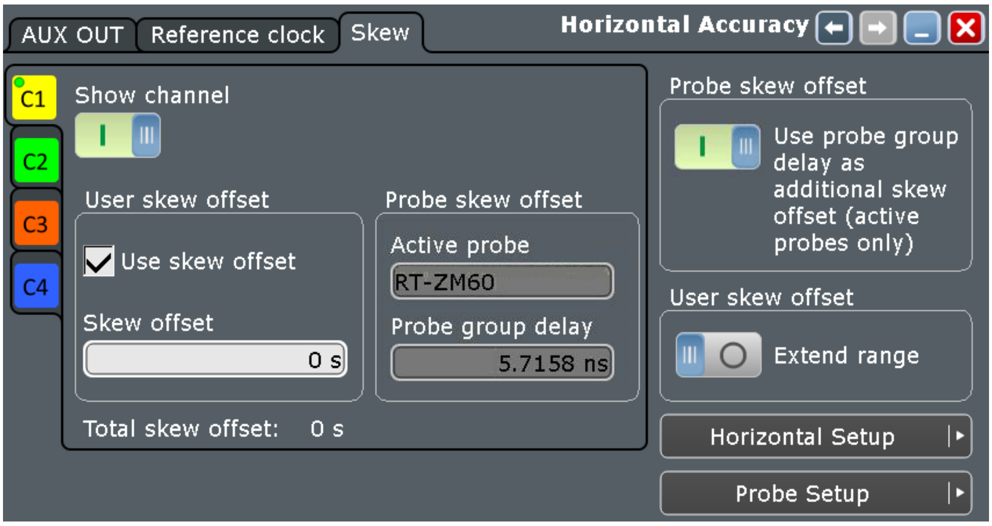
Enables the use of the external reference signal instead of the internal OCXO reference.

If an external reference is used, the frequency of the reference output signal is the same as of the reference input signal. Otherwise, the frequency of the reference output signal is 10 MHz, that is the frequency of the OCXO.

Remote command:
`SENSe[:ROSCillator]:SOURce` on page 1052

4.8.2 Skew

Skew compensates signal propagation differences between channels caused by the different length of cables, probes, and other sources. Correct skew values are important for accurate triggering and timing relations between channels.



Make sure that the correct channel tab is selected.

Show channel
Switches the channel signal on or off. The signal icon appears on the sidebar. The waveform of the last acquisition is displayed in the diagram.

Remote command:
`CHANnel<m>:STATe` on page 1011

Use skew offset
If enabled, the "Skew offset" value is used for compensation.

Remote command:
`CHANnel<m>:SKEW:MANual` on page 1049

Skew offset
Sets a delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically. It affects only the selected input channel.

The offset range and possible values depend on Extend range.

Remote command:
`CHANnel<m>:SKEW:TIME` on page 1049

Probe skew offset
Measures the skew of all connected active probes and includes it in the total skew offset.

"Use probe group delay ..."
If enabled, the skew of all connected active probes is measured, displayed, and used for deskewing. The setting affects all active channels.

"Active probe" Shows the type of the probe that is connected to the selected channel.

"Probe group delay" Shows the result of the probe skew measurement on the selected channel.

Remote command:
PROBe<m>:SKEState on page 1050

Total skew offset
If Extend range is disabled, the sum of the measured "Probe group delay" and the "Skew offset" is shown. If "Use skew offset" is disabled, the skew offset is ignored.

If Extend range is enabled, only the probe skew is shown, and the skew offset is always ignored.

Extend range
Allows you to set higher value in "Skew offset" to compensate for the delay of the measurement setup. Without extension, the deskew range is ±100 ns, and delays shorter than the sample interval can be compensated.

With extension, the maximum delay is ±1 s, and the instrument can compensate complete samples. Compensation takes effect after the trigger. The maximum number of acquisitions in the memory is reduced.

Use the extended skew range to compare signals: One signal goes directly from the generator to the scope, and the other signal goes from the generator through the DUT to the scope. The delay of the DUT is higher than ±100 ns.

Remote command:
CHANnel<m>:SKEW:EXTended on page 1051

4.8.3 AUX OUT

1 GHz Reference ON
Enables the 1 GHz reference signal and sends it to the [Aux Out] connector at the front panel. The signal is required for performance test to measure the frequency internal calibration signal.

Remote command:
CALibration:SOURce:FREQuency on page 1050
CALibration:SOURce:STATe on page 1050

4.9 Setting Up the Waveform

This chapter contains the fundamental procedures for setting up the acquisition and adjusting the channel waveforms.

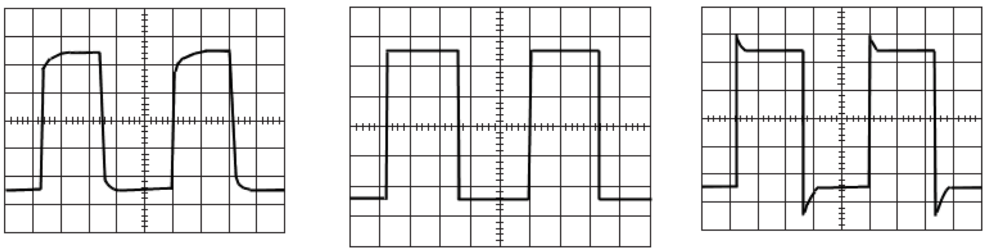
4.9.1 Adjusting Passive Probes

R&S RT-ZP10 passive probes are already pre-compensated to the R&S RTP front-end characteristics, and a compensation procedure is not required.

If you use other passive probes, the R&S RTP allows you to compensate it when it is connected to the instrument the first time. Compensation matches the probe cable capacitance to the oscilloscope input capacitance to assure good amplitude accuracy from DC to upper bandwidth limit frequencies. A poorly compensated probe reduces the performance of the probe-oscilloscope system and introduces measurement errors resulting in distorted waveforms and inaccurate results.

1. Connect the BNC connector of the probe to input [CH1].
2. Connect the probe's ground connector to the right compensation pin, and the tip with the left pin.
3. Press [Autoset].

   A square wave appears on the display.
4. Adjust the compensation trimmer of the probe to optimum square wave response. For details, refer to the documentation of your probe.



undercompensated   optimum   overcompensated

4.9.2 Setting Up the Signal Input with Autoset

Autoset is the solution for the major part of routine test-setup. It is also a good start if you need to use more complex trigger settings. Autoset finds appropriate horizontal and vertical scales, vertical offset, and trigger conditions to present a stable waveform.

1. Connect the probe to the input connector [Ch <n>].

   The instrument recognizes the probe and turns on the channel.
2. Press the [Autoset] button on the left of the display.

4.9.3 Adjusting the Signal Input Manually

1. Connect the probe to the input connector [Ch <n>].
   The instrument recognizes the probe and turns on the channel.
2. On the "Horizontal" menu, tap "Setup".
3. Set the "Time scale".
4. If you want to analyze the signal some time before or after the trigger, use the "Position" and "Reference point" to adjust the visible section of the waveform.
5. Select to set either the resolution or the record length. Enter the required value.
6. Press the channel button corresponding to the input channel. It is illuminated with the color of the channel waveform.
7. In the "Channels" tab, select the "Coupling".
8. Adjust the vertical "Scale", and the vertical "Position".
9. Tap "Acquisition" to proceed with the acquisition setup.

4.9.4 Setting the Acquisition

Prerequisites:
- Probes are connected.
- Vertical and horizontal settings are adjusted.

The settings are described in Chapter 4.2.2, "Acquisition", on page 125.

1. On the "Horizontal" menu, tap "Acquisition".
2. To configure the waveform-specific acquisition settings, enable "Multi waveform".
   Select the "Channel" subtab and activate the waveform.
   You can set up and display up to three waveforms per channel.
3. Select the "Mode" - for example, Peak detect or High res.
4. Select the "Wfm Arithmetic" - for example, Average or Envelope.
   The instrument precludes incompatible combinations, like "Peak detect" with "Average".
5. If "Average" is selected for a waveform, enter the "Average count", that is the number of waveforms used for average calculation.
6. Set the reset condition for the average and envelope calculation:
   a) If "Time" is selected, enter the "Reset time".
   b) If "Waveforms" is selected, enter the "Reset count".

4.9.5 Starting and Stopping Acquisition

You can control the acquisition in two ways:

- Running continuous acquisition until you stop it.
- Running one acquisition or a given number of acquisitions.
  If "Envelope" or "Average" is selected in the "Acquisition" tab, one acquisition means a cycle containing as many acquired waveforms as required to satisfy the reset conditions.

Prerequisites:

- Probes are connected.
- Vertical and horizontal settings are adjusted.
- Triggering is set.
- Channels to be acquired are turned on.

To start and stop continuous acquisition

1. Check if the trigger mode is set to "Normal". The trigger mode is shown in the trigger label in the upper right edge of the screen.
   If not, press the trigger [Mode] key on the front panel to toggle the setting.
2. Press the [Run Stop] key to start acquisition.
   The acquisition starts if a trigger occurs.
3. To stop , press the [Run Stop] key again.
   The acquisition stops immediately.

To acquire a limited number of acquisitions

1. Press the Trigger key and tap the "Control" tab.
2. In the "Control" area, select the "Normal" trigger mode.
3. Enter the number of acquisitions in the "Average count" field.
4. Press the [Single] key on the front panel.
   You can stop the running acquisition before it is finished by pressing the key again.

4.9.6 Using the Roll Mode

The roll mode can be used if the acquisition process is slow - that is if the time scale is large. In roll mode, the instrument shows the waveform immediately and saves waiting for the waveform display. The roll mode can be activated by the instrument if several conditions are fulfilled.

To set the roll mode manually

1. Make sure that all requirements for the roll mode are fulfilled: see "Roll mode" on page 124.
2. Press the [Horizontal] key.

3. In the "Roll mode" section of the "Setup" tab, set "Mode" to "Auto".
4. In the "Min roll mode gain" field, enter the acquisition time at which the instrument starts the roll mode.

4.9.7 Using Fast Segmentation

Fast Segmentation reduces the dead time between two waveform acquisition cycles.

The settings are described in Chapter 4.2.3, "Fast Segmentation", on page 129.

1. On the "Horizontal" menu, tap "Fast Segmentation".
2. Tap "Enable" to activate the Fast Segmentation mode.
3. If you want to sample the maximum number of acquisitions in a series, select "Acquire maximum".
   If you want to capture a defined number of acquisitions, disable "Acquire maximum" and enter the "Required" number of acquisitions.
4. Set the "Replay time", the display time of each acquisition.

4.9.8 Using Digital Filters

For details on filter settings and dependencies, see Chapter 4.7, "Digital Filter Setup", on page 171.

To filter the input channels

1. On the "Vertical" menu, tap "Digital Filter".
2. Enter the "Cut-off" frequency for each filter.
3. Enable "Use filter" for each channel to be filtered.

5 Triggers

5.1 Basics of Triggering

Triggering means to capture the interesting part of the relevant waveforms. Choosing the right trigger type and configuring all trigger settings correctly allows you to detect various incidents in analog, digital, and protocol signals.

Trigger

A trigger occurs if the complete set of trigger conditions is fulfilled. The trigger is the determining point in the waveform record. The instrument acquires continuously and keeps the sample points to fill the pre-trigger part of the waveform record. When the trigger occurs, the instrument continues acquisition until the post-trigger part of the waveform record is filled. Then it stops acquiring and waits for the next trigger. When a trigger is recognized, the instrument does not accept another trigger until the acquisition is complete and the holdoff time has expired.

Trigger setup

A simple trigger setup includes:

- Source of the trigger signal, its coupling and filtering
- Trigger type selection and setup
- Horizontal position of the trigger: see: Chapter 4.1.3.2, "Horizontal Position", on page 117
- Trigger mode

The R&S RTP provides various trigger types for troubleshooting and signal analysis, for example, edge trigger, glitch trigger, interval trigger, pattern trigger, and much more.

For complex tasks like verifying and debugging designs, advanced trigger settings are available:

- Hysteresis, that is the rejection of noise to avoid unwanted trigger events caused by noise
- Holdoff to define exactly which trigger event causes the trigger
- Qualification to consider the states of digital signals on other input channels and their logical combination
- Trigger sequences to combine two trigger type conditions

Action on trigger

A trigger can initiate one or more actions, for example, saving a screenshot or saving waveform data. All available actions can be initiated at the same time.

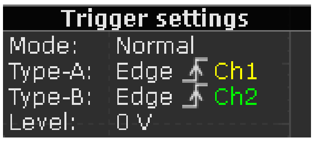
Trigger sequence

A complex trigger sequence joins two or more separate trigger conditions with an optional delay time and a reset time or reset condition. Similar setups are also known as multi-step trigger or A/B trigger.

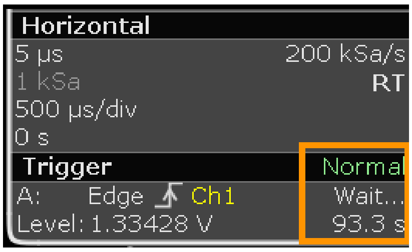
Trigger information

Information on the most important trigger settings is shown in the trigger label on top of the sidebar. If you double-tap the trigger label, the "Trigger" dialog box opens. The label shows:

- Trigger mode
- Trigger type, edge/polarity and trigger source, for A- and B-trigger
- Trigger level



If the trigger mode is normal, and no trigger has been found for longer than one second, the trigger state is shown in the sidebar. The state indicates the waiting for trigger time. For long timebases, it shows the remaining pretrigger time, and after the trigger the time until the acquisition is completed.



5.2 Setting Up the Trigger

This chapter provides step-by-step procedures for the important stages of trigger setup.

5.2.1 Configuring a Simple Trigger

Prerequisites:

- Horizontal and vertical settings are set appropriately to the signals.
- The acquisition is running, the [Run Stop] key lights green.

For details on settings, see Chapter 5.3, "Trigger Types", on page 184.

Proceed as follows:

1. Press the [Trigger] key on the front panel.
   The "Trigger" dialog box opens with the "Setup" tab.
2. At the left hand-side, select the "A" vertical sub tab.
3. Tap the "Source" button and select the trigger source.
4. Check the trigger coupling and filter settings. To change the settings, tap the "Channel Setup" button and "Digital Filter" button.
   If the trigger source is "Extern", you can adjust the coupling and filters directly in the "Setup" tab.
5. Tap the "Type" button and select the trigger type.
6. Under "Trigger type dependent settings", configure the settings for the selected trigger type.
   See: Chapter 5.3, "Trigger Types", on page 184
7. To let the instrument find the trigger level, tap "Find level".
8. Set the normal trigger mode. Do either of the following:
   - Press the [Mode] key on the front panel until "Normal" is shown in the trigger label.
   - Tap the "Normal" trigger mode option in the "Ctrl/Action" tab.

5.2.2 Positioning the Trigger

By positioning the trigger on the time axis, you define which part of the waveform is displayed: mainly the pre-trigger part, or the post-trigger part, or the part around the trigger point.

For details on position settings, see Chapter 4.2.2, "Acquisition", on page 125.

1. Press the [Horizontal] key.
   Alternatively, tap the "Horizontal" menu and then "Setup".
2. Set the "Reference point" and the "Position".
   If you want to set the trigger position outside the waveform display, make sure that "Restrict horizontal position to acquisition range" is disabled.

5.2.3 Using Holdoff

For details on holdoff settings, see Chapter 5.5, "Holdoff", on page 208.

1. Press the [Trigger] key and select the "Holdoff" tab.
   Alternatively, tap the "Trigger" menu and then "Holdoff".
2. Select the "Holdoff mode".

3. Enter the "Holdoff settings" belonging to the selected mode.

5.2.4 Setting Up a A → B → R Sequence

The complete configuration of a complex "A → B → R" trigger sequence consists of:

- A-trigger condition
- B-trigger condition in the same way as for the A-trigger, and optional delay time between the two triggers

For details on sequence settings, see Chapter 5.8, "Sequence", on page 214.

1. Press the [Trigger] key and select the "Setup" tab.
2. Select the type of the "Sequence": "A → B → R".
3. Tap the "A" subtab and configure the first condition.
   See: Chapter 5.2.1, "Configuring a Simple Trigger", on page 181.
4. Select the "B" subtab and configure the B-trigger condition.
5. Optionally, set the "Delay A -> B" that the instrument waits after an A-trigger until it recognizes B-triggers.
6. Set the "B event count". The last B-trigger causes the trigger.
7. You can also define a reset condition. The sequence restarts with the A-trigger if no B-trigger occurs and the reset condition is fulfilled.
   a) Select the "R" subtab.
   b) To specify a reset by timeout, enable "Reset timeout", and enter the time in "Timeout".
   c) To specify a reset trigger type condition, enable "Reset event" and configure the reset trigger type.
      The trigger types and settings are restricted dependent on the A and B trigger settings. The instrument provides only possible, reasonable combinations.

5.2.5 Qualifying the Trigger

Qualification considers the states of digital signals on other input channels and their logical combination as an additional trigger condition. For example, an edge trigger is configured for channel 1, and the instrument triggers only if the signal on channel 2 is high.

For details on qualification settings and restrictions, see Chapter 5.4, "Qualification", on page 206.

1. Press the [Trigger] key and select the Qualification tab.
   Alternatively, tap the "Trigger" menu and then "Qualification".
2. At the left hand-side, select the vertical tab of the trigger you want to qualify: "A".
   Qualification is not available for the B- and R-triggers.

3. Select the channel(s) with the digital input signal to be used as qualifying signal(s). Channels used as trigger source for the current trigger condition cannot be used for qualification and appear dimmed.
4. Check and set the trigger levels for all used channels, that is, the thresholds for digitization of analog signals.
You can set all levels to the currently selected value if you select "Couple levels".
5. Set the boolean operation for each channel.
6. If more than one channel is selected, set the logical combination of the channel states.
7. Tap "Qualify" to enable the qualification.

5.3 Trigger Types

The setup of the trigger type is the most important part of the trigger definition. It determines the method to identify specific signal phenomena. Almost all trigger types are available for all conditions in a trigger sequence, that is, you can combine different types in the sequence. The instrument checks the trigger settings for compatibility and feasibility, and disables settings that do not fit the previous settings in the sequence.

Make sure that the correct trigger tab is selected on the left before you enter the settings.

The settings in the "Setup" tab are:

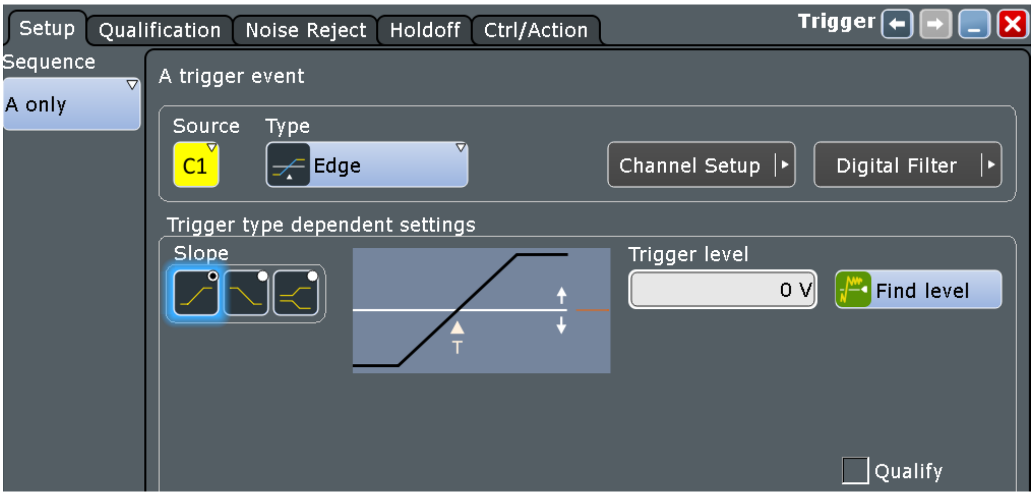
5.3.1 Basic Trigger Settings

Access: [Trigger] > "Setup" tab

The basic trigger settings are the trigger source and the trigger type, including the trigger level. These settings are specific for each condition in a trigger sequence "A → B → R". For the trigger source, the current ground/coupling settings are displayed, filtering is also possible.

Depending on the trigger type, additional settings are available. These settings are located under "Trigger type dependent settings".

- Let the R&S RTP find the trigger level: "Find level".
- Set the trigger levels to the same value for all channels.
- Enable trigger qualification.



Source

Selects the source of the trigger signal for the current trigger condition. The trigger source works even if it is not displayed in a diagram. It must be synchronized to the signal to be displayed and analyzed.

The trigger source can be:

- Channel 1...4: An analog input channel
- Extern: External analog signal connected to the external trigger input
  The external trigger source is supported for the "A only" sequence. It is not available if a longer trigger sequence is selected, or if qualification is enabled.
- Line: The instrument generates the trigger from the AC power input and synchronizes the signal to the AC power frequency. Use this source if you want to analyze signals related to the power line frequency, such as lighting equipment and power supply devices.
- Serial bus, D0...D15, Logic, Parallel bus 1...4:
  If options with trigger functionality are installed, the variety of trigger sources of the A-setup is enhanced with specific trigger sources.

Available sources depend on the trigger sequence setting. If "A only" is selected, all inputs (analog input channels, serial and parallel buses, digital channels) can be used as trigger source. If any other trigger sequence is selected, only channel inputs Ch1...4 can be set as trigger source, and all other input sources are disabled. See also: Chapter 5.8, "Sequence", on page 214

Remote command:

`TRIGger<m>:SOURce` on page 1053

Type

Selects the trigger type specific for each condition in a trigger sequence. The current trigger type is shown on the button.

The following trigger types are available:

- Edge, see page 186
- Glitch, see page 187
- Width, see page 188
- Runt, see page 190
- Window, see page 192
- Timeout, see page 193
- Interval, see page 194
- Slew Rate, see page 195
- Data2Clock, see page 197
- State, see page 199
- Pattern, see page 199
- Line Trigger, see page 205

Restrictions:

- If the external trigger input is used as trigger source, the analog edge trigger is the only available trigger type.
- For the R-trigger (reset), the trigger types and settings are restricted dependent on the A and B trigger settings. The instrument provides only possible, reasonable combinations.

Remote command:
TRIGger<m>:TYPE on page 1054

Find level

Sets the trigger level automatically to *0.5 * (MaxPeak – MinPeak)*. The function is not available for an external trigger source and the TV trigger.

Remote command:
TRIGger<m>:FINDlevel on page 1055

Qualify

Enables the settings for trigger qualification that are defined in the "Qualification" tab. Qualification adds additional trigger conditions considering the logic states of other digital channel signals.

The checkmark is only active if at least one qualification channel is selected.

Qualification is available for many trigger types: Edge, Glitch, Width, Runt, Window, Timeout, and Interval.

Qualification is not possible for the R-event.

See also: Chapter 5.4, "Qualification", on page 206.

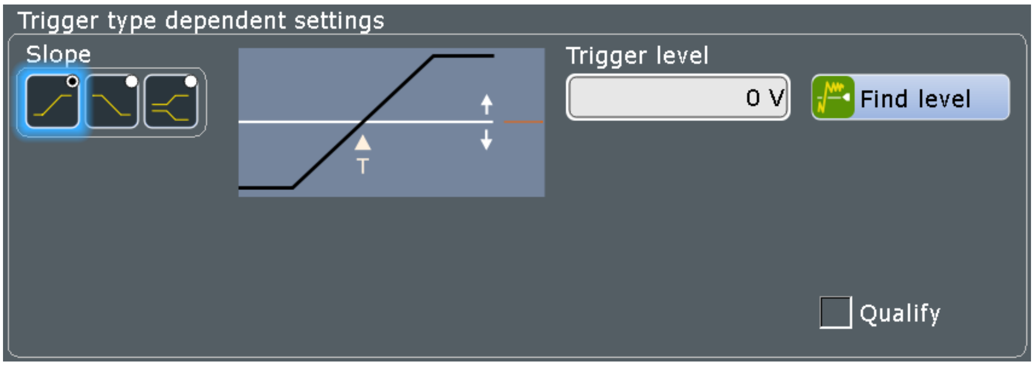
5.3.2 Edge

Access: [Trigger] > "Setup" tab > "Type = Edge"

The edge trigger is the most common trigger type. It is well-known from analog oscilloscopes; and you can use it for analog and digital signals.

The trigger condition is fulfilled when the signal from the trigger source passes the specified threshold voltage in the specified direction (slope).

If the trigger source is a channel signal, the edge trigger uses the digitized trigger signal. This signal can be qualified and filtered with the DSP filter. If the trigger source is the external trigger input, the coupling and filter for this signal is set directly in the trigger setup.



Slope

Sets the edge type for the trigger condition.

"Positive"	Selects the rising edge, that is a positive voltage change.
"Negative"	Selects the falling edge, that is a negative voltage change.
"Both"	Selects the rising as well as the falling edge. This option is not available if the trigger source is the external trigger input.

Remote command:
TRIGger<m>:EDGE:SLOPe on page 1056
TRIGger<m>:ANEDge:SLOPe on page 1058
TRIGger<m>:SLEW:SLOPe on page 1068

Trigger level

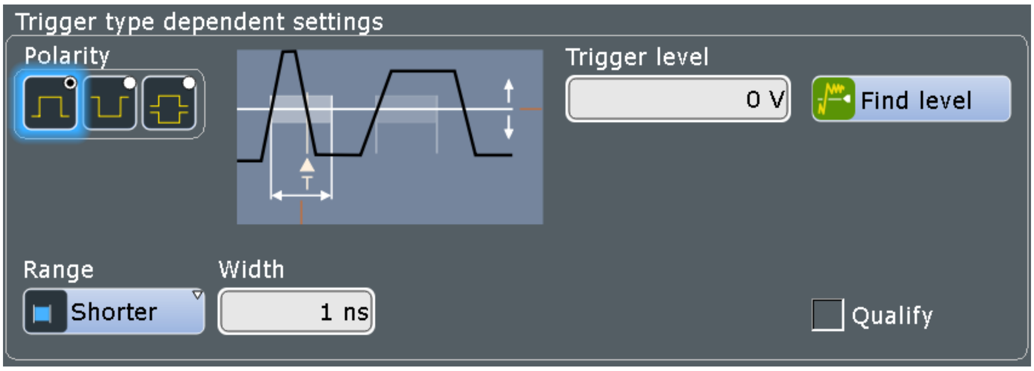
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display).

Remote command:
TRIGger<m>:LEVel<n>[:VALue] on page 1055

5.3.3 Glitch

Access: [Trigger] > "Setup" tab > "Type = Glitch"

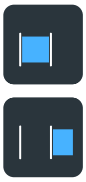
The glitch trigger detects pulses shorter or longer than a specified time. It identifies deviation from the nominal data rate and helps to analyze causes of even rare glitches and their effects on other signals.



Polarity
Indicates the polarity of a pulse, that is the direction of the first pulse slope.

"Positive"	Selects positive going pulses.
"Negative"	Selects negative going pulses.
"Either"	Selects both positive and negative going pulses.

Remote command:
TRIGger<m>:GLITch:RANGe on page 1059
TRIGger<m>:RUNT:POLarity on page 1061



Range
Selects which glitches are identified: shorter or longer than the specified "Width".

Remote command:
TRIGger<m>:GLITch:RANGe on page 1059

Width
Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value. The minimum width is 100 ps.

You need to know the expected pulse widths of the circuit to set the glitch width correctly.

Remote command:
TRIGger<m>:GLITch:WIDTh on page 1059

Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

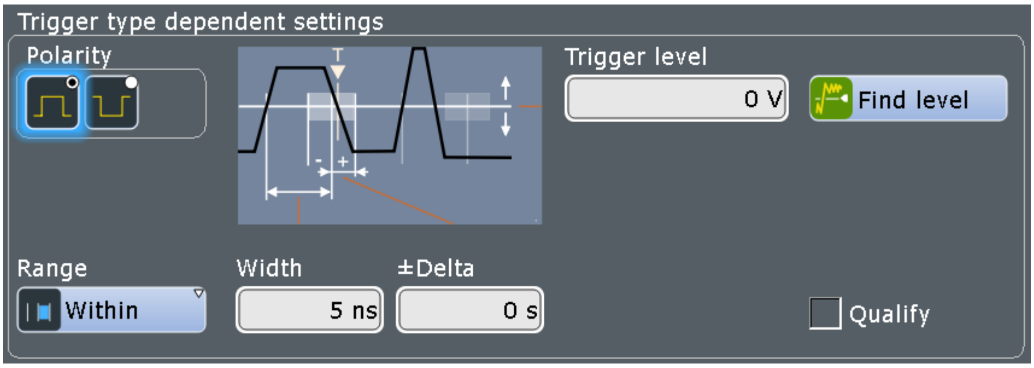
Remote command:
TRIGger<m>:LEVel<n>[:VALue] on page 1055

5.3.4 Width

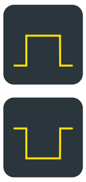
Access: [Trigger] > "Setup" tab > "Type = Width"

The width trigger compares the pulse width (duration of a pulse) with a given time limit. It detects pulses with an exact pulse width, pulses shorter or longer than a given time, and pulses inside or outside the allowable time range. The pulse width is measured at the trigger level.

Using the width trigger, you can define the pulse width more precisely than with the glitch trigger. However, using the range settings "Shorter" and "Longer", you can also trigger on glitches.



While the width trigger can only analyze **either** positive **or** negative polarity, searching for a width is also possible for both polarities at the same time ("Either").



Polarity

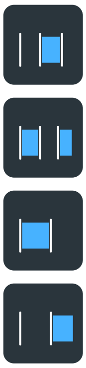
Indicates the polarity of a pulse, that is the direction of the first pulse slope.

"Positive" Triggers on positive going pulses.

"Negative" Triggers on negative going pulses.

Remote command:

TRIGger<m>:WIDTh:POLarity on page 1060



Range

Selects how the range of a pulse width is defined:

"Within" Triggers on pulses inside a given range. The range of the pulse width is defined by "±Delta" related to "Width".

"Outside" Triggers on pulses outside a given range. The range definition is the same as for "Within" range.

"Shorter" Triggers on pulses shorter than the given "Width".

"Longer" Triggers on pulses longer than the given "Width".

Remote command:

TRIGger<m>:WIDTh:RANGe on page 1060

Width
For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits ±Delta.

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Remote command:
`TRIGger<m>:WIDTh:WIDTh` on page 1060

±Delta
Defines a range around the given width value.

The combination "Range" = Within and "±Delta" = 0 triggers on pulses with a pulse width that equals "Width".

The combination "Range" = Outside and "±Delta" = 0 means to trigger on pulse widths ≠ "Width".

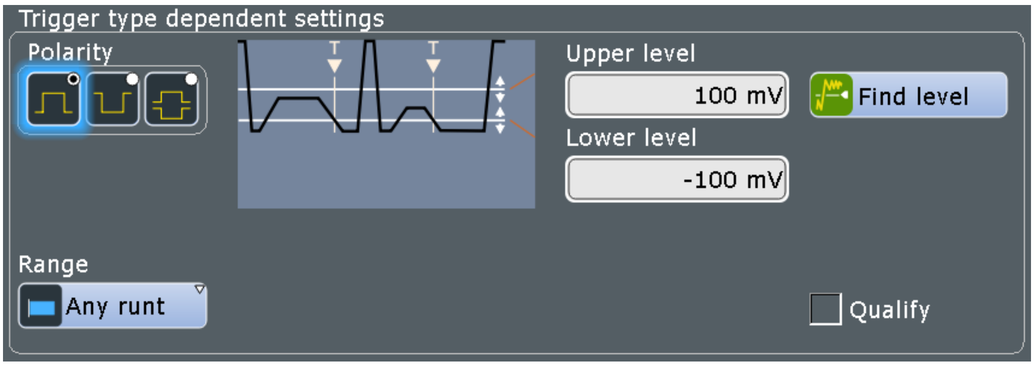
Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1055

5.3.5 Runt

Access: [Trigger] > "Setup" tab > "Type = Runt"

A runt is a pulse lower than normal in amplitude. The amplitude crosses the first threshold twice in succession without crossing the second one. In addition to the threshold amplitudes, you can define a time limit for the runt in the same way as for width triggers. For example, this trigger can detect logic, digital, and analog signals remaining below a specified threshold amplitude because I/O ports are in undefined state.



Polarity
Indicates the polarity of a pulse, that is the direction of the first pulse slope.


"Positive"	Selects positive going pulses.
"Negative"	Selects negative going pulses.
"Either"	Selects both positive and negative going pulses.

Remote command:
TRIGger<m>:GLITch:RANGe on page 1059
TRIGger<m>:RUNT:POLarity on page 1061

Upper level
Sets the upper voltage threshold.

Remote command:
TRIGger<m>:LEVel<n>:RUNT:UPPer on page 1062

Lower level
Sets the lower voltage threshold.

Remote command:
TRIGger<m>:LEVel<n>:RUNT:LOWer on page 1062





Range
Selects how the time limit of the runt pulse is defined:

"Any runt"	Triggers on all runts fulfilling the level condition, without time limitation.
"Longer"	Triggers on runts longer than the given "Runt width".
"Shorter"	Triggers on runts shorter than the given "Runt width".
"Within"	Triggers if the runt length is inside a given time range. The range is defined by "Runt width" and "±Delta".
"Outside"	Triggers if the runt length is outside a given time range. The range definition is the same as for "Within" range.

Remote command:
TRIGger<m>:RUNT:RANGe on page 1062

Runt width
For the ranges "Shorter" and "Longer", the runt width defines the maximum and minimum pulse width, respectively.

For the ranges "Within" and "Outside", the runt width defines the center of a range which is defined by "±Delta".

Remote command:
TRIGger<m>:RUNT:WIDTh on page 1062

±Delta
Defines a range around the given runt width.

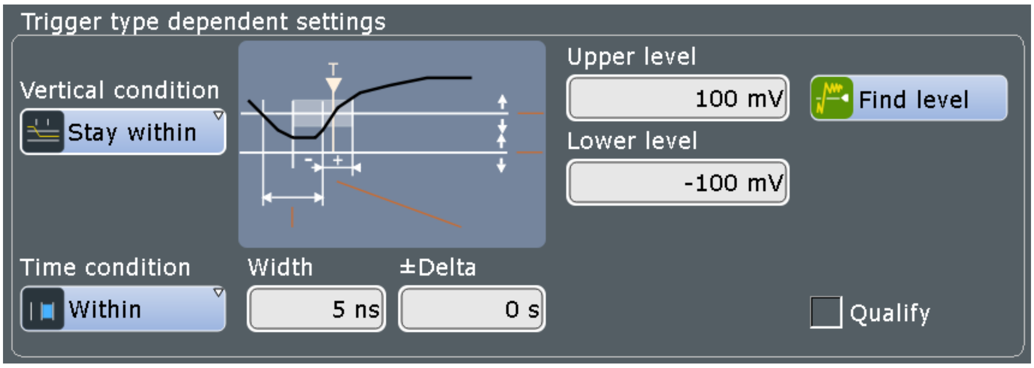
Remote command:
TRIGger<m>:RUNT:DELTa on page 1063

5.3.6 Window

Access: [Trigger] > "Setup" tab > "Type = Window"

The window trigger checks the signal run in relation to a "window". The window is formed by the upper and lower voltage levels. The trigger condition is fulfilled, if the waveform enters or leaves the window, or if the waveform stays inside or outside for a time longer or shorter than specified.

With the window trigger, you can display longer transient effects.






Vertical condition
Selects how the signal run is compared with the window:

"Enter" Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.

"Exit" Triggers when the signal leaves the window.

"Stay within" Triggers if the signal stays between the upper and lower level for a specified time. The time is defined in various ways by the Time condition.

"Stay outside" Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is also defined by the "Time condition".

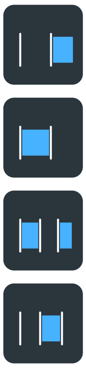
Remote command:
`TRIGger<m>:WINDow:RANGe` on page 1064

Upper level
Sets the upper voltage limit for the window.

Remote command:
`TRIGger<m>:LEVel<n>:WINDow:UPPer` on page 1063

Lower level
Sets the lower voltage limit for the window.

Remote command:
`TRIGger<m>:LEVel<n>:WINDow:LOWer` on page 1063



Time condition
Selects how the time limit of the window is defined. Time conditioning is available for the vertical conditions "Stay within" and "Stay outside".

"Within"	Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width* - *Delta* and for *Width* + *Delta* at the most.
"Outside"	"Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width* - *Delta* or longer than *Width* + *Delta*.
"Shorter"	Triggers if the signal crosses vertical limits before the specified "Width" time is reached.
"Longer"	Triggers if the signal crosses vertical limits after the specified "Width" time is reached.

Remote command:
`TRIGger<m>:WINDow:TIME` on page 1064

Width
For the ranges "Within" and "Outside", the width defines the center of a time range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

Remote command:
`TRIGger<m>:WINDow:WIDTh` on page 1065

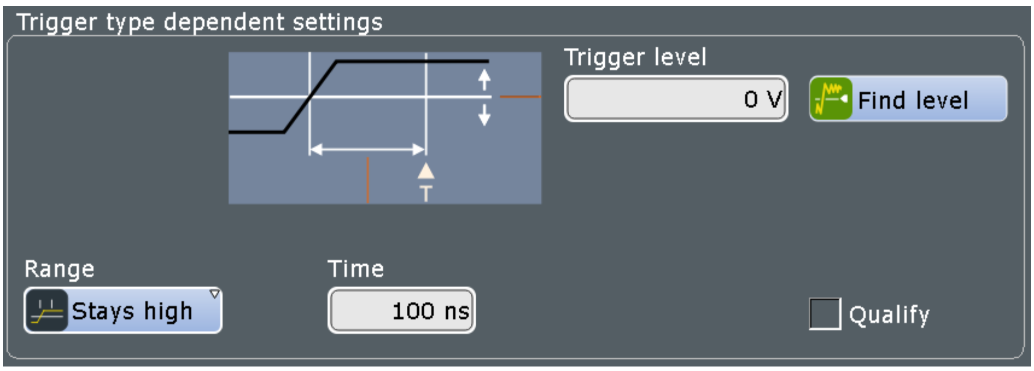
±Delta
Defines a range around the "Width" value.

Remote command:
`TRIGger<m>:WINDow:DELTa` on page 1065

5.3.7 Timeout

Access: [Trigger] > "Setup" tab > "Type = Timeout"

The timeout trigger checks if the signal stays above or below the threshold voltage for a specified time lapse. In other words, the trigger occurs if the trigger source does not have the expected transition within the specified time.



Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1055

Range
Selects the relation of the signal level to the trigger level:

"Stays high"	The signal level stays above the trigger level.
"Stays low"	The signal level stays below the trigger level.
"High or low"	The signal level stays above or below the trigger level.

Remote command:
`TRIGger<m>:TIMeout:RANGe` on page 1066

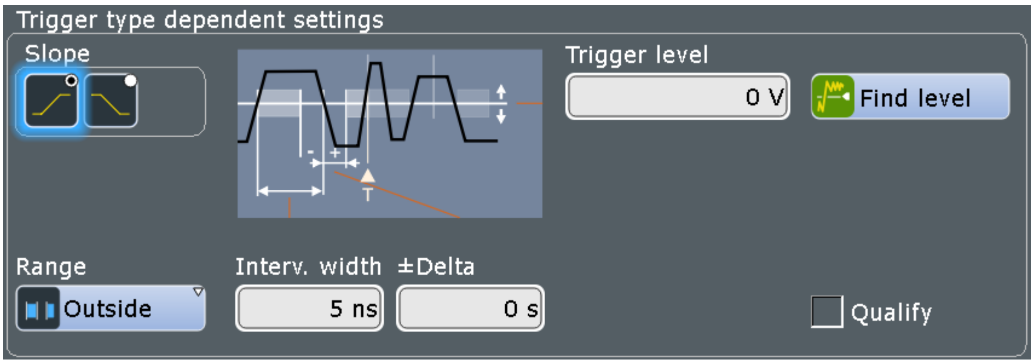
Time
Defines the time limit for the timeout at which the instrument triggers.

Remote command:
`TRIGger<m>:TIMeout:TIME` on page 1066

5.3.8 Interval

Access: [Trigger] > "Setup" tab > "Type = Interval"

The interval trigger analyzes the time between two pulses.



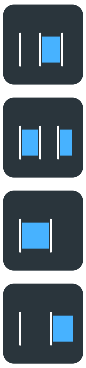
While the interval trigger can only analyze either rising or falling edges, searching for an interval is also possible for both edges at the same time ("Either").

Slope
Sets the edge for the trigger. You can analyze the interval between positive edges or between negative edges.

Remote command:
`TRIGger<m>:INTerval:SLOPe` on page 1067

Trigger level
Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
TRIGger<m>:LEVel<n>[:VALue] on page 1055



Range
Selects how the range of an interval is defined:

"Within"	Triggers on pulse intervals inside a given range. The range is defined by "Interv. width" and "±Delta".
"Outside"	Triggers on intervals outside a given range. The range definition is the same as for "Within" range.
"Shorter"	Triggers on intervals shorter than the given "Interv. width".
"Longer"	Triggers on intervals longer than the given "Interv. width".

Remote command:
TRIGger<m>:INTerval:RANGe on page 1067

Interv. width
Defines the time between two pulses.

Remote command:
TRIGger<m>:INTerval:WIDTh on page 1067

±Delta
Defines a range around the "Interval width" value.

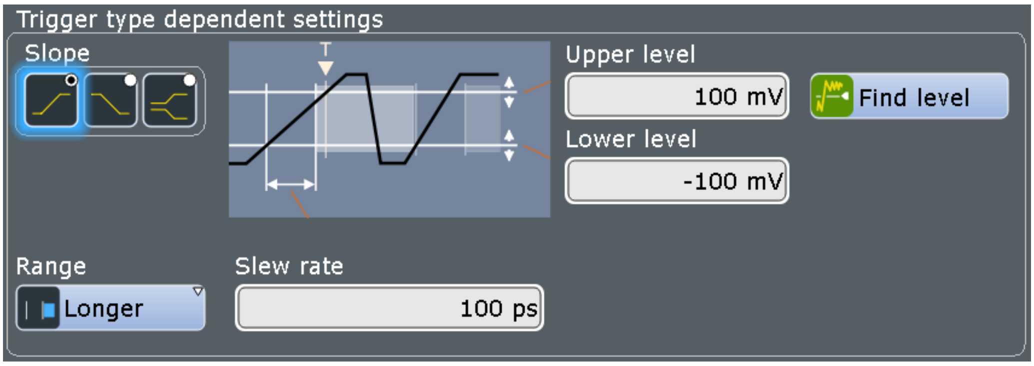
Remote command:
TRIGger<m>:INTerval:DELTa on page 1068

5.3.9 Slew Rate

Access: [Trigger] > "Setup" tab > "Type = Slew rate"

The slew rate trigger is also known as transition trigger. It triggers if the transition time from the lower to higher voltage level (or vice versa) is shorter or longer as defined, or outside or inside a specified time range.

The slew rate trigger finds slew rates faster than expected or permissible to avoid overshooting and other interfering effects. It also detects slow edges violating the timing in pulse series.



Slope

Sets the edge type for the trigger condition.

"Positive" Selects the rising edge, that is a positive voltage change.

"Negative" Selects the falling edge, that is a negative voltage change.

"Both" Selects the rising as well as the falling edge. This option is not available if the trigger source is the external trigger input.

Remote command:
TRIGger<m>:EDGE:SLOPe on page 1056
TRIGger<m>:ANEDge:SLOPe on page 1058
TRIGger<m>:SLEW:SLOPe on page 1068

Upper level

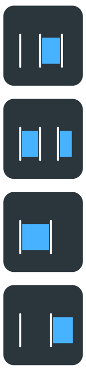
Sets the upper voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:
TRIGger<m>:LEVel<n>:SLEW:UPPer on page 1068

Lower level

Sets the lower voltage threshold. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:
TRIGger<m>:LEVel<n>:SLEW:LOWer on page 1068



Range

Selects how the time limit for the slew rate is defined. The time measurement starts when the signal crosses the first trigger level - the upper or lower level depending on the selected slope. The measurement stops when the signal crosses the second level.

"Within" Triggers on slew rates inside a given time range. The range is defined by "Slew rate" and "±Delta".

"Outside" Triggers on slew rates outside a given time range. The range definition is the same as for "Within" range.

"Shorter" Triggers on slew rates shorter than the given "Slew rate" limit.

"Longer" Triggers on slew rates longer than the given "Slew rate" limit.

Remote command:
TRIGger<m>:SLEW:RANGe on page 1069

Slew rate
For the ranges "Within" and "Outside", the slew rate defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the slew rate defines the maximum and minimum slew rate limits, respectively.

Remote command:
TRIGger<m>:SLEW:RATE on page 1069

±Delta
Defines a time range around the given slew rate.

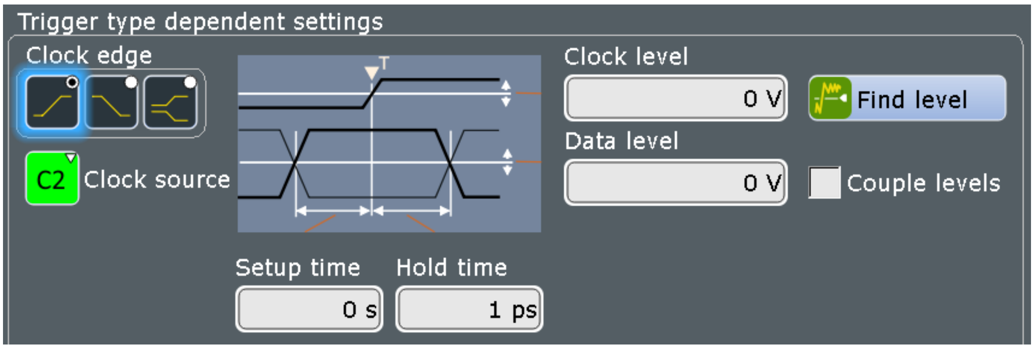
Remote command:
TRIGger<m>:SLEW:DELTa on page 1070

5.3.10 Data2Clock

Access: [Trigger] > "Setup" tab > "Type = Data2Clock"

With the Data2Clock trigger - also known as setup/hold trigger - you can analyze the relative timing between two signals: a data signal and the synchronous clock signal. Many systems require, that the data signal must be steady for some time before and after the clock edge, for example, the data transmission on parallel interfaces. With this trigger type, you can also test the time correlation of sideband and in-band signals.

The trigger occurs if the data signal crosses the data level during the setup and hold time. The reference point for the time measurement is defined by clock level and clock edge.



Clock source
Selects the input channel of the clock signal.

Remote command:
TRIGger<m>:DATatoclock:CSOurce[:VALue] on page 1070

Clock edge
Sets the edge of the clock signal to define the time reference point for the setup and hold time:

"Positive"	Rising edge, a positive voltage change.
"Negative"	Falling edge, a negative voltage change.
"Both"	Both the rising and the falling edge.

Remote command:
`TRIGger<m>:DATatoclock:CSOurce:EDGE` on page 1071

Clock level

Sets the voltage level for the clock signal. Both "Clock level" and "Clock edge" define the starting point for calculation of the setup and hold time.

Remote command:
`TRIGger<m>:DATatoclock:CSOurce:LEVel` on page 1071

Data level

Sets the voltage level for the data signal. At this level, the setup and hold time is measured.

Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1055

Couple levels (Trigger level and hysteresis coupling)

Sets the trigger levels and hysteresis values for all channels to the values of the currently selected trigger source. The function affects only the levels defined for the selected condition. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.

In trigger sequences, another coupling of trigger levels is possible: "Couple trigger levels" on page 216

Remote command:
`TRIGger<m>:SCOupling` on page 1071

Setup time

Sets the minimum time **before** the clock edge while the data signal must stay steady above or below the data level.

The setup time can be negative. In this case, the hold time is always positive. If you set a negative setup time, the hold time is adjusted by the instrument.

Remote command:
`TRIGger<m>:DATatoclock:STIMe` on page 1072

Hold time

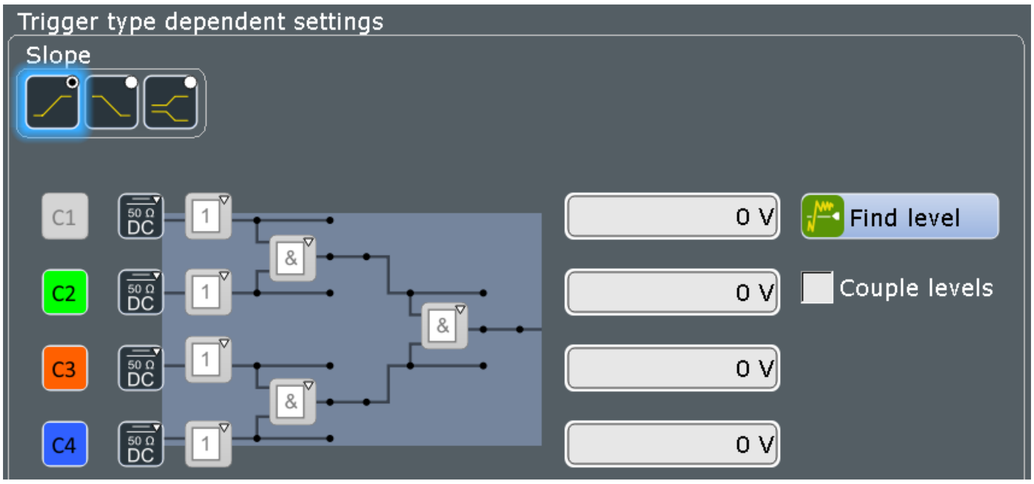
Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

The hold time can be negative. In this case, the setup time is always positive. If you set a negative hold time, the setup time is adjusted by the instrument.

Remote command:
`TRIGger<m>:DATatoclock:HTIMe` on page 1071

5.3.11 State

The state trigger is a qualified edge trigger. It combines the edge trigger settings with trigger qualification.



The individual settings are:
- "Slope" on page 187
- "Pattern" on page 199
- "Trigger Levels" on page 200
- "Find level" on page 186
- "Couple levels (Trigger level and hysteresis coupling)" on page 198

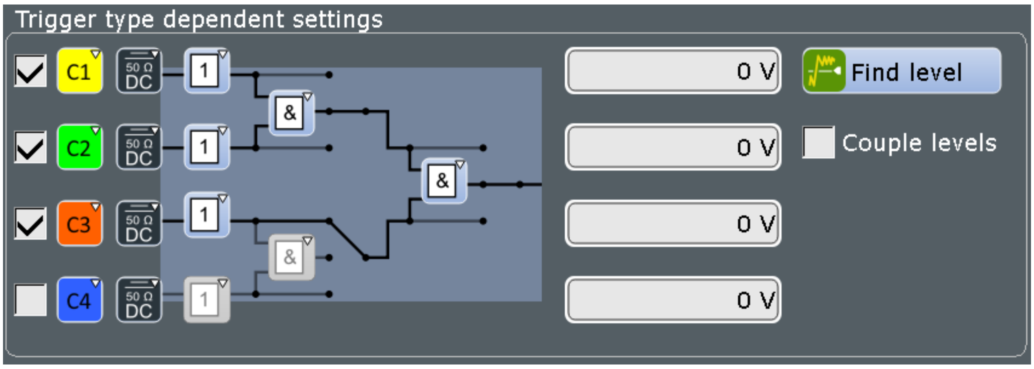
5.3.12 Pattern

Access: [Trigger] > "Setup" tab > "Type = Pattern"

The pattern trigger is a logic trigger. It provides logical combinations of the input channels and supports you in verifying the operation of digital logic.

The setup of the pattern trigger is similar to trigger qualification. In addition to the pattern and the trigger levels, you can define a timing condition. The complete settings for the pattern trigger are provided in the "Qualification" tab.

Pattern
The pattern contains the channel selection, and the logical operations structure of hardware-based Boolean logic.



"Channel" Select the channels to be considered. For qualification, you can select all channel signals except for the trigger source. In pattern trigger setup, the trigger source channel is selected by default, and you can select all other channel signals.

"Coupling" The current coupling or ground connection is shown for each channel and can be changed directly in the pattern, if necessary.

"Boolean operator" Defines the logical operation on the digital signal resulting from the comparison with the trigger level.

- "Direct": leaves the input value unchanged
- "NOT": inverts the input value

"Logical operator" Defines the logic combination of two sources. The sources are channel 1/2 and channel 3/4 on the first step, and in the second step the logical combination resulting from the first step.

- "AND": logical AND, conjunctive combination
- "NAND": logical NOT AND
- "OR": logical OR, disjunctive combination
- "NOR": logical NOT OR

Remote command:
`TRIGger<m>:QUALify<n>:A:LOGic` on page 1082
`TRIGger<m>:QUALify<n>:A[:ENABle]` on page 1082
`TRIGger<m>:QUALify<n>:AB:LOGic` on page 1083
`TRIGger<m>:QUALify<n>:ABCD:LOGic` on page 1083
`TRIGger<m>:QUALify<n>:B:LOGic` on page 1082
`TRIGger<m>:QUALify<n>:B[:ENABle]` on page 1082
`TRIGger<m>:QUALify<n>:C:LOGic` on page 1082
`TRIGger<m>:QUALify<n>:C[:ENABle]` on page 1082
`TRIGger<m>:QUALify<n>:CD:LOGic` on page 1083
`TRIGger<m>:QUALify<n>:D:LOGic` on page 1082
`TRIGger<m>:QUALify<n>:D[:ENABle]` on page 1082

Trigger Levels
Define the trigger level for each input channel. For state and pattern trigger, the trigger level is a decision threshold: If the signal value is higher than the trigger level, the signal state is high (1 or true for the Boolean logic). Otherwise, the signal state is considered low (0 or false) if the signal value is below the trigger level.

These trigger levels are also used in qualification setup.

You can set the trigger levels for all channels to the same value, see "Couple levels (Trigger level and hysteresis coupling)" on page 198.

Additional settings: Timing

"Timing" adds time limitation to the pattern condition.

You find this setting in the "Qualification" tab.

"Off"	No time limitation. The trigger occurs if the pattern condition is fulfilled.
"Timeout"	Defines how long the result of the pattern condition must be true or false.
"Width"	Defines a time range for keeping up the true result of the pattern condition. The range is defined in the same way as for width and interval triggers, see "Range" on page 189.

Remote command:
`TRIGger<m>:PATTern:MODE` on page 1073
`TRIGger<m>:PATTern:TIMeout:MODE` on page 1073
`TRIGger<m>:PATTern:TIMeout[:TIME]` on page 1074
`TRIGger<m>:PATTern:WIDTh:DELTa` on page 1075
`TRIGger<m>:PATTern:WIDTh:RANGe` on page 1074
`TRIGger<m>:PATTern:WIDTh[:WIDTh]` on page 1075

5.3.13 TV/Video Trigger

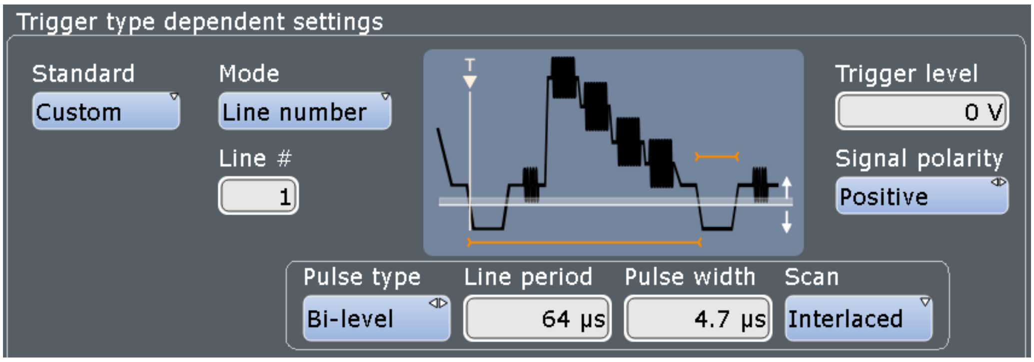
Access: [Trigger] > "Setup" tab > "Type = TV"

The TV or video trigger is used to analyze analog baseband video signals. You can trigger on baseband video signals from standard definition and high definition standards, and also on user defined signals.

The instrument triggers on the line start - the horizontal sync pulse. You can trigger on all lines, or specify a line number. You can also trigger on the field or frame start.

Also, a delay can be set: Set the "Holdoff events" in the "Holdoff" tab to the number of fields to be skipped. See also: Chapter 5.5, "Holdoff", on page 208.

Make sure that the trigger level crosses the synchronizing pulses of the video signal, see "Trigger level" on page 203.



Most video signals have an output impedance of 75 Ω. The channel inputs of the R&S RTP have an input impedance of 50 Ω. Make sure to provide the adequate matching to ensure amplitude fidelity.

Once the trigger is set correctly, you can use cursor and automatic measurements to perform amplitude and timing measurements.

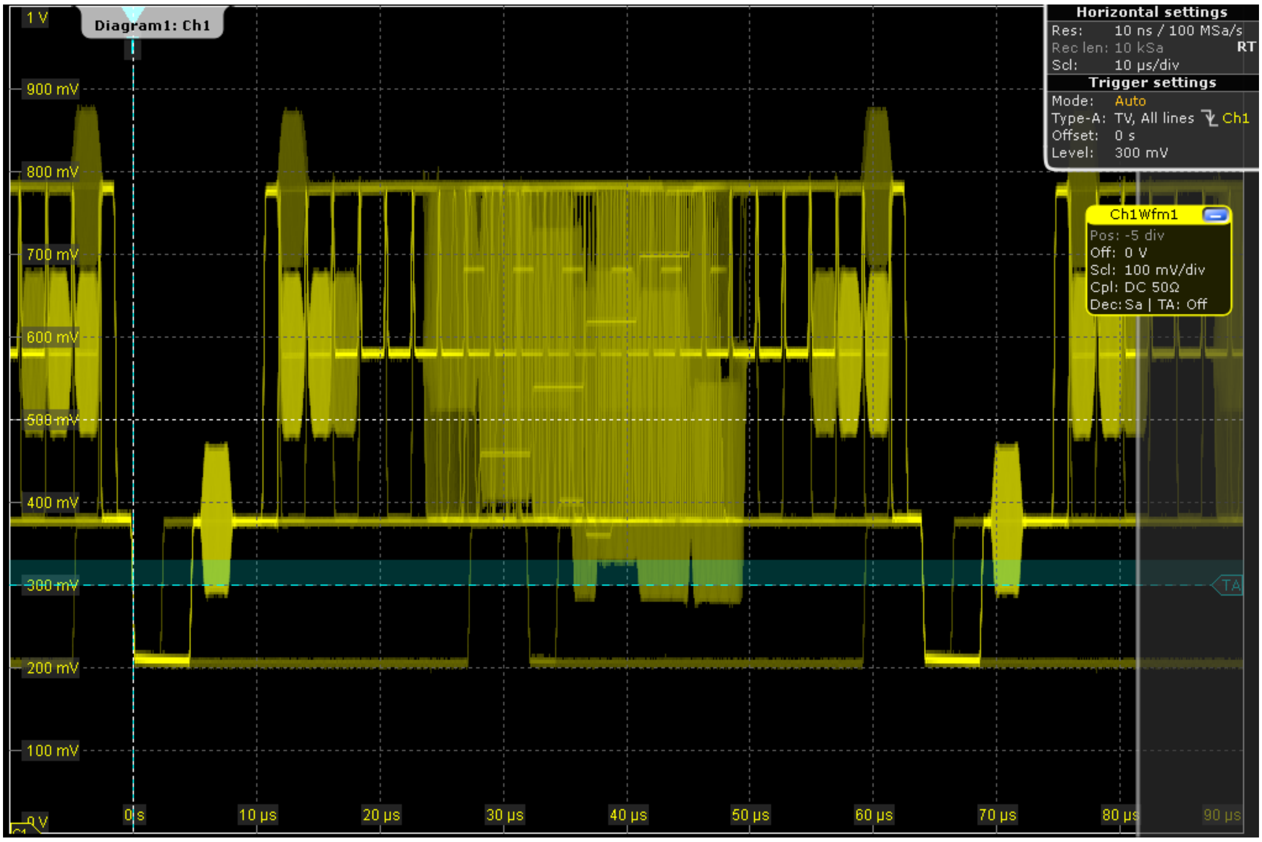


Figure 5-1: Trigger on all lines of a PAL signal with positive signal polarity, trigger level = 300 mV

Standard

Selects the TV standard or "Custom" for user-defined signals.

HDTV standards are indicated by the number of active lines, the scanning system (p for progressive scanning, i for interlaced scanning) and the frame rate. For interlaced scanning, the field rate is used instead of the frame rate. 1080p/24sF is an HDTV standard using progressive segmented frame scanning.

"Custom" can be used for signals of other video systems, for example, medical displays, video monitors, and security cameras. To trigger on these signals, you have to define the pulse type and length of the sync pulse, the scanning system and the line period.

Remote command:
`TRIGger<m>:TV:STANdard` on page 1076

Mode

Selects the lines or fields on which the instrument triggers. Available modes depend on the scanning system of the selected standard.

"All fields"	Triggers on the first video line of the frame (progressive scanning) or field (interlaced scanning), for example, to find amplitude differences between the fields.
"Odd fields / Even fields"	Triggers on the first video line of the odd or even field. These modes are available for interlaced scanning (PAL, PAL-M, SECAM, NTSC, 1080i) and progressive segmented frame scanning (1080p/24sF). They can be used, for example, to analyze the components of a video signal.
"All lines"	Triggers on the line start of all video lines, for example, to find maximum video levels.
"Line number"	Triggers on a specified line. Enter the line number in "Line #".

Remote command:
`TRIGger<m>:TV:MODE` on page 1076

Line #

Sets the number of the line to be triggered on if "Mode" is set to "Line number". Usually the lines of the frame are counted, beginning from the frame start.

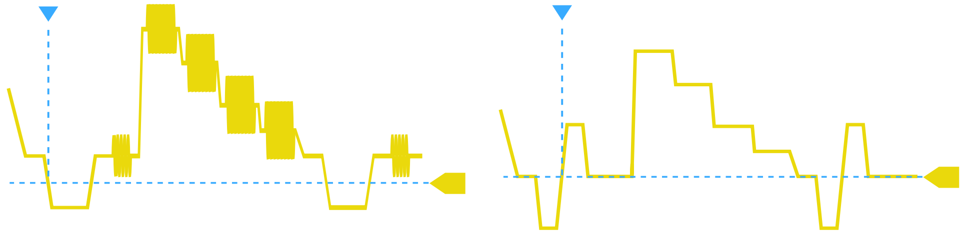
For NTSC signals, the lines are counted per field, not per frame. Therefore, you have to set the "Field" (odd or even), and the line number in the field.

Remote command:
`TRIGger<m>:TV:LINE` on page 1077
`TRIGger<m>:TV:LFIeld` on page 1078

Trigger level

Sets the trigger level as threshold for the sync pulse. Make sure that the trigger level crosses the synchronizing pulses of the video signal.

The hysteresis is set according to the settings in the "Noise Reject" tab.



Remote command:
`TRIGger<m>:LEVel<n>[:VALue]` on page 1055

Signal polarity

Sets the polarity of the signal. Note that the sync pulse has the opposite polarity, for example, a positive signal has a negative sync pulse.

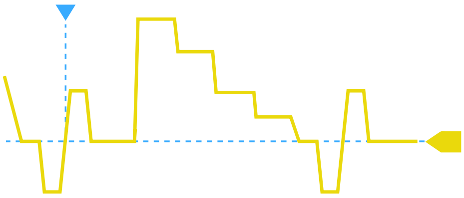


Figure 5-2: Signal with positive polarity and tri-level sync pulse

Remote command:
`TRIGger<m>:TV:POLarity` on page 1077

Pulse type

Sets the type of the sync pulse, either bi-level sync pulse (used in SDTV signals), or tri-level sync pulse (used in HDTV signals).

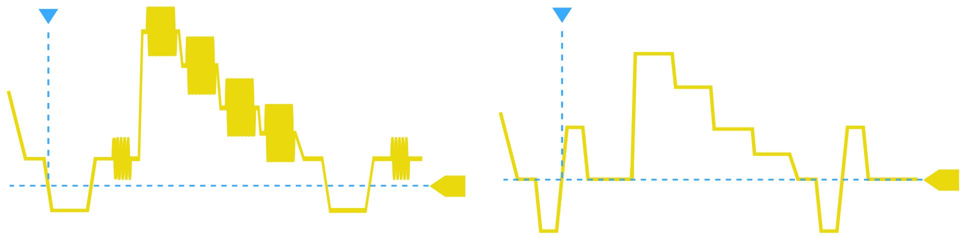


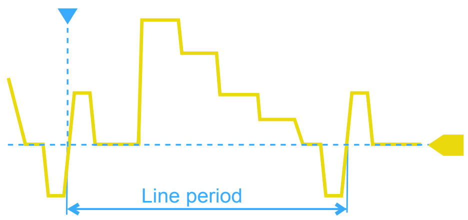
Figure 5-3: Bi-level (left) and tri-level (right) sync pulses

This setting is available for user-defined video signals if "Standard" is set to "Custom".

Remote command:
`TRIGger<m>:TV:CUSTom:STYPe` on page 1079

Line period

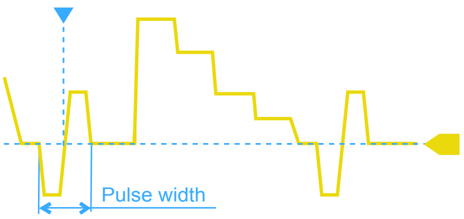
Sets the duration of a single video line, the time between two successive sync pulses.



This setting is available for user-defined video signals if "Standard" is set to "Custom".

Remote command:
`TRIGger<m>:TV:CUSTom:LDURation` on page 1079

Pulse width
Sets the width of the sync pulse.



This setting is available for user-defined video signals if "Standard" is set to "Custom".

Remote command:
`TRIGger<m>:TV:CUSTom:SDURation` on page 1080

Scan
Sets the scanning system.

This setting is available for user-defined video signals if "Standard" is set to "Custom".

"Interlaced"	Interlace scanning uses two fields to create a frame. One field contains all the odd lines (odd, first, or upper filed), the other contains all the even lines of the image (even, second, or lower field). First the lines of the odd filed are processed, then the lines of the even field.
"Progressive"	Progressive scanning is a method to capture, transmit and display all lines of a frame in sequence.
"Segmented"	Progressive segmented frame uses progressive scanning to capture the frame, and interlaced scanning for transmission and display.

Remote command:
`TRIGger<m>:TV:CUSTom:SCANmode` on page 1078

5.3.14 Line Trigger

Access: [Trigger] > "Setup" tab > "Source" = "Line"

The line trigger triggers on the AC power input and synchronizes the signal to the AC power frequency. It is not a trigger type but rather a special trigger source. Use the line source if you want to analyze signals related to the power line frequency, such as lighting equipment and power supply devices.

Slope

Selects the rising or falling edges of the AC power input for the trigger condition.

Remote command:
`TRIGger<m>:POWerline:SLOPe` on page 1080

5.3.15 Triggering on Serial Buses

Protocol analysis including configuration, triggering, and decoding is described in Chapter 12, "Protocol Analysis", on page 463.

For information on triggering on serial buses, see the "Trigger" chapter of the relevant protocol.

5.3.16 Triggering on Parallel Buses and Digital Channels

Triggering on digital signals requires the Mixed Signal Option. The option is described in Chapter 13, "Mixed Signal Option (MSO, R&S RTP-B1)", on page 837.

For information on triggering, see Chapter 13.3.1, "Trigger Settings for Digital Signals and Parallel Buses", on page 848.

5.4 Qualification

By qualifying a trigger event, you can logically combine the trigger signal with the state of other analog channel signals.

The instrument triggers if both of the following apply:

- The basic conditions of the trigger event definition are fulfilled.
- The logical conditions of the trigger qualification are true.

Qualification is only available for the A-event.

Qualification is not supported if:

- The trigger source is "Extern".
- One of the following trigger types is selected: Slew rate, Data2Clock and Serial pattern.

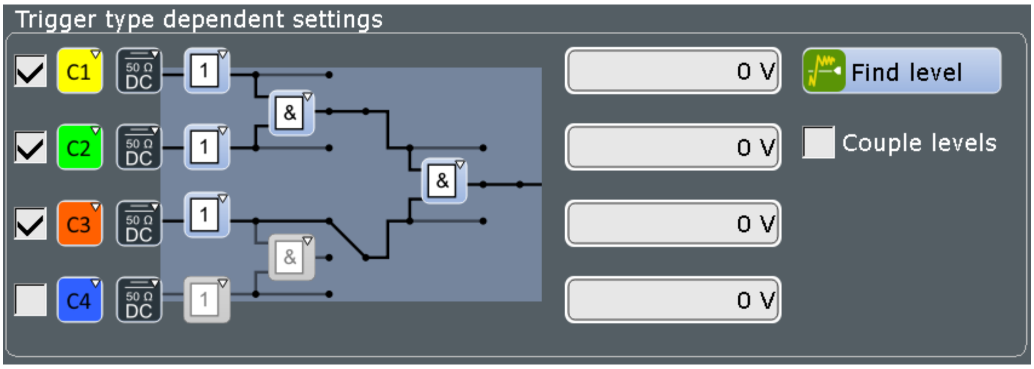
► To enable the qualification settings, select Qualify.

Example: Trigger on write access of a specific device of a bus system

In circuits using SPI, several slave devices use the same lines for reading and writing data, and each slave has its own select line. To trigger on write access of specific slave, the write line is the trigger source and the select line of the slave is set as qualifying condition.

Pattern

The pattern contains the channel selection, and the logical operations structure of hardware-based Boolean logic.



"Channel"	Select the channels to be considered. For qualification, you can select all channel signals except for the trigger source. In pattern trigger setup, the trigger source channel is selected by default, and you can select all other channel signals.
"Coupling"	The current coupling or ground connection is shown for each channel and can be changed directly in the pattern, if necessary.
"Boolean operator"	Defines the logical operation on the digital signal resulting from the comparison with the trigger level. ● "Direct": leaves the input value unchanged ● "NOT": inverts the input value
"Logical operator"	Defines the logic combination of two sources. The sources are channel 1/2 and channel 3/4 on the first step, and in the second step the logical combination resulting from the first step. ● "AND": logical AND, conjunctive combination ● "NAND": logical NOT AND ● "OR": logical OR, disjunctive combination ● "NOR": logical NOT OR

Remote command:

`TRIGger<m>:QUALify<n>:A:LOGic` on page 1082
`TRIGger<m>:QUALify<n>:A[:ENABle]` on page 1082
`TRIGger<m>:QUALify<n>:AB:LOGic` on page 1083
`TRIGger<m>:QUALify<n>:ABCD:LOGic` on page 1083
`TRIGger<m>:QUALify<n>:B:LOGic` on page 1082
`TRIGger<m>:QUALify<n>:B[:ENABle]` on page 1082
`TRIGger<m>:QUALify<n>:C:LOGic` on page 1082
`TRIGger<m>:QUALify<n>:C[:ENABle]` on page 1082
`TRIGger<m>:QUALify<n>:CD:LOGic` on page 1083
`TRIGger<m>:QUALify<n>:D:LOGic` on page 1082
`TRIGger<m>:QUALify<n>:D[:ENABle]` on page 1082

Trigger Levels
Define the trigger level for each input channel. For state and pattern trigger, the trigger level is a decision threshold: If the signal value is higher than the trigger level, the signal state is high (1 or true for the Boolean logic). Otherwise, the signal state is considered low (0 or false) if the signal value is below the trigger level.

These trigger levels are also used in qualification setup.

You can set the trigger levels for all channels to the same value, see "Couple levels (Trigger level and hysteresis coupling)" on page 198.

Couple levels (Trigger level and hysteresis coupling)
Sets the trigger levels and hysteresis values for all channels to the values of the currently selected trigger source. The function affects only the levels defined for the selected condition. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.

In trigger sequences, another coupling of trigger levels is possible: "Couple trigger levels" on page 216

Remote command:
`TRIGger<m>:SCOupling` on page 1071

Qualify
Enables the settings for trigger qualification. As soon as a qualification pattern is defined, the option is selected by default.

5.5 Holdoff

Access: "Trigger" menu > "Holdoff"

Holdoff conditions define a waiting time after the current trigger until the next trigger can be recognized.

Holdoff mode
Selects the method to define the holdoff condition.

The trigger holdoff defines when the next trigger after the current will be recognized. Thus, it affects the next trigger to occur after the current one. Holdoff helps to obtain stable triggering when the oscilloscope is triggering on undesired events.

Holdoff settings are not available if the trigger source is an external trigger input or serial bus. For the TV trigger, only the "Events" mode is useful.

Example:
You want to analyze the first pulse in a burst of several pulses. At first, you select a sufficiently slow time base to display the entire burst. Then, you set the holdoff time a little longer than the length of the burst. Now, each trigger corresponds to the first pulse in successive bursts, and you can change the time base to display the waveform in more detail.

The following methods are available:

"Time" Defines the holdoff directly as a time period. The next trigger occurs only after the "Holdoff time" has passed.

"Events" Defines the holdoff as a number of trigger events. The next trigger only occurs when this number of events is reached. The number of triggers to be skipped is defined in "Holdoff events".

"Random" Defines the holdoff as a random time limited by "Random minimum time" and "Random maximum time". For each acquisition cycle, the instrument selects a new random holdoff time from the specified range.
Random holdoff prevents synchronization to discover effects invisible with synchronized triggering, for example, the features of a pulse train.

"Auto" The holdoff time is calculated automatically based on the current horizontal scale.
"Auto time scaling" defines the factor the horizontal scale is multipied with.
"Auto time" shows the resulting holdoff time: *Auto time* = *Auto time scaling* * *Horizontal scale*.

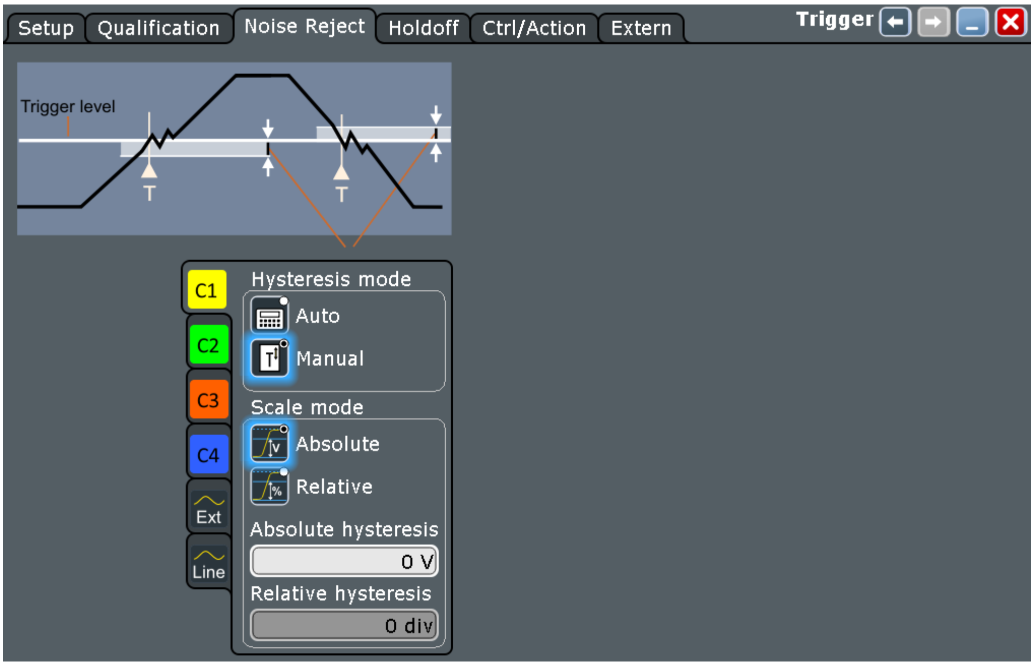
"Off" No holdoff

Remote command:
`TRIGger<m>:HOLDoff:MODE` on page 1083
`TRIGger<m>:HOLDoff:TIME` on page 1084
`TRIGger<m>:HOLDoff:EVENts` on page 1084
`TRIGger<m>:HOLDoff:MAX` on page 1085
`TRIGger<m>:HOLDoff:MIN` on page 1085
`TRIGger<m>:HOLDoff:AUTotime?` on page 1086
`TRIGger<m>:HOLDoff:SCALing` on page 1086

5.6 Noise Reject

The rejection of noise by setting a hysteresis avoids unwanted trigger events caused by noise oscillation around the trigger level.

You can select the hysteresis mode and value for each channel separately, or couple the trigger levels and set the same hysteresis for channels. The hysteresis of the external trigger input is an independent value, and it is not affected by level coupling.



Hysteresis mode

Selects how the hysteresis is set.

"Auto" This is the recommended mode. The hysteresis is set by the instrument to reject the internal noise of the instrument.

"Manual" The hysteresis is defined directly in absolute or relative values.

Remote command:

TRIGger<m>:LEVel<n>:NOISe[:STATe] on page 1087

Scale mode

Selects whether the hysteresis is defined in absolute or relative values. The setting is available only in manual hysteresis mode.

Remote command:

TRIGger<m>:LEVel<n>:NOISe:MODE on page 1087

Absolute hysteresis

Defines a range in absolute values around the trigger level. If the signal jitters inside this range and crosses the trigger level thereby, no trigger event occurs.

Remote command:

TRIGger<m>:LEVel<n>:NOISe:ABSolute on page 1088

Relative hysteresis

Defines a range in divisions around the trigger level. If the signal oscillates inside this range and crosses the trigger level thereby, no trigger event occurs.

Remote command:

TRIGger<m>:LEVel<n>:NOISe:PERDivision on page 1088

TRIGger<m>:LEVel<n>:NOISe:RELative on page 1088

Noise reject (external trigger)
Enables the noise reject for the external trigger input.

Remote command:
TRIGger<m>:ANEDge:NREJect on page 1089

5.7 Control / Action

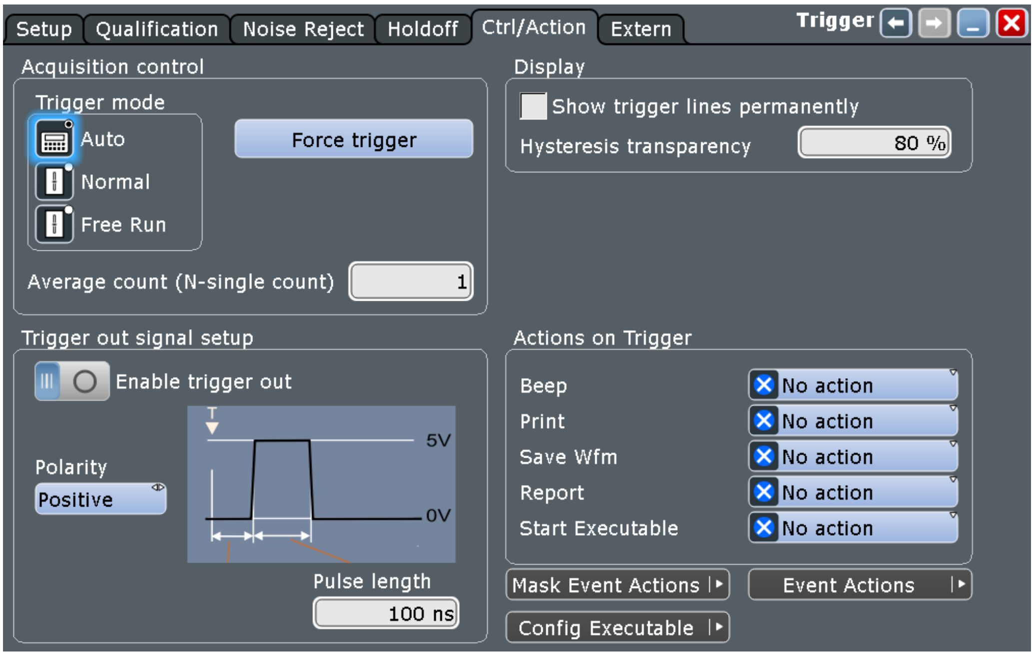
Access: [Trigger] > "Ctrl/Action" tab

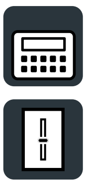
The settings and functions of trigger control define when the instrument triggers. They affect all trigger types and all triggers in a trigger sequence.

In addition to the settings in the dialog box, you need the [Run Stop] and [Single] keys on the front panel to start and stop the acquisition and thus the triggering.

The action settings define what happens when a trigger occurs. All available actions can be initiated at the same time.

The R&S RTP can provide an external trigger signal to synchronize the measurements of other instruments. The trigger out signal is also adjusted and enabled in the "Control" tab.





Trigger mode
Sets the trigger mode which determines the behavior of the instrument if no trigger occurs. The current setting is shown on the trigger label on top of the sidebar.

To toggle quickly between "Auto" and "Normal" mode, use the [Mode] key on the front panel (in "Trigger" section).

"Auto"	The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. This mode helps to see the waveform even before the trigger conditions are set correctly. The waveform on the screen is not synchronized, and successive waveforms are not triggered at the same point of the waveform. The time interval depends on the time base settings.
"Normal"	The instrument acquires a waveform only if a trigger occurs, that is, if all trigger conditions are fulfilled. If no trigger occurs, no waveform is acquired and the last acquired waveform is displayed. If no waveform was captured before, none is displayed. When no trigger has been found for longer than one second, a message box appears that shows the time elapsed since the last trigger.
"Free Run"	The instrument starts acquisition immediately and triggers after a short time interval independent of the time base settings and faster than in "Auto" mode. Real triggers are ignored. Use this mode if the "Auto" mode is too slow.

Remote command:
`TRIGger<m>:MODE` on page 1092

Acquisition/average count

Access:
- Trigger > "Control" tab > "Average count (N-single count)"
- [Acquisition] > "Average count"
- [Horizontal] > "Fast Segmentation" tab > disable "Acquire maximum" > "Required"
- [Math] > "Setup" tab > "Average count"

The acquisition and average count has several effects:
- It sets the number of waveforms acquired with [Single]
- It defines the number of waveforms used to calculate the average waveform. Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the value is, the better the noise is reduced.
- It sets the number of acquisitions to be acquired in a fast segmentation acquisition series. Thus, you can acquire exactly one fast segmentation acquisition series with [Single].
  If fast segmentation is enabled and configured to acquire the maximum number of acquisitions, the acquisition count is set to that maximum number and cannot be changed. See also: "Number of acquisitions" on page 131.
- It is the "Finished" criteria for the state of a mask test.

Remote command:
`ACQuire:COUNt` on page 1009

Force Trigger

If the acquisition is running in normal mode and no valid trigger occurs, forcing the trigger provokes an immediate single acquisition. Thus you can confirm that a signal is available and use the waveform display to determine how to trigger on it.

If you need this function frequently, you can add the "Force Trigger" icon to the toolbar.

Remote command:
TRIGger<m>:FORCe on page 1093

[Run Stop]/[Single]
Front panel keys to start and stop a continuous acquisition or a defined number of acquisition cycles, respectively. The number of acquisitions is set with "Average count".

Remote command:
RUN on page 1000
SINGle on page 1001
STOP on page 1001

Trigger out signal setup
Defines the pulse that is provided to the [Trigger Out] connector on the rear panel.

A trigger out pulse can be provided either when a trigger occurs, or when a mask test violation occurs, or when a limit check violation in a measurement occurs.

"Enable trigger out" Generates the trigger out signal on trigger event.
The setting is not available if:
- A mask test is running with "Trigger Out Pulse" set to "On violation".
- A measurement running with limit check enabled and "Trigger Out Pulse" set to "On violation".

"Polarity" Sets the polarity of the trigger out pulse, that is the direction of the first pulse edge.

"Pulse length" Sets the length of the trigger out pulse.

"Delay" Sets the delay of the first pulse edge to the trigger point. The setting is only available if "Enable trigger out" is active.

Remote command:
TRIGger<m>:OUT:STATe on page 1093
TRIGger<m>:OUT:POLarity on page 1093
TRIGger<m>:OUT:PLENgth on page 1093
TRIGger<m>:OUT:DELay on page 1094

Show trigger lines permanently
Displays the trigger levels and the hysteresis in the diagrams until you disable this option.

Remote command:
DISPlay:TRIGger:LINes on page 1053

Hysteresis transparency
Defines the transparency of the hysteresis area above or below the trigger level. The hysteresis is only visible if "Show trigger lines permanently" is enabled.

Actions on trigger
The trigger can initiate several actions, each time a trigger occurs. To activate an action, set it to "On trigger". The following actions are available:

"Beep" Generates a beep sound.

"Print"	Saves a screenshot according to settings in "File" menu > "Print Setup".
"Save Wfm"	Saves the waveform data to a file according to settings in [Save Recall] > "Waveform / Results" > "Waveforms".
"Report"	Creates and saves a report using the settings defined in "File" menu > "Report Setup".
"Start Executable"	Starts an external application. Tap "Config Executable" to set the application path and parameters. See: Chapter 3.5, "External Application", on page 102.

Remote command:

`TRIGger<m>:EVENt:BEEP` on page 1094

`TRIGger<m>:EVENt:PRINt` on page 1094

`TRIGger<m>:EVENt:WFMSave` on page 1095

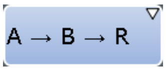
`TRIGger<m>:EVENt:RUNexec` on page 1095

5.8 Sequence

A trigger sequence consists of at least one trigger condition and additional conditions defining when the trigger occurs.

A only

The simple sequence "A only" only contains the A-trigger condition.



A → B → R

The trigger sequence "A → B → R" consists of two subsequent conditions: A-trigger and B-trigger with optional B-trigger delay and count. In addition, a reset condition R can be configured: timeout or R-trigger condition. A-, B-, and R-triggers are configured in the same way.

After the A-trigger conditions have been met, and an optional delay has passed, the B-trigger with independent conditions is enabled. The instrument waits until one or a specified number of B-trigger conditions occur. If the reset condition is not fulfilled, the latest B-trigger causes the trigger event, and then the sequence starts again. The B-trigger can only cause the trigger event if it occurs after the A-trigger and after the delay time.

If you expect, for example, an irregular B-trigger, you can configure a reset condition to restart the sequence. The reset condition can be a simple timeout, and/or a trigger condition that is defined in the same way as the A- and B-trigger conditions. Most trigger types except for Data2Clock, pattern, serial pattern, NFC, CDR, and TV can be used as reset event.

The "A → B → R" trigger sequence requires that input channels CH1...4 are set as trigger sources for all conditions. All other input sources are disabled. The "A → B → R" sequence is not available if one the following trigger types is set as A-trigger:

- Data2Clock
- TV

A OR B

The trigger sequence "A OR B" consists of two independent conditions: A-trigger and B-trigger. The instrument triggers if one of the two conditions is fulfilled. A- and B-triggers are configured in the same way.

The "A OR B" trigger sequence requires that input channels CH1...4 are set as trigger sources for all conditions. All other input sources are disabled. The "A OR B" sequence is not available if one the following trigger types is set as A-trigger:

- Data2Clock
- TV

The instrument checks all trigger settings for compatibility and disables settings that do not fit the previous settings in the sequence.

See also: Chapter 5.2.4, "Setting Up a A → B → R Sequence", on page 183.

If the zone trigger option R&S RTP-K19 is installed, more trigger sequences are available, see Chapter 5.9, "Zone Trigger (Option R&S RTP-K19)", on page 217.

Remote command:

- `TRIGger<m>:SEQuence:MODE` on page 1089

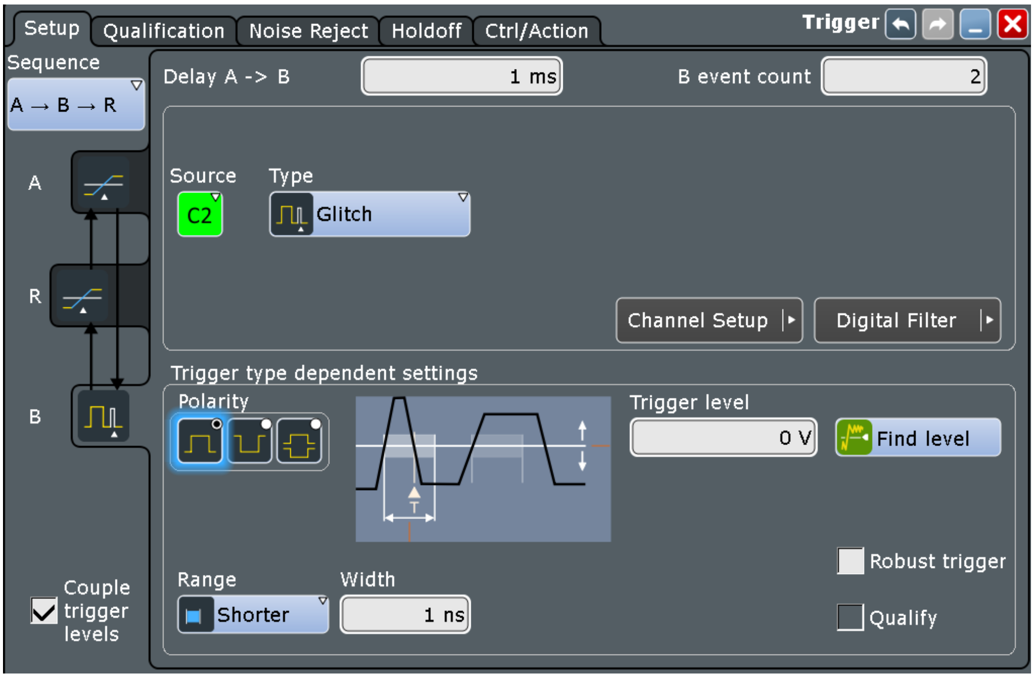
5.8.1 B-Trigger Setup

Access: [Trigger] > "Setup" tab > "A → B → R" sequence > "B" subtab

Access: [Trigger] > "Setup" tab > "A OR B" sequence > "B" subtab

In an "A → B → R" sequence, the B-trigger is the second condition of the trigger sequence. You can configure a delay between the A- and B-trigger, and define a number of fulfilled B-trigger conditions to be ignored. The B-trigger condition is configured in the same way as the A-trigger. The instrument disables settings that do not fit the previous settings in the sequence.

In an "A OR B" sequence, the delay between the events and the B-trigger count are not relevant and cannot be set.



Couple trigger levels
Sets the trigger levels to the values of the current trigger condition. Each channel has its own trigger level.

Example:

If the "A" tab is selected in the "Setup" tab, and the trigger level for C1 is 70 mV, the coupling sets the trigger levels for C1 in the B- and R trigger conditions also to 70 mV. If the B-trigger and/or R-trigger uses another source as the A-trigger, the level remains unchanged.

Remote command:
`TRIGger<m>:ECOupling` on page 1090

Delay
Sets the time that the instrument waits after an A-trigger until it recognizes B-triggers.

Only available in "A → B → R" sequences.

Remote command:
`TRIGger<m>:SEQuence:DELay` on page 1091

B-event count
Sets the number of B-trigger conditions to be fulfilled after an A-trigger. The last B-trigger causes the trigger event.

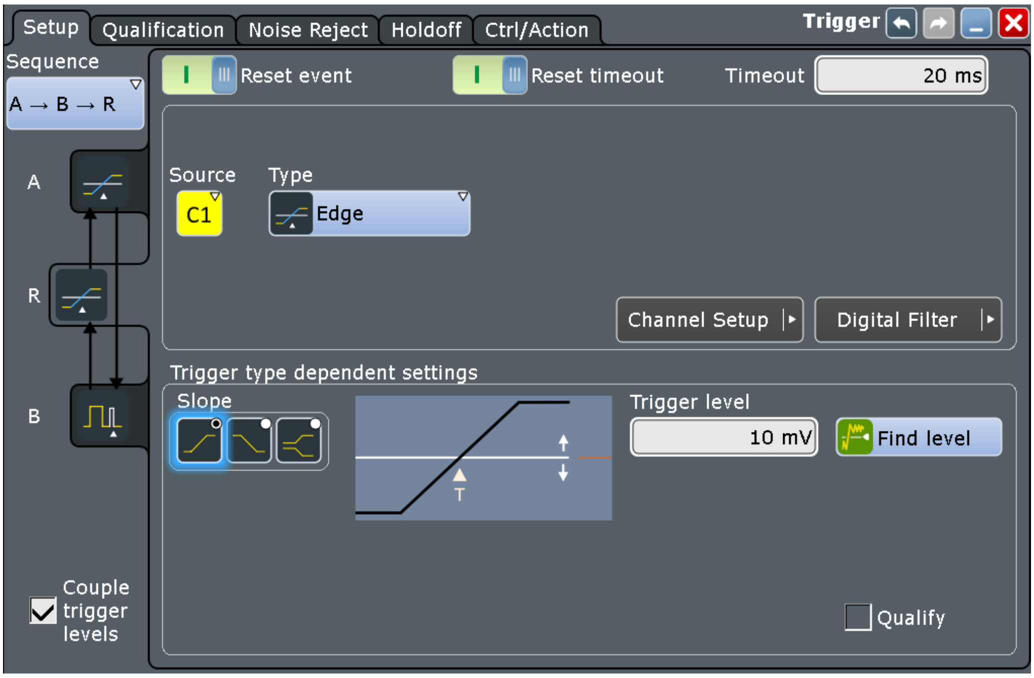
The waiting time for B-triggers can be restricted with a reset condition: timeout or reset event.

Only available in "A → B → R" sequences.

Remote command:
`TRIGger<m>:SEQuence:COUNt` on page 1091

5.8.2 R-Trigger Setup

The reset condition R can be a timeout or a trigger condition, or a combination of both.



Reset timeout / Timeout
If timeout is enabled, the instrument waits for the "Timeout" time for the specified number of B-triggers. If no trigger occurs during that time, the sequence is restarted with the A-trigger.

Remote command:
`TRIGger<m>:SEQuence:RESet:TIMeout[:ENABle]` on page 1091
`TRIGger<m>:SEQuence:RESet:TIMeout:TIME` on page 1092

Reset event
If enabled, the trigger sequence is restarted by the R-trigger condition if the specified number of B-triggers does not occur before the trigger conditions are fulfilled. The R-trigger condition is configured in the same way as the A-trigger. The instrument disables settings that do not fit the previous settings in the sequence.

Remote command:
`TRIGger<m>:SEQuence:RESet:EVENt` on page 1091

5.9 Zone Trigger (Option R&S RTP-K19)

The zone trigger triggers on the intersection or non-intersection of the signal and one or more zones or masks. The zone can be applied to any active input signal, math waveform including FFT, and XY-waveform.

You can use the zone trigger, for example, to solve the following tasks:

- Trigger if a peak in the spectrum occurs, define a zone in the FFT diagram to filter amplitude peaks. In the same way, you can filter harmonics.
- Separate rising and falling edges, define a zone around the base or top of the data signal.
- Separate read/write cycles - define a zone in the eye diagram.
- Identify a tube violation of signals with an infrequent non-monotonic edge.
- Filter events in the history, after acquisition

To document the trigger events, use the actions on trigger. For example, create a report when the instrument triggers, or save the waveform.

You can also combine the zone trigger with common trigger conditions and use one of the following trigger sequences:

- "A → ZoneTrigger"
- "A → B → R → ZoneTrigger"
- "(A OR B) → ZoneTrigger"

Zone trigger is not available for serial protocol triggers.

5.9.1 About Trigger Zones

A zone is a mask without result box. You can adjust the shape of the zone in the same way as mask segments, graphically by dragging the corner points, or numerically in the "Masks" > "Mask Definition" dialog box. You can also use existing masks in the zone trigger. The zone trigger and usual mask tests run in parallel.

If you switch off a mask test that is used by the zone trigger, the mask is removed from the zone trigger expression automatically.

All zones and masks that are included in the zone trigger expression are indicated with yellow color.

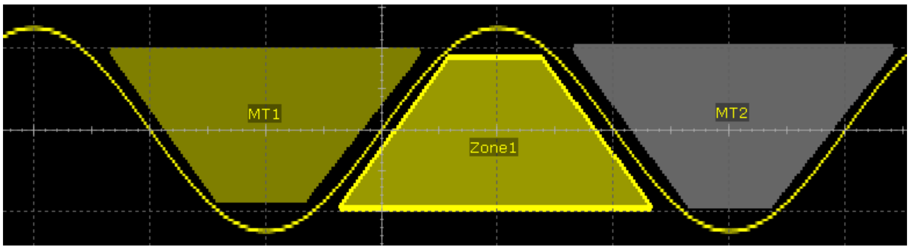


Figure 5-4: Indication of trigger zones

MT1 = Mask is included in zone trigger. Trigger if signal hits the mask (must intersect).
MT2 = Mask is not included in zone trigger.
Zone1 = Zone is included in zone trigger. Trigger if signal does not hit the zone (must not intersect).

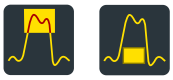
If average or envelope acquisition is enabled, only triggered waveforms are used for envelope and average calculation on channel and math waveforms.

5.9.2 Creating Trigger Zones

You can define the trigger zones on the display, or use existing mask definitions as trigger zones.

Define trigger zones

1. Tap the "Zone trigger" icon on the toolbar.



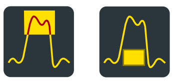
2. In the sidebar, select if the signal must violate the zone to cause a trigger (Must Intersect), or vice versa (Must Not Intersect).
3. Tap the corner points of the zone on the screen.
4. If all points are set, tap "Finish zone" in the sidebar.
   "Zone1" is shown in the expression field.

5. If you want to define another zone, select the logic combination of the zones AND (both zones) or OR (either zone).
6. To create the second zone, repeat steps 3 and 4.
7. To define more zones, repeat steps 5 and 6.

Use existing masks for zone trigger

Prerequisites: At least one mask is created and visible on the display.

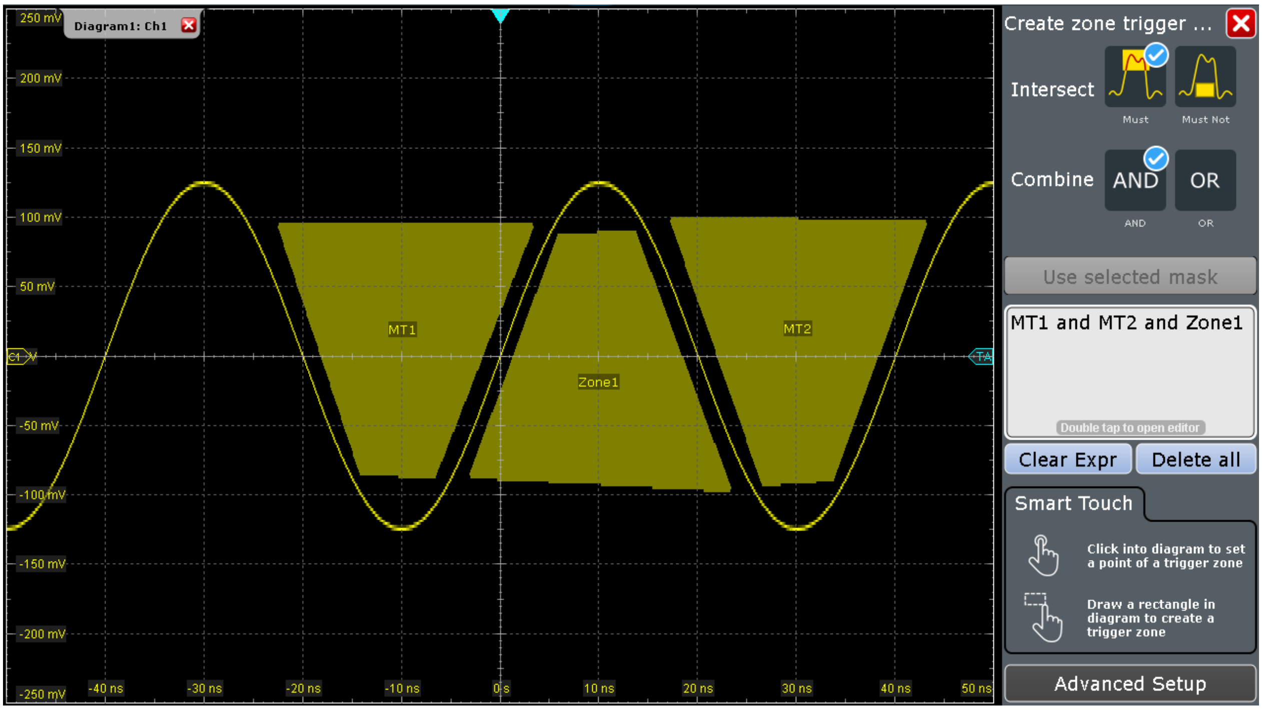
1. Tap the "Zone trigger" icon on the toolbar.



2. In the sidebar, select if the signal must violate the zone to cause a trigger (Must Intersect), or vice versa (Must Not Intersect).
3. Tap the mask on the display.
4. Tap "Use selected mask" in the sidebar.
   "MT1" is shown in the expression field.

5. If you want to add another mask test or zone, select the logic combination of the zones AND (both zones) or OR (either zone).
6. To add another mask, tap the mask on the display.
   Tap "Use selected mask" in the sidebar.
7. To add another zone, tap the corner points of the zone on the screen.
   If all points are set, tap "Finish zone" in the sidebar.

If a zone trigger is already defined, you can also add a new mask to the zone trigger when creating the mask.



Intersect
Defines if the signal must intersect the zone to allow the instrument to trigger, or if it must not intersect the zone.

Combine
Sets the logic combination of two zones.

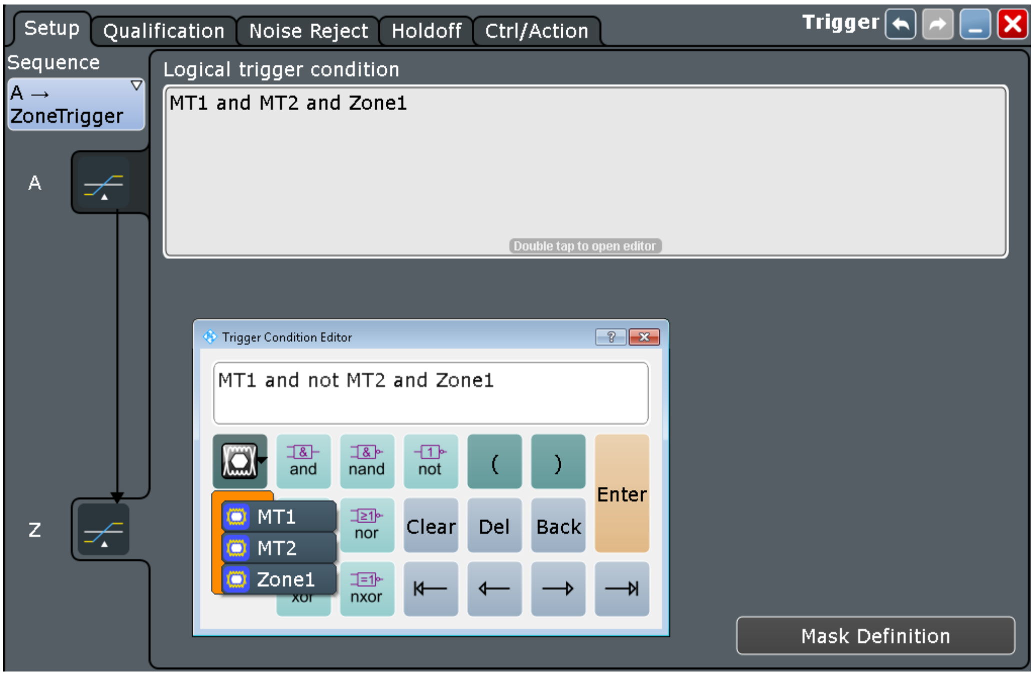
Use selected mask
Includes the selected zone or mask in the zone expression.

Clear Expr
Deletes the zone trigger expression. The zones are not deleted, they remain as usual masks, and the result boxes of the mask test appear.

Delete all
Deletes the zone trigger expression and the zones.

5.9.3 Advanced Setup and Analysis with Zone Trigger

Access: Zone trigger sidebar > "Advanced Setup", or "Trigger" menu > "Setup" > select sequence with zone trigger > "Z" subtab



Logical trigger condition
If all required mask tests and zones are defined, you can type the logical expression directly, or use the trigger condition editor. All logical combinations are available in the editor. To express the "Must Not Intersect" condition, use the logic NOT.

Remote command:
`TRIGger<m>:ZONE:EXPRession[:DEFine]` on page 1095

Apply ZoneTrigger to history
Applies the zone trigger condition to the acquisitions in the history memory.

The history saves all acquisitions that fulfill the trigger condition that is set during acquisition (zone trigger condition, or another trigger condition). If "Apply ZoneTrigger to history" is disabled, the history "Play" reads and displays all saved acquisitions from the memory.

If the setting is enabled, the zone trigger is applied to the history replay. "Play" displays only acquisitions that fulfill the zone trigger condition.

Using "Apply ZoneTrigger to history", you can:
- Acquire waveforms with high speed and filter them afterwards in the history.
- Change the zone trigger condition after acquisition.

Remote command:
`SWTRigger:HISTory` on page 1096

5.10 External Trigger Input

Except for using analog or digital input channels as trigger source, you can also use external signals as trigger source. The external signal is connected to the external trigger input, which is equipped with the Rohde & Schwarz probe interface. Thus, you can use all Rohde & Schwarz probes to connect the external trigger signal. The only trigger type to trigger on external signals is the edge trigger.

1. Connect the external trigger signal to the external trigger input.
2. Set up the probe: "Trigger" menu > "Extern" tab.
   See Chapter 5.10.1, "Probe Setup: Extern Tab", on page 222.
3. Set up the trigger:
   a) Select the "Trigger" > "Setup" tab.
   b) Select the source: "Extern"
   c) Adjust the trigger settings.
      See Chapter 5.10.2, "External Trigger Setup", on page 223.

If the trigger source is a channel input, the trigger system uses the digitized signal. The trigger system of the instrument is a separate system, thus the signal processing by enhancement, decimation and arithmetic has no impact on the trigger signal. Most of the R&S RTP trigger types use the digitized trigger signal.

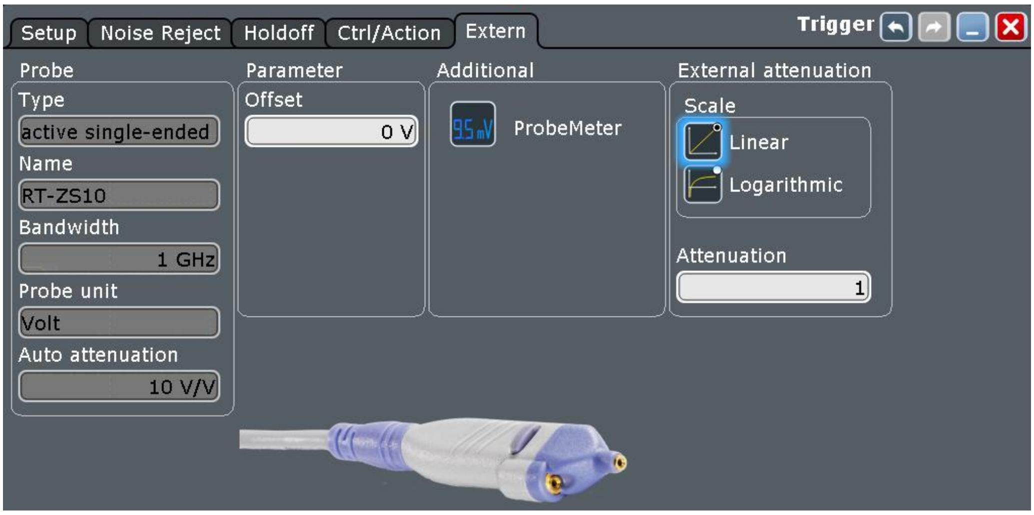
If the trigger source is the external trigger input, the trigger comparator uses the analog input signal. For the external trigger signal, only the edge trigger of the A-trigger is available. Trigger sequence is not supported.

Qualification of the external trigger signal is not available.

5.10.1 Probe Setup: Extern Tab

The "Trigger" > "Extern" tab provides all settings that are relevant for the probe that is connected to the external trigger input. The functionality on the tab changes according to the type of the attached probe. They are the same as for probe setup of input channels: see Chapter 4.5, "Probes", on page 139.

If the external trigger input is overloaded, a message informs you.



Remote commands:

- TRIGger<m>:EXTern:OVERload on page 1096
- TRPRobe:ID:PARTnumber? on page 1037
- TRPRobe:SETup:STATe? on page 1018
- TRPRobe:SETup:TYPE? on page 1018
- TRPRobe:SETup:ATTenuation:DEFProbe on page 1035
- TRPRobe:SETup:ATTenuation:MANual on page 1025
- TRPRobe:SETup:ATTenuation:MODE on page 1024
- TRPRobe:SETup:ATTenuation:UNIT on page 1025
- TRPRobe:SETup:ATTenuation[:AUTO]? on page 1019
- TRPRobe:SETup:NAME? on page 1018
- TRPRobe:SETup:BANDwidth? on page 1018
- TRPRobe:SETup:CMOFfset on page 1026
- TRPRobe:SETup:GAIN:MANual on page 1025
- TRPRobe:SETup:ZAXV on page 1026

R&S ProbeMeter: remote commands:

- TRPRobe:SETup:DISPlaydiff on page 1022
- TRPRobe:PMETer:VISibility on page 1022
- TRPRobe:PMETer:RESults:COMMon? on page 1023
- TRPRobe:PMETer:RESults:DIFFerential? on page 1023
- TRPRobe:PMETer:RESults:NEGative? on page 1023
- TRPRobe:PMETer:RESults:POSitive? on page 1024
- TRPRobe:PMETer:RESults:SINGle? on page 1022

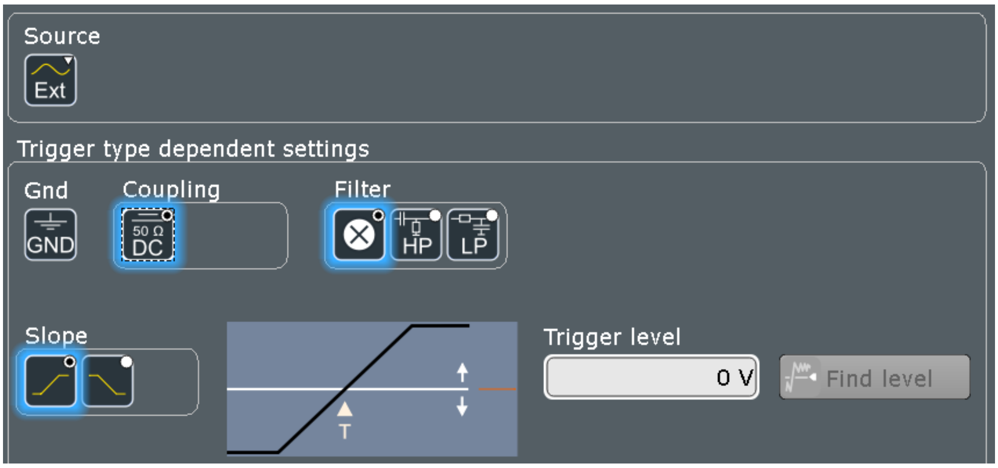
Probe attributes: remote commands

- TRPRobe:ID:PRDate? on page 1037
- TRPRobe:ID:SRNumber? on page 1038
- TRPRobe:ID:SWVersion? on page 1037
- TRPRobe:SETup:CAPacitance? on page 1038
- TRPRobe:SETup:IMPedance? on page 1038

5.10.2 External Trigger Setup

Access: [Trigger] > "Setup" tab > "Source = Extern"

External trigger signals, which are connected to the external trigger input, can be triggered with an edge trigger. The "Find level" function is not available for external trigger signals.



Ground

If the selected trigger source is the external trigger input, you can connect the trigger input to the ground.

Remote command:

`TRIGger<m>:ANEDge:GND` on page 1058

Coupling

The external trigger input is a direct connection with 50 Ω termination, which passes both DC and AC components of the trigger signal.

Remote command:

`TRIGger<m>:ANEDge:COUPling` on page 1056

Filter

If the selected trigger source is "Extern" (external trigger input), you can directly select a filter to reject high or low frequencies.

For all other trigger sources, you can add a digital filter using the Digital Filter Setup.

"Off"	The trigger signal is not filtered.
"Highpass"	Frequencies below the "Cut-off" frequency are rejected, higher frequencies pass the filter. You can adjust the "Cut-off" frequency, the default is 50 kHz.
"Lowpass"	Frequencies higher than the "Cut-off" frequency are rejected, lower frequencies pass the filter. You can adjust the "Cut-off" frequency, the default is 50 kHz.

Remote command:

`TRIGger<m>:ANEDge:FILTer` on page 1056

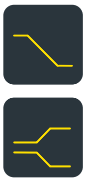
`TRIGger<m>:ANEDge:CUToff:HIGHpass` on page 1057

`TRIGger<m>:ANEDge:CUToff:LOWPass` on page 1057

Slope

Sets the edge type for the trigger condition.

"Positive"	Selects the rising edge, that is a positive voltage change.
"Negative"	Selects the falling edge, that is a negative voltage change.



"Both" Selects the rising as well as the falling edge. This option is not available if the trigger source is the external trigger input.

Remote command:
TRIGger<m>:EDGE:SLOPe on page 1056
TRIGger<m>:ANEDge:SLOPe on page 1058
TRIGger<m>:SLEW:SLOPe on page 1068

Trigger level

Sets the voltage level for the trigger condition. You can also drag the trigger level marker on the display (TA or TB on the right edge of the display). The range of the trigger level is limited in a way so that always a hysteresis for stable trigger conditions is available.

Remote command:
TRIGger<m>:LEVel<n>[:VALue] on page 1055

5.11 Acquisition Info

Access: "Trigger" menu > "Acquisition Info"

Shows the current number of acquisitions that have been acquired. The count is shown for a running acquisition cycle and as well for the last stopped acquisition cycle.

Remote command:

ACQuire:CURRent? on page 1096

6 Waveform Analysis

This chapter describes general methods to check and analyze waveforms. These are:

6.1 Zoom

The zoom functions allow you to magnify a specific section of the diagram in order to view more details. You can define several zoom areas for the same diagram and even couple them, or you use the hardware zoom.

6.1.1 Methods of Zooming

The R&S RTP provides various ways of zooming: You define the section of a diagram that you want to magnify, and the zoomed view is shown in a separate zoom diagram. Additionally, you can magnify the diagram directly: The hardware zoom changes the horizontal and vertical scales of the diagram so that you see the selected section.

There are different ways to initiate and configure the zoom function:

- **Fingertip zoom**: magnifies the waveforms around your fingertip. When you drag your finger, the magnifier moves, too. You can convert the fingertip zoom into a standard zoom diagram.
- **Graphical method**: you draw, move and adjust the zoom area on the touchscreen – a very quick and simple method for standard zoom and hardware zoom.
- **Numeric method**: you enter x- and y-values in a dialog box or adjust them using navigation controls. These are precise ways which can be used to optimize a graphically defined zoom.
  With the numeric method there are two ways of defining the zoom area:
  – Specifying **start and stop values** for the x- and y-axes; the acquired data within those values is zoomed.

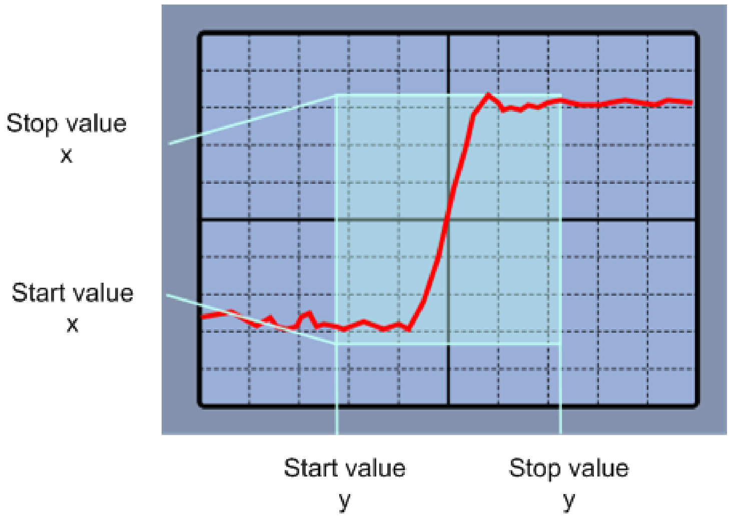


Figure 6-1: Numeric zoom using start and stop values

– Specifying the x- and y-**position** of the centerpoint of the area plus a **range** for the x- and y-axes; the area defined by that centerpoint and the ranges is zoomed.

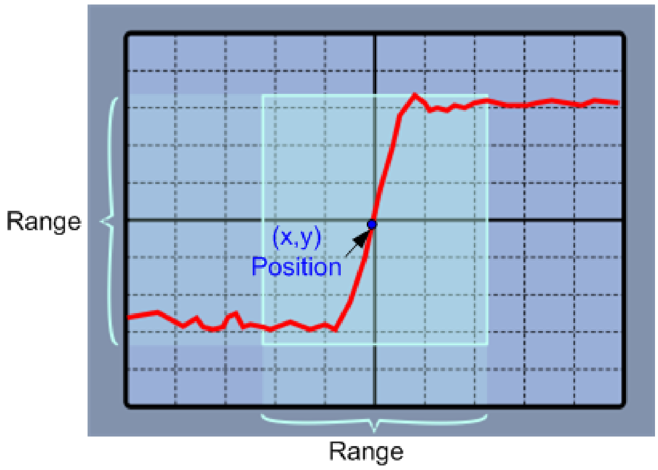


Figure 6-2: Numeric zoom using position and range

- **Coupled zoom** creates a copy of the selected zoom area. Coupled zoom areas always have the same size (size coupling). They can be positioned separately or together (position coupling).

Zoom areas can be used for gating, for example, to define a measurement gate. You can set the gate exactly to the limits of the zoom.

Evaluation gates - available histogram areas, masks, and measurement gates - can be displayed in zoom diagrams to simplify the graphical gate adjustment on the touch-screen. See: "Show evaluation gate(s) in zoom" on page 96.

6.1.2 Zoom Settings

The zoom area, i.e. the section to be enlarged, can be defined using two different methods:

- Using the zoom functions on the toolbar and draw the zoom area on the touch-screen
- Specifying numeric values:
  - start and stop values for the x- and y-axes
  - x and y position of one point in the diagram plus a range for the x- and y-axes

  See also: Chapter 6.1.1, "Methods of Zooming", on page 226.

6.1.2.1 Zoom Functions on the Toolbar

The zoom icon on the toolbar shows the last selected zoom type. A short tap on the icon activates the selected zoom. If you touch the icon and drag your finger down, a menu opens where you can select another zoom type.

Standard zoom
Displays a magnified section of the diagram in an additional zoom diagram. It is a display zoom, instrument settings are not changed.

Touch and hold the zoom area to open the "Zoom" dialog box.

Remote command:
`LAYout:ZOOM:ADD` on page 1097

Hardware zoom
Changes the instrument settings - horizontal and vertical scales as well as trigger level and offset - to display a part of the diagram in greater detail.

Coupled zoom
Creates a coupled zoom area and its related zoom diagram. If you change the size of one zoom area, the size of all coupled zoom areas is changed as well.

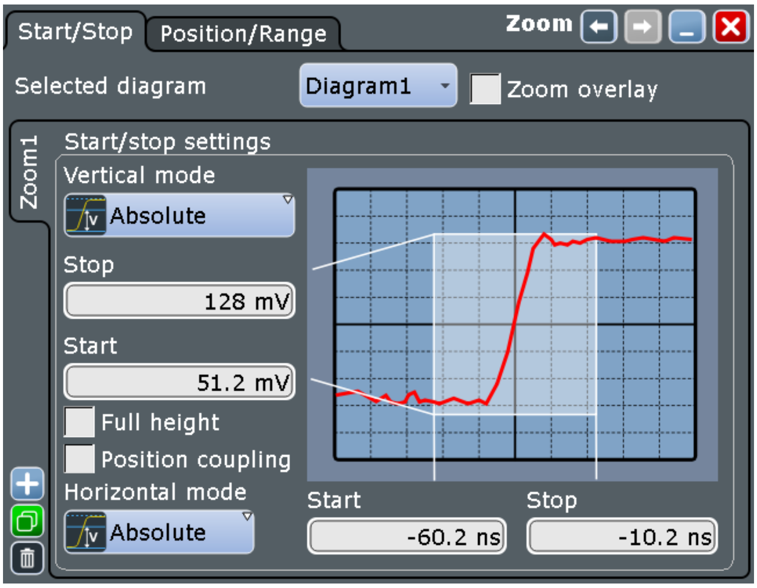
Remote command:
`LAYout:ZOOM:ADDCoupled` on page 1098

Fingertip zoom
Magnifies the waveforms around your fingertip.

Tap the icon and put your finger on the waveform. The touched part of the waveform is displayed in a magnifier. Drag your finger on the screen to move the magnifier. You can change the zoom factor using the Navigation knob.

6.1.2.2 Start and Stop Settings

The "Start/Stop" tab allows you to specify start and stop values for the x- and y-axes. The acquired data within these ranges is zoomed.



Selected diagram
Indicates which of the waveform diagrams is selected for zooming.

Zoom overlay
Shows all zooms of a diagram in one zoom window. The zoomed areas are overlaid for better comparison of the zoomed waveforms.

The setting affects all zoom diagrams.

Remote command:
`LAYout:ZOOM:ONEDiagram` on page 1098

Vertical
Defines whether absolute or relative values are used to specify the y-axis values.

Remote command:
`LAYout:ZOOM:VERTical:MODE` on page 1102
`SEARch:RESDiagram:VERT:MODE` on page 1268

Stop / Relative stop
Defines the upper limit of the zoom area on the y-axis.

Remote command:
`LAYout:ZOOM:VERTical:RELative:STOP` on page 1104
`LAYout:ZOOM:VERTical:ABSolute:STOP` on page 1103

Start / Relative start
Defines the lower limit of the zoom area on the y-axis.

Remote command:
LAYout:ZOOM:VERTical:RELative:STARt on page 1104
LAYout:ZOOM:VERTical:ABSolute:STARt on page 1102

Full height
Uses the full diagram height for the zoom area. Only horizontal zoom settings can be changed.

Position coupling
Enables or disables the position coupling of coupled zooms. If position coupling is enabled and you move one zoom area, the other coupled zoom areas are moved, too, and keep their distance.

Remote command:
LAYout:ZOOM:POSCoupling on page 1098

Horizontal
Defines whether absolute or relative values are used to specify the x-axis values.

Remote command:
LAYout:ZOOM:HORZ:MODE on page 1099
SEARch:RESDiagram:HORZ:MODE on page 1266

Start / Relative start
Defines the lower limit of the zoom area on the x-axis.

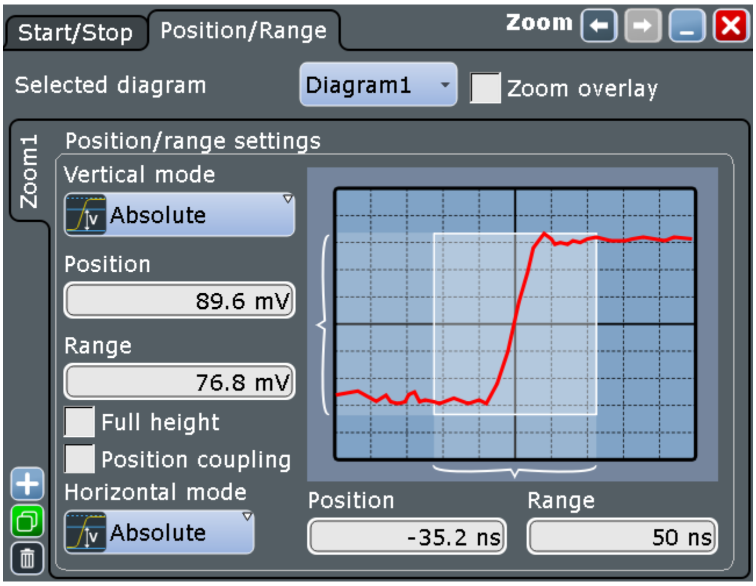
Remote command:
LAYout:ZOOM:HORZ:ABSolute:STARt on page 1100
LAYout:ZOOM:HORZ:RELative:STARt on page 1101

Stop / Relative stop
Defines the upper limit of the zoom area on the x-axis.

Remote command:
LAYout:ZOOM:HORZ:ABSolute:STOP on page 1100
LAYout:ZOOM:HORZ:RELative:STOP on page 1101

6.1.2.3 Position and Range Settings

In the "Position/Range" tab, you specify the x and y position of center point of the zoom area plus a range for the x- and y-axes; the area defined by that point and the ranges is zoomed.



Vertical

Defines whether absolute or relative values are used to specify the y-axis values.

Remote command:

LAYout:ZOOM:VERTical:MODE on page 1102

SEARch:RESDiagram:VERT:MODE on page 1268

Position / Relative position (vertical)

Defines the y-value of the centerpoint of the zoom area.

Remote command:

LAYout:ZOOM:VERTical:ABSolute:POSition on page 1102

LAYout:ZOOM:VERTical:RELative:POSition on page 1103

SEARch:RESDiagram:VERT:ABSolute:POSition on page 1267

SEARch:RESDiagram:VERT:RELative:POSition on page 1268

Range / Relative Range (vertical)

Defines the height of the zoom area.

Remote command:

LAYout:ZOOM:VERTical:RELative:SPAN on page 1103

LAYout:ZOOM:VERTical:ABSolute:SPAN on page 1102

SEARch:RESDiagram:VERT:ABSolute:SPAN on page 1268

SEARch:RESDiagram:VERT:RELative:SPAN on page 1268

Full height

Uses the full diagram height for the zoom area. Only horizontal zoom settings can be changed.

Position coupling

Enables or disables the position coupling of coupled zooms. If position coupling is enabled and you move one zoom area, the other coupled zoom areas are moved, too, and keep their distance.

Remote command:
LAYout:ZOOM:POSCoupling on page 1098

Horizontal
Defines whether absolute or relative values are used to specify the x-axis values.

Remote command:
LAYout:ZOOM:HORZ:MODE on page 1099
SEARch:RESDiagram:HORZ:MODE on page 1266

Position / Relative position (horizontal)
Defines the x-value of the centerpoint of the zoom area.

Remote command:
LAYout:ZOOM:HORZ:ABSolute:POSition on page 1099
LAYout:ZOOM:HORZ:RELative:POSition on page 1100
SEARch:RESDiagram:HORZ:ABSolute:POSition on page 1266
SEARch:RESDiagram:HORZ:RELative:POSition on page 1267

Range / Relative Range (horizontal)
Defines the width of the zoom area.

Remote command:
LAYout:ZOOM:HORZ:ABSolute:SPAN on page 1099
LAYout:ZOOM:HORZ:RELative:SPAN on page 1101
SEARch:RESDiagram:HORZ:ABSolute:SPAN on page 1266
SEARch:RESDiagram:HORZ:RELative:SPAN on page 1267

6.1.3 Zooming for Details

The usage of the various zoom methods is described in the following procedures:

- To define the zoom area graphically on the touchscreen
- To define the zoom area numerically using start-stop values
- To define the zoom area numerically using position and range values
- To define multiple zoom areas
- To define coupled zoom areas
- To close the zoom diagram
- To use the hardware zoom

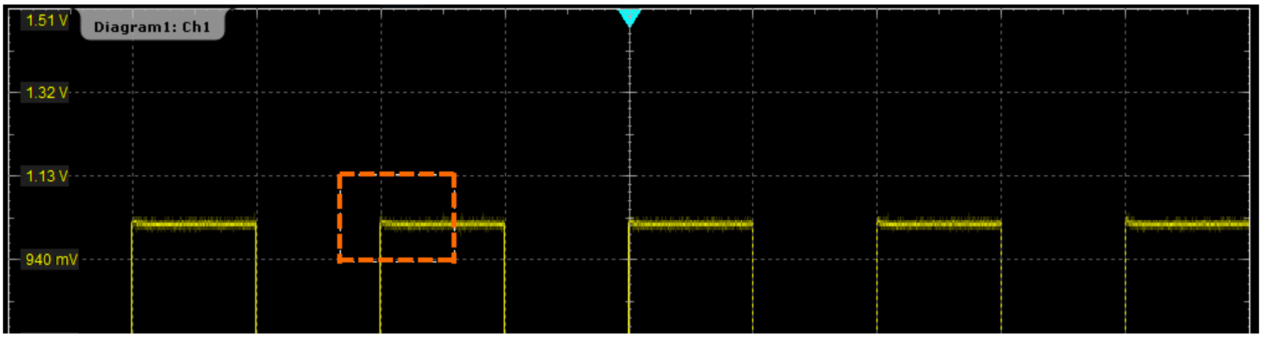
The usage of zooms is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Zoom".

To define the zoom area graphically on the touchscreen

For graphical zooming, you use your finger on the screen.

1. On the toolbar, tap the "Standard Zoom" icon.

2. Touch the position that you want to define as one corner of the zoom area. Then drag your finger to the opposite corner of the zoom area.
   While you drag your finger on the touchscreen, a dotted rectangle indicates the current zoom area. When the rectangle covers the required zoom area, remove your finger.



The indicated area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle.

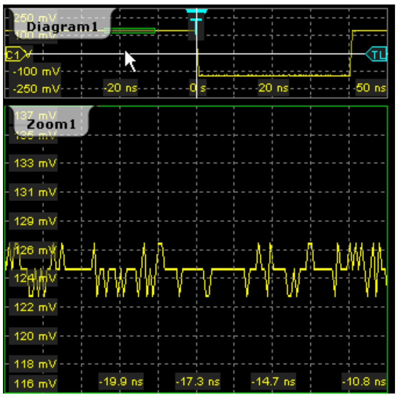


Figure 6-3: Zoom diagram and overview diagram

3. If the position of the zoom area is not correct, drag the rectangle in the overview to the correct position.
4. If the size of the zoom area is not yet ideal, tap the rectangle in the overview diagram.
   Now, 4 red lines indicate the edges of the zoom area. A dashed red line indicates the selected edge, which you can adjust.

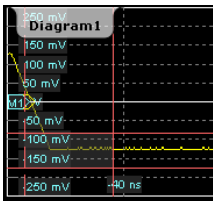


Figure 6-4: Zoom area indicated by edges

Note: Tapping the zoom area toggles between area and edge adjustment.

If the rectangle area is too small to select by tapping, press the CHECKMARK key in the navigation area to toggle between area adjustment and edge adjustment modes.

5. Touch the edge that you want to move, and drag it to the required position.

To optimize the zoom definition of an active zoom diagram, double-tap the zoom diagram. The "Zoom" dialog box for numeric definition is opened.

To adjust the zoom area using navigation controls

If you have created a zoom, and the size and position are not yet ideal, you can adjust them using the navigation knob and the navigation keys. You can adjust the size and position of the zoom area, or adjust the edges of the zoom area individually.

1. To adjust the size and position of the zoom area:
   a) Press the [☑] key until the zoom area is active (grey rectangle with white border).
   b) Turn the navigation knob to shift the zoom area. Press the knob twice to toggle between vertical and horizontal move.
   c) To adjust the size of the zoom area, press the navigation knob until "Span" is shown in the upper left corner.
   d) Turn the knob to increase or decrease the zoom area.

   Note: Pressing the navigation knob toggles between: horizontal position > horizontal span > vertical position > vertical span.

   Tip: If several zoom areas are visible, or cursors are active in addition, the [⇤] and ⇥ keys toggle between the zoom areas and the cursor sets.

2. To adjust the edges of the zoom area:
   a) Press the [☑] key until 4 red lines indicate the edges of the zoom area. A dashed red line indicates the selected edge, which you can adjust.
   b) Press the navigation knob until the required edge is selected (dashed red line).
   c) Turn the navigation knob to move the active edge to the required position.
   d) Press the navigation knob again. Adjust the next edge.

   Tip: Pressing the [▲] or [▼] keys moves the selected edge to the next division line left (DOWN) or right (UP). In area adjustment mode, these keys move the zoom area one division to the left (DOWN) or right (UP).

To create a new zoom using the Zoom dialog box

1. There are two ways to create a new zoom:
   - If you want to create a new, unconfigured zoom, tap the "Add" icon.
   - If you want to create zoom based on an existing one, tap the "Copy" icon.

2. Enter a name for the zoom using the on-screen keyboard.

To define the zoom area numerically using start-stop values

1. On the "Display" menu, tap "Zoom".
2. Select the Start and Stop Settings tab.
3. Under "Vertical mode", select whether you want to define absolute or relative y-axis values. Relative values cause the zoom area to adapt to the input values dynamically.
4. Define the "Start" and "Stop" values that define the lower and upper borders (respectively) of the zoom area on the y-axis (see Figure 6-1).
5. Under "Horizontal mode", select whether you want to define absolute or relative x-axis values.
6. Define the "Start" and "Stop" values that define the lower and upper borders (respectively) of the zoom area on the x-axis.

   When you close the dialog box, the specified area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle (see Figure 6-3).

To define the zoom area numerically using position and range values

1. On the "Display" menu, tap "Zoom".
2. Select the Position and Range Settings tab.
3. Under "Vertical mode", select whether you want to define absolute or relative y-axis values. Relative values cause the zoom area to adapt to the input values dynamically.
4. Under "Position", define the y-value of the center point of the zoom area (see Figure 6-2).
5. Under "Range", define the height of the zoom area.
6. Under "Horizontal mode", select whether you want to define absolute or relative x-axis values.
7. Under "Position", define the x-value of the center point of the zoom area.
8. Under "Range", define the width of the zoom area.

   When you close the dialog box, the specified area is magnified in a new zoom diagram. The original diagram is displayed with the zoom area indicated as a rectangle.

To define multiple zoom areas

You can define more than one zoom area for the same diagram, for example to compare several peaks in a measurement. These zoom areas can be displayed in separate zoom diagrams, or together in one zoom diagram.

To define multiple zoom areas graphically, simply repeat the steps described in To define the zoom area graphically on the touchscreen - for each area. Numerically, proceed as follows:

1. On the "Display" menu, tap "Zoom".
2. Select the required tab according to the method you want to use to define the zoom area.
3. To copy the current zoom area definition, tap the "Copy" icon.
   Alternatively, tap the "Add" icon to add a new zoom area.
4. Enter a name for the new zoom diagram using the displayed on-screen keyboard.
5. Define the zoom area as described for the first zoom.

   An additional zoom diagram is displayed for the new zoom area, and another rectangle in the original diagram indicates the new zoom area. Each rectangle in the overview has the same color as the corresponding zoom diagram frame.
6. In the "Zoom" dialog box, enable "Zoom overlay".

   The zooms are shown in the same zoom diagram, as if the zoom areas are overlaid.

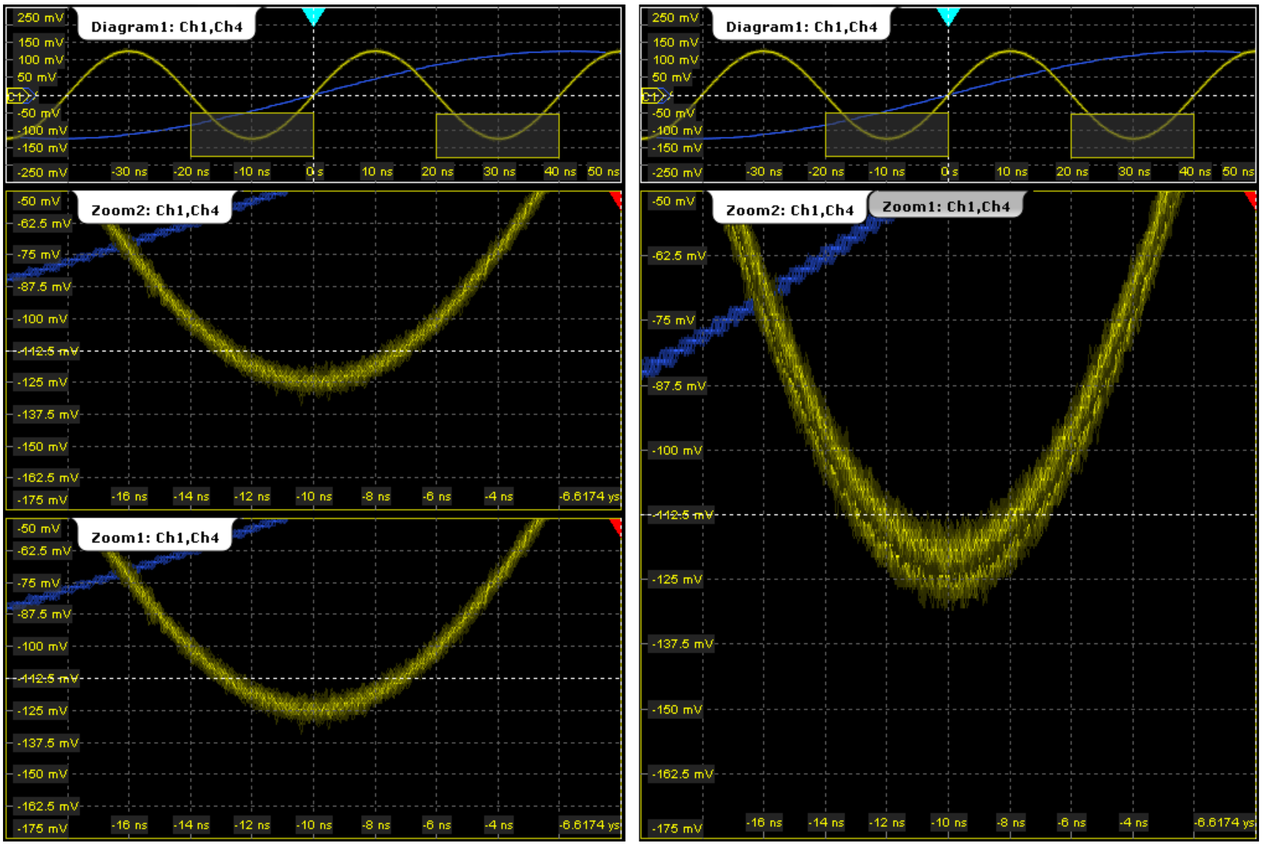


Figure 6-5: Multiple zoom diagrams. Left: separate zoom diagrams. Right: overlaid zoom

To define coupled zoom areas

You can define multiple zoom areas for one diagram that are coupled. If you change the size of one zoom area, the size of all coupled zoom areas is changed as well. Furthermore, you can couple also the position in order to move all coupled zooms at once. Coupling is useful, for example, if you want to compare recurring peaks in a signal.

1. On the toolbar, tap the "Coupled Zoom" icon.

2. In the diagram overview, tap an existing zoom area.

   The selected zoom area is duplicated.

3. Drag the duplicate zoom area to the required position.
4. To create further coupled zooms, repeat the steps above.

   Now, if you change the zoom area size of any of the coupled zoom areas in the "Zoom" dialog box, the settings are changed for all coupled zoom areas.

5. In the "Zoom" dialog box, select the diagram that contains the coupled zooms.
6. Select a zoom tab.
7. Enable "Position coupling".

   If you move one of the coupled zoom areas in the diagram, all other coupled zooms are moved as well, and their distance is kept unchanged.

To close the zoom diagram

1. Tap the "Delete" icon on the toolbar.
2. Tap the zoom diagram.

   The diagram in the overview diagram returns to the original display size.

To use the hardware zoom

In contrast to the normal zoom, the hardware zoom changes the instrument settings - horizontal and vertical scales, and also the trigger level and offset. Thus, the selected area is displayed in the diagram instead of the original waveform. No additional zoom diagram is opened.

1. On the toolbar, tap the "Hardware Zoom" icon.

2. Drag your finger on the touch screen to mark the zoom area.
   A dotted rectangle indicates the current zoom area. When the rectangle covers the required zoom area, remove your finger. The diagram changes and shows the magnified area.

   Tip: To return to the previous display, use the "Undo" icon.

Note: You can combine hardware zoom and normal zoom - first use the hardware zoom, then the zoom into the display. The reverse approach is also possible: Create a zoom diagram, and then apply the hardware zoom to the waveform diagram. Both the waveform and the zoom diagrams are changed.

6.2 Reference Waveforms

You can configure up to four reference waveforms to display stored waveforms. Any active signal or mathematical waveform can be stored as a reference waveform. It can then be loaded again later to restore the waveform on the screen.

6.2.1 Working with Reference Waveforms

Reference waveforms can be displayed in addition to the signal waveforms, saved to file, and loaded back for further analysis. Reference waveforms can be loaded only from BIN files.

Note: Saving and loading reference waveforms, and preset with active reference waveform delete the undo stack. After these actions, undo is not possible.

To update a reference waveform using the toolbar icon

If you often need to update a reference waveform, you can use the "Update Ref Wfm" toolbar icon.

1. Add the "Update Ref Wfm" icon to the toolbar, see Chapter 2.3.5.2, "Configuring the Toolbar", on page 64.
2. Touch the icon and open the icon menu.

3. Select the reference waveform to be used.
4. Tap the waveform to be used as reference waveform.

To display a reference waveform

1. In the "Math" menu, select "Reference Waveform > Setup", or press the [Ref] key.
2. Select the tab for the reference waveform you want to display ("Ref1"-"Ref4").
3. Load a stored reference waveform as described in "To load a reference waveform" on page 239, or select a source to be displayed as a reference:

a) In the "Reference" tab, tap the "Selected source" icon and select a source from the selection list. The source can be any active signal, math, or other reference waveform.
b) Tap the "Update with" button to update the current reference waveform with the source data.

4. Tap the "Show reference waveform" icon so it is highlighted.

   The reference waveform is displayed on the screen.

To save a reference waveform

1. In the "Math" menu, select "Reference Waveform > Setup", or press the [Ref] key.

   Tip: You can also save a waveform as a reference waveform in the "File" dialog box, see Chapter 11.2.6, "Saving and Loading Waveform Data", on page 446. Here, you can also save multiple waveforms in one file.
2. Select the tab for the reference waveform you want to store ("Ref1"-"Ref4").
3. Display and configure the reference waveform as described in "To display a reference waveform" on page 238.
4. Select the file format.

   Note: Reference waveforms can be loaded only from BIN files. XML and CSV formats are meant for further processing in other applications.
5. To save the waveform to the currently selected file, tap "Save". By default, the prefix for reference waveform files is "RefCurve".
   To save the waveform to another file, select "Save As".
   Enter a file name and select the directory. The file type is already defined according to the selection in the previous step. In order to load the reference waveform on the instrument again later, use the file type BIN.

   The source settings of the reference waveform and the current scaling settings are stored to the specified file.

To load a reference waveform

Note: Reference waveforms can be loaded only from BIN files.

1. In the "Math" menu, select "Reference Waveform > Setup", or press the [Ref] key.
2. Select the tab for the reference waveform you want to load ("Ref1" - "Ref4").
3. To load the waveform from the specified file, tap "Load".
   To load the waveform from a different file, tap "Open". Select the file from the file selection dialog box. Only BIN files are displayed in the file list.

   The selected waveform is loaded as the specified reference waveform.
   If multiple waveforms are saved in the file, you are asked to assign each waveform to a reference waveform. All waveforms are loaded together.
4. If the reference waveform is not visible, tap the "Show reference waveform" icon.

To view a reference waveform

► You can view a reference waveform, using the "Graphical Recall" function.
For details, see: Chapter 11.1.3, "Graphical Recall Function", on page 425.

6.2.2 Settings for Reference Waveforms

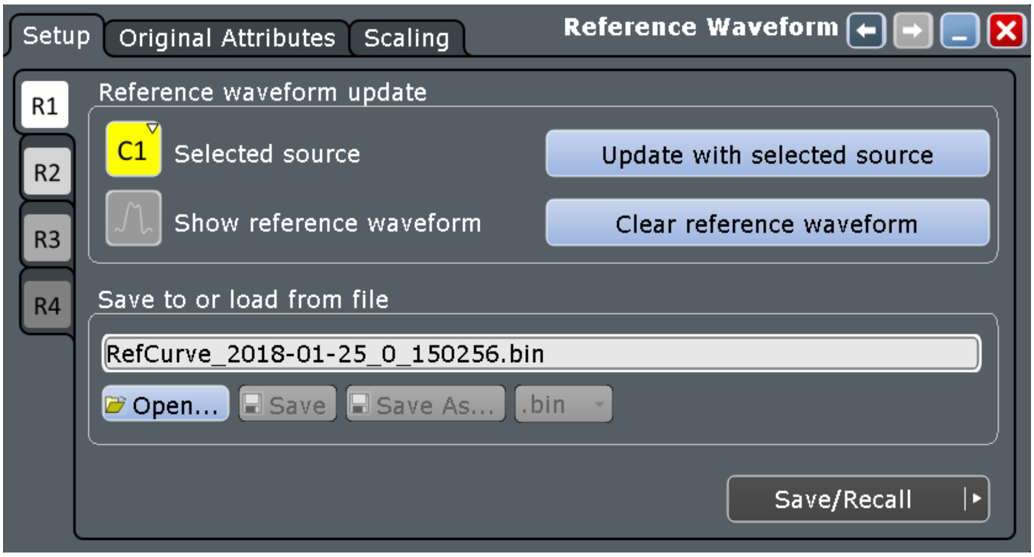
To compare waveforms and analyze differences between waveforms, you can use up to four reference waveforms R1 to R4. Each reference waveform has its own memory on the instrument. You can also save an unlimited number of reference waveforms and load them for further use.

The display of a reference waveform is independent from that of the source waveform; you can move, stretch and compress the curve vertically and horizontally.

6.2.2.1 Reference Waveform Setup

Access: [Ref] key

In the "Setup" tab, you select the reference waveform and its source. The source can be an active waveform - trace of an input channel, math waveform or another reference waveform - or a stored waveform.



Ref 1/2/3/4
Each tab contains the settings for one of the four available reference waveforms.

Source
Selects the source waveform from the active waveforms of input channels, math signals and other reference waveforms.

Remote command:
`REFCurve<m>:SOURce` on page 1105

Update with selected source
Copies the selected source waveform with all its settings to the memory of the reference waveform. If the acquisition is running, the reference waveform is a snapshot.

Remote command:
`REFCurve<m>:UPDate` on page 1106

Show reference waveform
Displays the reference waveform in the diagram.

Remote command:
`REFCurve<m>:STATe` on page 1105

Clear reference waveform
The selected reference waveform disappears, its memory is deleted.

Remote command:
`REFCurve<m>:CLEar` on page 1107

Save to or load from file
Enter the file name of the stored reference waveform and select the file format with the format button on the right. Double-tap the file name to open the file selection dialog box, see also Chapter 11.7, "File Selection Dialog", on page 461.

By default, the file name has the prefix "RefCurves_". You can define a pattern for automatic naming in the "Autonaming" tab.

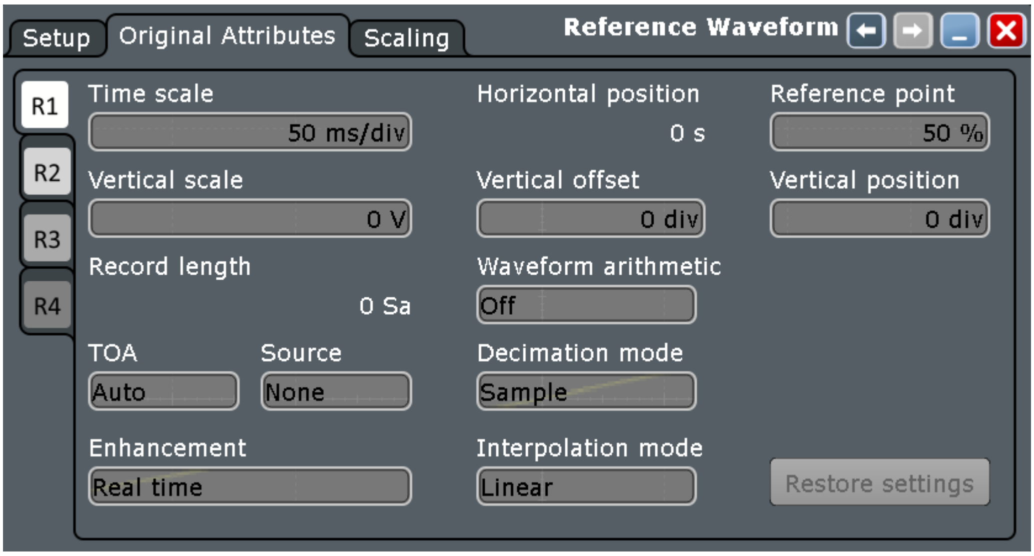
Note: Note that reference waveforms can be loaded from `.bin` files only. xml and csv formats are meant for further processing in other applications.

"Load"	Loads the specified reference waveform.
"Open"	Opens a file selection dialog box and loads the selected reference waveform file.
"Save"	Saves the waveform as a reference waveform in the selected file.
"Save As..."	Opens the file selection dialog box and saves the waveform to the selected file.
".bin/.xml/.csv"	Selects the file format.

Remote command:
`REFCurve<m>:OPEN` on page 1106
`REFCurve<m>:SAVE` on page 1106
`REFCurve<m>:DELete` on page 1107

6.2.2.2 Original Attributes

As a reference waveform can be scaled, stretched and positioned in the diagram, this tab shows the settings of the original reference waveform for information.

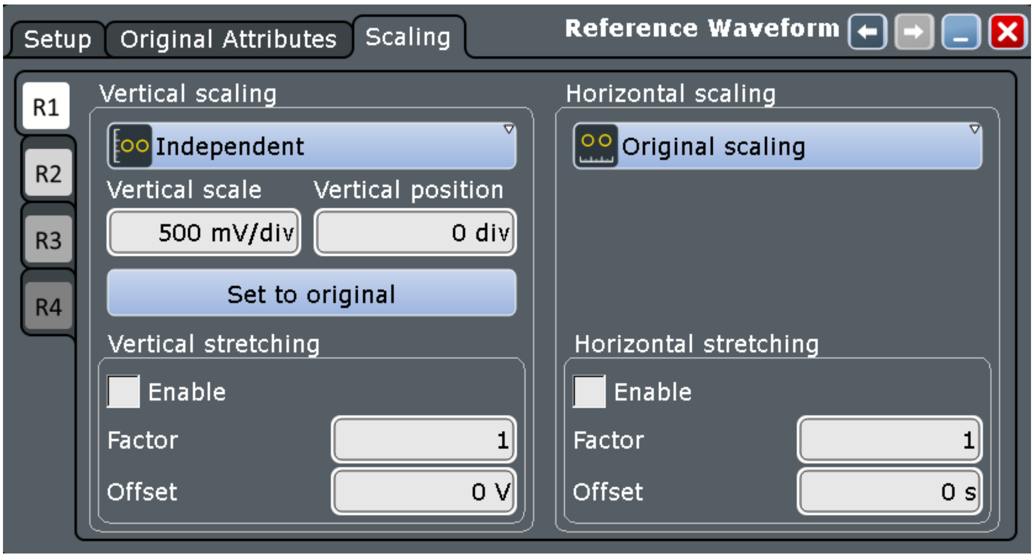


- "Time scale" on page 122
- "Vertical scale" on page 132
- "Resolution / Record length (Resolution dependency)" on page 123
- " Source " on page 241
- "Position" on page 122
- "Offset" on page 133
- "Wfm Arithmetic" on page 128
- "Mode" on page 127
- "Interpolation" on page 127
- "Reference point" on page 122
- "Position" on page 133

Restore Settings
Restores the original waveform settings from the source waveform to the reference waveform.

6.2.2.3 Scaling

A reference waveform can have its own settings, for example, vertical position and scale. Also, it can be stretched or compressed in vertical and horizontal direction. The current settings and the settings of the source waveform are stored.



Vertical Scaling

Selects the type of vertical settings:

"Coupled to source" Vertical position and scale of the source are used.

"Independent" Scaling and position can be set specific to the reference waveform.

Remote command:
REFCurve<m>:VMODe on page 1107

Vertical scale

Sets the vertical scale for the reference waveform, if vertical scaling is set to "Independent". You can also use the vertical [Scale] knob to adjust this value.

Remote command:
REFCurve<m>:SCALe on page 1108

Vertical position

Moves the reference waveform up or down in the diagram, if vertical scaling is set to "Independent". You can also use the vertical [Position] knob to adjust this value.

Remote command:
REFCurve<m>:POSition on page 1108

Set to original

Restores the settings of the source waveform, if vertical scaling is set to "Independent".

Remote command:
REFCurve<m>:RESTore on page 1107

Vertical Stretching

Stretching and offset change the display of the waveform independent of the vertical scale and position.

Enable ← Vertical Stretching
If enabled, the vertical offset and stretching factor are applied to the reference waveform.

Remote command:
REFCurve<m>:RESCale:VERTical:STATe on page 1108

Factor ← Vertical Stretching
A factor greater than 1 stretches the waveform vertically, a factor lower than 1 compresses the curve.

Remote command:
REFCurve<m>:RESCale:VERTical:FACTor on page 1109

Offset ← Vertical Stretching
Moves the reference waveform vertically. Enter a value with the unit of the waveform. Like vertical offset of a channel waveform, the offset of a reference waveform is subtracted from the measured value. Negative values shift the waveform up, positive values shift it down.

Note: As for all waveforms, a vertical offset of a reference waveform can be set using the vertical [Position] knob. This offset is independent from the reference scaling offset, which is described here. If both offsets are set, their values are added up.

Remote command:
REFCurve<m>:RESCale:VERTical:OFFSet on page 1109

Horizontal Scaling
Selects the type of horizontal settings:

"Adjust to X Axis"	The current horizontal settings of the diagram are used.
"Original Scaling"	Horizontal scaling and reference point of the source waveform are used.

Remote command:
REFCurve<m>:HMODe on page 1109

Horizontal Stretching
Stretching and offset change the display of the waveform independent of the horizontal settings of the source waveform and of the horizontal diagram settings.

Enable ← Horizontal Stretching
If enabled, the horizontal offset and stretching factor are applied to the reference waveform.

Remote command:
REFCurve<m>:RESCale:HORizontal:STATe on page 1110

Factor ← Horizontal Stretching
A factor greater than 1 stretches the waveform horizontally, a factor lower than 1 compresses the curve.

Remote command:
REFCurve<m>:RESCale:HORizontal:FACTor on page 1110

Offset ← Horizontal Stretching
Moves the waveform horizontally. Enter a value with a time unit suitable for the time scale of the diagram. Positive values shift the waveform to the right, negative values shift it to the left.

Remote command:
`REFCurve<m>:RESCale:HORizontal:OFFSet` on page 1110

6.3 Mathematics

Math waveforms are calculated waveforms. You can define up to four math waveforms and display them on the screen, and use it as source for further analysis.

Math waveforms are defined by mathematical expressions (formulas). You can enter mathematical expressions using two different methods:

- "Basic": you define a simple math function in a graphical editor by selecting the source waveform(s) and the operator.
- "Advanced": you define sophisticated math functions in a formula editor, as required to your needs.

The result of an FFT analysis is a specific math waveform. For information on FFT and spectrograms, see Chapter 8, "Spectrum Analysis", on page 347.

The vertical scale of a math waveform is adapted automatically to the measurement results to ensure optimal display. Furthermore, you can scale each math waveform manually in vertical direction like a channel waveform.

As for channel waveforms, you can also change the arithmetic mode for the waveform to display the envelope or an average over several calculations.

You can store a math waveform as a reference waveform and restore it later, see "To save a reference waveform" on page 239.

6.3.1 Displaying Math Waveforms

Math waveforms can be displayed in addition to the channel and other waveforms. They also can be used for analysis, e.g. measurements, even if the math waveform is not active.

1. In the "Math" menu, select "Math Setup".
   Alternatively, press the [Math] key.
2. Define the math expression for calculation in one of the following ways:
   - Chapter 6.3.2.2, "Defining a Formula in the Basic Editor", on page 248
   - Chapter 6.3.3, "Advanced Expressions", on page 249

- Chapter 8.1.2, "Configuring Spectrum Waveforms", on page 351

3. In the "Math Setup" dialog box, in the "Setup" tab, tap the "Enable math signal".

   The math waveform is displayed on the screen.

4. To change the vertical scaling of the math waveform, tap the "Manual" icon.

5. Enter the "Vertical scale" factor (per division). If necessary, add a "Vertical offset". By default the instrument performs an automatic scaling.

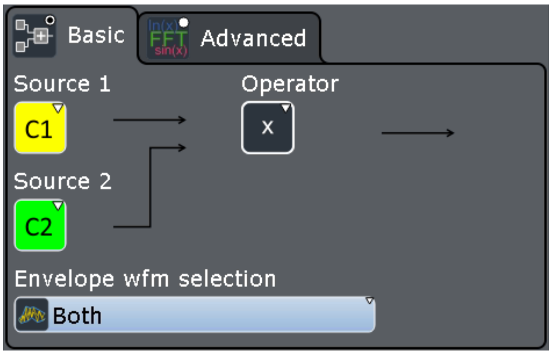
   Tip: You can also use the vertical [Scale] rotary knob for scaling. In this case, the scale mode is set to "Manual" temporarily.

6. If you need the envelope or average of the math waveform over several calculations, change the arithmetic mode for the waveform as for channel waveforms. See also: "Wfm Arithmetic" on page 128.

7. Close the "Math Setup" dialog box.

6.3.2 Basic Editor

In the basic editor, you can define the most common mathematical formulas without knowing their correct syntax.



Remote command:

- `CALCulate:MATH<m>[:EXPRession][:DEFine]` on page 1113

6.3.2.1 Settings in the Basic Editor

Source 1 / 2

Defines the signal source to be evaluated by the math function. Waveform 1 of channel signals can be selected.

Note: If you require other signal sources not listed here, use the formula editor provided in the "Advanced" tab. In advanced mode, any waveform of any input channel can be used as a source. See: Chapter 6.3.3, "Advanced Expressions", on page 249.

Operator

Defines the type of operation to be performed on the selected signal sources. The following functions are available:

Note: If you require other operators not listed here, use the formula editor provided in the "Advanced" tab. See: Chapter 6.3.3, "Advanced Expressions", on page 249.

"+"	Adds up the sources
"-"	Subtracts source 2 from source 1.
"x"	Multiplies source 1 by source 2.
"|x|"	Determines the absolute value of the source.
"dx/dt"	Differentiates the source value with respect to the time value. Not possible on envelope waveforms and waveforms with "Peak detect" decimation.
"log(x)"	Calculates the logarithm of the source value based on 10.
"ln(x)"	Calculates the natural logarithm of the source value (based on e).
"ld(x)"	Calculates the binary logarithm of the source value (binary logarithm, based on 2).
"Rescale"	Rescales the source values by a factor "a" and an offset "b": *ax+b*. See also: "a / b" on page 247.
"FIR filter"	Finite impulse response filter - highpass or lowpass filter for a specified cut-off frequency and characteristic. See also: "FIR: Type, Cut-Off, Characteristics" on page 247.
"Mag(FFT(x))"	Determines the magnitude of the FFT for the source values.

Noise reject

Only available for the "dx/dt" operator.

Sets the number of neighboring samples that are skipped for differentiation.

To suppress noise effects during differentiation, it can be useful not to consider two directly neighboring points to calculate *dx* (x_n-x_{n-1}). Instead, some samples in-between are skipped and a point a few samples further is used (e.g. x_n-x_{n-3}).

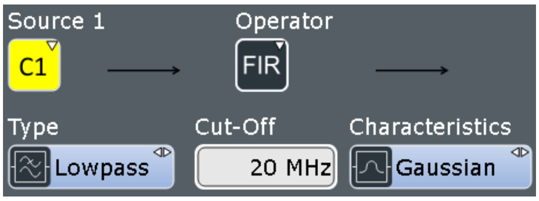
a / b

Defines the values for the "Rescale" function (ax+b).

"a"	Is the factor the signal source is multiplied with.
"b"	Is the offset of the signal source on the y-axis.

FIR: Type, Cut-Off, Characteristics

The finite impulse response filter ("Operator" = FIR) is a filter that requires three additional settings:



- "Type": defines whether the FIR filter is a highpass or lowpass filter.
- "Cut-Off": sets the limit frequency for the FIR filter.
- "Charcteristics": defines whether the FIR filter has a Gaussian or a rectangular shape

The cut-off frequency depends on the horizontal resolution and the filter characteristics. The frequency for the lowpass filter can only be set in this range:

f_g_3dB = *(0.001 ... 0.2)* f_a_in* for Gaussian FIR filter

f_g_3dB = *(0,001 ... 0.4)* f_a_in* for rectangular FIR filter

Where: *f_g_3dB* = cut-off frequency to be set for the lowpass filter, and *f_a_in* = reciprocal of the resolution, or sample rate.

To check limit frequency for the highpass filter, convert it to an equivalent lowpass frequency:

f_LP = f_a_in/2 - f_HP

Where f_HP is the requested highpass limit frequency and f_LP the equivalent lowpass frequency that has to comply with the limits given above.

For advanced expression, see Table 6-10.

Envelope wfm selection
Selects the upper or lower part of the waveform for mathematic calculation, or a combination of both.

The setting is relevant for waveforms with waveform arithmetic mode "Envelope" or with "Peak detect" decimation. All mathematic operations - except for derivation - can be applied to envelope waveforms and waveforms with "Peak detect" decimation.

Remote command:
`CALCulate:MATH<m>:ENVSelection` on page 1114

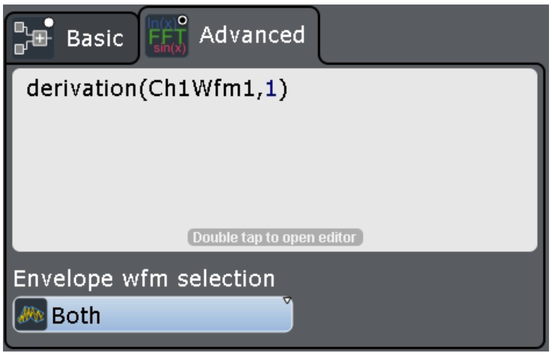
6.3.2.2 Defining a Formula in the Basic Editor

1. In the "Math" menu, select "Math Setup".
   Alternatively, press the [Math] key.
2. In the "Setup" tab, select the "Basic" tab.
3. Tap the "Source 1" and "Source 2" icons and select the signal sources to which the math function is applied. For details on available signal sources, see "Source 1 / 2" on page 246.
4. Tap the "Operator" icon and select the mathematical function.
   For details on available operators, see "Operator" on page 247.

5. If the operator requires additional parameters, enter them in the input fields.

6.3.3 Advanced Expressions

In the "Advanced" tab, you can enter complex formulas to define a math waveform. The formula editor helps to enter formulas easily with correct syntax, using a large selection of operators and signal sources. Double-tap the "Advanced" tab to display the formula editor.



6.3.3.1 Advanced Formula Editor

Using the formula editor you can define math functions freely, using a large selection of operators and signal sources. For a procedure on using the editor, see Chapter 6.3.3.2, "Defining a Formula in the Advanced Formula Editor", on page 255.

Remote command:

- `CALCulate:MATH<m>[:EXPRession][:DEFine]` on page 1113

The following tables describe the buttons of the formula editor and their usage.

Table 6-1: Basics

Icon	Description	Usage/Comment, *FormulaEditor expression*
(	left bracket	enclose operands
,	comma	separates operands
)	right bracket	enclose operands
e / π	math. constants	e: Euler number: 2.7182... Pi: 3.1415...
[	left square bracket	enclose unit
V / A / Ω	units	[<unit>]
]	right square bracket	enclose unit
x^a	exponentiation with base x	x: base, a: exponent *x^a*
/	division	
*	multiplication	
-	subtraction	
+	addition	
0...9	numeric characters	
.	decimal point	
Exp	exponentiation with base 10	*e*
Enter	expression complete	insert expression in Setup dialog and close the formula editor
Clear	clear expression in editor	restart editing
Del	Delete	remove selected part of expression
Back	Backspace	remove last symbol, operator or operand to the left of the cursor
M / k / µ	SI-prefix for unit	<SI-prefix>[<unit>]

Table 6-2: Signal sources

Icon	Description	Usage/Comment, *FormulaEditor expression*
Ch	signal waveform	*Ch<1...4>Wfm<1...3>*
Math	math waveform	*Math<1...4>*
Ref	reference waveform	*Ref<1...4>*
Meas	measurement waveform	*Meas<1...8>*
Track	track waveform	*Track<1...8>*

Table 6-3: Cursor keys

Icon	**Description**	**Usage/Comment, *FormulaEditor expression***
|←	move cursor to beginning	
←	move cursor 1 step to the left	
→	move cursor 1 step to the right	
→|	move cursor to end	

Table 6-4: Algebra

Icon	**Description**	**Usage/Comment, *FormulaEditor expression***
$\|x\|$	absolute x value	*abs(x)*
$\sqrt{x}$	square root of x	*sqrt(x)*
x^2	x*x	*pow(x)*
$\log_{10}$	common logarithm (base 10)	*log(x)*
$\log_e$	natural logarithm (base e)	*ln(x)*
$\log_2$	binary logarithm (base 2)	*ld(x)*
e^x	exponentiation with base e	*exp(x)*
$\int x dx$	integral of x	*integral(x)*
d/dx	derivation of x	*derivation(x,y)* with x = waveform and y = number of skipped samples (noise reject)
ax+b	scaling of x	*rescale(x,a,b)*

Table 6-5: Bit operations

Icon	**Description**	**Usage/Comment, *FormulaEditor expression***
digitize	convert to 0 or 1	*digitize(x)*
not	negation	*not(x)*
and		*and*
nand	negation of and	*nand*
or		*or*
nor	negation of or	*nor*
xor	exclusive or	*xor*
nxor	negation of exclusive or	*nxor*

Table 6-6: Comparison

Icon	**Description**	**Usage/Comment, *FormulaEditor expression***
=	equal	=
≠≠	not equal	<>

Icon	Description	Usage/Comment, *FormulaEditor expression*
<	smaller	<
>	greater	>
≤	smaller or equal	<=
≥	greater or equal	>=
More	display additional keys	

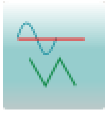
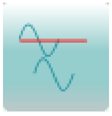
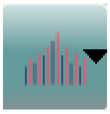
Table 6-7: FFT ("More" keys)

Icon	Description	Usage/Comment, *FormulaEditor expression*
|FFT|	magnitude of FFT value	*fftmag(x)*
FFT (φ)	FFT phase value	*fftphi(x)*
FFT -dφ*df	FFT group delay	*fftgroupdelay(x)*
FFT (re)	real part of FFT value	*fftre(x)*
FFT (im)	imag part of FFT value	*fftim(x)*

Table 6-8: Trigonometry ("More" keys)

Icon	Description	Usage/Comment, *FormulaEditor expression*
sinh	hyperbolic sine	*sinh(x)*
cosh	hyperbolic cosine	*cosh(x)*
tanh	hyperbolic tangent	*tanh(x)*

Table 6-9: Correlation ("More" keys)

Icon	Description	Usage/Comment, *FormulaEditor expression*
	Cross correlation function of two waveforms Measures the similarity of two waveforms as a function of a time-lag applied to one of them. Function limits the maximum record length to 4 MSa. Two modes of normalization are supported: biased and unbiased. The length of the correlation buffer is $N_0 + N_1 - 1$ samples. The length of the first input signal is N_0 samples and the length of the second signal is N_1 samples.	*correlation(x1, x2, biased)* *correlation(x1, x2, unbiased)* with x1 = waveform 1 and x2 = waveform 2 *correlation(x1, x2)* performs an unbiased correlation
	Auto correlation Used to find repeating patterns, for example, a periodic signal obscured by noise. The length of the auto correlation buffer is $2N - 1$ samples, if the length of the input signal is N samples. Two modes of normalization are supported: biased and unbiased.	*autocorrelation(x, biased)* *autocorrelation(x, unbiased)* with x = channel waveform *autocorrelation(x)* performs an unbiased autocorrelation
	biased / unbiased normalization for correlation and auto correlation	see above

Mathematic background for correlation:

$$Temp1\_R_{xy}(m) = \sum_{n=0}^{N1} y_n^* x_{n+m} \qquad m \in [0; N_1[$$

$$Temp0\_R_{xy}(m) = \sum_{n=1}^{N0} x_n^* y_{n+m} \qquad m \in [1; N_0[$$

The R&S RTP uses only the real part of the signal. Two modes of normalization are supported: biased and unbiased.

$$R_{xy}(m) = \begin{cases} \dfrac{1}{\min(N_0, N_1)} Temp1\_R_{xy}(m) & m \in [N_0 - 1; N_1 + N_0 - 1[\\ \dfrac{1}{\min(N_0, N_1)} Temp0\_R_{xy}^*(-m) & m \in [0; N_0 - 1[\end{cases}$$

Equation 6-1: Biased correlation

$$R_{xy}(m) = \begin{cases} \dfrac{1}{a(m)} Temp1\_R_{xy}(m) & m \in [N_0 - 1; N_1 + N_0 - 1[\\ \dfrac{1}{a(m)} Temp0\_R_{xy}^*(-m) & m \in [0; N_0 - 1[\end{cases}$$

Equation 6-2: Unbiased correlation

Mathematic background for auto correlation:

$$R_{xx}(m) = \begin{cases} \dfrac{1}{N} \sum\limits_{n=0}^{N-m-1} x_n^{*} x_{n+m} & m \geq 0 \\ R_{xx}^{*}(-m) & m < 0 \end{cases}$$

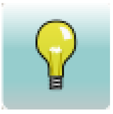
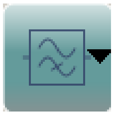
Equation 6-3: Biased auto correlation

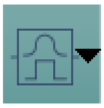
$$R_{xx}(m) = \begin{cases} \dfrac{1}{N-|m|} \sum\limits_{n=0}^{N-m-1} x_n^{*} x_{n+m} & m \geq 0 \\ R_{xx}^{*}(-m) & m < 0 \end{cases}$$

Equation 6-4: Unbiased auto correlation

The R&S RTP uses only the real part of the signal.

Table 6-10: Filter and power ("More" keys)

Icon	Description	Usage, comment, *FormulaEditor expression*
	Electric power	Electric power is calculated from voltage, based on measurement impedance (see "Measurement impedance" on page 135) *elecpower(x)* = U^2/R
	Finite impulse response (FIR) filter	*FIR(highpass,x,y,c)* or *FIR(lowpass,x,y, c)* with: x = source (channels only), y = cut-off frequency, c = Gaussian or rectangle characteristics Example: *FIR(lowpass,Ch1Wfm1,12e+006,gaussian)* sets a Gaussian lowpass filter with 12 MHz cut-off frequency See also: "FIR: Type, Cut-Off, Characteristics" on page 247.
	Type of FIR filter	*highpass* / *lowpass*, see FIR filter

Icon	Description	Usage, comment, *FormulaEditor expression*
	Characteristics of FIR filter	*gaussian* / *rectangle*, see FIR filter
	Moving average	Calculates a mean value of several adjacent sample points. The result is a smoothed waveform. The moving average uses the full data and can be used for non-periodic signals. It works like a low-pass filter and increases the vertical resolution at the expense of bandwidth reduction. *MovingAverage(x,y)* with: x = source (channels only), y = number of samples to be averaged Example: *MovingAverage(Ch1Wfm1,1000)* Averages 1000 subsequent samples of the channel 1 waveform

6.3.3.2 Defining a Formula in the Advanced Formula Editor

1. In the "Math" menu, select "Math Setup".
2. In the "Setup" tab, select the "Advanced" tab.
3. Double-tap the editing area.

   The "Formula Editor" is displayed.
4. Enter the math formula including all required signal sources and operators by selecting the corresponding keys in the editor. For details on the available keys, see Chapter 6.3.3.1, "Advanced Formula Editor", on page 249.
5. To insert a physical unit in the formula, proceed as follows:
   a) If necessary, insert a decimal prefix using the "M/k/µ" key.
   b) Insert an opening square bracket using the "[" key.
   c) Insert the physical unit using the "V/A/Ω" key.
   d) Insert a closing square bracket using the "]" key.

   The resulting expression could be, for example: `m[V]`
6. To perform a rescaling function, proceed as follows:
   a) Select the rescaling function using the "ax+b" key.
   b) Behind the left bracket, insert the signal source using one of the following keys:
      - "Ch" for a channel
      - "Math" for a math function
      - "Ref" for a reference waveform
      - "Meas" for a measurement

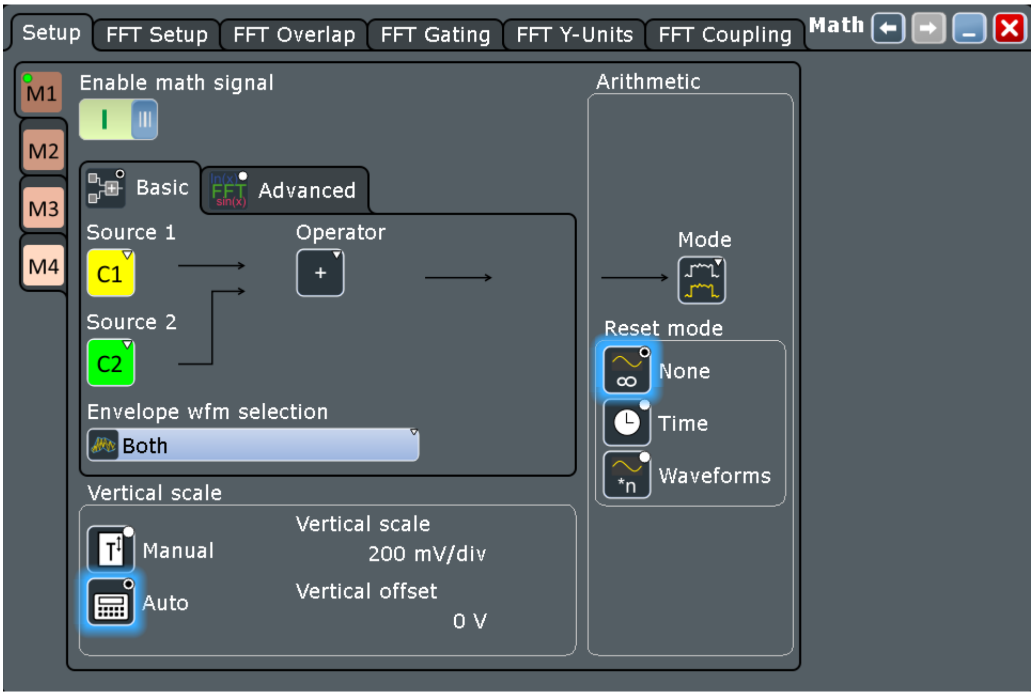
   c) Insert a comma using the "," key.
   d) Insert the "a" value, i.e. the scaling factor, using the number keys.

e) Insert a comma using the "," key.
f) Insert the "b" value, i.e. the scaling offset, using the number keys.
g) Insert the closing bracket using the ")" key.

The resulting expression could be, for example: `rescale(Ch1Wfm1,3,4)`

6.3.4 Math Setup - General Settings

You can define up to 4 different math waveforms. Each waveform is defined in a separate tab in the "Math" dialog box ("Math 1"-"Math 4").



The settings for input of mathematical formulas in basic and advanced editors are described in separate chapters:

- Chapter 6.3.2.1, "Settings in the Basic Editor", on page 246
- Chapter 6.3.3, "Advanced Expressions", on page 249

The general settings for enabling, scaling and waveform arithmetic are:

Enable Math Signal
If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:
`CALCulate:MATH<m>:STATe` on page 1114

Vertical Scale
Functions to set the vertical parameters of the math waveform.

Note: If an FFT expression is defined, the vertical scaling for spectrum displays is available: "Vertical maximum" and "Vertical range" instead of "Vertical Scale" and "Vertical Offset". See Chapter 8.1.3.2, "FFT Overlap", on page 358.

Vertical scaling mode (Manual/Auto) ← Vertical Scale
By default, the vertical scale is adapted to the current measurement results automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

Note: When you change the scaling values manually using the "Scale" rotary knob, the scale mode is set to "Manual" temporarily. When you edit the math function, scaling is automatically set back to "Auto" mode. "Manual" mode is only maintained during math function changes if you select it yourself.

"Manual"	Enter the required values for "Vertical scale" and "Vertical offset". For FFT, set "Vertical range" and "Vertical maximum".
"Auto"	"Vertical scale" and "Vertical offset" are read-only. For FFT, only the "Vertical maximum" is read-only.

Vertical Scale ← Vertical Scale
Defines the scale of the y-axis in the math function diagram. The value is defined as "<unit> per division", e.g. *50m V/div*. In this case, the horizontal grid lines are displayed in intervals of 50 mV.

If the "Vertical scaling mode (Manual/Auto)" on page 257 is set to "Auto", this setting is read-only.

Remote command:
`CALCulate:MATH<m>:VERTical:SCALe` on page 1116

Vertical Offset ← Vertical Scale
Sets a voltage offset to adjust the vertical position of the math function on the screen. Negative values move the waveform , positive values move it down.

If the "Vertical scaling mode (Manual/Auto)" on page 257 is set to "Auto", this setting is read-only.

Remote command:
`CALCulate:MATH<m>:VERTical:OFFSet` on page 1115

Arithmetic
Functions to specify the waveform arithmetic for the math waveforms.

Mode ← Arithmetic

Waveform arithmetic builds the resulting waveform from several consecutive acquisitions and subsequent math calculations of the signal. For details, see "Wfm Arithmetic" on page 128.

"Original"	The original results are displayed.
"Envelope"	The envelope curve of all acquired and calculated results is displayed.
"Average"	The average of all acquired and calculated results is displayed.
"RMS"	The root mean square of the math data is displayed. The result is the average power spectrum. If you measure the channel power on this RMS spectrum, you get the same result as for the average channel power measurement on waveforms.
"MinHold"	Determines the minimum result for each input value from the data of the current acquisition and a number of acquisitions before.
"MaxHold"	Determines the maximum result for each input value from the data of the current acquisition and a number of acquisitions before.

Remote command:

`CALCulate:MATH<m>:ARIThmetics` on page 1114

Reset now ← Arithmetic

Forces the immediate restart of the envelope and average calculation for all waveforms.

Remote command:

`ACQuire:ARESet:IMMediate` on page 1009

Acquisition/average count ← Arithmetic

Access:

- Trigger > "Control" tab > "Average count (N-single count)"
- [Acquisition] > "Average count"
- [Horizontal] > "Fast Segmentation" tab > disable "Acquire maximum" > "Required"
- [Math] > "Setup" tab > "Average count"

The acquisition and average count has several effects:

- It sets the number of waveforms acquired with [Single]
- It defines the number of waveforms used to calculate the average waveform. Thus, the instrument acquires sufficient waveforms to calculate the correct average if "Average" is enabled for waveform arithmetic. The higher the value is, the better the noise is reduced.
- It sets the number of acquisitions to be acquired in a fast segmentation acquisition series. Thus, you can acquire exactly one fast segmentation acquisition series with [Single].
  If fast segmentation is enabled and configured to acquire the maximum number of acquisitions, the acquisition count is set to that maximum number and cannot be changed. See also: "Number of acquisitions" on page 131.
- It is the "Finished" criteria for the state of a mask test.

Remote command:

`ACQuire:COUNt` on page 1009

Auto reset mode / Reset mode ← Arithmetic

Defines when the envelope and average evaluation restarts.

"None"	No restart, the number of acquisitions considered by the waveform arithmetics is not limited.
"Time"	Restarts the envelope and average calculation after the time defined in "Reset time".
"Waveforms"	Restarts the envelope and average calculation after a number of acquired waveforms defined in "Reset count".

Remote command:
`ACQuire:ARESet:MODE` on page 1009
`ACQuire:ARESet:TIME` on page 1010
`ACQuire:ARESet:COUNt` on page 1010

6.4 History

The history accesses the data of previous acquisitions and provides them for further analysis.

6.4.1 About History

If a continuous acquisition runs, the captured data is stored in the sample memory and the current acquisition is processed and shown on the display. After the acquisition was stopped, the history accesses the captured samples that were stored, displays these samples as history waveforms, and makes them available for further analysis. It considers all channels that were enabled during the running acquisition. When a new acquisition is started with [Run Stop] or [Single], the memory is cleared and written anew.

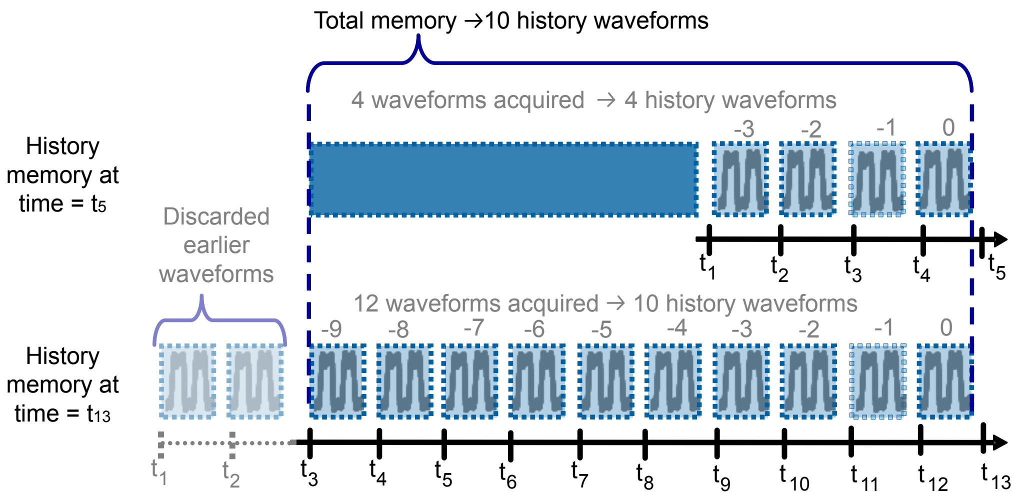


Figure 6-6: History memory. In this example, the memory can store 10 waveforms.

You can work with history waveforms in the same way as with the waveform of the latest acquisition: use zoom, cursor measurements, and automatic measurements, create math waveforms, perform mask testing and so on. Saving the history data is also possible, either completely or a part of the data.

The number of stored history waveforms depends on the memory size, the number of enabled channels, and the record length. The shorter the record length, the less the number of channels, and the larger the memory, the more history waveforms are saved.

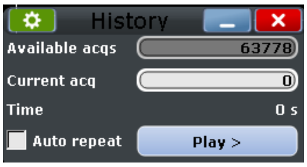
Memory extension

The memory can be enhanced with options R&S RTP-B101/102/105/110/120. For details, refer to the "Specifications" data sheet.

Quick-access History dialog box

When you press the [History] key on the front panel or tap "Display" menu > "Show history", the history mode is enabled and the quick-access "History" dialog box is displayed. A running acquistion stops immediately.

The small quick-access "History" dialog box can remain visible on the screen during history replay, so that the history can be replayed at any time by a simple tap on the "Play" button. Closing the quick-access "History" dialog box, or starting a new acquisition disables the history mode.



Export of history waveforms

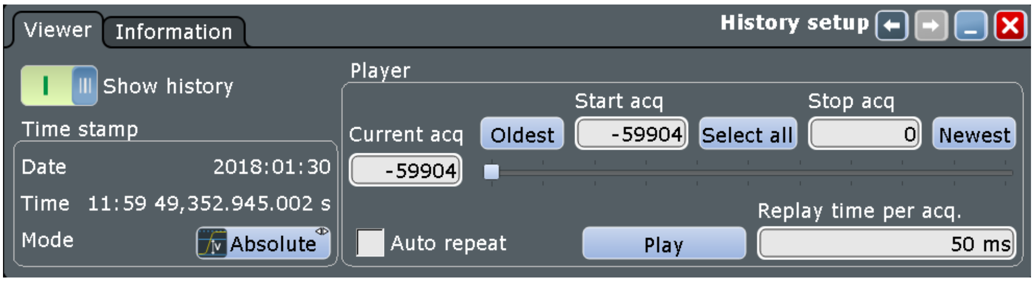
You can export history data, see "To save the history data" on page 265.

6.4.2 History Setup

The "History" dialog box contains the complete functionality on history viewing and information. The most important information and functions are also provided in the quick-access history dialog box.

6.4.2.1 Viewer

The settings in the "Viewer" tab control the display of history waveforms.



The numbering of the waveforms refers to the current memory content. With every [Run Stop] or [Single] action, the memory content changes.

Show history / Export history

Enables the history mode and allows you to save history waveforms to file.

The history display is enabled automatically when you press the [History] button. It is disabled when you close the quick-access "History" dialog box.

For details on data export, see "Export history" on page 438.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory[:STATe]` on page 1118

Current acq

Accesses a particular acquisition in the memory to display it, or to save it. The newest acquisition always has the index "0". Older acquisition have a negative index.

If a history replay is running, the field shows the number of the currently shown acquisition.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:CURRent` on page 1118

Start acq

Sets the index of the first (oldest) acquisition to be displayed or exported. The index is always negative. The number of stored history acquisitions is shown in Available acquisitions on the "Information" tab.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:STARt` on page 1119

Stop acq

Sets the index of the last (newest) acquisition to be displayed or exported. The newest acquisition of the complete acquisition series always has the index "0".

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:STOP` on page 1119

Select all

All acquisitions that are saved in the memory are in the viewer.

Current
Sets the newest acquisition in the sample memory as "Stop acq" and "Current acq". This acquisition always has the index "0".

Oldest
Sets the oldest acquisition in the sample memory as "Start acq" and "Current acq".

Auto repeat
If selected, the replay of the history waveform sequence repeats automatically. Otherwise, the replay stops at the "Stop index".

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:REPLay` on page 1120

Play
Starts and stops the replay of the history waveforms from "Start acq" to "Stop acq".

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:PLAY` on page 1120

Replay time per acq.
Sets the display time for one acquisition. The shorter the time, the faster the replay is. The setting takes effect for history replay and the display of a Fast Segmentation series, see Chapter 4.2.3, "Fast Segmentation", on page 129.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:TPACq` on page 1119

Time stamp
The time stamp shows the time of the currently displayed history acquisition. Thus, the time relation between acquisitions is always available.

The time stamp "Mode" can be absolute or relative:
- In "Absolute" mode, the instrument shows the date and the daytime of the current acquisition.
- In "Relative" mode, the time difference to the newest acquisition (index = 0) is shown.

The time stamp can be included in waveform data export, see "Timestamps" on page 439.

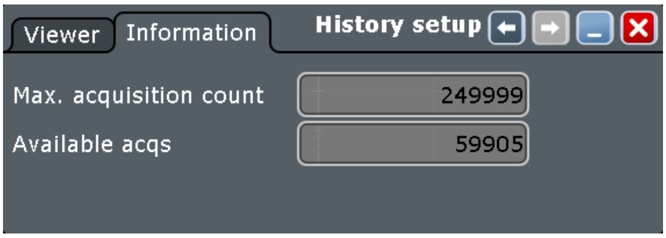
During history replay, the time value is displayed and updated if the replay speed ("Time per acquisition") is slow enough, that is 40 ms or slower.

The quick-access history dialog box always shows the relative time. In the "History Viewer" tab, you can select the time mode.

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory:TSDate?` on page 1120
`CHANnel<m>[:WAVeform<n>]:HISTory:TSABsolute?` on page 1121
`CHANnel<m>[:WAVeform<n>]:HISTory:TSRelative?` on page 1121
`CHANnel<m>[:WAVeform<n>]:HISTory:TSRReference?` on page 1121

6.4.2.2 Information

The "Information" tab shows the maximum number and the number of captures acquisitions.



Max. acquisition count
Displays the maximum number of acquisitions that can be saved in the sample memory and displayed with the history viewer. With Fast Segmentation, it is also the maximum number of acquisitions in a Fast Segmentation acquisition series.

Available acquisitions
Displays the number of acquisitions currently saved in the sample memory. This memory is also used to save a Fast Segmentation acquisition series, so the number of acquisitions available for history viewing is the same as the number of acquisitions in a Fast Segmentation acquisition series.

Remote command:
`ACQuire:AVAilable?` on page 1118

6.4.3 Using History

You can access the history waveforms in two ways:

- Display a particular acquisition.
- Replay all or a part of the saved waveforms to track the signal run.

Furthermore, you can export history data to a file.

- "To open the history and get information" on page 263
- "To display a particular acquisition" on page 264
- "To replay history waveforms" on page 264
- "To exit the history" on page 265
- "To save the history data" on page 265

To open the history and get information

1. Press the [History] key on the front panel. A running acquisition is stopped, the history mode is enabled and the quick-access "History" dialog box is displayed.

   The [History] key is illuminated as long as the history mode is active.

2. Open the full configuration dialog box:
   - Tap the icon.
   - Press the [History] key again.

- On the "Display" menu, tap "History setup".

3. In the "History" configuration dialog box, select the "Information" tab to see how many history waveforms are saved, and how many can be saved as maximum.

To display a particular acquisition

1. In the quick-access "History" dialog box, enter the number of the required acquisition in the "Current index" field. The newest acquisition always has the index "0", older acquisitions have a negative index
2. Tap "Play" to start.

Alternatively, you can configure and start the history display from the "History" configuration dialog box:

1. Open the "History" configuration dialog box and select the "Viewer" tab.
2. If the history mode is off (the [History] key is not illuminated), select "Show history".

   The quick-access dialog box is displayed.
3. Drag the slider to the required acquisition. The current number is shown in the "Current index" field.
   Alternatively, enter the number of the required acquisition in the "Current index" field.
4. Tap "Play" to start.

To replay history waveforms

If you want to see the complete acquisition series without any setup, simply tap "Play" in the quick-access "History" dialog box. For specific analysis of history data, use the hestory "Viewer" setup.

1. In the "History" configuration dialog box, select the "Viewer" tab.
2. If the history mode is off (the [History] key is not illuminated), enable "Show history".

   The quick-access dialog box is displayed.
3. Define the part of the history you want to see by doing one of the following:
   - Tap "Select all" to see the complete history.
   - Enter the "Start Index" of the oldest acquisition to display and the "Stop Index" of the newest acquisition to display. All waveforms between the two indexes will be displayed.
     To enter the oldest or newest acquisition for either index, tap the appropriate button. The newest acquisition always has the index "0". The "Start index" is always negative.
4. Tap "Play" to start.

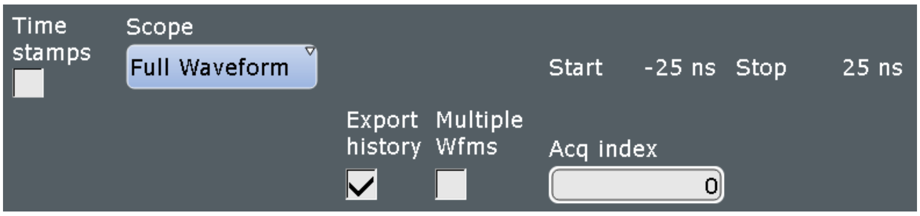
To exit the history

► Choose one of the following ways:
- Close the quick-access "History" dialog box.
- On the "Display" menu, tap "Show history".
- In the "Viewer" tab, disable "Show history".
- Start the acquisition.

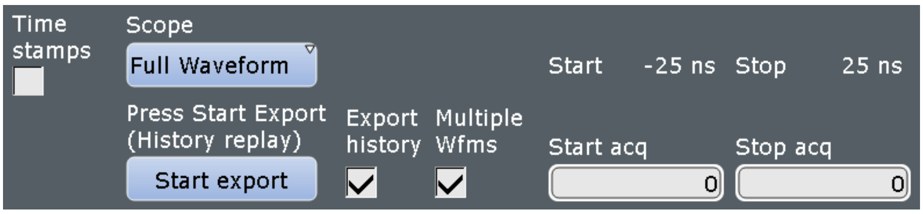
To save the history data

You can save the complete history, or some subsequent waveforms from the history, or a single history waveform. You can also decide to save the complete waveforms, or a part of each waveform.

1. Press the [Save Recall] key.
2. Select the "Save/Recall" tab.
3. Select the "Waveform" tab.
4. Tap the source icon to select the waveform you want to save.
5. If you want to save only a part of each waveform, set the "Scope".
   For settings, see "Scope" on page 437.
6. Enable "Export history".
7. If you want to write the timestamps into the data file, enable "Timestamps".
8. To save one waveform out of the history memory:
   a) Make sure that "Multiple Wfms" is disabled.
   b) Enter the number of the required acquisition in "Acq index". The newest acquisition in the memory always has the index "0". Older acquisition have a negative index.



   c) Tap "Save" or "Save As" to save the waveform data to the specified file.
9. To save several subsequent history waveforms:
   a) Enable "Multiple Wfms".
   b) Define the range of the waveforms to be saved with "Start acq" and "Stop acq".



c) Tap "Start Export" to play the history and to save the history data to the specified file.

Se also Chapter 11.2.2, "Waveforms - Export Settings", on page 435.

6.5 XY-Diagram

XY-diagrams combine the voltage levels of two waveforms in one diagram. They use the voltage level of a second waveform as the x-axis, rather than a time base. This allows you to perform phase shift measurements, for example. You can display up to four different XY-diagrams.

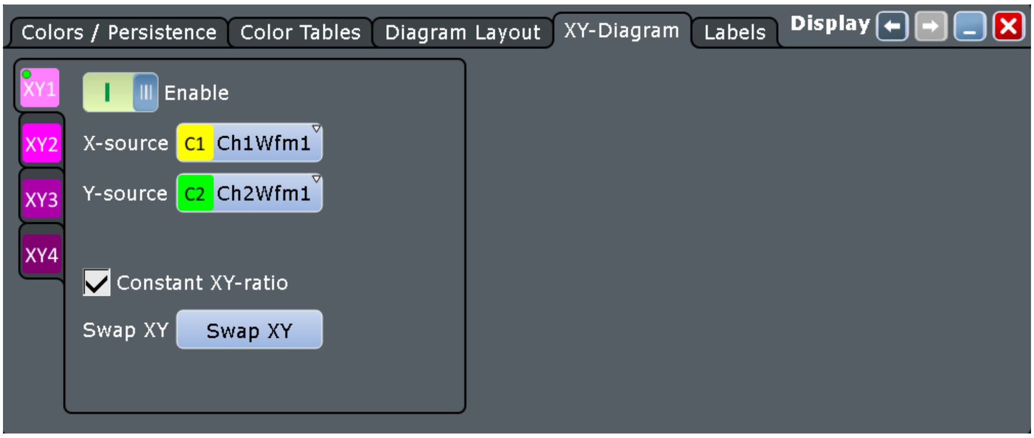
XY-diagrams can be used to display the IQ representation of a signal.

6.5.1 Settings for XY-Diagrams

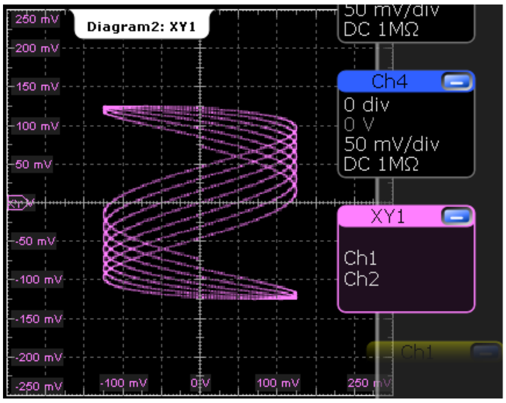
Access: "Display" > "XY-Diagram" tab

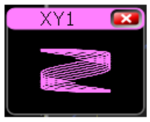
You can display up to four different XY-diagrams that use the voltage level of a waveform as the x-axis, rather than a time base.

Make sure to select the tab of the required XY-diagram.



Enable
If activated, the XY-waveform is active and shown in a diagram, or it is minimized in a signal icon.





Remote command:
`WAVeform<m>:XYCurve:STATe` on page 1122

X-source
Defines the signal source that supplies the x-values of the XY-diagram. Select one of the following:

- One of the waveforms of any channel
- A reference waveform
- The results of a mathematical function

Remote command:
`WAVeform<m>:XYCurve:XSOurce` on page 1123

Y-source
Defines the source to be used as the y-axis of the XY-diagram. Select one of the following:

- One of the waveforms of any channel
- A reference waveform
- The results of a mathematical function

Remote command:
`WAVeform<m>:XYCurve:YSOurce` on page 1124

Constant XY-ratio
If enabled, the x- and y-axes maintain a constant ratio in the diagram.

Remote command:
`WAVeform<m>:XYCurve:RATio` on page 1122

Swap XY
Replaces the source of the x-axis with the source of the y-axis and vice versa.

Remote command:
`WAVeform<m>:XYCurve:SWAP` on page 1122

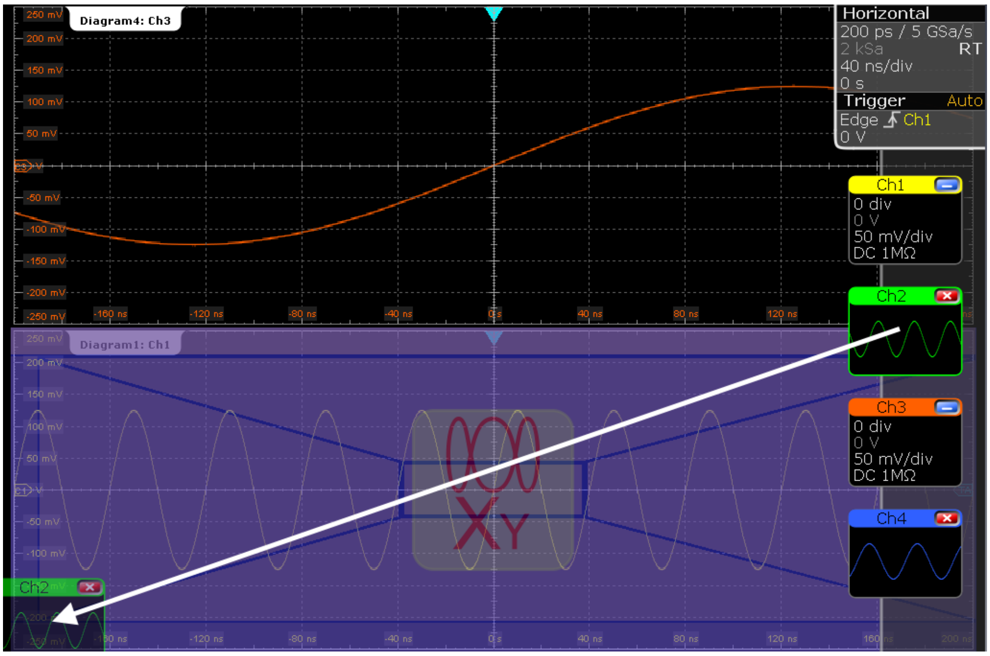
6.5.2 Displaying an XY-Diagram

You can create the diagram from active waveforms with drag&drop, or use the dialog box for setup.

To display an XY-diagram with drag&drop

Prerequisites: The source waveform for the y-axis is active in a diagram, the source waveform for the x-axis is either active or minimized.

1. Drag the x-axis waveform to the lower left corner of the diagram with the y-axis waveform.
2. Drop the icon when it overlaps the left and lower diagram borders.



The diagram is converted into an XY-diagram.

To set up an XY-diagram

1. On the "Display" menu, tap "XY-diagram".
2. Activate the "State" option.
3. In the "X-source" field, define the signal source that supplies the x-values of the XY-diagram. Select one of the following:
   - One of the waveforms of any channel
   - A reference waveform
   - The results of a mathematical function
4. In the "Y-source" field, define the signal source that supplies the y values of the XY-diagram.
5. To switch the x- and y-values quickly, tap the "Swap XY" button.

6. To maintain a constant ratio while the x- and y-axes are adapted to the acquired data dynamically, activate the "Constant XY-ratio" option.

If the XY-diagram is active or minimized, touch and hold the signal icon to open the "XY-diagram" tab.

7 Measurements

Using the R&S RTP you can perform and display different measurements simultaneously, based on the active signal or math waveforms. The color of the results in the result table corresponds with the source waveform color.

The following measurement methods are available:

- Cursor measurements: measurements can be configured for up to 4 cursor sets to determine specific results at the manually defined cursor positions of an active waveform; the results are displayed in a result box.
- Automatic measurements: up to eight measurements can be configured and performed simultaneously on different sources; the results of each measurement are displayed in a result box.
- Quick measurements: performs a set of automatic measurements on the selected waveform at the push of a button. You can configure the set of measurements.

7.1 Cursor Measurements

7.1.1 Cursors and Results of Cursor Measurements

Cursor measurements determine the results at the current cursor positions. The cursors can be positioned manually, or can be configured to follow the waveform. You can measure on one waveform, or on two different waveforms (sources).

Up to 4 cursor sets can be configured and displayed. Each cursor set consists of a pair of horizontal or vertical cursors, or both. Cursor lines can be coupled so that the initially defined distance is always maintained.

The cursors are displayed in the diagrams of the source waveform only, or in all diagrams. For each measurement, labels can be defined for the cursors. By default, the cursors are labeled as C1.1, C1.2, C2.1, C2.2, C3.1, C3.2, C4.1, C4.2.

How to set up cursor measurements is described in Chapter 7.1.2, "Using Cursors", on page 272. The Chapter 7.1.3, "Settings for Cursor Measurements", on page 275 provides a detailed description of all settings.

Cursors can also define a gate to limit the measurement to the section of the waveform between the cursor lines. See Chapter 7.2.3.2, "Gate Settings for Measurements", on page 292.

7.1.1.1 Cursor Measurements on Time-Based Waveforms

The results of cursor measurements are displayed in a result box. For each measurement, a separate result box is displayed. The result box is displayed automatically when a cursor measurement is enabled. Similar to waveform diagrams, you can minimize the result box to a result icon on the sidebar, and display results in a separate diagram on the screen.

For details on using the result box, see Chapter 2.3.6, "Displaying Results", on page 69.

The result box for measurement on time-based waveforms shows the following information.

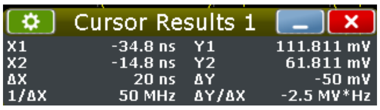


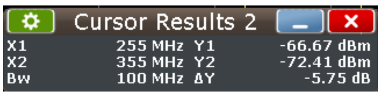
Figure 7-1: Measurement results of a cursor measurement

Label	Description
X1, X2	Time at the position of the vertical cursors.
Y1, Y2	Vertical values of the waveform at the position of the horizontal cursors in V or A.
ΔX	Difference between the vertical cursor (time) values
ΔY	Difference between the horizontal cursor values
1/ΔX	Inverse time difference
ΔY/ΔX	Slope of the waveform between the cursors (if measured on one source)

7.1.1.2 Cursor Measurements on Spectrum Waveforms

If the measurement source is a spectrum waveform, the results have a different meaning. Measurement on 2 spectrum waveforms is not possible.

The result box for measurement on spectrum waveforms shows the following information.



Label	Description
X1, X2	Frequency at the position of the vertical cursors
Y1, Y2	Vertical values of the waveform at the position of the horizontal cursors in dB.
Bw	Difference between the vertical cursor (frequency) values
ΔY	Difference between the horizontal cursor values

To set the cursor lines to the peaks, various functions are available in the "Peak Search" tab, see Chapter 7.1.3.3, "Peak Search ", on page 279.

7.1.2 Using Cursors

Cursor measurements can be started simply by using the "Cursor" icon on the toolbar. For detailed configuration, use the "Cursor" dialog box.

7.1.2.1 Starting a Simple Cursor Measurement

To display cursors using the toolbar

1. Select the waveform that you want to measure.
2. Tap the "Cursor" icon on the toolbar.

3. Tap the diagram where you want to set the cursors. Alternatively, you can draw a rectangle in the diagram to position the cursor lines.

   The cursor lines appear and the "Cursor Results" box for the selected waveform opens.

To display cursors using the [Cursor] key

1. Select the waveform that you want to measure.
2. Press the [Cursor] key.

   The cursor lines appear and the "Cursor Results" box for the selected waveform opens.

To disable one cursor measurement

► Close the result box.

To disable all cursor measurements

1. Press the [Cursor] key.
2. Select the "Setup" tab.
3. Tap the "All Off" button.

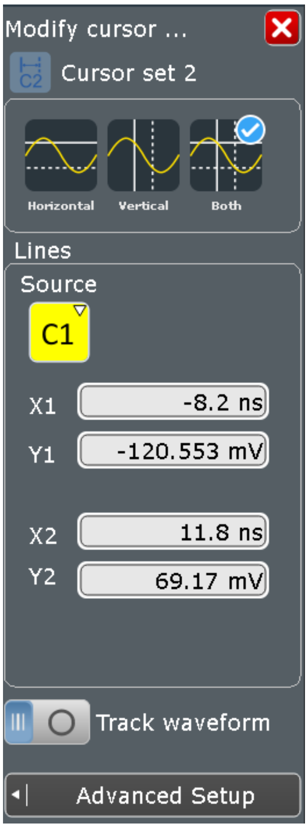
   All cursor measurements are disabled, the cursors and cursor result boxes are removed from the display.

7.1.2.2 Configuring a Cursor Measurement

To modify the position of the cursor lines, you can simply drag the lines on the screen. In addition, various settings are possible to refine the measurement.

The complete configuration of cursor measurements is provided in the "Cursors" dialog box.

► You can adjust the basic settings of an active cursor measurement in the sidebar: cursor type, source, positions, and track. To open the sidebar, tap the icon in the result box.



1. To open the "Cursors" dialog box, use one of these ways:
   - Tap the icon in the result box.
     On the sidebar, tap "Advanced Setup".
   - Press the [Cursor] key.
   - Use the "Cursor" menu.
2. Select the "Setup" tab.
3. Select the subtab for the cursor set that you want to use.
4. Tap the source icon and select the measured waveform. you can select any active input channel, math, reference or XY-waveform.
5. If necessary, enable and select a 2nd waveform.

6. Select the cursor type: horizontal, vertical, or both.
7. Define the position of the cursors:
   a) To define exact positions of the cursors manually, enter the X-position for each vertical cursor and the Y-position for each horizontal cursor. Horizontal cursors can only be positioned manually if the "Track waveform" setting is disabled.
   b) To position the horizontal cursors automatically, select "Track waveform". In this case, cursor 1 indicates the current maximum, cursor 2 indicates the current minimum. If both horizontal and vertical cursors are displayed, the horizontal cursors are placed at the crossing points of the vertical cursors with the waveform. Adjust the vertical cursors manually.
   If the waveform arithmetics are set to "Envelope" and the "Track waveform" is active, select which horizontal cursor is positioned to the maximum and which to the minimum envelope values.
   c) To keep the distance between the vertical cursors when one cursor is moved, select "Coupling".
8. Optionally, select "Show in all diagrams" in the "Setup" tab. This setting enables the cursor display in all diagrams that are in the same domain as the selected source (time or spectrum).
9. To set the cursors for a spectrum measurement to peak values automatically, select the "Peak Search" tab.
   Tap one of the search function buttons to place the cursors on the selected peak value. For details, see Chapter 7.1.3.3, "Peak Search ", on page 279.
   Optionally, define a peak excursion. Peak excursion is the minimum level value by which the waveform must rise or fall so that it is identified as a maximum or a minimum by the search functions.
10. Tap the "Enable" icon in the "Setup" tab to activate the cursor measurement.

    The cursors are displayed in the waveform diagrams of the measurement source and the "Cursor" result box is displayed. For details on cursor measurement results, see Chapter 7.1.1, "Cursors and Results of Cursor Measurements", on page 270.

7.1.2.3 Configuring the Cursor Display

By default, the cursors are displayed as lines in the diagrams and labeled according to the syntax: C<cursor set number>.<1|2>

The cursors for the cursor set 2, for example, are labeled 2.1 and 2.2. The horizontal and the vertical cursors lines have the same labels.

You can change the default cursor display and labels.

1. Press the [Cursor] key.
2. Select the subtab for the cursor set you want to configure.
3. To change the display of the cursor lines:

a) Select the "Setup" tab.
b) Select the cursor style. See also "Cursor style" on page 276.

4. Select the "Label" tab.
5. For each vertical and horizontal cursor, enter a label.
6. Select "Show labels".

7.1.3 Settings for Cursor Measurements

Cursor measurements are configured in the "Cursors" dialog box.

7.1.3.1 Cursor Setup

Access: [Cursor] key

The "Setup" tab contains general settings for cursor measurements. If you want to save the measurement results to a file, tap "Result export". See also: Chapter 11.2.4, "Numeric Results", on page 442.

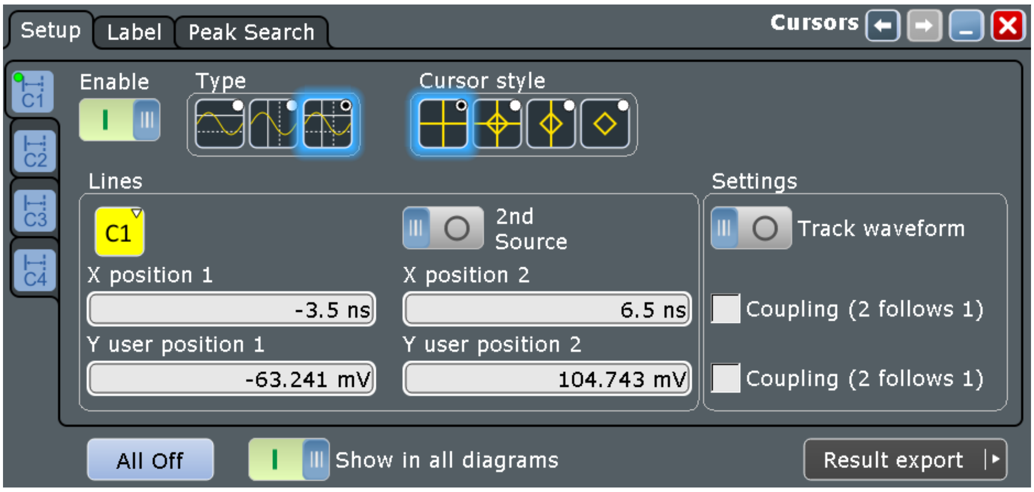


Figure 7-2: Setup for cursor on 1 source

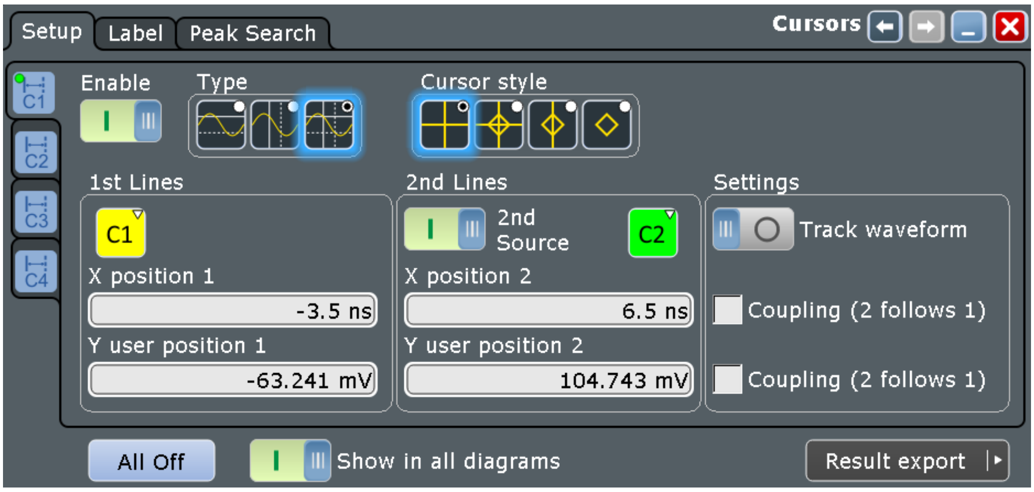


Figure 7-3: Setup for cursor on 2 sources

Cursor set (vertical tab)
The settings for each cursor measurement (or cursor set) are configured on separate tabs. For each measurement, a horizontal pair of cursors, a vertical pair of cursors, or both can be displayed.

Enable
Enables the selected cursor measurement.

Remote command:
`CURSor<m>:STATe` on page 1125

Type
Defines the cursor type to be used for the measurement.

"Horizontal cursors"	The horizontal cursors are positioned automatically along the waveform or can be positioned manually.
"Vertical cursors"	The vertical cursors are positioned manually.
"Both horizontal and vertical cursors"	The horizontal cursors are positioned automatically along the waveform or can be positioned manually. The vertical cursors are positioned manually.

Remote command:
`CURSor<m>:FUNCtion` on page 1125

Cursor style
Defines how the cursor is displayed in the diagram.

"Lines" The cursors are displayed as lines.

"Line & Rhombus" The cursors are displayed as lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

"Vertical line and rhombus" The cursors are displayed as vertical lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

"Rhombus" The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

Remote command:
CURSor<m>:STYLe on page 1132

Source

Defines the source of the cursor measurement. Any of the input signal, math, reference or XY waveforms can be selected.

Remote command:
CURSor<m>:SOURce on page 1126

2nd source

Enables and selects a second source for the cursor measurements. If enabled, the second cursor lines Cx.2 measure on the second source. Using a second source, you can measure differences between two channels with cursors.

Remote command:
CURSor<m>:USSource on page 1127
CURSor<m>:SSOurce on page 1126

Y user position 1|2

Defines the position of the horizontal cursor lines. The setting corresponds to the V1 and V2 values in the "Cursor Results" box.

If "Track waveform" is enabled, the user setting is disabled and the measurement results are displayed in the "Cursor Results" box.

Remote command:
CURSor<m>:Y1Position on page 1128
CURSor<m>:Y2Position on page 1128

Track waveform

The horizontal cursors track the waveform. The first cursor line indicates the current vertical minimum, and the second cursor line indicates the maximum. If the waveform changes, e.g. during a running measurement, the cursors move along with it. If both horizontal and vertical cursors are displayed, the horizontal cursors are positioned to the crossing points of the vertical cursors with the waveform. The measurement results are displayed in the "Cursor Results" box.

Tracking disables the Y-coupling (coupling horizontal cursor lines) and the Y user position settings.

Remote command:
CURSor<m>:TRACking[:STATe] on page 1125

X position 1|2

Defines the position of the vertical cursors.

Remote command:
CURSor<m>:X1Position on page 1127
CURSor<m>:X2Position on page 1127

Coupling (2 follows 1)
Couples the horizontal and vertical cursor pairs so that the distance between the two lines remains the same if one cursor is moved.

Remote command:
`CURSor<m>:YCOupling` on page 1128
`CURSor<m>:XCOupling` on page 1127

Envelope wfm selection 1|2
Envelope selection is effective under the following conditions:
- The waveform arithmetic of the cursor source waveform is set to envelope waveform (see "Wfm Arithmetic" on page 128)
- "Track waveform" is enabled.
- Both horizontal and vertical cursors are enabled ("Type" = *Both*).

The setting defines which horizontal cursor is positioned to the maximum and which to the minimum envelope values.

"Minimum"	The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope.
"Maximum"	The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope.

Remote command:
`CURSor<m>:X1ENvelope` on page 1129
`CURSor<m>:X2ENvelope` on page 1129

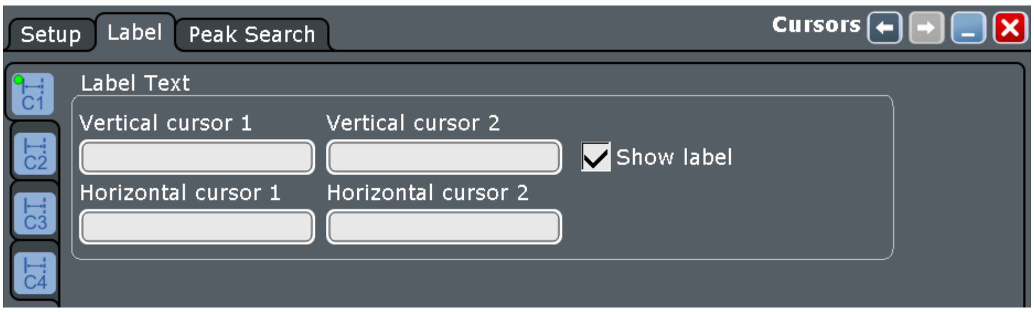
All Off
Disables all cursor measurements at once.

Remote command:
`CURSor<m>:AOFF` on page 1125

Show in all diagrams
Shows the enabled cursor measurements in all active diagrams of the same (time/spectrum) domain.

7.1.3.2 Cursor Labels

The settings in this tab configure the display of the cursors.



Cursor set (vertical tab)
The settings for each cursor measurement (or cursor set) are configured on separate tabs. For each measurement, labels can be defined for the cursors.

By default, the cursors are labeled as C1.1, C1.2, C2.1, C2.2, C3.1, C3.2, C4.1, C4.2.

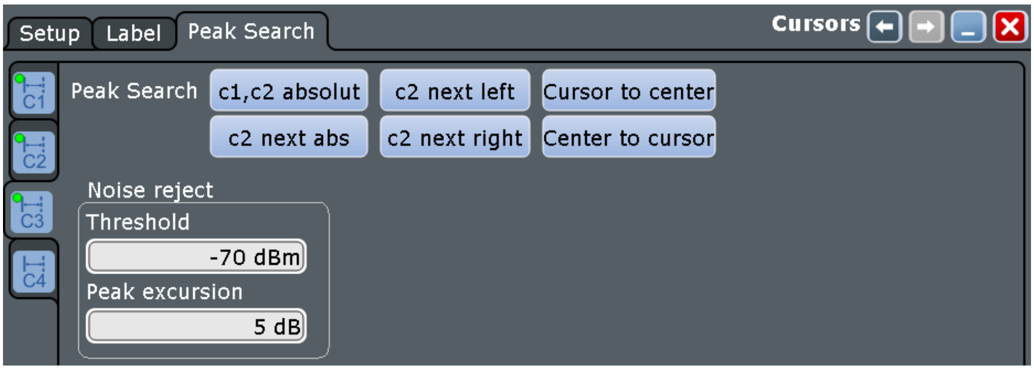
Vertical cursor 1|2
Defines a label to be displayed with the vertical cursors.

Horizontal cursor 1|2
Defines a label to be displayed with the horizontal cursors.

Show label
Shows the cursor labels in the diagram.

7.1.3.3 Peak Search

The settings on this tab are only available in spectrum mode, i.e. the source of the cursor measurement is an FFT math waveform. In this case, the cursors can indicate the results of a peak search on the waveform. You can define which peaks the instrument determines by defining the noise reject settings.



Threshold
Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

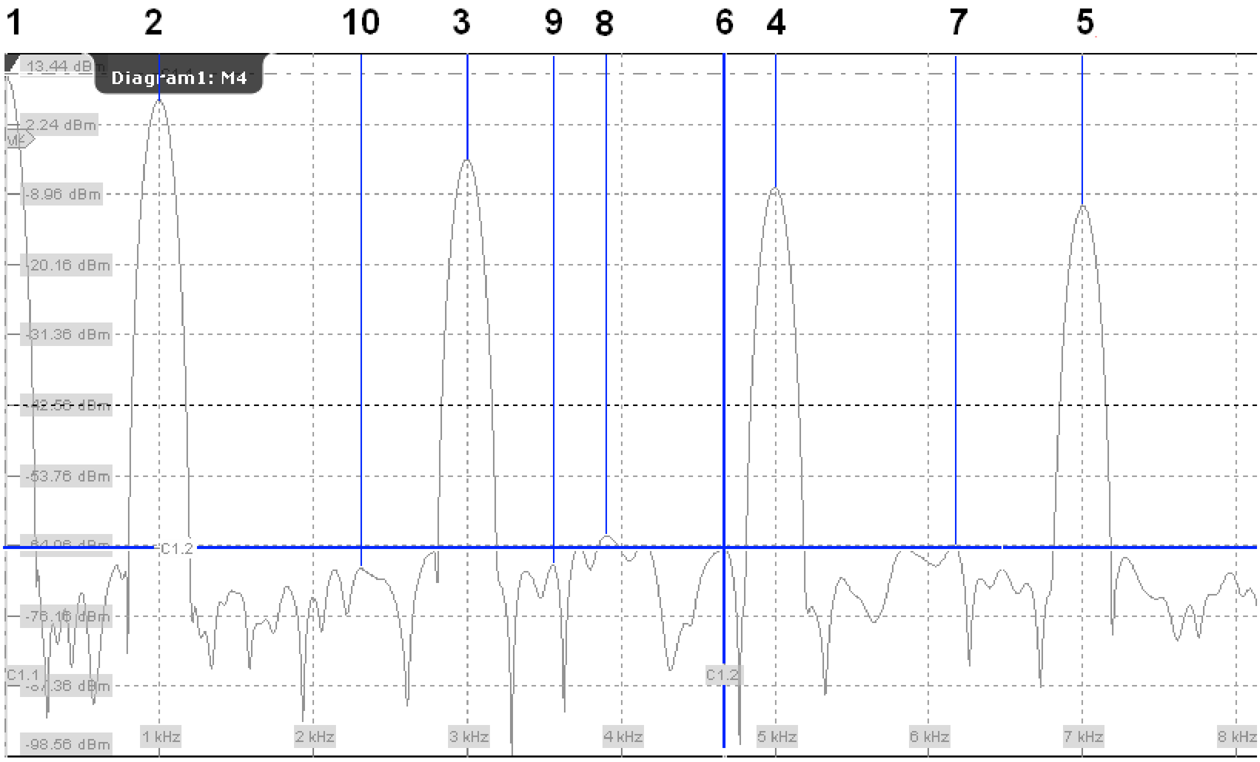
This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Remote command:
`CURSor<m>:THReshold` on page 1132
`MEASurement<m>:SPECtrum:ATHReshold` on page 1159

Peak excursion
Defines a relative threshold, the minimum level value by which the waveform must rise or fall to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

The following figure shows a cursor measurement on a spectrum waveform:



If "Peak excursion" is 30 dB, the peaks 1 to 5 are found. If "Peak excursion" is 20 dB, also the peaks 6 to 10 are found. The cursor position is on peak 6.

Remote command:

`CURSor<m>:PEXCursion` on page 1132

`MEASurement<m>:SPECtrum:PEXCursion` on page 1158

c1, c2 absolute

Both cursors are set to the absolute peak value.

Remote command:

`CURSor<m>:MAXimum[:PEAK]` on page 1131

c2 next abs

Cursor 2 is set to the next smaller absolute peak from the current position.

Remote command:

`CURSor<m>:MAXimum:NEXT` on page 1132

c2 next right

Cursor 2 is set to the next peak to the right of the current position.

Remote command:

`CURSor<m>:MAXimum:RIGHt` on page 1132

c2 next left

Cursor 2 is set to the next peak to the left of the current position.

Remote command:
`CURSor<m>:MAXimum:LEFT` on page 1131

Cursor to center
Sets the vertical cursor line C1 to the center frequency.

Remote command:
`CURSor<m>:FFT:TOCenter` on page 1131

Center to cursor
Sets the center frequency to the frequency value that is measured at cursor line C1.

Remote command:
`CURSor<m>:FFT:SETCenter` on page 1131

7.2 Automatic Measurements

The R&S RTP can perform many measurements in parallel. The measurements are combined in up to 8 measurement groups. In addition, you can run the quick measurement.

The basic measurement settings are source, category, and the selection of the measurement. You can refine the setup to get more specific results:

- **Gating**
  A gate limits the measurement to a user-defined part of the waveform. See Chapter 7.2.3, "Measurement Gates", on page 291.
- **Statistics and long term measurements**
  To evaluate time-dependent behavior of measurement results, you can use statistics, long term measurements, and tracks. You can also decide, how many measurement results per acquisition contribute to the calculation. See: Chapter 7.2.10, "Result Analysis", on page 331.
- **Limit checks and actions on test result**
  Limit and margin checks evaluate if the measurement result exceeds a specified value. You can define actions that are performed on limit or margin violation. See: Chapter 7.2.11, "Limit and Margin Checks", on page 341.

Measurement categories

The various measurement are grouped in several categories. The category defines which sources can be analyzed.

Time domain:

- Amp/Time: amplitude and time measurements
- Eye: eye diagram measurements
- Histogram: measurements on histograms
- Jitter measurements (only available if option R&S RTP-K12 is installed)

Frequency domain

- Spectrum: measurements on spectrum waveforms

- Histogram: measurements on histograms

Details on automatic measurements are described in the following chapters:

7.2.1 Measurement Setup in General

Up to 8 measurement groups can be defined. Each measurement group is configured in its own subtab. For each measurement group, the category and the source are defined in the "Meas Group" tab, and you can also enable statistic evaluation. Available sources and measurements depend on the selected category, for example, histogram measurements need a defined histogram as source. For each measurement group, you select all required measurements. If further settings are available for a measurement, a settings icon is shown beside the measurement's name.

7.2.1.1 Starting an Automatic Measurement

There are three methods to start an automatic measurement, each with slightly different effects:

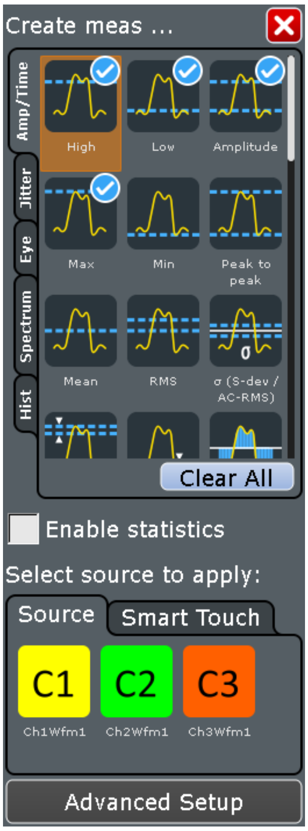
- Using the "Measurement" icon on the toolbar:
  See: "To start a measurement using the toolbar icon" on page 282.
- Pressing the [Meas] key on the front panel.
  See: "To start a measurement with the [Meas] key" on page 283.
- Using the "Meas" menu.
  See: Chapter 7.2.1.2, "Configuring Measurements", on page 283.

To start a measurement using the toolbar icon

1. Select the waveform that you want to measure.
2. Tap the "Measurement" icon on the toolbar.

3. On the sidebar, select the category, the measurements and the source.



4. Define the measurement range in one of these ways:
   - To measure the complete waveform, tap the diagram with the waveform.
   - To define a gate that limits the measurement, draw a rectangle on the screen.

   The "Meas Results" are displayed.

To start a measurement with the [Meas] key

1. Select the waveform on the screen.
2. Press the [Meas] key.

   The measurement for the selected waveform is enabled using the next available measurement configuration. The "Meas Results" are displayed.

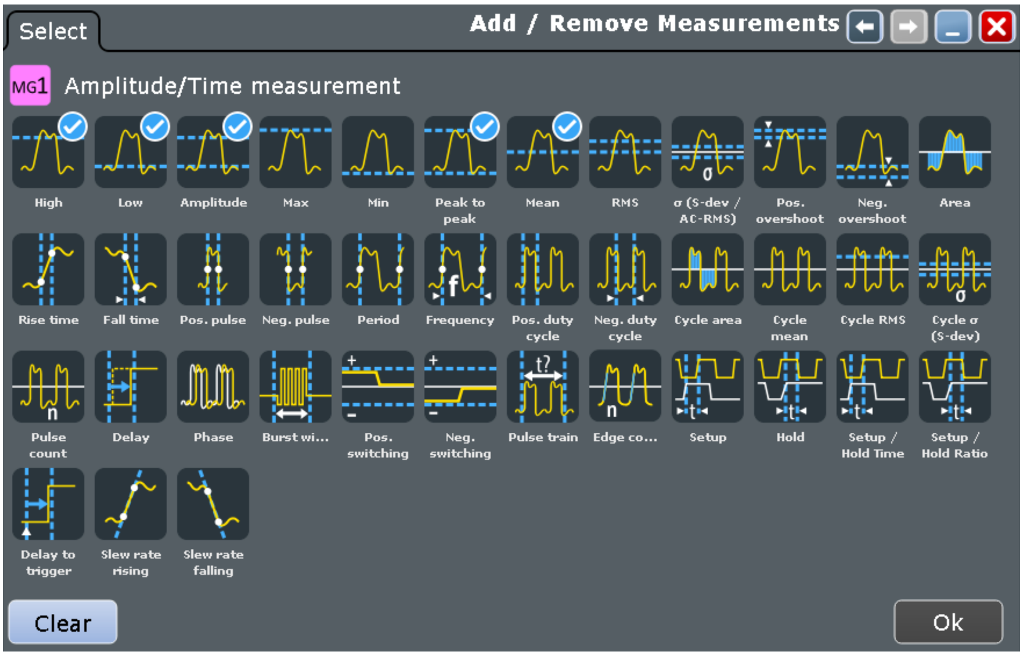
7.2.1.2 Configuring Measurements

1. To open the "Measurements" dialog box, choose one of these ways:

   If a measurement is already running:
   - Tap the icon in a floating result box, or double-tap a docked result box. On the sidebar, tap "Advanced Setup".
   - Tap the result box. Then press the [Meas] key.

   If no measurement is running, open the "Meas" menu and select "Meas Group".

2. Select the vertical subtab for the measurement group that you want to configure.
3. Select the measurement "Category", for example, "Amp/Time".
4. Tap "Source" and select the waveform to be measured.
   Spectrum measurements require an FFT math waveform as measurement source. Histogram measurements require a histogram as source.
5. Tap "Add / Remove Measurements" to select the measurements.
   Select all measurements that you want to include in the measurement group.



6. Tap "OK" to close the dialog box.
   All selected measurements are displayed in the list of active measurements.
7. A "Settings" icon indicates whether further settings are required. Tap the measurement. A dialog box opens, and you can adjust the measurement.

   The settings are explained in the following chapters:
   - Chapter 7.2.5.2, "Settings for Amplitude/Time Measurements ", on page 309
   - Chapter 7.2.6.2, "Settings for Eye Diagram Measurements", on page 318
   - Chapter 7.2.7.2, "Settings for Spectrum Measurements ", on page 320
   - Chapter 7.2.8.5, "Settings for Histogram Measurement ", on page 329
8. Optionally, define a gate to restrict the measurement to a part of the waveform. See Chapter 7.2.3.1, "Using Measurement Gates", on page 291.

   If you enabled the measurement with the toolbar icon and drew a rectangle on the diagram, the gate is already defined and enabled.
9. To compile and display statistics for the measurement, enable "Statistics". See also Chapter 7.2.10.1, "Statistics", on page 331.
10. Optionally, perform a limit or margin check as described in Chapter 7.2.11.1, "Performing Limit Checks", on page 341.

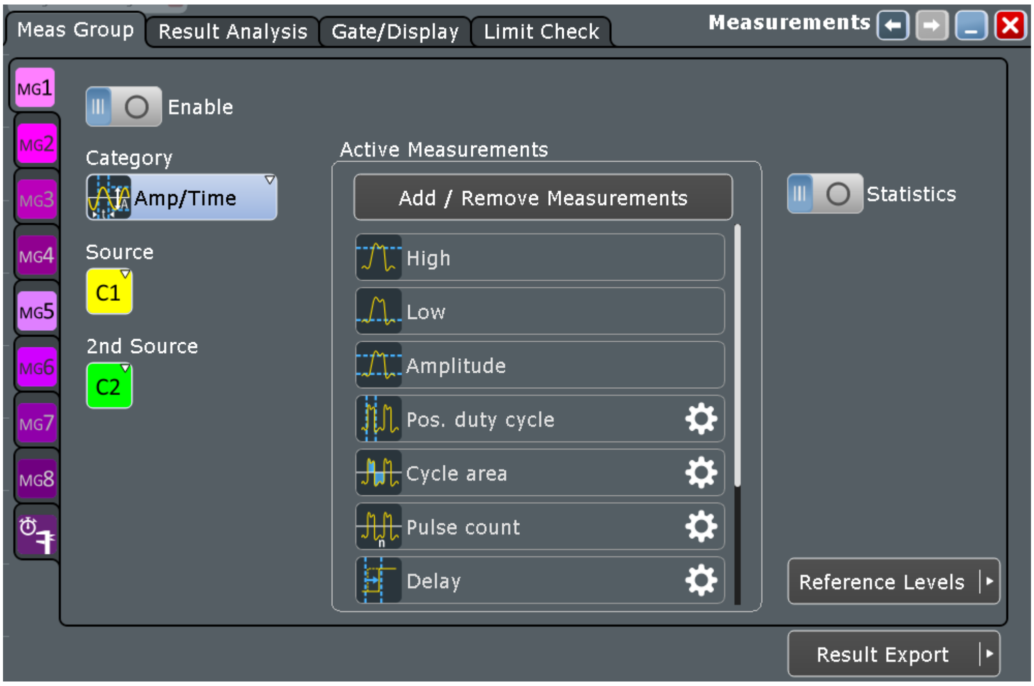
11. "Enable" the measurement group.

    The measurement results are displayed by default below the waveform diagram.

7.2.1.3 General Measurement Settings

Automatic measurements are configured in the "Measurements" dialog box.

Access: "Meas" menu > "Meas Group"



This section describes the settings that relate to all measurements. Specific settings are described in the corresponding category chapters:

- Chapter 7.2.5.2, "Settings for Amplitude/Time Measurements ", on page 309
- Chapter 16.1, "Jitter Measurements", on page 892
- Chapter 7.2.6.2, "Settings for Eye Diagram Measurements", on page 318
- Chapter 7.2.7.2, "Settings for Spectrum Measurements ", on page 320
- Chapter 7.2.8.5, "Settings for Histogram Measurement ", on page 329

MG 1/2/3/4/5/6/7/8/Quick Meas
Subtabs for each measurement group, and for the quick measurement. The subtabs contain the configuration settings. A green dot on the tab indicates that the measurement group is active.

Enable
Starts the measurements of the selected measurement group.

Remote command:
`MEASurement<m>[:ENABle]` on page 1134

Category
Measurement category. The following categories are available:

Time domain:
- Amp/Time: amplitude and time measurements
- Eye: eye diagram measurements
- Histogram: measurements on histograms
- Jitter measurements (only available if option R&S RTP-K12 is installed)

Frequency domain
- Spectrum: measurements on spectrum waveforms
- Histogram: measurements on histograms

Remote command:
`MEASurement<m>:CATegory` on page 1137

Source, 2nd source
Define the source of the measurement group. The source can be any input signal, math or reference waveform. The 2nd source is required for amplitude/time measurements that are performed on two waveforms (e.g. delay, phase). Availability of sources depends on the selected category.

Remote command:
`MEASurement<m>:SOURce` on page 1134

Active Measurements, Add / Remove Measurements
The "Active Measurements" list shows the measurements that are selected for the current category. At least, one measurement must be selected. If further settings are available for a measurement, a settings icon is shown beside the measurement's name.

To change the selection, tap "Add / Remove Measurements".

In the "Add / Remove Measurements" dialog box, select the measurements that you need. Tap "Clear" to disable all selected measurements. Tap "OK" to confirm the selection.

Remote command:
`MEASurement<m>:MAIN` on page 1138
`MEASurement<m>:ADDitional` on page 1139

Envelope
This setting is only available for measurements on envelope waveforms, see "Wfm Arithmetic" on page 128.

"Both"	The upper and the lower envelope are used in measurements. For time measurements, the averages of min and max values are used, that is, the measurement is performed on the average waveform built from the upper and lower envelope.
"Maximum"	Measurements are performed on the upper envelope.
"Minimum"	Measurements are performed on the lower envelope.

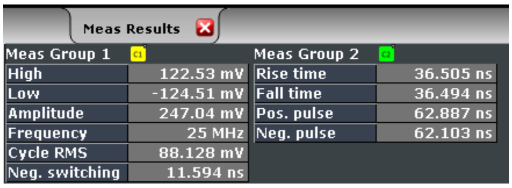
Remote command:
`MEASurement<m>:ENVSelect` on page 1146

Statistics / Enable
Enables the calculation and display of statistical results.

Remote command:
`MEASurement<m>:STATistics[:ENABle]` on page 1175

7.2.2 Measurement Results

By default, the results of automatic measurements are displayed below the waveform diagram when an automatic measurement is enabled.



If you want to save space in the display, drag the results to the sidebar. The most important results are displayed and updated in a results icon.

The function "Clear all" in the "Display" menu resets all results including long-term measurement and statistic results, and also deletes all waveforms and the history.

Which results are displayed depends on the selected measurements and is described in detail in the following chapters.

The following additional results are available:

- **Statistics**
  You can enable statistical evaluation of the measurement results. Statistic information is provided in the result box. Stopping and restarting the acquisition does not reset statistics but only stops and continues them.
  See Chapter 7.2.10, "Result Analysis", on page 331
- **Measurement histograms**
  The results of measurements can be displayed in a histogram which shows the density distribution of the measurement results in a graphic and thus illustrates the statistics of the measurements.
  See Chapter 7.2.8, "Histograms and Histogram Measurements", on page 323
- **Long-term measurements**
  Long-term measurements show the behavior of measurement results over a longer time or for many samples. You can define the number of long-term points and export the long-term data, including statistical results. The measurement histogram is a vertical histogram shown in the long-term diagram.
  Long-term measurements are performed on the measurement that is selected for analysis and math on the "Result Analysis" tab.
  See: Chapter 7.2.10, "Result Analysis", on page 331
- **Intermediate results**
  You can display auxiliary result lines and reference levels in the source diagram, see Chapter 7.2.2.2, "Configuring the Results Display", on page 288.

Remote commands:
- `MEASurement<m>:ARES?` on page 1140
- `MEASurement<m>:ARNames` on page 1141
- `MEASurement<m>:RESult[:ACTual]?` on page 1141
- `MEASurement<m>:RESult:COUNt?` on page 1143

7.2.2.1 Measurement Status

The overall status of measurement results is indicated by various icons. In general, a question mark before the result value indicates that the measurement result might not be correct due to insufficient amplitude level. Check your amplitude and reference level settings. The icon colors indicate the state of the limit and margin checks.

Icon	Description
No icon, no result value ("---")	The instrument cannot measure the required value, for example, if the acquisition does not contain at least one complete period for frequency and cycle measurements. Check and adjust the waveform settings to get results.
	The measurement result might not be correct due to insufficient amplitude level. Check your amplitude and reference level settings. Limit and margin checks are disabled.
	Limit and margin checks passed, measurement results are reliable.
	The measurement result might not be correct due to insufficient amplitude level. Check your amplitude and reference level settings. Limit and margin checks passed.
	The measurement result might not be correct due to insufficient amplitude level. Check your amplitude and reference level settings. Margin checks failed.
	Margin checks failed.
	The measurement result might not be correct due to insufficient amplitude level. Check your amplitude and reference level settings. Limit checks failed.
	Limit checks failed.

7.2.2.2 Configuring the Results Display

The measurement results can be displayed in a table below the waveform diagrams, in a floating result box, or in a minimized result icon on the sidebar.

The display settings for measurements are provided on the "Gate/Display" tab, see Chapter 7.2.2.3, "Display Settings for Results", on page 289.

To display measurement information and results

You can display auxiliary lines in the diagram to determine how a measurement result was obtained. Auxiliary lines show gate areas, reference levels or intermediate result lines, such as the signal thresholds for rise and fall time measurements.

1. From the "Meas" menu, select "Gate/Display".
2. Select the subtab for the measurement group you want to configure.
3. To display intermediate result lines, select "Display result lines".
4. To display reference levels, select "Display reference levels".
5. To show each measurement in a separate result box, disable "Group result dialogs".
   Enable this setting to show all measurement results together in one result box.
6. If you use separate (ungrouped) result boxes, you can extend the result box of a selected measurement with a small control panel. It provides source settings and statistics enabling for quick access: enable "Show result control panel".

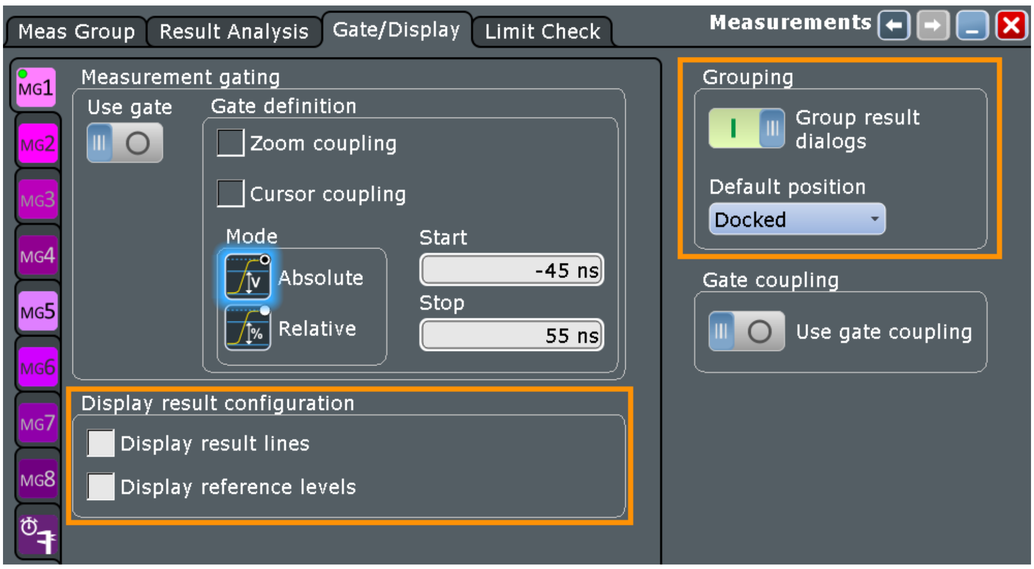
To clear the measurement results

1. On the "Display" menu, tap "Clear all".
2. To restart measurement statistics, without deleting other results, select "Reset" on the "Result Analysis" tab.

   The results in the selected measurement result box are cleared and written anew.

7.2.2.3 Display Settings for Results

The display settings for measurement results are set on the "Gate/Display" tab. Display settings are specific for each measurement group.



Gate settings are described in Chapter 7.2.3.2, "Gate Settings for Measurements", on page 292.

Display result lines

Displays intermediate result lines in the measurement waveform (e.g. signal thresholds) required to obtain the measurement result.

Remote command:

`MEASurement<m>:DISPlay:RESults` on page 1173

Display reference levels

Displays the reference levels used for the measurement in the diagram.

Remote command:

`MEASurement<m>:DISPlay:LEVels` on page 1172

Show result control panel

Extends the result box of the selected measurement group with the source settings and the statistics enabling. Thus you can check and change the measurement sources directly in the results box, and also enable statistics there. The setting is only available if the result boxes are not grouped ("Group result dialogs" = Off).

Group result dialogs

If enabled, all results are shown in one result box (default).

If disabled, the results of each measurement group are shown in a separate result box. The default position is ignored.

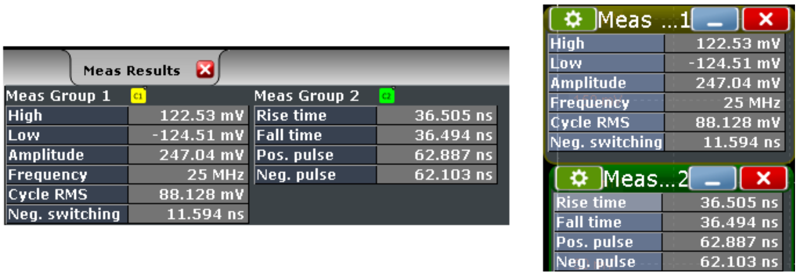


Figure 7-4: Left: Grouped and docked results. Right: Ungrouped, floating results

The setting affects all measurements except for the peak list.

Remote command:

`MEASurement<m>:DISPlay:GROuping` on page 1173

Default position

Defines the default position of the result table:

- "Docked": fixed tab below the diagrams
- "Preview": result icon on the sidebar
- "Floating": floating result box in front of the diagrams

The setting affects only grouped result boxes.

Remote command:

`DISPlay:RESultboxes:MEPosition` on page 1174

7.2.3 Measurement Gates

Gate areas limit the measurement to a user-defined range of the waveform. The gate settings are defined on the "Gate/Display" tab.

Each measurement group can use its own gate. Make sure to select the correct measurement group on the left.

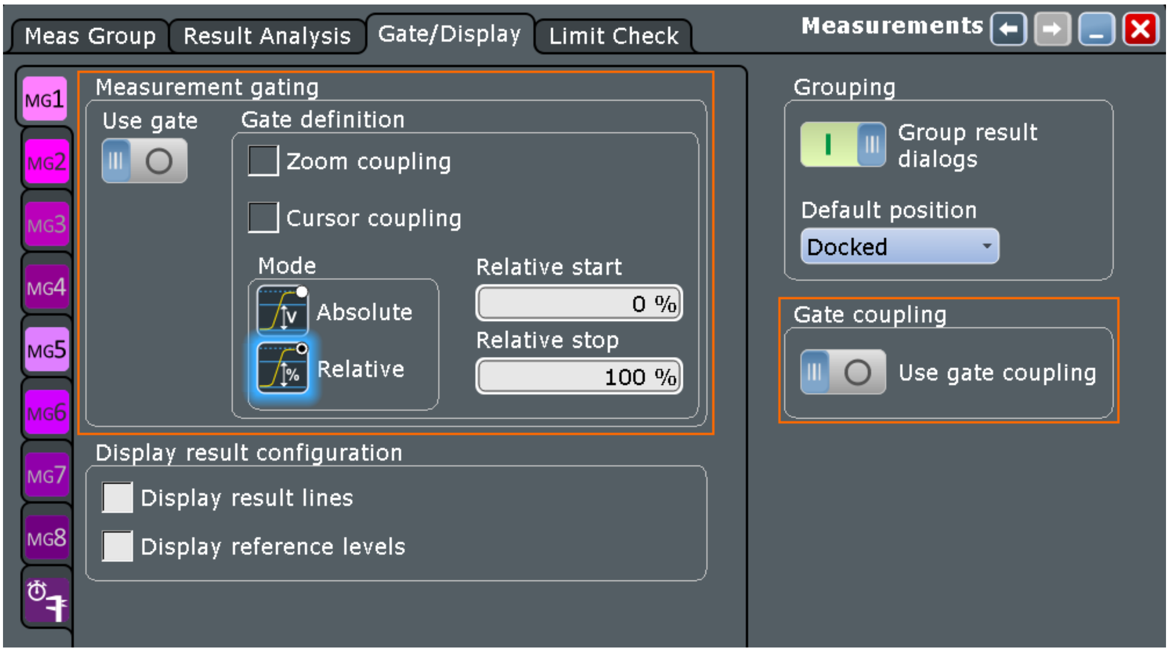
7.2.3.1 Using Measurement Gates

If you have enabled the measurement with the toolbar icon and drew a rectangle on the diagram, the gate is automatically defined and enabled. If you want to create a gate for a running measurement, or if you want to modify the gate area, configuration is done in the "Measurements" > "Gate/Display" dialog box.

1. On the "Meas" menu, tap "Gate/Display".
2. Select the subtab for the measurement group you want to configure.
3. To define the gate, use one of the following methods:
   - Define the start value and the stop value of the gate area by entering either absolute or relative values.
   - If a zoom area has already been defined for the waveform, couple the gate area to the zoom area by selecting the "Zoom coupling" option.
   - If a cursor measurement has already been defined for the waveform, couple the gate area to the cursor lines by selecting the "Cursor coupling" option.
4. If you want to use the same gate for all measurement group, enable "Use gate coupling".
5. Tap the "Use gate" icon to enable the gate usage.

   The measurement is performed on the selected part of the waveform. The gate is shown in the diagram.

7.2.3.2 Gate Settings for Measurements



Result display settings are described in Chapter 7.2.2.3, "Display Settings for Results", on page 289.

Use gate

Considers the gating settings for the selected measurement and displays the gate.

Remote command:

`MEASurement<m>:GATE[:STATe]` on page 1181

Zoom coupling

Zoom coupling is available if a zoom is defined. As long as "Zoom coupling" is enabled, the gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.

If several zoom diagrams are defined, select the zoom diagram to be used for gating. The "Start" and "Stop" values of the gate are adjusted accordingly.

Zoom coupling can be set for measurement gates, FFT gates, and search gates.

Remote command:

`MEASurement<m>:GATE:ZCOupling` on page 1183
`MEASurement<m>:GATE:ZDIagram` on page 1184
`CALCulate:MATH<m>:FFT:GATE:ZCOupling` on page 1208
`SEARch:GATE:ZCOupling` on page 1263
`SEARch:GATE:ZDIagram` on page 1263

Cursor coupling
If enabled, the gate area is defined by the cursor lines of an active cursor measurement. If several cursor measurements are enabled, select the cursor set to be used for gating. The "Start" and "Stop" values of the gate are adjusted to the values of the cursor line positions. The measurement is limited to the part of the waveform between the cursor lines.

Remote command:
MEASurement<m>:GATE:CCOupling on page 1183
MEASurement<m>:GATE:CURSor on page 1183

Mode
Defines whether the gate settings are configured using absolute or relative values.

"Absolute" The gate is defined by absolute start and stop values.

"Relative" The gate's start and stop values are defined by a percentage of the value range.

Remote command:
CALCulate:MATH<m>:FFT:GATE:MODE on page 1207
MEASurement<m>:GATE:MODE on page 1182
SEARch:GATE:MODE on page 1261

(Relative) Start
Defines the starting value for the gate.

Remote command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt on page 1206
CALCulate:MATH<m>:FFT:GATE:RELative:STARt on page 1207
MEASurement<m>:GATE:ABSolute:STARt on page 1182
MEASurement<m>:GATE:RELative:STARt on page 1182
SEARch:GATE:ABSolute:STARt on page 1262
SEARch:GATE:RELative:STARt on page 1262

(Relative) Stop
Defines the end value for the gate.

Remote command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP on page 1207
CALCulate:MATH<m>:FFT:GATE:RELative:STOP on page 1207
MEASurement<m>:GATE:ABSolute:STOP on page 1182
MEASurement<m>:GATE:RELative:STOP on page 1182
SEARch:GATE:ABSolute:STOP on page 1262
SEARch:GATE:RELative:STOP on page 1263

Use gate coupling
If you enable the gate coupling, the gate settings of the selected measurement are copied to all other measurements. Thus, all measurements use the same gate. If zoom or cursor coupling is active in a measurement, the zoom size and cursor positions are adjusted.

Remote command:
MEASurement<m>:GATE:GCOupling on page 1184

7.2.4 Reference Levels

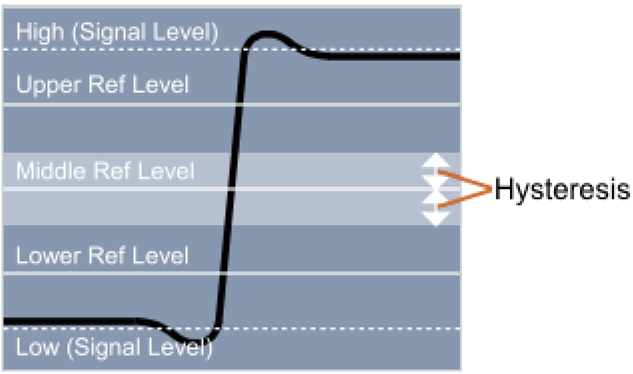
Some measurement require reference levels to obtain the measurement points, e.g. time measurements or pulse count. Reference levels are referred to the signals, for each waveform you can define specific reference levels. Thus, for all measurements on a waveform the same reference levels are used.

Usually, reference levels are determined automatically. The instrument determines the high and low signal levels based on amplitude and histogram measurements of the acquisition. The reference levels are set relatively to the determined signal levels.

However, for irregular data and in special measurement setups it may be useful to configure the levels manually:

- Data signals can contain intervals where no data is transmitted, so that a high and low state cannot be determined for each acquisition. In this case, you can define the high and low signal levels manually to evaluate other measurement results.
- If the signal levels vary strongly or have large overshoots, the rise and fall levels may be difficult to determine.
- If fixed levels are defined for the DUT, you can configure the reference levels in the R&S RTP correspondingly and analyze the resulting measurement data.

In manual configuration, the reference levels can be set relatively to defined signal levels or as absolute values. You can also set the reference levels directly.



In addition to reference and signal levels, you can define a hysteresis for the middle reference level and tubes for signal levels. Hysteresis is useful for measurements that determine zero-crossings. Period, frequency, and pulse measurements are based on hysteresis - the instrument returns results if the amplitude of the signal exceeds the hysteresis. Thus, measurement during the transient oscillation is also possible. Tubes define evaluation ranges for measurements that require detection of the high level or low level. If the signal value remains within the defined tubes, it is considered to be high or low.

Reference levels and result lines can be displayed in the diagram, see "To display reference levels and result lines" on page 296.

7.2.4.1 Configuring Reference Levels

To determine reference and signal levels automatically

By default, the histogram of the measurement data is evaluated to determine the required levels automatically. However, you can define several parameters to adapt the evaluation to your data.

1. On the "Meas" menu, select "Reference Levels" > "Levels".
2. Define the "Source", the waveform for which the reference is defined. The source can be any signal input, math or reference waveform.
3. Select automatic "Reference level mode".
4. Define the "Signal level mode", the method which is used to determine the signal levels. For details, see "Signal level mode" on page 299.
5. By default, the lower reference level is defined at 10% of the signal amplitude, the middle reference level at 50% and the upper reference level at 90%. You can select other "Relative levels" to be used for evaluation.
   If default percentages do not fit, select "User defined" and enter the percentages for the upper, middle, and lower reference levels.
   The signal levels are determined by the instrument.
6. To determine the reference levels using average values from several histograms, enable the "Histogram averaging" option and define an "Average Count" to define how many histograms are averaged.
   Averaging is not available if "Absolute peaks" are selected as the "Signal level mode".

To determine reference levels manually

You can configure the reference levels manually as fixed absolute or relative values.

1. On the "Meas" menu, select "Reference Level" > "Levels".
2. Define the "Source", the waveform for which the reference levels are defined. The source can be any signal input, math or reference waveform.
3. Select manual "Reference level mode".
4. Under "Level definition", select whether you want to define the levels using absolute or relative values.
5. Under "User level selection", select whether you want to configure the high and low signal levels ("User signal level") or the lower, middle and upper reference levels ("User reference level").
6. To define high and low signal levels if "User signal level" is selected:
   a) Enter the absolute high and low signal levels.

   b) If "Level definition" is relative, select one of the predefined "Relative levels". If default percentages do not fit, select "User defined" and enter the percentages for the upper, middle, and lower reference levels.
      The upper and lower reference levels are computed from the signal level values and the percentage values.
   c) If "Level definition" is absolute, set the absolute "Top distance" and "Bottom distance" values, the differences between signal and reference levels.
      The upper and lower reference levels are computed from the signal level values and the distances.

7. To define lower, middle and upper reference levels if "User reference level" is selected:
   a) Enter the absolute upper and lower reference levels.
   b) If "Level definition" is relative, select one of the predefined "Relative levels". If default percentages do not fit, select "User defined" and enter the percentages for the upper, middle, and lower reference levels.
      The high and low signal levels are computed from the reference level values and the percentage values.
   c) If "Level definition" is absolute, set the absolute "Top distance" and "Bottom distance" values, the differences between signal and reference levels.
      The high and low signal levels are computed from the reference level values and the distances.

To define hysteresis and tubes

1. To define a hysteresis for the middle reference level:
   a) Select the "Hysteresis" tab.
   b) Enter a percentage of the selected signal level.

   A rise or fall from the middle reference value that does not exceed the hysteresis is rejected and not considered a zero-crossing.
2. To define a tube for the high and low signal levels:
   a) Select the "Tube" tab.
   b) In the "Relative outer" field, define a percentage of the signal level by which the absolute signal level may be larger than high signal level or lower than the low signal level.
   c) In the "Relative inner" field, define a percentage of the signal level by which the absolute signal level may be higher than the low signal level or lower than the high signal level.

To display reference levels and result lines

1. On the "Meas" menu, select "Gate/Display".
2. Select the tab for the measurement you want to configure.

3. Enable "Display result lines" or "Display reference levels" option, or both.

   The reference levels and intermediate results are displayed in the waveform diagram.

7.2.4.2 Level Settings

Access: "Meas" menu > "Reference Level" > "Levels" tab.

On the "Levels" tab, you define how the reference levels are calculated, or you set them directly.

In automatic reference level mode, the reference levels are always relative values. You can select one of the predefined sets, or define individual percentage values.

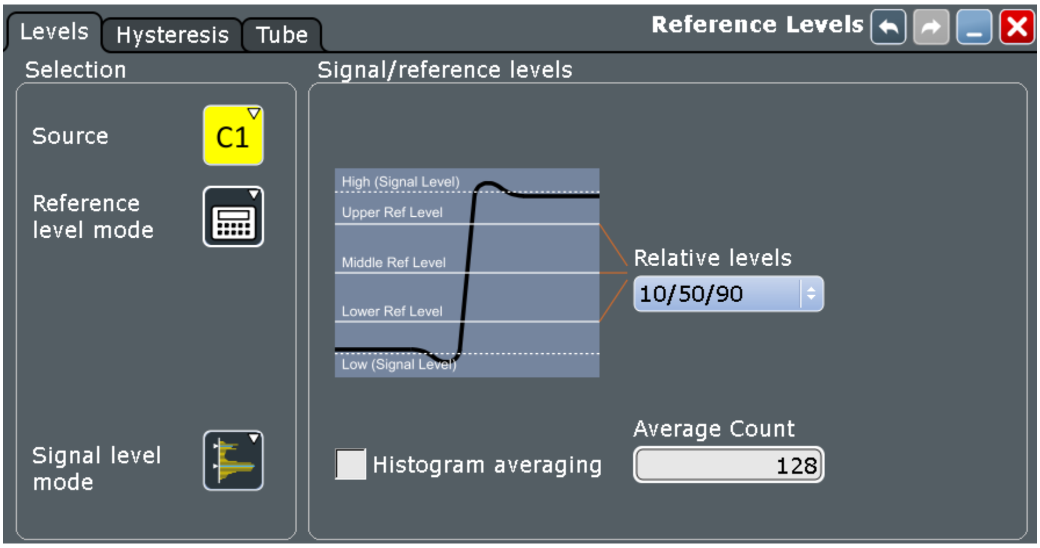


Figure 7-5: Automatic reference level definition

In manual reference level mode, relative and absolute level definitions are possible.

In manual reference level mode with relative level definition, you define the absolute values of high and low signal levels or reference levels, and the reference levels as percentages of the signal amplitude.

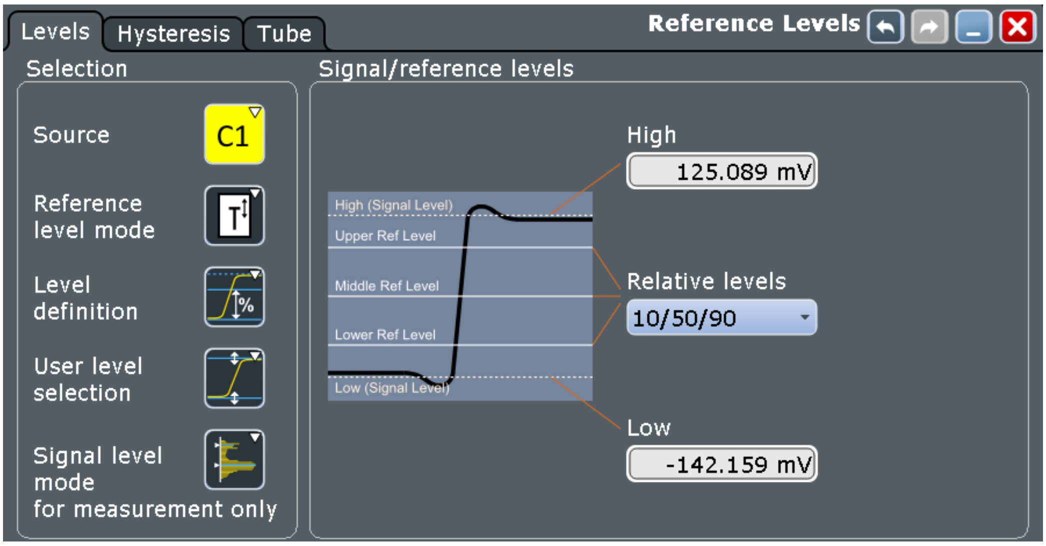


Figure 7-6: Manual reference level mode, relative level definition

In manual reference level mode with absolute level definition, you define the absolute values of high and low signal levels or reference levels, and the distances between reference and signal levels.

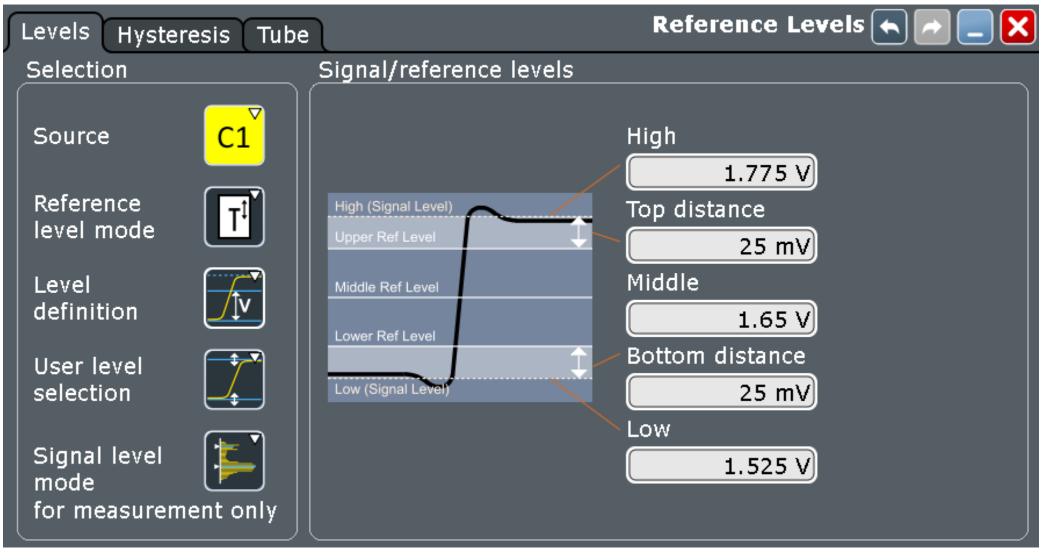


Figure 7-7: Manual reference level mode, absolute level definition

Source

Defines the source for which the reference levels are defined. The source can be any signal input, math or reference waveform.

Remote command:

Source is defined by suffix <m> in "REFLevel" subsystem, see Chapter 20.12.12, "Reference Levels", on page 1187

Reference level mode
Defines whether the reference level is configured manually or automatically.

Remote command:
REFLevel<m>:LDETection on page 1187

Signal level mode
Defines the computation method for high and low signal levels. The instrument analyzes the signal, performs amplitude and histogram measurements, and defines the signal levels using the selected method.

The selected method is used to compute the signal levels for determination of reference levels in automatic reference level mode. It is also used for high, low, and amplitude measurements in automatic and manual reference level modes.

See also: Chapter 7.2.8, "Histograms and Histogram Measurements", on page 323

"Auto select absolute probability"	The most suitable signal levels for the selected measurement are used.
"Peak probability"	The signal levels with the highest probability values are used. These are the upper peak value and the lower peak value of the histogram measurement.
"Mean probability"	The signal levels with mean probabilities are used.
"Absolute peak"	The absolute peak signal levels are used. These are the maximum and minimum signal values of the amplitude measurement.
"Upper absolute peak - Lower mean probability"	The high signal level is the upper absolute peak (the maximum signal level), and the low signal level is the level with the mean probability in the lower half of the histogram.
"Upper mean probability - Lower absolute peak"	The high signal level is the level with mean probability in the upper half of the histogram, and the low signal level is the lower absolute peak (the minimum signal level).
"Upper absolute peak - Lower manual"	The high signal level is the maximum result value of the amplitude measurement. The low signal level is manually set using "Low".
"Upper manual - Lower absolute peak"	The high signal level is set manually using "High". The low signal level is the minimum result value of the amplitude measurement.

Remote command:
REFLevel<m>:AUTO:MODE on page 1189

Level definition
In manual reference level mode, the setting defines whether the reference is configured using absolute or relative values.

Remote command:
REFLevel<m>:LMODe on page 1188

User level selection
In manual reference level mode, the setting defines whether the user-defined signal levels or user-defined reference levels are used for the measurements.

"User signal level"	You can define the high and low signal levels.
"User reference level"	You can define the reference levels.

Remote command:
REFLevel<m>:USRLevel on page 1189

Relative levels
Sets the lower, middle and upper reference levels, defined as percentages of the signal amplitude.

Available relative levels:

- 5/50/95
- 10/50/90
- 20/50/80
- User defined: Enter "Upper ref level", "Middle ref level", and "Lower ref level".

For example, for "5/50/95" the levels are set to the following values:

- Lower reference level = 5% of the signal amplitude
- Middle reference level = 50% of the signal amplitude
- Upper reference level = 95% of the signal amplitude

Remote command:
REFLevel<m>:RELative:MODE on page 1188

Upper ref level, Middle ref level, Lower ref level
Define the reference levels in percent, if "Relative levels" is set to "User-defined".

Remote command:
REFLevel<m>:RELative:UPPer on page 1194
REFLevel<m>:RELative:MIDDle on page 1194
REFLevel<m>:RELative:LOWer on page 1195

High
Sets the high signal level.

The high signal level is set in manual reference level mode, for absolute level definition and user signal level selection.

Remote command:
REFLevel<m>:ABSolute:HIGH on page 1191

Low
Sets the low signal level.

The low signal level is set in manual reference level mode, for absolute level definition and user signal level selection.

Remote command:
REFLevel<m>:ABSolute:LOW on page 1192

Middle
For user signal level selection, the level is the middle level between high and low signal level. The value is adjusted automatically if you change the high or low signal levels. Vice versa, if you change the middle level, the high and low signal levels are adjusted.

For user reference level selection, the level is the middle level between upper and lower reference level. The value is adjusted automatically if you change the upper or lower reference levels. Vice versa, if you change the middle level, the upper and lower reference levels are adjusted.

Remote command:
`REFLevel<m>:ABSolute:MLEVel` on page 1193

Top distance
The distance between the high signal level and the upper reference level - for manual reference level mode and absolute level definition.

Remote command:
`REFLevel<m>:ABSolute:TDIStance` on page 1192

Bottom distance
The distance between the lower reference level and the low signal value - for manual reference level mode and absolute level definition.

Remote command:
`REFLevel<m>:ABSolute:BDIStance` on page 1192

Upper level
The upper reference level required, for example, to determine a rise - for manual reference level mode, absolute level definition and user reference level.

Remote command:
`REFLevel<m>:ABSolute:ULEVel` on page 1193

Lower level
The lower reference level required, for example, to determine a fall - for manual reference level mode, absolute level definition and user reference level.

Remote command:
`REFLevel<m>:ABSolute:LLEVel` on page 1194

Histogram averaging
Enables averaging over several histograms to determine the reference levels.

This function is only available in automatic reference level mode.

Remote command:
`REFLevel<m>:AUTO[:STATe]` on page 1190

Average Count
Defines the number of histograms to calculate the average from.

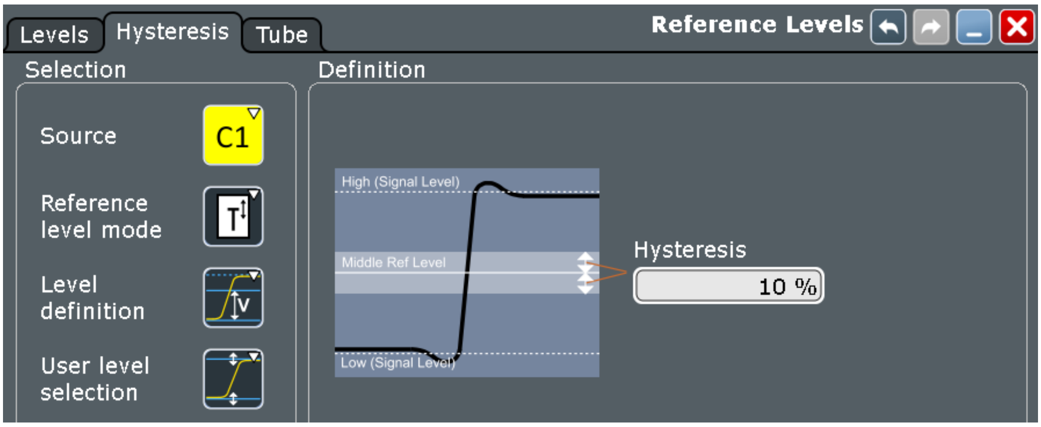
This function is only available in automatic reference level mode.

Remote command:
`REFLevel<m>:AUTO:COUNt` on page 1191

7.2.4.3 Hysteresis Tab

Access: "Meas" menu > "Reference Level" > "Hysteresis" tab.

This tab allows you to define a hysteresis for measurements that determine zero-crossings.



For a description of settings under "Selection", see Chapter 7.2.4.2, "Level Settings", on page 297.

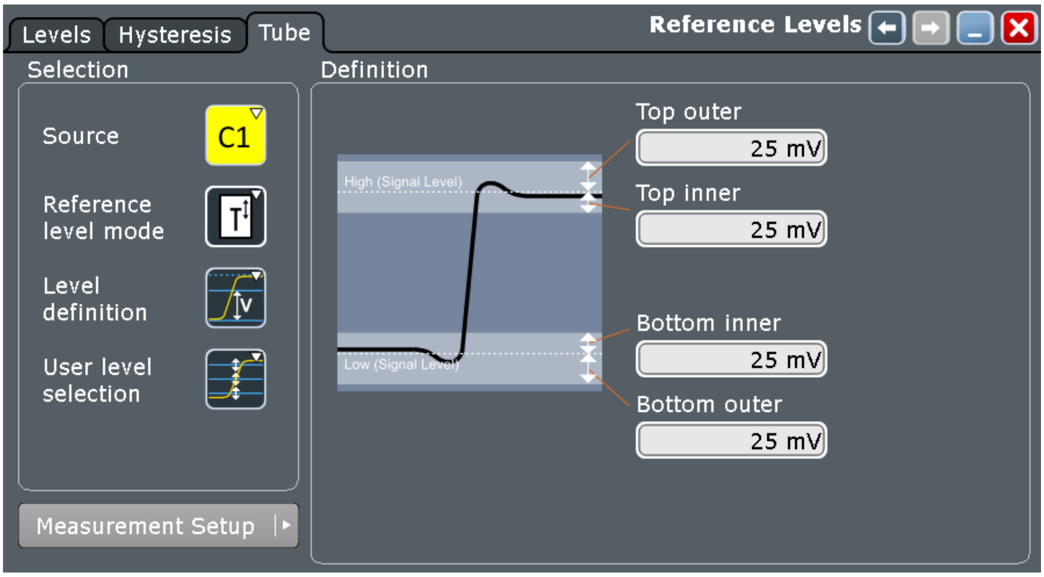
Hysteresis
Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Remote command:
`REFLevel<m>:RELative:HYSTeresis` on page 1195

7.2.4.4 Tube Tab

Access: "Meas" menu > "Reference Level" > "Tube" tab.

This tab allows you to define evaluation tubes for measurements that require high-level or low-level detection. If the signal value remains within the defined tubes, it is considered to be high or low.



For a description of settings under "Selection", see Chapter 7.2.4.2, "Level Settings", on page 297.

Top outer
Defines an area above the high signal level which is still considered to be high level.

Remote command:
`REFLevel<m>:ABSolute:TOTube` on page 1196
`MEASurement<m>:REFLevel:RESult:TOUTer?` on page 1199

Top inner
Defines an area beneath the high signal level which is still considered to be high level.

Remote command:
`REFLevel<m>:ABSolute:TITube` on page 1197
`MEASurement<m>:REFLevel:RESult:TINNer?` on page 1199

Bottom inner
Defines an area above the low signal level which is still considered to be low level.

Remote command:
`REFLevel<m>:ABSolute:BITube` on page 1197
`MEASurement<m>:REFLevel:RESult:BINNer?` on page 1198

Bottom outer
Defines an area beneath the low signal level which is still considered to be low level.

Remote command:
`REFLevel<m>:ABSolute:BOTube` on page 1197
`MEASurement<m>:REFLevel:RESult:BOUTer?` on page 1198

Relative outer
Defines a percentage of the signal level by which the absolute signal level may be larger than the high signal level or lower than the low signal level to be considered high or low, respectively.

Remote command:

REFLevel<m>:RELative:OTUBe on page 1196

Relative inner

Defines a percentage of the signal level by which the absolute signal level may be higher than the low signal level or lower than the high signal level to be considered low or high, respectively.

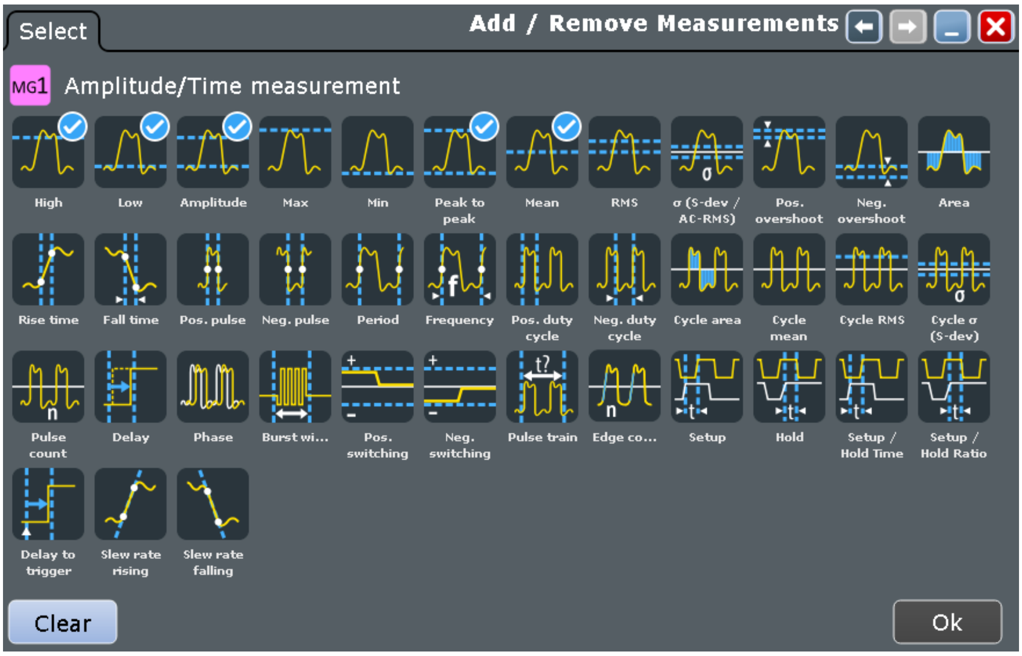
Remote command:

REFLevel<m>:RELative:ITUBe on page 1196

7.2.5 Amplitude/Time Measurements

7.2.5.1 Overview of Amplitude/Time Measurements

Access: "Meas" menu > "Meas Group" > "Amp/Time" category

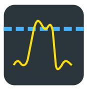
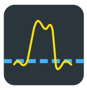
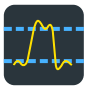
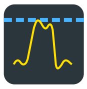
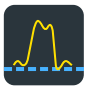
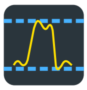
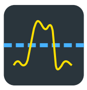
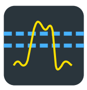
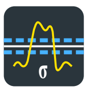
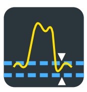
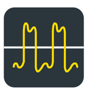


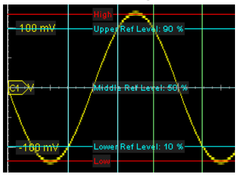
The R&S RTP provides various voltage, time, area and counting measurements in the category "Amp/Time". Some measurements require reference levels to be set according to the measurement purpose.

Reference levels are explained in Chapter 7.2.4, "Reference Levels", on page 294.

Amplitude Measurements

Table 7-1: Amplitude measurements

	Meas. type	Symbol	Description/Result
	High	X_{High}	High signal level
	Low	X_{Low}	Low signal level
	Amplitude	X_{Ampl}	Amplitude of the signal: the difference of high and low signal levels $X_{Ampl} = X_{High} - X_{Low}$
	Max	X_{Max}	Absolute maximum value of the waveform
	Min	X_{Min}	Absolute minimum value of the waveform
	Peak to peak	X_{PkPk}	Peak-to-peak value of the waveform: the difference of maximum and minimum values $X_{Ampl} = X_{Max} - X_{Min}$
	Mean	X_{Mean}	Arithmetic average of the waveform voltage values $X_{Mean} = \frac{1}{N_{Eval}} \sum_{i=1}^{N_{Eval}} x(i)$
	RMS	X_{RMS}	RMS (root mean square, quadratic mean) of the waveform voltage values $X_{RMS} = \sqrt{\frac{1}{N_{Eval}} \sum_{i=1}^{N_{Eval}} x^2(i)}$
	σ (S-dev)	σ_X	Standard deviation of the waveform samples $\sigma_X = \sqrt{\frac{1}{N_{Eval}-1} \sum_{i=1}^{N_{Eval}} (x(i) - X_{Mean})^2}$
	Pos. overshoot	R_{Pos}	Positive overshoot of a square wave, calculated from measurement values High, Max, and Amplitude $+Ovr = \frac{V_{top} - V_{P+}}{V_{Amp}} \cdot 100\%$
	Neg. overshoot	R_{Neg}	Negative overshoot of a square wave, calculated from measurement values Min, Low, and Amplitude $-Ovr = \frac{V_{base} - V_{P-}}{V_{Amp}} \cdot 100\%$
	Cycle mean		The mean value of one cycle

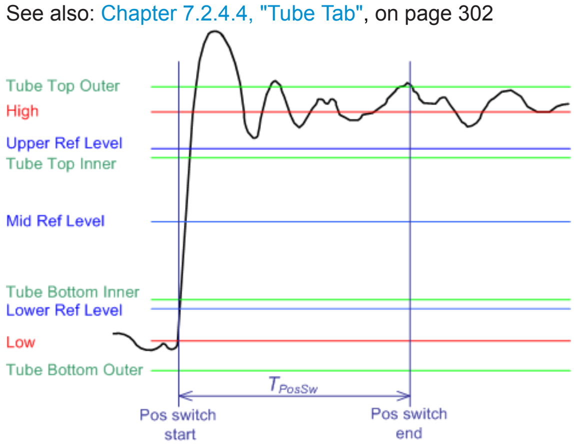
	Meas. type	Symbol	Description/Result
	Cycle RMS		The RMS (root mean square) value of one cycle
	Cycle σ (S-dev)		The standard deviation of one cycle
	Trig. ProbeMeter		The DC voltage from the connected probe. Only available if an active Rohde & Schwarz probe with ProbeMeter is connected.
	Slew rate rising		Steepness of the rising edge: voltage difference between the lower and higher reference level, divided by the rise time. Result in V/s = V*Hz (blue vertical lines in the picture below).
	Slew rate falling		Steepness of the falling edge: voltage difference between the higher and lower reference level, divided by the fall time. Result in V/s = V*Hz (green vertical lines in the picture below). 

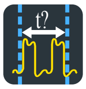
Time Measurements

See also: Chapter 7.2.4, "Reference Levels", on page 294.

Table 7-2: Time measurements

	Meas. type	Symbol	Description/Result
	Rise time	T_{Rise}	Rise time of the left-most rising edge of the waveform. Rise time is the time it takes the signal to rise from the low reference level to the high reference level. Measurement all events in the acquisition is possible.
	Fall time	T_{Fall}	Falling time of the left-most falling edge of the waveform. Fall time is the time it takes the signal to fall from the high reference to the low reference. Measurement all events in the acquisition is possible.
	Pos. pulse	$T_{PosPulse}$	Width of a positive pulse: time between a rising edge and the following falling edge measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Measurement all events in the acquisition is possible.
	Neg. pulse	$T_{NegPulse}$	Width of a negative pulse: time between a falling edge and the following rising edge measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Measurement all events in the acquisition is possible.
	Period	T_{Period}	Time between two consecutive waveform edges of the same direction, measured on the middle reference level. The measurement requires at least one complete period of a triggered signal. Measurement all events in the acquisition is possible.

	Meas. type	Symbol	Description/Result
	Frequency	f_{Period}	Frequency of the signal, reciprocal value of the period. $f_{Period} = 1 / T_{Period}$
	Pos. duty cycle	R_{PosCyc}	Positive duty cycle: Width of a positive pulse in relation to the period in %. The measurement requires at least one complete period of a triggered signal. Multiple measurements are possible. $R_{PosCyc} = \frac{T_{PosPulse}}{T_{Period}} \cdot 100\%$
	Neg. duty cycle	R_{NegCyc}	Negative duty cycle: Width of a negative pulse in relation to the period in %. The measurement requires at least one complete period of a triggered signal. Multiple measurements are possible. $R_{NegCyc} = \frac{T_{NegPulse}}{T_{Period}} \cdot 100\%$
	Delay		Time difference between any two edges of two measurement sources at any reference level. The measurement result is negative if the edge of the second source comes before the edge of the first source. Set the slope and reference level for each source. See: "Delay settings (analog sources)" on page 311
	Phase		The phase difference between two waveforms (*delay / period * 360*)
	Burst width		The duration of one burst, measured from the first edge to the last
	Pos. switching	T_{PosSw}	Settling time at rising edges: Time between crossing the lower reference level and the last return of the signal into the top tolerance tube. See also: Chapter 7.2.4.4, "Tube Tab", on page 302 
	Neg. switching	T_{NegSw}	Settling time at falling edges: Time between crossing the upper reference level and the last return of the signal into the bottom tolerance tube. See also "Pos. switching" above.

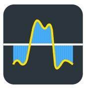
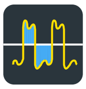
	Meas. type	Symbol	Description/Result
	Pulse train		Duration of N positive pulses, measured from the rising edge of the first pulse to the falling edge of the N-th pulse. Define N for the measurement.
	Setup Hold Setup/Hold time	T_{Setup} and T_{Hold}	Setup and Hold time measurement with positive and/or negative clock edge. See: "Setup/Hold measurement settings" on page 312
	Setup/Hold ratio	$T_{Setup} / (T_{Setup} + T_{Hold})$	Setup/Hold ratio measurement with positive and/or negative clock edge. See: "Setup/Hold measurement settings" on page 312
	Delay to trigger		Time between the trigger event and a following signal slope. High accuracy even if the trigger event is outside the acquisition data. See: • "Delay to trigger measurement settings" on page 313 • Chapter 7.2.5.3, "Measuring the Delay to Trigger", on page 314

Area Measurements

Access: "Meas" menu > "Meas Group" > "Amp/Time" category

Area measurements are voltage over time measurements.

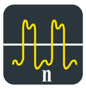
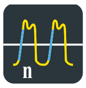
Table 7-3: Area measurements

	Meas. type	Symbol	Description/Result
	Area	A_{Ref}	Area between the waveform and a reference level ("Area level", X_{Ref}). $A_{Ref} = \frac{T_{Eval}}{N_{Eval}} \cdot \sum_{i=1}^{N_{Eval}} (x(i) - X_{Ref})$ T_{Eval}: Evaluation time, time of a full waveform or limited by a gate
	Cycle area	A_{RefCyc}	Area between the waveform and a reference level ("Area level") measured for one period, see also "Area" measurement. The measurement requires at least one complete period of a triggered signal. Multiple measurements are possible.

Counting

Access: "Meas" menu > "Meas Group" > "Amp/Time" category

Table 7-4: Counting measurements

	Meas. type	Symbol	Description/Result
	Pulse count		The number of positive or negative pulses of the waveform, or of both positive and negative pulses. The mean value of the signal is determined. If the signal passes the mean value, an edge is counted. A positive pulse is counted if a rising edge and a following falling edge are detected. A negative pulse is counted if a falling edge and a following rising edge are detected.
	Edge count		The number of positive or negative edges, or of both positive and negative edges. The instrument determines the mean value of the signal and counts an edge every time the signal passes the mean value.

7.2.5.2 Settings for Amplitude/Time Measurements

Access: "Meas" menu > "Meas Group" > "Amp/Time" category

Amplitude and time measurements are available for sources in the time domain. For some amplitude/time measurements, such as delay, setup/hold and delay to trigger, further setting are required to get a measurement result.

If further settings are available for a measurement, a settings icon is shown beside the measurement's name in the "Active Measurements" list. Tap the icon to configure the measurement.

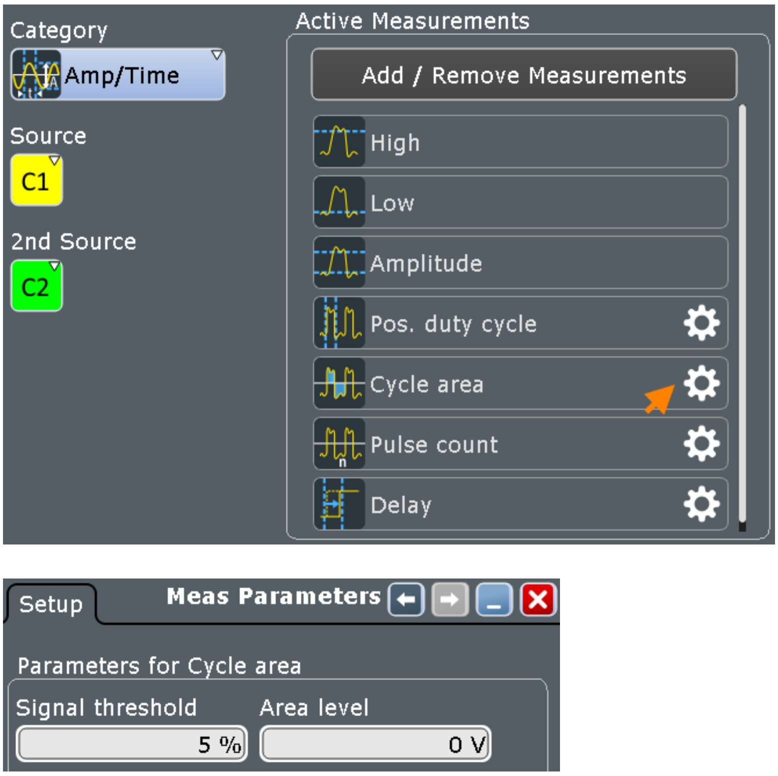


Figure 7-8: Parameters for cycle area measurement

This chapter explains all settings for amplitude/time measurements. For a description of available measurement, see Chapter 7.2.5.1, "Overview of Amplitude/Time Measurements", on page 304.

Signal threshold

Defines a signal value that must be exceeded for the signal value to be included in the measurement. The setting is relevant for area, time, and counting measurements.

Remote command:
`MEASurement<m>:DETThreshold` on page 1147

Area level

The reference level used to integrate the waveform. The setting is only relevant for area measurements.

Remote command:
`MEASurement<m>:AMPTime:ALEVel` on page 1147

Pulses slope

Sets the first slope of the pulses to be counted.

The setting is available only for the "Pulse count" measurement.

"Positive"	Positive pulses are counted.
"Negative"	Negative pulses are counted.
"Either"	Both positive and negative pulses are counted.

Remote command:
`MEASurement<m>:AMPTime:PSLope` on page 1148

Measured slope

Selects the slope direction for frequency and period measurements.

"Positive / Negative"	Measures the time between rising or falling edges, respectively.
"Either"	In multiple measurements, the time is measured both between rising edges and between falling edges. In single measurements. The first edge is taken for the measurement.

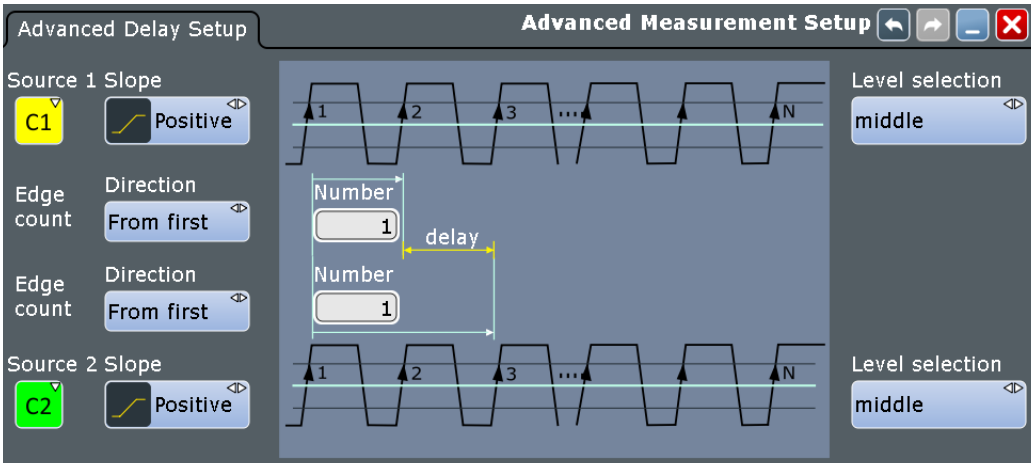
"First edge" Time is measured either between rising edges or between falling edges. The first edge is taken for the measurement. In single measurements, it works the same way as "Either".
Only available for analog measurement sources.

Remote command:
`MEASurement<m>:AMPTime:PFSLope` on page 1147

Delay settings (analog sources)
The specific settings for delay measurement allow you to measure the time between any two slopes at any reference level. Therefore, the reference levels and the slopes must be defined for each source individually. The measurement result is negative if the edge of the second source comes before the edge of the first source.

Example:

With the settings shown in the picture, the time between the second rising edge and the third from last falling edge is measured.



"Level selection" Selects the reference level on which the time is measured.

"Slope" Sets the edge of each source, between which the delay is measured: positive, negative, or either of them.

"Direction" Selects the direction for counting slopes for each source: from the beginning of the waveform, or from the end.

"Number" Sets the number of the edge that is relevant for delay measurement.

Remote command:
`MEASurement<m>:AMPTime:DELay<n>:LSELect` on page 1149
`MEASurement<m>:AMPTime:DELay<n>:SLOPe` on page 1149
`MEASurement<m>:AMPTime:DELay<n>:DIRection` on page 1148
`MEASurement<m>:AMPTime:DELay<n>:ECOunt` on page 1149

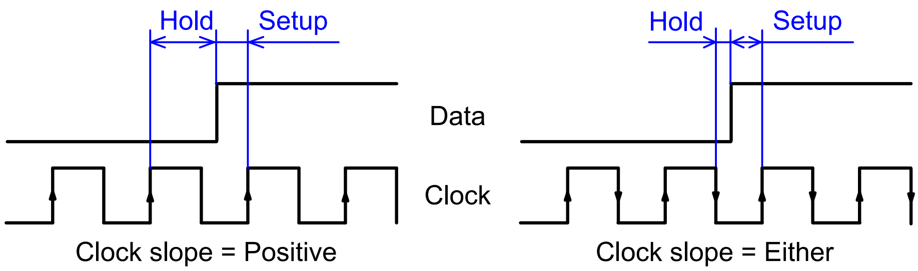
Delay settings (digital sources)
Delay measurement on digital channels is reduced to measure the time between two subsequent rising or two subsequent falling edges.

The edge direction is set with Edges slope.

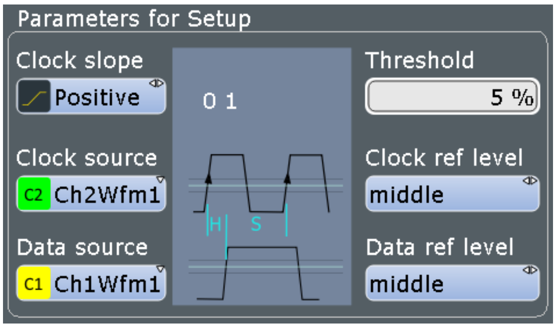
Setup/Hold measurement settings
Setup/Hold measurements analyze the relative timing between two signals: a data signal and the synchronous clock signal. Setup time is the time that the data signal is steady before clock edge - the time between a data transition and the next specified clock edge. Hold time is the time that the data signal is steady after clock edge - the time between a data transition and the previous specified clock edge.

Setup/Hold Time measures and displays the setup and hold durations. Setup/Hold Ratio measurements return the ratio of the setup time to the sum of hold and setup time: $T_{Setup} / (T_{Setup} + T_{Hold})$.

The clock edge can be defined, the polarity of the data signal does not matter.



If at least one of the setup/hold measurements is selected, more settings appear to specify the measurement.



"Clock slope"	Sets the edge of the clock from which the setup and hold times are measured: positive, negative, or either of them. If "Either" is selected, the clock edges next to the data edge are considered regardless of the clock slope.
"Clock source"	The "Clock source" is identical to the measurement "Source". It defines the waveform used as clock in the setup/hold measurement.
"Data source"	The "Data source" is identical to the "2nd Source" of the measurement. It sets the data signal.
"Clock ref level"	See "Clock ref level" on page 313.
"Data ref level"	See "Data ref level / Reference level" on page 313.
"Threshold"	See "Signal threshold" on page 310.

Remote command:
Clock slope: MEASurement<m>:AMPTime:CSLope on page 1150

Clock ref level

Selects the reference level of the clock on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

The setting is used for setup and hold measurements, and for jitter measurements (option R&S RTP-K12).

Remote command:
MEASurement<m>:AMPTime:CLCK<n>:LSELect on page 1150

Data ref level / Reference level

The setting defines the "Data ref level" for setup and hold measurements, and for time-interval error measurements (option R&S RTP-K12). It selects the reference level of the data signal on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

For clock jitter measurements (option R&S RTP-K12), it sets the "Reference level" for the time measurement.

Remote command:
MEASurement<m>:AMPTime:DATA<n>:LSELect on page 1151

Pulse count

Sets the number N of positive pulses for the "Pulse train" measurement. This measurement measures the duration of N positive pulses from the rising edge of the first pulse to the falling edge of the N-th pulse.

Remote command:
MEASurement<m>:AMPTime:PTCount on page 1150

Edges slope

Sets the edge direction to be considered. The setting is relevant for edge count measurement and delay measurement on digital channels.

"Positive" Positive edges are considered.

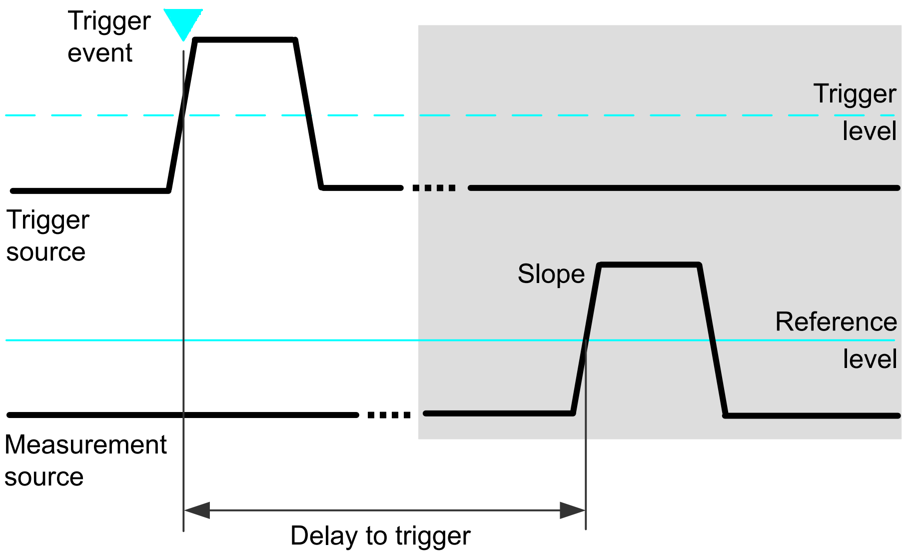
"Negative" Negative edges are considered.

"Either" Both positive and negative edges are counted (edge count). Delay is measured either between rising edges or between falling edges. The first edge is taken for the measurement.

Remote command:
MEASurement<m>:AMPTime:ESLope on page 1150

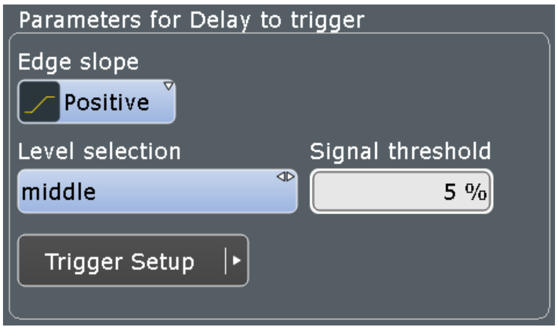
Delay to trigger measurement settings

Delay to trigger measures the time between the trigger point and the following slope of a waveform. The delay between the trigger and the slope can be high compared to the accuracy of the acquisition, and the trigger point can even be outside of the current acquisition.



See also: Chapter 7.2.5.3, "Measuring the Delay to Trigger", on page 314.

To configure the trigger conditions, use the trigger setup. To set up the slope, additional settings appear in the measurements "Setup" dialog box.



"Edge slope" Sets the edge direction to be used for delay measurement: positive, negative, or either edge.

"Level selection" Selects the reference level of the measurement source on which the delay is measured: upper, middle, or lower level.

"Signal threshold"
See "Signal threshold" on page 310.

Remote command:
`MEASurement<m>:AMPTime:DTOTrigger<n>:SLOPe` on page 1151
`MEASurement<m>:AMPTime:DTOTrigger<n>:LSELect` on page 1151

7.2.5.3 Measuring the Delay to Trigger

Delay to trigger measures the time between the trigger point and the following slope of a waveform. If the delay is unknown, it can be measured in two stages - first a coarse and then a precise measurement.

See also: "Delay to trigger measurement settings" on page 313.

1. Set the horizontal scale and horizontal position so that the trigger point and the slope both are visible on the screen.
2. Select the delay to trigger measurement:
   a) In the "Meas Group" dialog, set the "Category" to "Amp/Time".
   b) Press "Add/ Remove Measurements" button.
   c) In the dialog, enable "Delay to trigger".
   d) Tap "OK".
3. Configure the "Delay to trigger" measurement:
   a) In the "Active Measurements" list, tap the "Delay to trigger" measurement.
   b) Select the source, that is the waveform with the delayed slope.
   c) Select the slope and the reference level.
   d) Check the trigger settings.
4. Enable the measurement. Note the result.
5. Turn the horizontal [Position] knob and enter the measured delay as horizontal position.

   Thus, the slope is moved to the center of the screen.
6. Adjust the horizontal scale and the horizontal resolution parameters ([Res Rec Len]) to the required accuracy: "Sample rate", "Resolution", or "Acquisition time".

   The trigger is outside the display and is not part of the current acquisition.
7. Repeat the "Delay to trigger" measurement.

   Now the delay is measured with high accuracy. You can analyze the variance of delay values using statistical evaluation and histogram functions.

7.2.6 Eye Diagram Measurements

The eye diagram is a tool for evaluation of signal quality and shows the combined effects of channel noise and intersymbol interference. It is a significant means of visualizing jitter and allows you to analyze the reasons for it. By creating histograms of the eye diagram, important jitter parameters can be determined.

The eye diagrams are a superposition of repetitively sampled waveforms, which have a length of about 1 bit.

The waveform display style must be set to vectors: [Display] > "Signal Colors / Persistence" tab > "Style = Vectors"

To obtain optimized settings for an eye measurement, use the "Autoset" function that is provided on the right side of the "Eye" tab.

The following characteristic values can be determined:

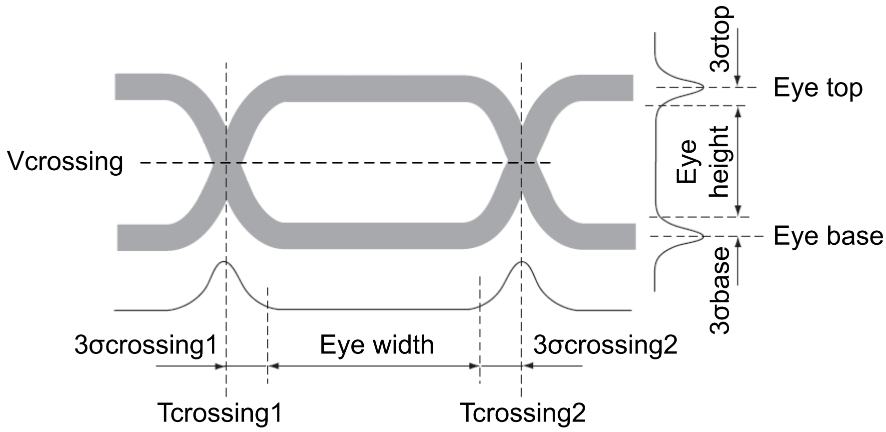


Figure 7-9: Basic eye diagram characteristics

Eye top	=	Mean of the upper vertical histogram
σtop	=	Standard deviation of the upper vertical histogram
Eye base	=	Mean of the lower vertical histogram
σbase	=	Standard deviation of the lower vertical histogram
Tcrossing	=	First and second mean of the horizontal histogram
σcrossing	=	Standard deviation of the horizontal histogram

7.2.6.1 Overview of Eye Diagram Measurements

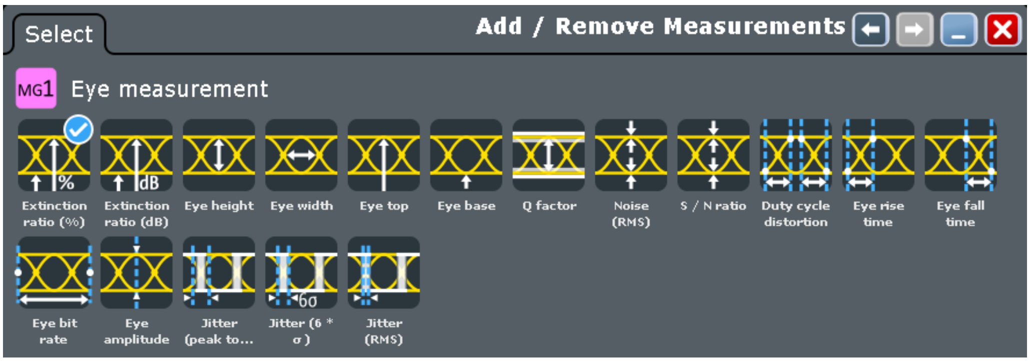
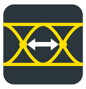
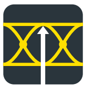
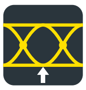
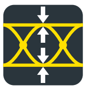
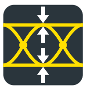
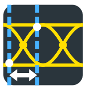
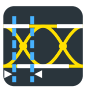
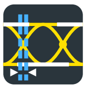


Table 7-5: Eye measurements

	Meas. type	Description/Result
	Extinction ratio (%)	The extinction ratio is an indication of efficiency. It describes the ratio of the power used to transmit a logic level 1, to the energy used to transmit a logic level 0. The R&S RTP provides extinction ratio measurements as a percentage, and in decibels: ER (%) = Eye base / Eye top *100 Prerequisite: Eye base > 0 and Eye top > 0 because extinction ratio is defined only for positive values.
	Extinction ratio (dB)	ER (dB) = 10*log (Eye top / Eye base)

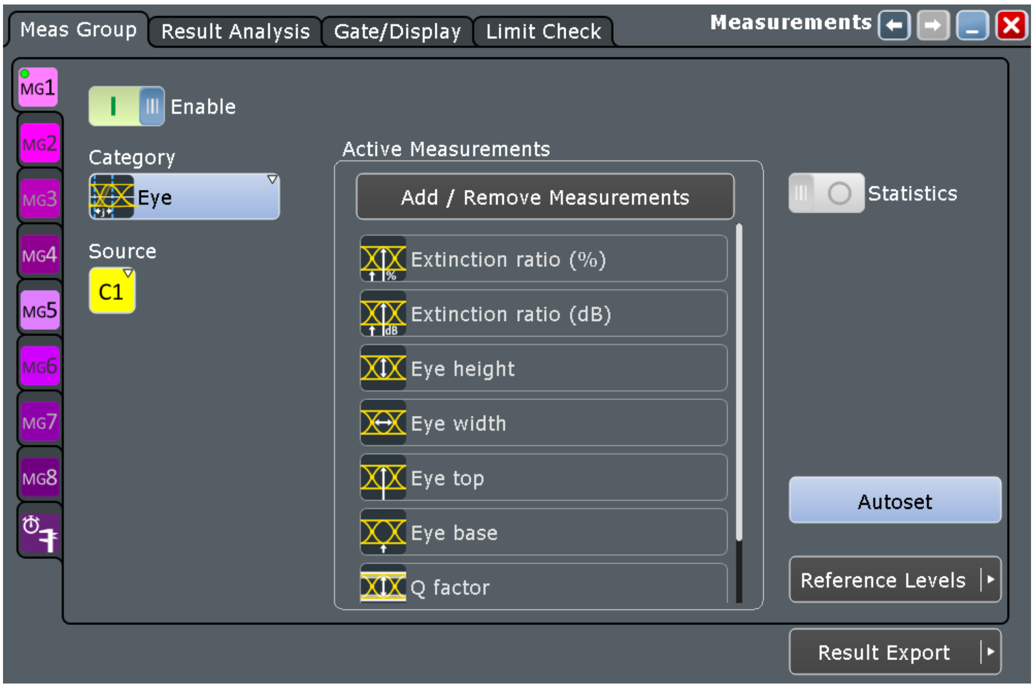
	Meas. type	Description/Result
	Eye height	The vertical eye opening indicates the sensitivity of the transmission to noise. (Eye top – 3 * σtop) – (Eye base + 3 * σbase)
	Eye width	The horizontal eye opening indicates the time range during which the sampling of the logical state is possible. (Tcrossing2 – 3 * σcrossing2) – (Tcrossing 1 – 3 * σcrossing1)
	Eye top	Mean of the upper vertical histogram
	Eye base	Mean of the lower vertical histogram
	Q factor	Q factor = (Eye top – Eye base) / (σtop + σbase)
	Noise (RMS)	Quadratic mean of the noise of eye top and eye base
	S/N ratio	Signal-to-noise ratio SNR = 10 * log (Eye amplitude / Noise RMS)
	Duty cycle distortion	Duty cycle distortion = 20 * log (Eye amplitude / Noise RMS)
	Eye rise time	Duration for signal to rise from 10% to 90% of the high signal level
	Eye fall time	Duration for signal to fall from 90% to 10% of the high signal level
	Eye bit rate	Frequency between two crossings
	Eye amplitude	Eye top - Eye base
	Jitter (peak to peak)	Average of the jitter for both crossing points. Jitter = (σcrossing1 + σcrossing2) / 2

	Meas. type	Description/Result
	Jitter (6*σ)	Jitter (6*σ) = Jitter * 6
	Jitter (RMS)	Quadratic mean of the jitter at both crossing points

7.2.6.2 Settings for Eye Diagram Measurements

Access: "Meas" menu > "Meas Group" > "Eye" category

Eye diagram measurements are only available for sources in the time domain.



To obtain optimized settings for an eye measurement, use the "Autoset" function that is provided on the right side of the tab.

Autoset

Defines optimized settings for eye diagram measurements on the selected source.

Remote command:

MEASurement<m>:EYEJitter:AUToscale on page 1154

7.2.7 Spectrum Measurements

Spectrum analysis determines the frequencies of a given input signal over time. Various measurements can then be performed based on the signal spectrum.

7.2.7.1 Overview of Spectrum Measurements

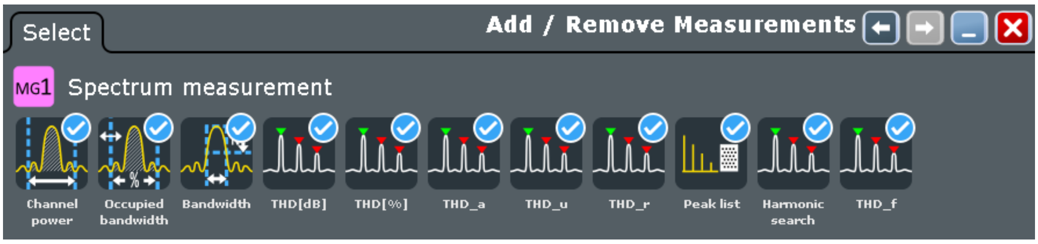
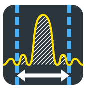
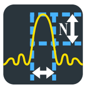


Table 7-6: Spectrum measurements

	Meas. type	Description, result
	Channel power	Power integrated over the sample values defined by a center frequency and a bandwidth; based on a defined impedance; the result is given in dBm
	Occupied bandwidth	From the defined center frequency, symmetric sample value pairs to the left and right are integrated until a user-defined percentage of the total power is reached. The occupied bandwidth is the difference between the frequencies at which the requested power was reached.
	Bandwidth	n dB down bandwidth; the samples to the left and right of the peak value are analyzed until the n dB threshold is exceeded. The frequencies at which the threshold is exceeded define the limits of the requested bandwidth.
	THD[dB], THD[%] Total harmonic distortion	Power sum of the harmonic waves divided by the power of the fundamental wave: $THD = \frac{\sum_{n=2}^{\infty} P_n}{P_1}$

	Meas. type	Description, result
	THD_f, THD_a, THD_u, THD_r Total harmonic distortion	These measurements require option R&S RTP-K37 Spectrogram. THD_f is the root mean square of the sum of all amplitudes of the harmonic waves in relation to the amplitude at the fundamental frequency (first harmonic): $THD_F = \frac{\sqrt{\sum_{i=2}^{n} U_i^2}}{U_1}$ THD_a corresponds to THD[dB]: $THD_a = \frac{\sum_{i=2}^{n} U_i^2}{U_1^2}$ THD_u: $THD_u = \frac{\sqrt{U^2 - U_1^2}}{U_1}$ Distortion factor: $THD_R = \frac{\sqrt{U^2 - U_1^2}}{U}$ Where: • U_i: effective value of the harmonic with index i • U_1: effective value of the first harmonic • U: effective value of the signal
	Peak list	This measurement requires option R&S RTP-K37 Spectrogram. Table with measured peaks. For each peak, the frequency and the power value are listed in a table row. The number of determined peaks can be defined. You can sort the results by frequency or power value, and the peak labels are adjusted accordingly.
	Harmonic search	Table with measured harmonics. For each harmonic, the frequency and the value are listed in a table row.

For remote command parameters and suffix types, see Table 20-7.

7.2.7.2 Settings for Spectrum Measurements

Access: "Meas" menu > "Meas Group" > "Spectrum" category

Spectrum measurements require a source in the frequency domain, i.e. a math waveform with an FFT operation.

For spectrum measurements, make sure that the start frequency and other FFT parameters are set correctly, and the fundamentals are not covered by the DC component of the signal. Consider also a gated measurement if the instrument cannot return any result.

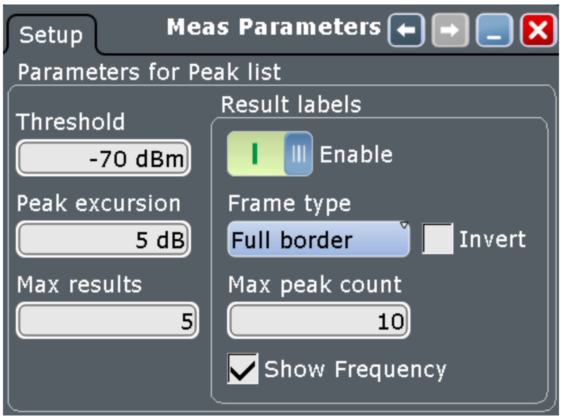


Figure 7-10: Parameters of peak list measurement (with option R&S RTP-K37)

N db down

The threshold until which the samples to the left and right of the peak value are analyzed to determine the "Bandwidth".

Remote command:

`MEASurement<m>:SPECtrum:NDBDown` on page 1158

Channel BW

Bandwidth over which the channel power is calculated.

Remote command:

`MEASurement<m>:SPECtrum:CPOWer:BANDwidth` on page 1157

Channel CF

Center frequency from which the channel power is calculated over the specified bandwidth.

Remote command:

`MEASurement<m>:SPECtrum:CPOWer:CFRequency` on page 1158

Occup. BW

Percentage of the total power used to determine the occupied bandwidth.

Remote command:

`MEASurement<m>:SPECtrum:OBANdwidth` on page 1157

Threshold

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Remote command:

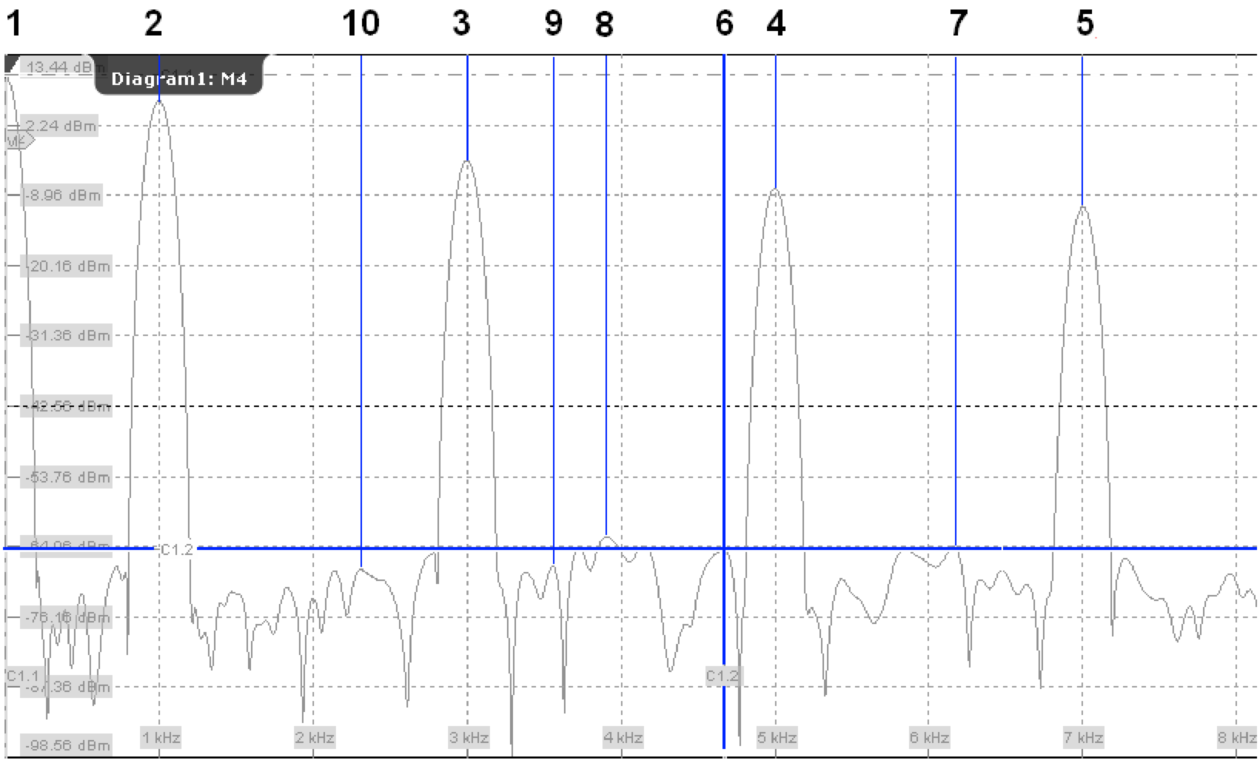
`CURSor<m>:THReshold` on page 1132

`MEASurement<m>:SPECtrum:ATHReshold` on page 1159

Peak excursion
Defines a relative threshold, the minimum level value by which the waveform must rise or fall to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

The following figure shows a cursor measurement on a spectrum waveform:



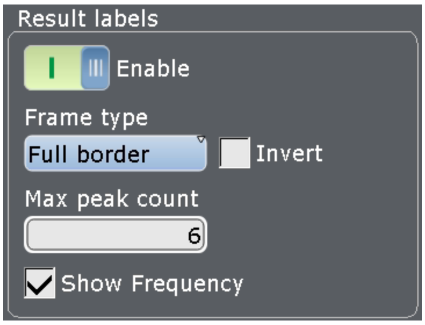
If "Peak excursion" is 30 dB, the peaks 1 to 5 are found. If "Peak excursion" is 20 dB, also the peaks 6 to 10 are found. The cursor position is on peak 6.

Remote command:
`CURSor<m>:PEXCursion` on page 1132
`MEASurement<m>:SPECtrum:PEXCursion` on page 1158

Max results
Sets the maximum number of measurement results that are listed in the result table. Available for peak list and harmonic search measurements.

Remote command:
`MEASurement<m>:SPECtrum:RESult<n>:COUNt` on page 1159

Result labels
For peak lists only, requires option R&S RTP-K37: Use labels to describe the detected peaks in the spectrum diagram. You can configure the look of the labels.



"Enable"	Displays a description for each detected peak in the spectrum diagram.
"Frame type"	Defines the layout of the labels (full border, underline, or none).
"Invert"	Displays black font on white background using the "Full frame" label type.
"Max. peak count"	Defines the maximum number of peaks that are labeled in the diagram. The result table lists all peaks.
"Show Frequency"	Includes the frequency of the detected peak in the diagram labels.

Remote command:
`MEASurement<m>:RESult:SHLabels` on page 1161
`MEASurement<m>:RESult:LABorder` on page 1160
`MEASurement<m>:RESult:INVerse` on page 1160
`MEASurement<m>:RESult:MAXCount` on page 1159
`MEASurement<m>:RESult:SHFRequency` on page 1161

7.2.8 Histograms and Histogram Measurements

7.2.8.1 Histogram Characteristics

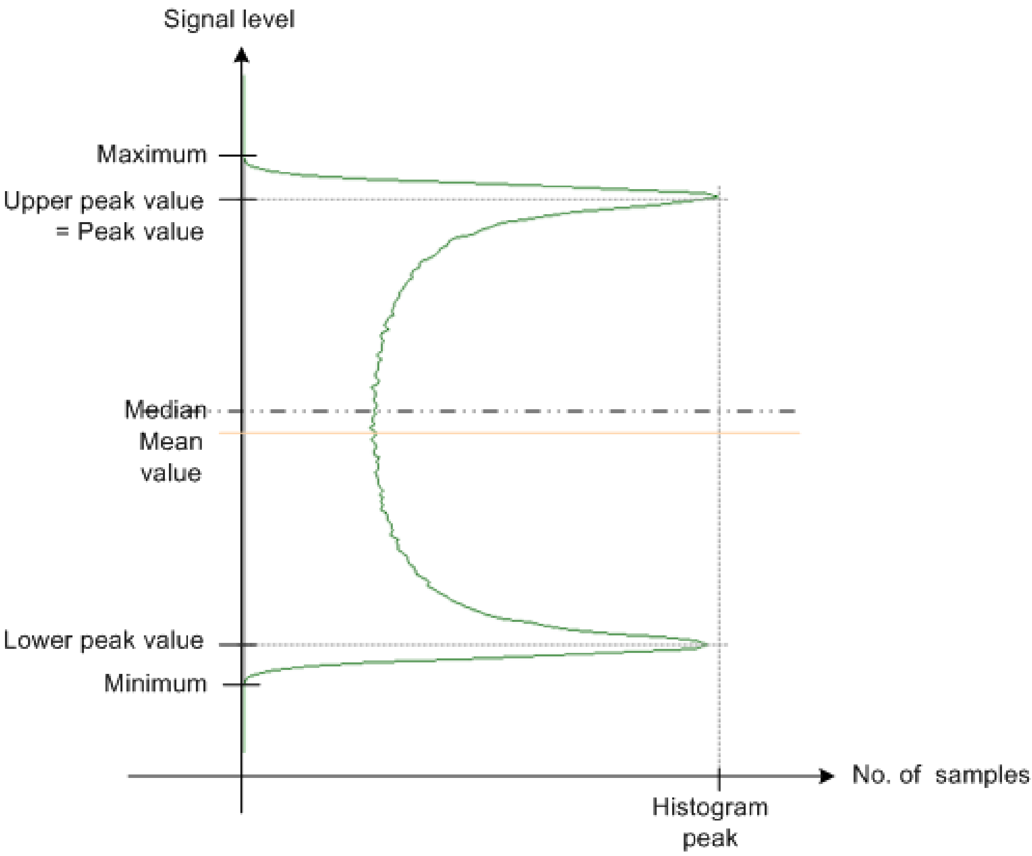
Histograms are used to plot density of data, i.e. to display graphically how often which signal values occur. The histogram can be based on the input signal levels (amplitudes) or the timebase in a time domain measurement, or on frequencies or frequency levels in a spectrum measurement. They are a prerequisite for histogram measurements.

Depending on which data the histogram is based on, a vertical or horizontal histogram can be selected. A vertical, or amplitude, histogram displays horizontal bars across amplitude values. A horizontal or time/frequency histogram displays vertical bars over time/frequencies.

You can define up to 8 histograms in a diagram, one of them is displayed. They can be created quickly using toolbar icons, or in the "Meas" menu > "Histogram" dialog box. To switch the histogram display, tap the required histogram area, or select it in the "Histogram" dialog box. For histogram measurements, the measured histogram is selected independently in the measurement setup.

In a histogram, the maximum count of a waveform value is assigned to the full height (histogram peak). All other count values are displayed relative to the maximum.

The following characteristic values can be determined for histograms (illustrated for a vertical histogram):



7.2.8.2 Overview of Histogram Measurements

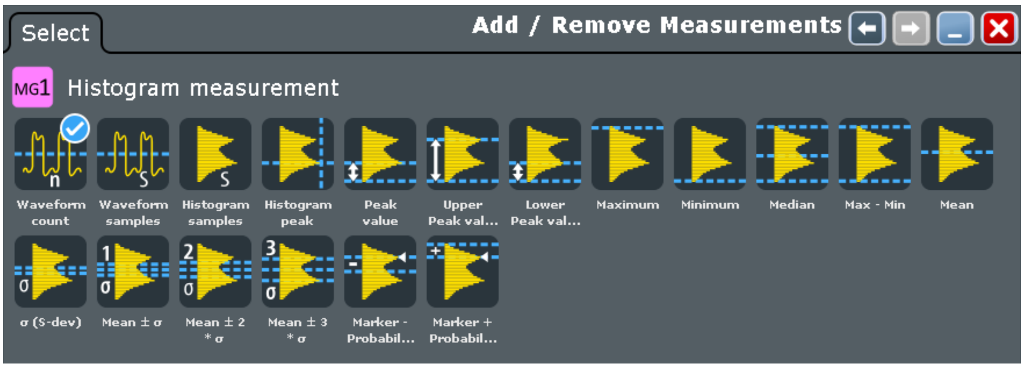
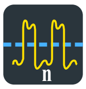
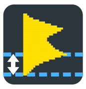


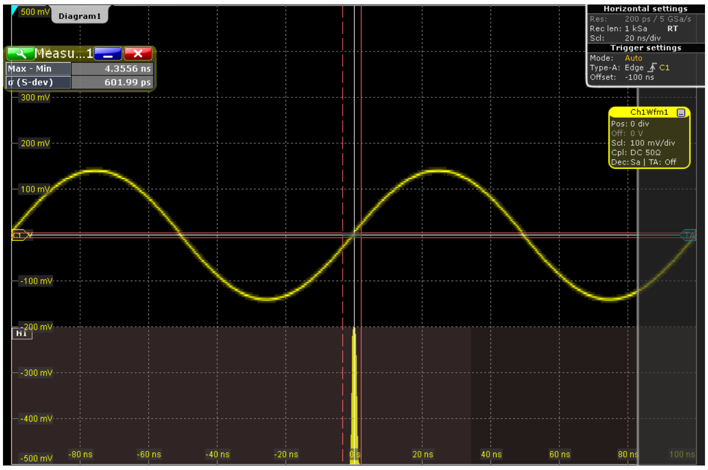
Table 7-7: Histogram measurements

	Meas. type	Description/Result
	Waveform count	The number of acquisitions (waveforms) the histogram is based on
	Waveform samples	The number of samples from the most recent acquisition included in the current histogram
	Histogram samples	The number of samples from all acquisitions included in the current histogram
	Histogram peak	The maximum count value in the histogram
	Peak value	The signal value at the histogram peak
	Upper peak value	The signal value at the maximum count value in the upper half of the histogram
	Lower peak value	The signal value at the maximum count value in the lower half of the histogram
	Maximum	The highest signal value with a probability > 0
	Minimum	The lowest signal value with a probability > 0
	Median	The signal value for which half the samples lie above, the other half below in the histogram The sample count of one signal value after the other are accumulated until half the total number of samples in the histogram is reached. The signal value for which 50% of the samples are accumulated is the median.
	Max - Min	The range of signal values with a probability > 0
	Mean	The weighted arithmetic average of the histogram
	σ (S-dev)	Standard deviation of the sample numbers

	Meas. type	Description/Result
	Mean ±σ	The range between (mean value + standard deviation) and (mean value - standard deviation)
	Mean ±2*σ	The range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)
	Mean ±3*σ	The range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)
	Marker + Probability %	The marker value (according to the selected probability domain marker type) plus the defined limit. Note that the value is restricted to the histogram range.
	Marker - Probability %	The marker value (according to the selected probability domain marker type) minus the defined limit. Note that the value is restricted to the histogram range.

Rough jitter evaluation using a histogram

You can use a horizontal histogram to perform a rough jitter measurement. Define a histogram for a narrow amplitude range close to the trigger time. The "Max-Min" value indicates the peak jitter, while the "StdDev" value indicates the RMS jitter.



In addition to histograms on channel, math and reference waveforms, histograms can be created based on statistic measurement results. These histograms are enabled in the "Result Analysis" tab, see Chapter 7.2.10, "Result Analysis", on page 331.

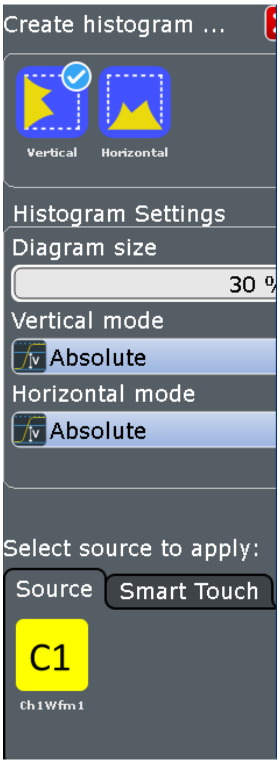
7.2.8.3 Creating Histograms

Histograms can be used to evaluate the sample value occurrences directly. They are a prerequisite for histogram measurements.

The usage of histograms is also shown in a short video that is available on the instrument: "File" menu > "Tutorials > Histogram".

To create a histogram quickly with toolbar icons

1. Select the waveform for which you need a histogram.
2. Tap the histogram icon on the toolbar.
3. Select the histogram type in the sidebar: vertical for an amplitude, horizontal for a time-based histogram.
   Check and adjust the histogram settings.



4. Tap the diagram with the waveform to be measured, or draw a rectangle on the screen to define the area for histogram calculation.

   The histogram range is indicated in the diagram and a histogram with the selected waveform as a source is defined and displayed.

To create and configure a histogram in the dialog box

1. Select "Meas" > "Histogram", or touch and hold an existing histogram or histogram area.

   The "Histogram Setup" dialog box is displayed.

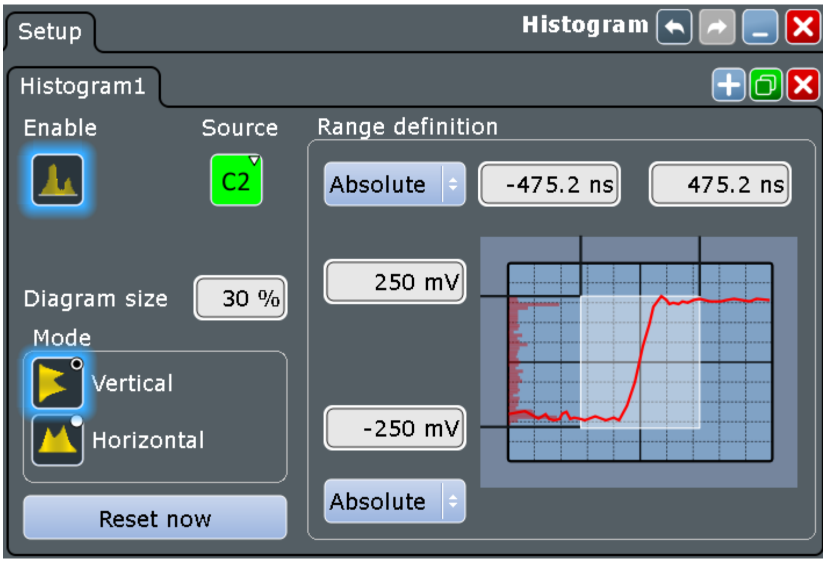
2. To create a histogram, tap the "Add" icon in the upper right corner of the dialog box.

3. To copy an existing histogram and configure a new one based on those settings, tap the "Copy" icon.
4. To change the name of a histogram, double-tap the tab label. Enter a name for the histogram using the on-screen keyboard.
5. Select a "Source" for the histogram. The source can be any input signal, math or reference waveform.
6. Define the histogram "Mode": vertical for an amplitude, horizontal for a time-based histogram.
7. Define the range of the waveform for which the histogram is to be generated. Enter the start value and the stop value in x and in y direction, either as absolute or relative values.
8. Enable the histogram.

7.2.8.4 Histogram Setup

Access: "Meas" menu > "Histogram"

In this dialog box, you configure histograms on which you can perform further measurements.



Enable

Enables or disables the histogram evaluation and display. The histogram settings are kept until the histogram is deleted.

Source

Defines the source of the histogram. Any analog channel waveform, math or reference waveform can be selected. Also measurements can serve as histogram source. In this case, the density distribution of the results of the main measurement is displayed.

Remote command:
`LAYout:HISTogram:SOURce` on page 1164

Diagram size
Defines the size of the histogram in percent of the diagram.

Mode
Defines the type of histogram.

"Vertical" Amplitude histogram (horizontal bars across amplitude)

"Horizontal" Time histogram (vertical bars over time). For spectrum waveforms, horizontal histograms over spectrum are not available.

Remote command:
`LAYout:HISTogram:MODE` on page 1165

Reset now
Resets the values to begin a new histogram.

Remote command:
`LAYout:HISTogram:RESet` on page 1168

Range definition mode (Absolute/Relative)
Defines whether the value range limits are entered as absolute or relative values.

Remote command:
`LAYout:HISTogram:HORZ:MODE` on page 1165
`LAYout:HISTogram:VERTical:MODE` on page 1167

Horizontal start/stop value
Defines the horizontal value range of the histogram.

Remote command:
`LAYout:HISTogram:HORZ:ABSolute:STARt` on page 1166
`LAYout:HISTogram:HORZ:ABSolute:STOP` on page 1166
`LAYout:HISTogram:HORZ:RELative:STARt` on page 1166
`LAYout:HISTogram:HORZ:RELative:STOP` on page 1166

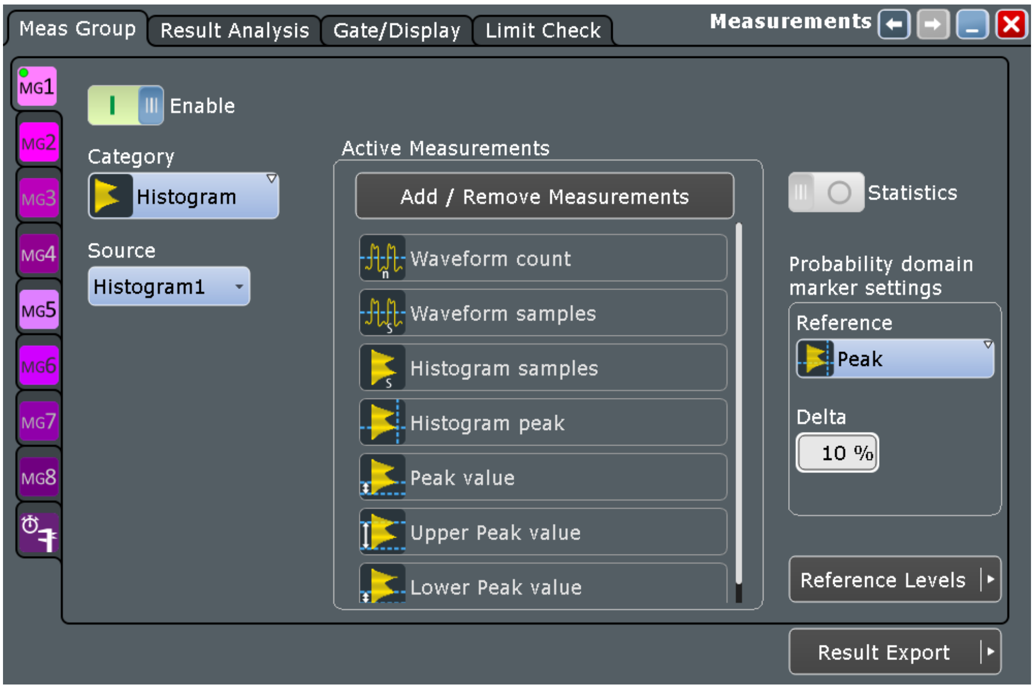
Vertical start/stop value
Defines the vertical value range of the histogram.

Remote command:
`LAYout:HISTogram:VERTical:ABSolute:STARt` on page 1167
`LAYout:HISTogram:VERTical:ABSolute:STOP` on page 1167
`LAYout:HISTogram:VERTical:RELative:STARt` on page 1167
`LAYout:HISTogram:VERTical:RELative:STOP` on page 1168

7.2.8.5 Settings for Histogram Measurement

Access: "Meas" menu > "Meas Group" > "Hist" category

You can perform measurements on histograms. Before, you have to define a histogram, see Chapter 7.2.8.3, "Creating Histograms ", on page 326.



The measurement parameters are common for all histograms measurements, you find them directly on the "Meas Group" tab.

Histogram

Selects the histogram on which the measurement is based. Histograms are defined via the "Meas > Histogram" menu item.

Remote command:

MEASurement<m>:HISTogram:SELect on page 1170

Probability domain marker reference

Defines the marker reference in the probability domain.

"Peak"	The y-value with the maximum sample value in the histogram
"Upper Peak"	The y-value at the maximum sample value in the upper half of the histogram
"Lower Peak"	The y-value at the maximum sample value in the lower half of the histogram
"Maximum"	The highest y-value with a probability > 0
"Minimum"	The lowest y-value with a probability > 0
"Median"	The y-value for which half the samples lie above, the other half below in the histogram.
"Mean"	The weighted arithmetic average of the histogram

Remote command:

MEASurement<m>:HISTogram:PROBability:TYPE on page 1170

Delta

Defines a range around the marker.

Remote command:
`MEASurement<m>:HISTogram:PROBability:LIMit` on page 1171

7.2.9 Jitter Measurements

Jitter measurements are availabe if option R&S RTP-K12 is installed.

See Chapter 16.1, "Jitter Measurements", on page 892.

7.2.10 Result Analysis

The behavior of measurement results over time can be evaluated in different ways:

- Statistics
- Long-term measurements
- Histograms on measurement results
- Track

7.2.10.1 Statistics

Statistics can be compiled for each measurement group separately, and also for long-term measurements. If enabled, statistical results are shown in the result box.

To obtain meaningful results, specific measurement settings can be useful:

- Measure all events in each acquisition: the measurement result is not only determined once within one acquisition, but repeatedly, if available. More results provide a larger basis for statistical evaluation.
- Reference/signal levels: configuring user-defined levels can compensate for irregular data, see Chapter 7.2.4.1, "Configuring Reference Levels", on page 295.
- Gate areas: restricting the waveform range for measurement can eliminate irregular data, see Chapter 7.2.3, "Measurement Gates", on page 291.
- Defining a "Signal threshold" for time, area and counting measurements can eliminate noise from the evaluation, see "Signal threshold" on page 310.
- Spectrum measurements: you can eliminate noise from the evaluation, see Threshold and "Peak excursion" on page 279

► To enable statistics, use one of the following ways.
Make sure to select the subtab of the measurement group for which you want to compile statistics.
  - On the "Meas" > "Meas Group" tab, enable "Statistics".
  - On the "Meas" > "Result Analysis" tab, "Enable" statistics.

  From the "Meas" menu, select "Setup".

If statistics are enabled, the following information is provided in the result box for each measurement.

Label	Description
Current	Currently measured value
+Peak	Positive peak value (maximum)
-Peak	Negative peak value (minimum)
μ (Avg)	Average
RMS	Root mean square
σ (S-dev)	Standard deviation
Event count	Number of measured events (e.g. rising edges, pulses etc.)
Wave count	Number of waveforms (acquisitions) the measurement is based on

Remote commands:
- `MEASurement<m>:RESult[:ACTual]?` on page 1141
- `MEASurement<m>:RESult:AVG?` on page 1141
- `MEASurement<m>:RESult:COUNt?` on page 1143
- `MEASurement<m>:RESult:EVTCount?` on page 1141
- `MEASurement<m>:RESult:NPEak?` on page 1141
- `MEASurement<m>:RESult:PPEak?` on page 1141
- `MEASurement<m>:RESult:RMS?` on page 1141
- `MEASurement<m>:RESult:STDDev?` on page 1141
- `MEASurement<m>:RESult:WFMCount?` on page 1141
- `MEASurement<m>:RESult:STARt?` on page 1143
- `MEASurement<m>:RESult:STOP?` on page 1143
- `MEASurement<m>:ARNames` on page 1141
- `MEASurement<m>:ARES?` on page 1140

The peak and average values and the standard deviation of the long-term points are also shown in the graph of the long-term measurement.

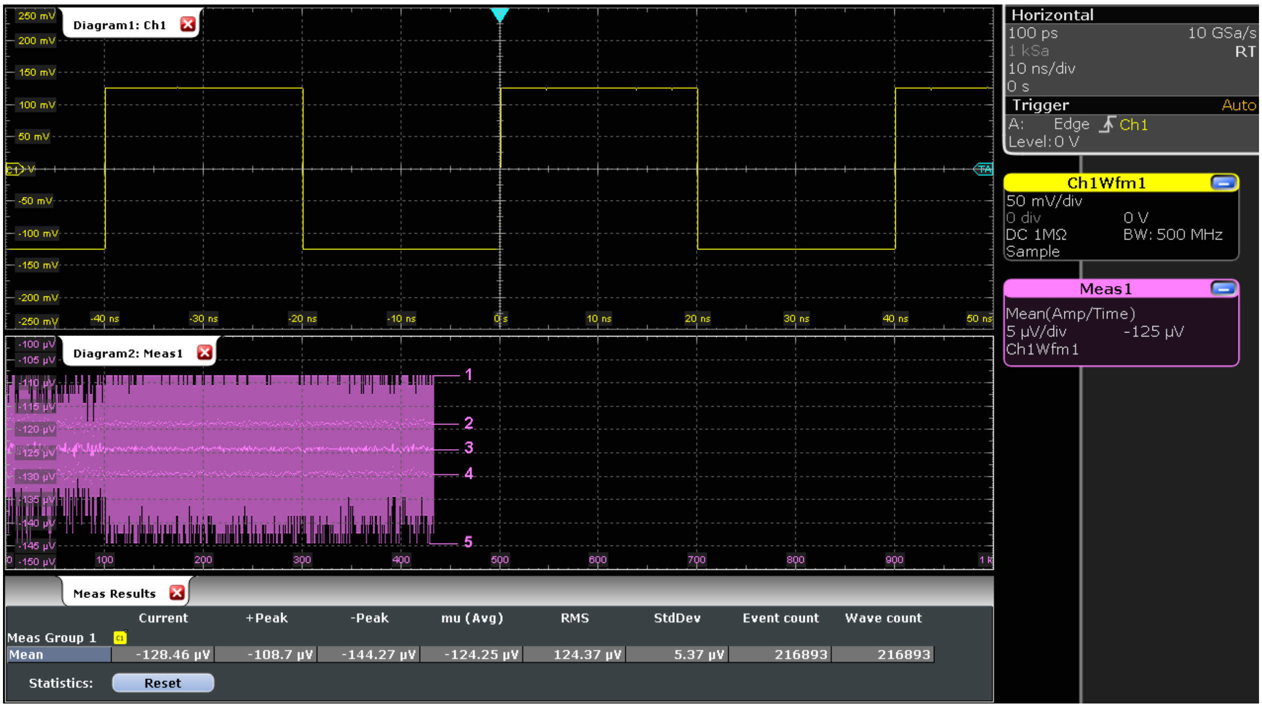


Figure 7-11: Long-term measurement with statistics

1 = +Peak, maximum
2 = Average + standard deviation
3 = Average
2 = Average - standard deviation
1 = -Peak, minimum

Stopping and starting the acquisition does not reset statistics but only stops and continues them.

The instrument only resets statistical evaluation if you change measurement setup:

- Select measurement
- Create or modify gate
- Enable/disable long-term measurement and histogram
- Enable continuous autoscale with enabled histogram
- Switch on/off channels
- Enable/disable cursors
- Tap "Reset" or "Clear sreen results"

After a reset, new statistics are compiled beginning with the next acquired waveform.

If limit and margin check is enabled, the icons in the result table indicate if statistical results exceed a limit or margin. These violations do not initiate an action.

7.2.10.2 Long-Term Measurements

Long-term measurements show the behavior of measurement results over a longer time or for many samples. Therefore the measurement results of a specified time period are summarized into one long-term point. For each point, the current value measured at the end of the time period is written to the long-term waveform. In addition, statistical results for each time period are calculated, saved, and reset. This reset avoids constantly rising maximum or constantly falling minimum values until the end of the measurement.

You can define the number of long-term points and export the long-term data, including statistical results. The measurement histogram is a vertical histogram shown in the long-term diagram.

Long-term measurements are done on the selected "Measurement for analysis / math".

See also: "Enable (Long term)" on page 337.

Performing Long-Term Measurements

1. On the "Meas" menu, select "Result Analysis".
2. Select the subtab for the measurement group you want to configure.
3. Under "Long term", tap "Enable".
4. Since the waveform can change in the process of time, enable "Continuous auto scale" to adapt the scaling automatically.
   Alternatively, tap the "Auto scale" to adjust the scale once and to see the long-term waveform.
5. Tap "Horizontal scaling".
6. Define the "Number of points" to be shown in the long-term diagram.
7. Set the "Scale mode" that defines the period of time from which one long-term point is created.
   See "Scale mode" on page 340 for setting details.

   For each long-term measurement point, the current measurement value is added to the long-term waveform.
8. If you need the statistical data of the long-term points:
   a) Tap "Result Analysis" to return to the measurement settings.
   b) Enable statistics.
   c) Let the measurement run and export the data when finished, see Chapter 11.2.5, "Result Analysis", on page 444.

7.2.10.3 Histograms on Measurement Results

Histograms are available not only for channel, math and reference waveforms, but also on measurement results. These histograms cannot be configured, and they are shown in a separate diagram. The source is a measurement. If the histogram is based on long-term measurement, it is shown in the long-term diagram.

The histogram is built from the results of the selected "Measurement for analysis / math".

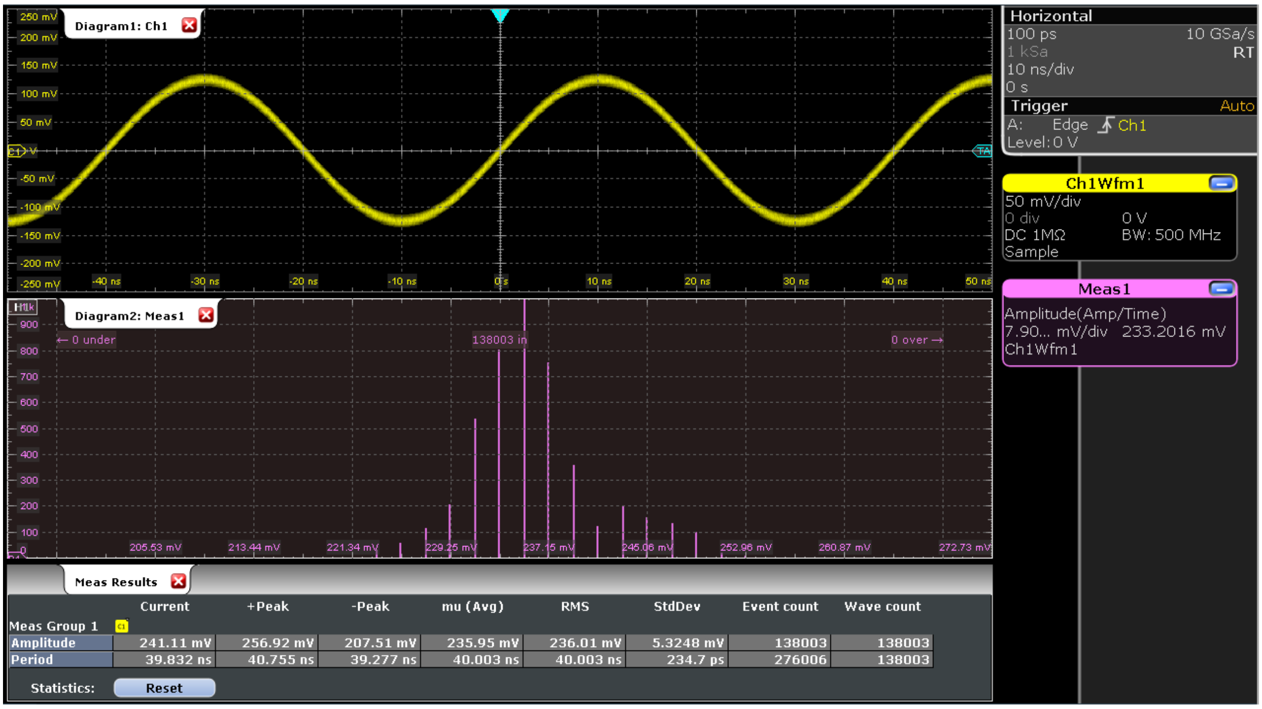


Figure 7-12: Statistical results and measurement histogram of an amplitude measurement

See also: "Enable (Histogram)" on page 337.

7.2.10.4 Track

The track is a waveform that shows measurement values in time-correlation to the measured signal. It is the graphical interpretation of all measurement values of a single acquisition.

The track is available for most amplitude/time measurements (except for High, Low, Amplitude, Max, Min, Peak to peak, Mean, RMS, S-dev, Pos. and Neg. overshoot, and Area), and for jitter measurements.

Enabling the track enables also the Continuous auto scale and Measure all events in each acquisition.

To analyze the track, you can use cursor measurements and zoom.

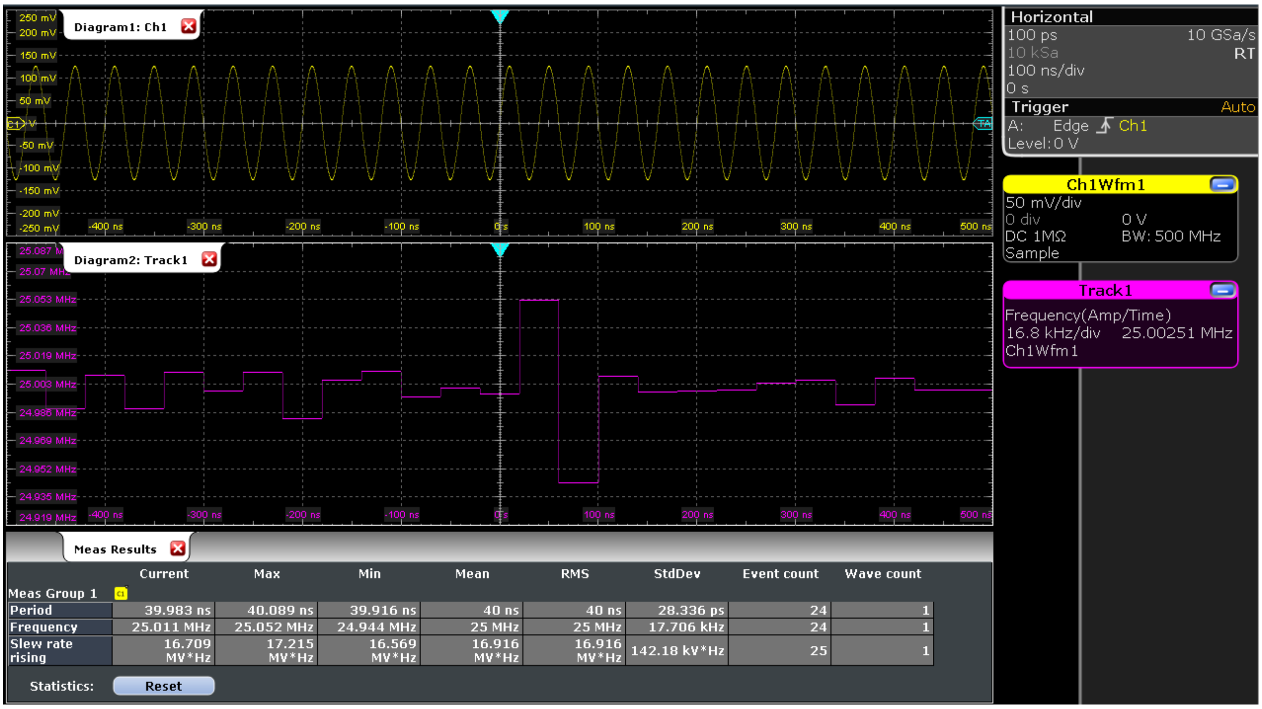


Figure 7-13: Track on a frequency measurement

Creating a track waveform

1. Configure the measurement group.
2. Activate the measurement group.
3. Select the "Result Analysis" tab.
4. If several measurements are enabled, select the "Measurement for analysis / math".
5. Enable the track.

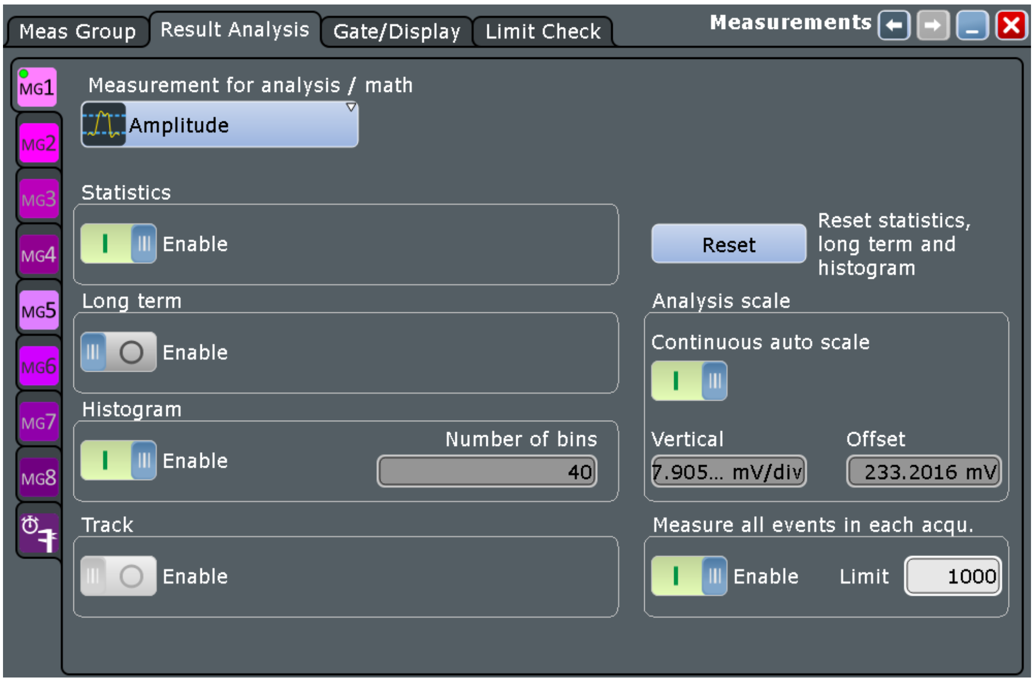
See also: "Enable (Track)" on page 338.

7.2.10.5 Settings for Result Analysis

Access: "Meas" menu > "Result Analysis"

The settings in the "Result Analysis" tab activate and configure long-term measurements, statistical calculations, and the histogram of measurement results over a longer period of time.

For scaling settings of the long-term diagram, see Chapter 7.2.10.6, "Horizontal Long-Term Scaling", on page 339.



Measurement for analysis / math

Selects the measurement that is used as source for mathematic calculations, long-term measurements, and histograms. These evaluations are performed on one measurement only, not on all measurements of the group. Statistics are calculated for all measurements.

The selected measurement cannot be disabled in the "Add / Remove Measurement" dialog box.

Remote command:

`MEASurement<m>:MAIN` on page 1138

Statistics / Enable

Enables the calculation and display of statistical results.

Remote command:

`MEASurement<m>:STATistics[:ENABle]` on page 1175

Enable (Long term)

Enables long-term measurement of the main measurement.

Long-term measurements are performed on the "Measurement for analysis / math".

Remote command:

`MEASurement<m>:LTMeas[:STATe]` on page 1179

Enable (Histogram)

Displays a histogram of measurement results - the cumulative occurrence distribution of measurement results in a graphic. Enabling the histogram enables also the statistics.

The histogram is built from the results of the "Measurement for analysis / math".

Remote command:
`MEASurement<m>:STATistics:HISTogram` on page 1176

Number of bins
Sets the number of bins - the number of vertical bars that build the histogram.

If "Continuous auto scale" is enabled, the instrument determines the number of bins based on the timebase, the current measurements, and other settings. To set the number of bins manually, disable "Continuous auto scale".

Remote command:
`MEASurement<m>:STATistics:HBINs` on page 1176

Enable (Track)
Enables the track of measurement results over time and displays the track waveform. It is the graphical interpretation of all measurement values of a single acquisition.

The track is available for most amplitude/time measurements (except for High, Low, Amplitude, Max, Min, Peak to peak, Mean, RMS, S-dev, Pos. and Neg. overshoot, and Area), and for jitter measurements.

Enabling the track enables also the Continuous auto scale and Measure all events in each acquisition.

Before you can enable the track, activate the appropriate measurement.

If option R&S RTP-K12 basic jitter analysis is installed, you can use tracks to display the jitter measurement results as a time-correlated waveform, see Chapter 16.1.5, "Track of Jitter Measurement Results", on page 901.

Remote command:
`MEASurement<m>:TRACk[:STATe]` on page 1180

Reset
Immediately resets the histogram, the long-term measurement and the statistics.

Stopping and starting the acquisition does not reset these analyses but only stops and continues them.

To delete all results, waveforms and history, select "Display" menu > "Clear all".

Remote command:
`MEASurement<m>:STATistics:RESet` on page 1178

Analysis scale
The measurement scale of a long-term measurement diagram or measurement histogram can be set automatically by the instrument, or manually.

Use automatic scaling if the measurement is running and you cannot see the expected results.

"Continuous auto scale"
Performs an automatic scaling whenever the long-term waveform or the histogram does not fit in the diagram during the measurement period.

"Vertical" Defines the vertical scaling per division for long-term measurement period and the measurement histogram.

"Offset" Defines an offset for the long-term measurement and the measurement histogram.

Remote command:
`MEASurement<m>:VERTical:CONT` on page 1178
`MEASurement<m>:VERTical:AUTO` on page 1178
`MEASurement<m>:VERTical:SCALe` on page 1179
`MEASurement<m>:VERTical:OFFSet` on page 1178

Measure all events in each acquisition
Normally, only one measurement is performed for each acquired waveform to get best performance. If "Measure all events in each acquisition" is enabled, more than one result is taken from one acquired waveform and the results are included evaluation. For example, the rise time is measured on all pulses in the waveform, not only on the first.

The result box shows only the first result of the waveform, the following results are used only for evaluation.

All event results are also considered in limit and margin checks and can initiate an action. However, the icons in the result box only indicate violations of the first result.

Measuring all events is useful when calculating statistics or generating tracks; however, it reduces the performance of the instrument.

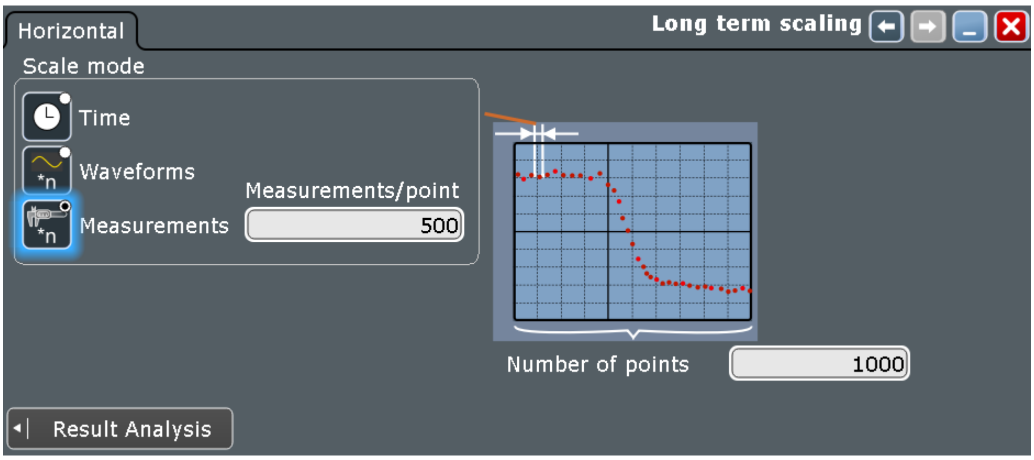
The number of considered results can be restricted: "Limit" sets the maximum number of measurement results per acquisition.

Remote command:
`MEASurement<m>:MULTiple` on page 1175
`MEASurement<m>:MNOMeas` on page 1175

7.2.10.6 Horizontal Long-Term Scaling

In this dialog box, you define the horizontal scale of long-term measurement diagrams. The length of the long-term measurement is defined by the number of points.

If option R&S RTP-K5 I²S Audio Signals is installed, the trend diagram is configured here.



Number of points
Defines the total number of points to be displayed in the long-term measurement diagram.

Remote command:
`MEASurement<m>:LTMeas:COUNt` on page 1179

Scale mode
Defines when the points of a long-term measurement are created.

If statistics are enabled, each long-term measurement point shows the statistical mean and standard deviation of the results measured during the defined period.

If statistics are disabled, the first measurement result of each period is taken as long-term measurement point.

"Time"	Sets one long-term measurement point for the time defined in "Time/point".
"Waveforms"	Sets one long-term measurement point for several acquired waveforms. The number is defined in "Waveforms/point".
"Measurements"	Sets one long-term measurement point for several measurement results. The number is defined in "Measurements/point".

Remote command:
`MEASurement<m>:STATistics:MODE` on page 1176

Time / point
Defines the time to create one point of the long-term measurement. The "Time / point" value is a lower time limit. The actual time between two points depends on the acquisition and postprocessing time.

The long-term measurement is not a data logger with equidistant points as the time between two points varies.

This setting is only available if "Scale mode" is set to "Time".

Remote command:
`MEASurement<m>:STATistics:RTIMe` on page 1177

Measurement time
Defines the total duration of the long-term measurement: *Time/point * Number of points*.

This setting is only available if "Scale mode" is set to "Time".

Remote command:
`MEASurement<m>:LTMeas:TIME` on page 1180

Wfms / point
Defines the number of measured waveforms from which one point of the long-term measurement is created.

This setting is only available if "Scale mode" is set to "Waveforms".

Remote command:
`MEASurement<m>:STATistics:RCOunt` on page 1177

Measurements / point
Defines the number of measurement results from which one point of the long-term measurement is created.

This setting is only available if "Scale mode" is set to "Measurements".

Remote command:
`MEASurement<m>:STATistics:RMEascount` on page 1177

7.2.11 Limit and Margin Checks

Limit and margin checks evaluate whether the measurement result exceeds a specified value. Violations are indicated by icons in the result box. Furthermore, you can define actions that are performed on limit or margin violation, like saving the waveform or printing the measurement results.

The following results are considered in limit and margin checks:
- All selected measurements.
- All measured events in an acquisition: all results can initiate an action. However, the icons in the result box indicate only violations of the first result.
- Statistical results. Limit and margin violations of statistical results are indicated by icons in the result box. These violations do not initiate an action.

See also: Chapter 7.2.2.1, "Measurement Status", on page 288

7.2.11.1 Performing Limit Checks

1. On the "Meas" menu, select "Limit Check".
2. Select the subtab of the measurement group you want to configure.
3. Under "Limit check", select "Limit only" to distinguish only between valid and non-valid values.
   Select "Margin&Limit" to perform a two-level value check, where the margin is still valid, while the limit is not.
4. Define the valid value range for each active measurement. The margins must always be within the valid value range. If necessary, the limit or margin values are adapted to match the selected valid range.
   See also "Upper limit, Lower limit, Upper margin, Lower margin, Valid range" on page 342
5. Define what happens when the defined limits and margins are exceeded.

   For each action, define when the instrument starts it:
   - If the limits or margins are exceeded.
   - If the measurement is completed without limit violations.
   - Not at all.

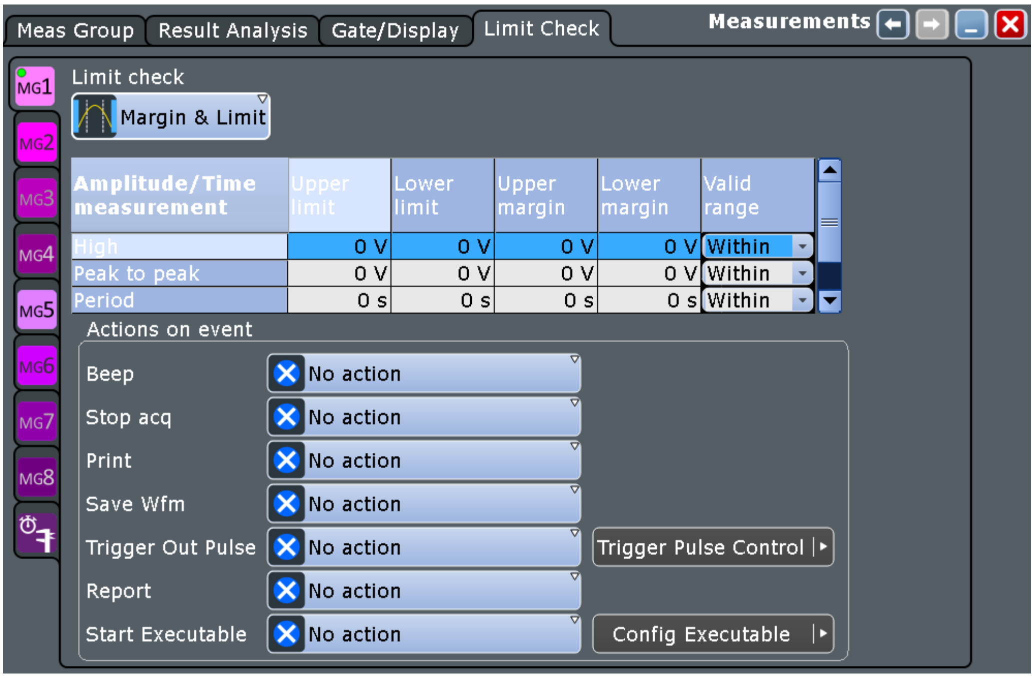
If "Print" is selected, configure the print settings as described in Chapter 11.3.2, "Printing Screenshots", on page 453.

As a result of the limit check, the specified actions are performed and an icon indicates the status in the result box.

7.2.11.2 Limit and Margin Settings

Access: "Meas" menu > "Limit Check".

If the check is enabled, a table is displayed where you can set the limit and margin values and the range of valid measurement results.



Limit check
Enables the limit or margin check.

"Off"	No limit check is performed.
"Limit only"	Limits are checked for violation.
"Margin & Limit"	Margins and limits are checked for violation.

Upper limit, Lower limit, Upper margin, Lower margin, Valid range
Set the limits and margins for each measurement, and also specify the valid range.

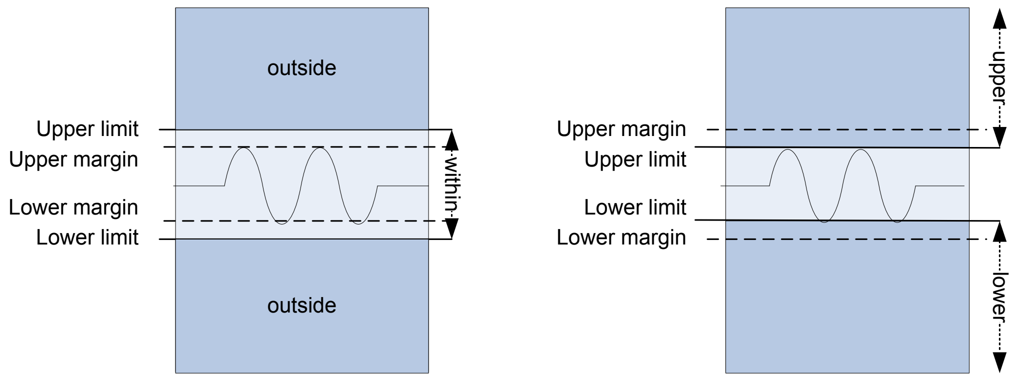


Figure 7-14: Limit and margin definition

Limits are stricter than the margins for the value check. Thus, the margins must be within the valid range. If necessary, the limit and margin values are adapted according to the selected valid range.

The settings are only visible if "Limit check" is enabled.

Remote command:
`MEASurement<m>:AMPTime:LCHeck<n>:LOWer:LIMit` on page 1152
`MEASurement<m>:AMPTime:LCHeck<n>:LOWer:MARGin` on page 1153
`MEASurement<m>:AMPTime:LCHeck<n>:UPPer:LIMit` on page 1152
`MEASurement<m>:AMPTime:LCHeck<n>:UPPer:MARGin` on page 1153
`MEASurement<m>:AMPTime:LCHeck<n>:VALid` on page 1152
To check limits and margins of jitter measurements, use the AMPTime remote commands.
`MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:LIMit` on page 1155
`MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:MARGin` on page 1155
`MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:LIMit` on page 1155
`MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:MARGin` on page 1155
`MEASurement<m>:EYEJitter:LCHeck<n>:VALid` on page 1155
`MEASurement<m>:HISTogram:LCHeck<n>:LOWer:LIMit` on page 1171
`MEASurement<m>:HISTogram:LCHeck<n>:LOWer:MARGin` on page 1172
`MEASurement<m>:HISTogram:LCHeck<n>:UPPer:LIMit` on page 1171
`MEASurement<m>:HISTogram:LCHeck<n>:UPPer:MARGin` on page 1172
`MEASurement<m>:HISTogram:LCHeck<n>:VALid` on page 1171
`MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:LIMit` on page 1162
`MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:MARGin` on page 1163
`MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:LIMit` on page 1162
`MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:MARGin` on page 1163
`MEASurement<m>:SPECtrum:LCHeck<n>:VALid` on page 1162

7.2.11.3 Actions on Limit Check Results

On the "Limit Check" tab, you also define what happens when the limits and margins are exceeded. Limit checking must be enabled.

Actions are initiated by all measurements and all results measured on one acquisition.

Note that the violation actions do not distinguish between a margin violation and a limit violation. However, different icons are displayed in the result box.

For each action, you can define the event on which the action is initiated:

- On violation
  The action is initiated when the limits or margins are exceeded during the measurement.
- On successful completion
  The action is initiated when a defined number of acquisitions has been captured, and the limits or margins were not exceeded.

Independent of these actions, an icon is displayed in the result box, see Chapter 7.2.2, "Measurement Results", on page 287.

Beep
Generates a beep sound.

Remote command:
`MEASurement<m>:ONViolation:BEEP` on page 1185

Stop acq
Stops data acquisition on violation.

Remote command:
`MEASurement<m>:ONViolation:ACQStop` on page 1185

Print
Prints a screenshot including the measurement results to the printer defined in the "Print" dialog box (see Chapter 11.3.2, "Printing Screenshots", on page 453).

Remote command:
`MEASurement<m>:ONViolation:PRINt` on page 1185

Save Wfm
Saves the waveform data to the file specified in [Save Recall] > "Save" > "Waveform".

Remote command:
`MEASurement<m>:ONViolation:WFMSave` on page 1186

Trigger Out Pulse
Creates a pulse on the Trigger Out connector on limit violation.

When "Trigger Out Pulse" is used, the trigger control option "Enable trigger out" is disabled. Thus, the trigger-out pulse is created only on limit violation but not when a trigger occurs. The pulse is provided always with the minimum delay of 800 ns, the "Delay" cannot be set.

See also: "Trigger out signal setup" on page 213.

Remote command:
`MEASurement<m>:ONViolation:TRIGgerout` on page 1186

Report

Creates and saves a report using the settings defined in "File" menu > "Report Setup".

Remote command:

`MEASurement<m>:ONViolation:REPort` on page 1186

Start Executable

Starts an external application. Tap "Config Executable" to set the application path and parameters.

See: Chapter 3.5, "External Application", on page 102.

Remote command:

`MEASurement<m>:ONViolation:RUNexec` on page 1187

7.3 Quick Measurements

Quick measurement performs a set of up to eight amplitude/time measurements on one source, simply by tapping the "Quick measurement" toolbar icon. The results are displayed in a results box. You can configure the measurement to be included in quick measurement. The current configuration can be saved to repeat the measurement quickly.

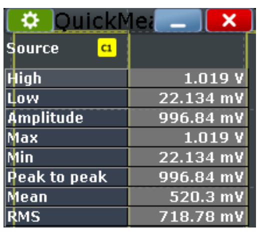
7.3.1 Starting the Quick Measurement

If the "Quick measurement" icon is not visible on the toolbar, add it to the toolbar: see Chapter 2.3.5.2, "Configuring the Toolbar", on page 64.

1. Tap the waveform that you want to measure.
2. Tap the "Quick measurement" icon on the toolbar.

3. Tap the diagram.

The result box shows the results of the default quick measurement.



7.3.2 Configuring the Quick Measurement

The default configuration of the quick measurement includes already 8 amplitude measurements. If these measurements do not fit the measurement task, you can modify the selection.

1. On the "Meas" menu, select "Meas Group".
2. Select the QuickMeas subtab.

3. Tap "Add/Remove Measurements".
4. Disable all measurements that you do not need.
5. Select the measurements that you want to add to the quick measurement.
6. Tap "OK".
7. A "Settings" icon indicates whether further settings are required. Tap the measurement. A dialog box opens, where you can adjust the measurement.
8. Tap "Save as QuickMeas" to save the setup.

   The saved QuickMeas setup is used when you start a new quick measurement.
9. "Enable" the measurement.

Set as QuickMeas
Saves the current QuickMeas setup. The saved QuickMeas configuration is used when you start a new quick measurement. It remains until you save another QuickMeas setup, or until you reset the instrument to "Factory defaults". The "Set as QuickMeas" is not available if the current configuration already has been saved.

8 Spectrum Analysis

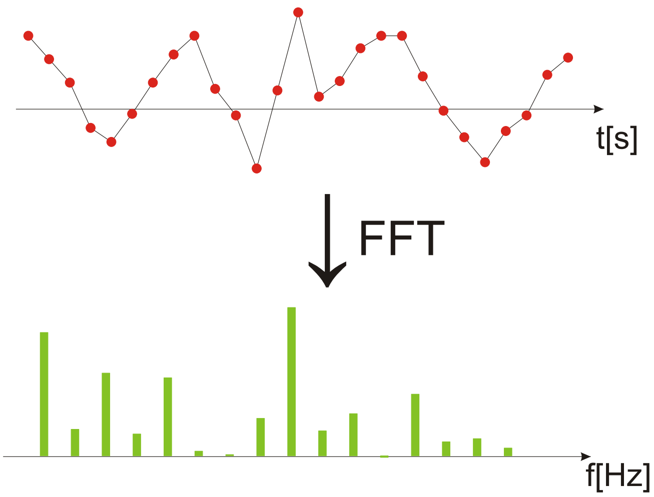
The R&S RTP provides two ways of spectrum analysis:

- Basic FFT calculation, which is included in the firmware
- Spectrogram option R&S RTP-K37, which provides a wide range of analysis possibilities, for example, spectrogram, cursor and automatic measurements.

8.1 FFT Analysis

8.1.1 Fundamentals of FFT Analysis

During FFT analysis, a signal in the time domain is converted to a spectrum of frequencies. As a result, either the magnitude or the phase of the determined frequencies can be displayed. FFT analysis can be restricted to an extract of the original time base, and the results display can be restricted to a specified frequency range.

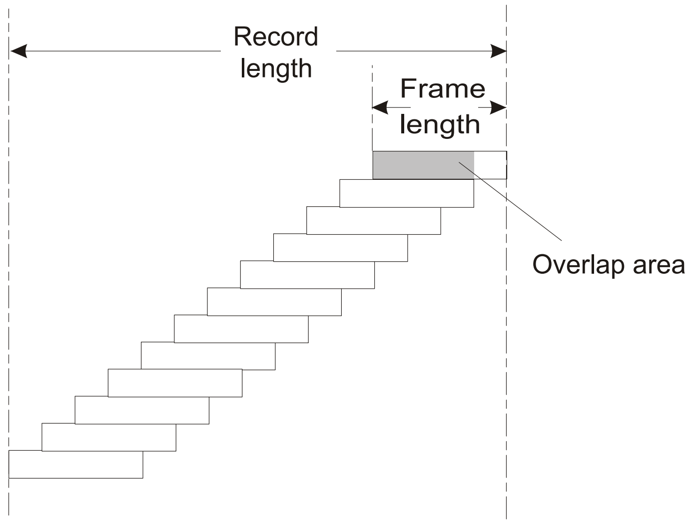


Frames/Segments

To convert the time domain signal to a frequency spectrum, an FFT (Fast Fourier Transformation) unit is used which converts a vector of input values into a discrete spectrum of frequencies.

Conventional oscilloscopes calculate one FFT per capture. The R&S RTP can calculate multiple FFTs per capture by dividing one capture into several *segments*, or *frames*. Thus, the R&S RTP can visualize how the frequency content of a signal changes over time which helps to detect intermittent or sporadic signal details. Furthermore, the R&S RTP allows consecutive frames to overlap. This is especially useful in conjunction with window functions since it enables a gap-free frequency analysis of the signal.

The overlapping factor can be set freely. The higher the overlap factor, the more frames are used. This leads to more individual results and improves detection of transient signal effects. However, it also extends the duration of the calculation. The size of the frame depends on the number of input signal values (record length), the overlap factor, and the FFT size (number of samples used for FFT calculation).



Window functions

Each frame is multiplied with a specific window function after sampling in the time domain. Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

There are several window functions that can be used in FFT analysis. Each of the window functions has specific characteristics, including some advantages and some tradeoffs. Consider these characteristics carefully to find the optimum solution for the measurement task.

For details, see "Window type" on page 357.

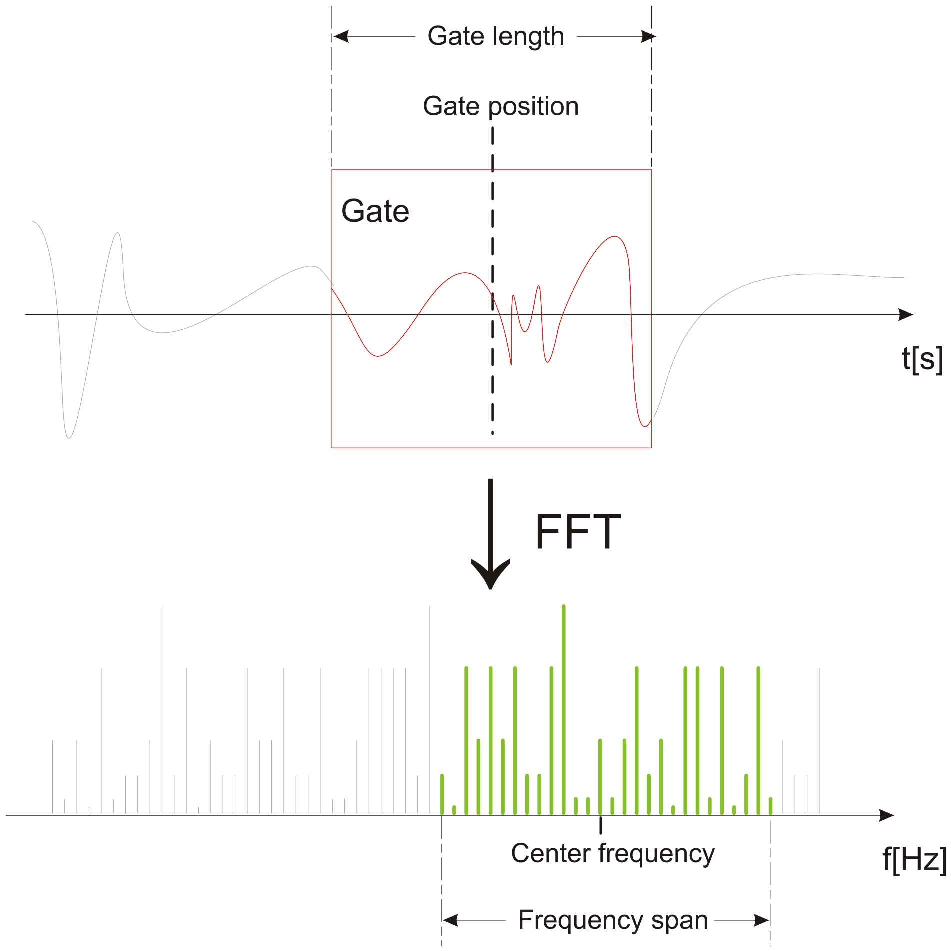
Combining FFT results

After the window function has been applied to the FFT results for each segment, the results for all segments of the data acquisition must be combined to obtain the final waveform. Various arithmetic functions are available for FFT segments, such as averaging, enveloping, or minimum and maximum calculation.

Gating functions

You can restrict the time base of the input signal for which FFT analysis is to be performed. There are various methods to do so:

- Define absolute start and stop times for the time base extract
- Define relative start and stop values that define a percentage of the original time base
- Couple the time base extract for FFT to an active zoom area.



Restricting the result range

You can restrict the results of the FFT analysis to a specified frequency range. The frequency range can be defined in two ways:

- Define a center frequency and frequency span
- Define start and stop frequencies

Using the new cursor functions for spectrum waveforms you can easily determine the results for the current center frequency by moving the cursor to that frequency ("C1 to Center"). If you detect a point of interest in the spectrum diagram, you can place the cursor on it and then move the center frequency to the position of the cursor automatically ("Center to C1").

See Chapter 7.1, "Cursor Measurements", on page 270.

Magnitude vs. phase display

The result of an FFT analysis is a spectrum of frequencies. Either the magnitudes or the phases of those frequencies are displayed, depending on the used FFT function. In "Basic" mode, and for the "Advanced" mode FFT functions |FFT|, FFT (re) and FFT (im), the magnitude is displayed. For the "Advanced" mode FFT (φ) function, the phase is displayed.

For magnitude display, you can select the scale and range of magnitudes to be displayed. For linear scaling, the vertical value range of the input signal is used. For logarithmic scaling, the logarithmic power of the frequency is displayed. In this case, the input signal must be given in either Volt or Watt. The resulting value range is defined by a maximum value and a range size. Logarithmic scaling can also be set in relation to a given reference value.

For phase display, you can select the unit and suppress phases beneath a threshold value which are most likely caused by noise. The value range [-π, + π] or [-180°, +180°] is used. Phase shifts due to a limitation of the value range can be eliminated using the "Unwrap" function.

Dependencies between FFT parameters

FFT analysis in the R&S RTP is highly configurable. Several parameters, including the resolution bandwidth, frequency span and center frequency, can be defined according to your requirements. Note, however, that several parameters are correlated and not all can be configured independently of the others.

The **resolution bandwidth** defines the minimum frequency separation at which the individual components of a spectrum can be distinguished. Small values result in high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase measurement speed.

The minimum achievable RBW depends on the integration time which is equivalent to the number of samples available for FFT calculation. If a higher spectral resolution is required, the number of samples must be increased by using a higher sample rate or longer record length. To simplify operation some parameters are coupled and automatically calculated, such as record length and RBW.

The **frequency span** and **center frequency** define the start and stop frequency of the spectral diagram. By default, a suitable frequency range according to the resolution bandwidth is selected, in respect to performance and precision. Span and RBW settings are coupled, so that the parameters can be adjusted automatically as necessary.

With a **Span/RBW ratio** of 100 and a screen resolution of 1000 pixels, each frequency in the spectrum is displayed by 10 pixels. A span/RBW ratio of 1000 provides the highest resolution. For full flexibility, the span/RBW coupling can also be disabled. Note, however, that a higher span/RBW ratio (i.e. low RBW values and large frequency spans) result in large amounts of data and extend the duration of the calculation.

Advanced FFT functions

In "Advanced" math definition mode, other FFT results than the basic frequency magnitude can be displayed.

- **FFT (φ)**: phase display
- **FFT (im)**: imaginary part of FFT value (magnitude)
- **FFT (re)**: real part of FFT value (magnitude)

- **FFT -dφ*df** (group delay): the negative derivative of the phase with respect to frequency; useful to measure phase distortion

8.1.2 Configuring Spectrum Waveforms

During FFT analysis, a signal in the time domain is converted to a spectrum of frequencies. A basic spectrum waveform can be displayed quickly. By defining additional FFT parameters, the waveform can be configured in more detail.

As a result, either the magnitude or the phase of the determined frequencies can be displayed, or more complex FFT functions. Analysis can be restricted to an extract of the original time base, and the results display can be restricted to a specified frequency range.

The usage of FFT is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > FFT".

To display a basic spectrum waveform using the [Math] key

1. Press the [Math] key to open the "Math" dialog box.
2. In the "Setup" tab, in the "Basic" editor, select the input signal as "Source 1".
3. Select "Mag(FFT(x))" as the "Operator".
4. Select the "Enable math signal" icon.
5. If necessary, edit the spectrum waveform parameters as described in the following procedures.

To display advanced spectrum waveforms

In "Advanced" math definition mode, other FFT results than the basic frequency magnitude can be displayed.

1. In the "Setup" tab of the "Math" dialog box, select the "Advanced" expression editor.
2. Double-tap the edit area.

   The "FormulaEditor" is displayed.
3. Delete the contents of the edit field.
4. Tap the "More" key to display further functions in the editor.
5. Tap the required FFT function key.
6. Select the source channel.
7. Close the parenthesis.
8. Tap "Enter"

To configure the spectrum of FFT analysis

By default, a suitable frequency range for the expected horizontal values according to the resolution bandwidth is selected, in respect to performance and precision. Span and RBW settings are coupled. If a more precise evaluation is required, for example for postprocessing in a different application, disable the coupling and change the frequency ranges and resolution bandwidth values as required.

1. On the "Math", select "FFT Setup".
2. Tap the "Frequency axis" button to select the type of scaling you want to use: linear or logarithmic.
3. Disable the "Span/RBW coupling".
4. Specify the frequency range you want to display using one of the following methods:
   - Enter a "Center frequency" and a "Frequency span" that define the spectrum.
   - Enter a "Start frequency" and "Stop frequency" that define the spectrum.
   - Tap the "Full Span" button to display the complete spectrum resulting from the FFT analysis.
5. Define the resolution bandwidth for the FFT result.
   The resolution bandwidth defines how precise the results are, i.e. how close together the individual frequencies can be. Small values result in high precision, as the distance between two distinguishable frequencies is small. Higher values decrease the precision, but increase performance.

   You can define the RBW manually, or couple it to other FFT settings. Do one of the following:
   - To couple the RBW to the span, enable the "Span/RBW coupling" option and define the "Span/RBW ratio". The smaller the ratio, the higher the RBW becomes to display the same frequency span.
   - Enter the "Resolution BW" manually. The "Span/RBW coupling" option is automatically disabled.
   - To couple the RBW to the specified record length, in the "FFT Gating" tab of the "Math" dialog box, select the "Record length controlled" option. This option is only available if no gate is being used ("Use Gate" disabled).
6. Select the most suitable "Window type" for your source data. Window functions are multiplied with the input values and thus can improve the FFT display. For details, see "Window type" on page 357.
7. Optionally, select an arithmetic mode for the FFT segments. This mode defines how the individual segment results are combined to a final spectrum waveform. In the "FFT Overlap" tab of the "Math" dialog box, tap "FFT Segment Arithmetic" and select the required mode from the list.
8. If you use an arithmetic mode, increase the "Overlap factor" for neighboring segments to increase the accuracy of the results.

To restrict the input values (gating)

By default, the FFT is calculated for the entire record length as defined for the data acquisition. However, you can restrict the time range for which the FFT is calculated, resulting in a restricted spectrum. Alternatively, the record length can be determined automatically according to the selected RBW.

1. Select the "FFT Gating" tab of the "Math" dialog box.
2. Determine how the input length is configured by selecting one of the following options:
   - To ensure that the FFT is calculated for the full defined record length, select the "Record length controlled" option. This option is only available if no gate is being used ("Use Gate" disabled). The RBW is adapted so that the record length can be acquired in the specified acquisition time. However, the RBW is restricted, so that data acquisition may fail if the record length is too long for the specified acquisition time.
   - To couple the used record length to the required RBW, select the "RBW controlled" option. This option is only available if no gate is being used ("Use Gate" disabled).
     The required acquisition time for the defined RBW value is indicated.
   - To restrict the basis of the FFT calculation to a certain time base, configure a time gate, that is: an extract of the time base in the original diagram. To do so, enable the "Use Gate" option, then do one of the following:
     – Select the "Absolute" mode and enter the "Start" and "Stop" times that define the gate area.
     – Select the "Relative" mode and enter the percentages of the total time base that define the "Relative Start" and "Relative Stop" times.
     – If a zoom area has already been defined in the original diagram and you want to use the same time base for FFT analysis, select "Zoom coupling".

   The spectrum waveform displays the spectrum for the specified time span.

To configure magnitude results

1. Open the "FFT Y-Units" tab of the "Math" dialog box.
2. Select the scaling unit. Use logarithmic scaling only for input values in Volt or Watt.
3. Decide whether you want to configure the value range manually or use the automatic settings by tapping the corresponding icon.
4. In manual mode, define the size of the "Vertical range" and the "Vertical maximum" to be displayed.
   In automatic mode, define the size of the "Range" to be displayed.
   For logarithmic scaling in dB, also define the "Reference level" to be used.

To configure phase results

1. Open the "FFT Y-Units" tab of the "Math" dialog box.
2. Select the scaling unit.

3. To eliminate phase shifts due to a limitation of the value range, enable the "Unwrap" function.
4. To suppress small phase values due to noise, enable the "Suppression" function and enter a "Threshold" value.

To couple spectrum displays

The settings for one or more spectrums can be coupled. Thus, if any FFT setting for any of the coupled spectrums are changed, they are changed for all coupled spectrums.

1. Open the "FFT Coupling" tab of the "Math" dialog box.
2. Select the spectrums to be coupled. The spectrum for the currently selected math waveform cannot be selected. Its settings are applied to the selected spectrums.
3. If necessary, define an FFT function to be used for the coupled math waveforms so that a spectrum is displayed. See Chapter 6.3.1, "Displaying Math Waveforms", on page 245.

8.1.3 FFT Configuration Settings

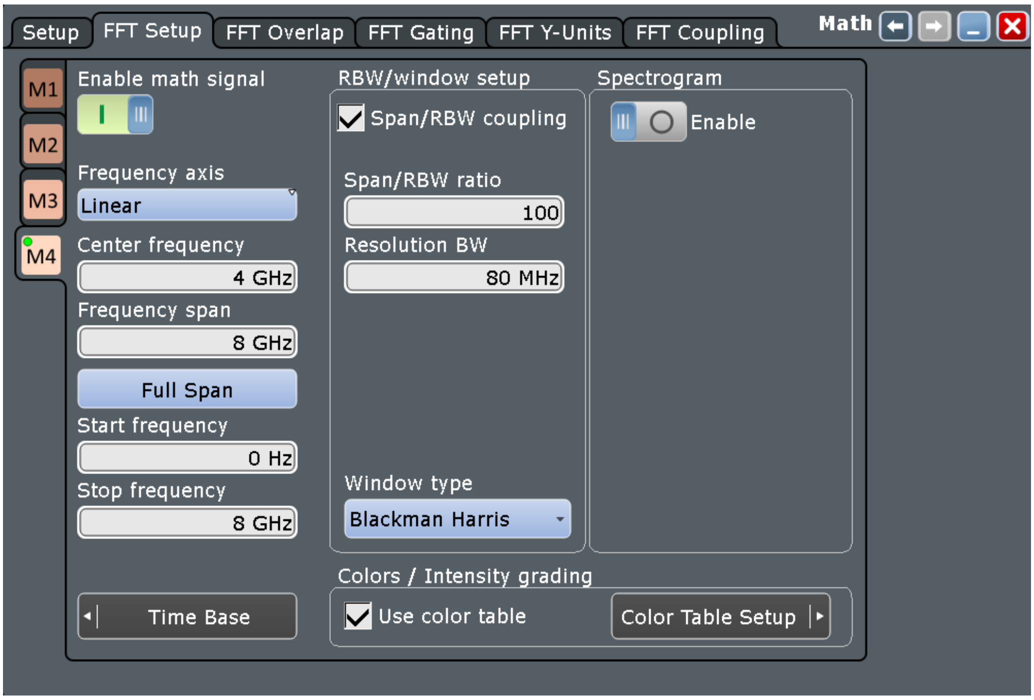
8.1.3.1 FFT Setup

Access: [Math] > "FFT Setup"

In this tab, you define the settings for the FFT window. The display can be restricted to the results for a certain time base extract and to a specified frequency range.

Additional settings are available on this tab if the Spectrogram option (R&S RTP-K37) is installed.

See Chapter 8.2.4, "Spectrogram Configuration Settings", on page 368.



Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:

`CALCulate:MATH<m>:STATe` on page 1114

Frequency axis (R&S RTP-K37 only)

Defines the scaling method for the frequency (x-) axis of the spectrogram.

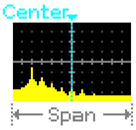
"Logarithmic" Logarithmic scaling

"Linear Unit" Linear scaling

Remote command:

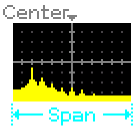
`CALCulate:MATH<m>:FFT:LOGScale` on page 1200

Center frequency
Defines the position of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The width of the range is defined using the "Frequency span" setting.



Remote command:
`CALCulate:MATH<m>:FFT:CFRequency` on page 1201

Frequency span
The span is specified in Hertz and defines the width of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The position of the span is defined using the "Center frequency" setting.



Remote command:
`CALCulate:MATH<m>:FFT:SPAN` on page 1202

Full span
Displays the full frequency span.

Remote command:
`CALCulate:MATH<m>:FFT:FULLspan` on page 1201

Start frequency
Defines the start frequency of the displayed frequency span.

Remote command:
`CALCulate:MATH<m>:FFT:STARt` on page 1200

Stop frequency
Defines the stop frequency of the displayed frequency span.

Remote command:
`CALCulate:MATH<m>:FFT:STOP` on page 1201

Span/RBW Coupling
Couples the frequency span to the "Resolution BW" setting.

Remote command:
`CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO` on page 1202

Span/RBW Ratio
Defines the coupling ratio for Span/RBW. This setting is only available if `CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO` is ON.

Remote command:
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:RATio on page 1202

Resolution BW

Defines the resolution bandwidth. Note that the resolution bandwidth is correlated with the span, record length and acquisition time. If a constant record length is to be used, the RBW may be adapted if the required number of samples cannot be acquired. If span and RBW values are coupled, changing the span will also change the RBW.

For details see Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 347.

Remote command:
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution][:VALue] on page 1203
CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:ADJusted? on page 1202

Window type

Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

Various different window functions are provided in the R&S RTP to suit different input signals. Each of the window functions has specific characteristics, including some advantages and some trade-offs. These characteristics need to be considered carefully to find the optimum solution for the measurement task.

Window type	Frequency resolution	Magnitude resolution	Measurement recommendation
Rectangular	Best	Worst	Separation of two tones with almost equal amplitudes and a small frequency distance
Hamming Hann	Good	Poor	Frequency response measurements, sine waves, periodic signals and narrow-band noise
Blackman Harris (default)	Worst	Best	Mainly for signals with single frequencies to detect harmonics Accurate single-tone measurements
Gaussian	Good	Good	Weak signals and short duration
Flattop2	Poor	Best	Accurate single-tone measurements
Kaiser Bessel	Poor	Good	Separation of two tones with differing amplitudes and a small frequency distance

Remote command:
CALCulate:MATH<m>:FFT:WINDow:TYPE on page 1203

Use color table

If enabled, the spectrum waveform (and a spectrogram, if available) is displayed according to the assigned color table. For information on the available color tables, see Chapter 3.4.2.2, "Color Tables", on page 92.

If this option is disabled, the preset color of the selected channel source is displayed, and the intensity of the specific signal color varies according to the cumulative occurrence of the values. For spectrum diagrams, this setting corresponds to the common waveform display. The spectrogram, on the other hand, is then displayed in gray tones, which is not very useful.

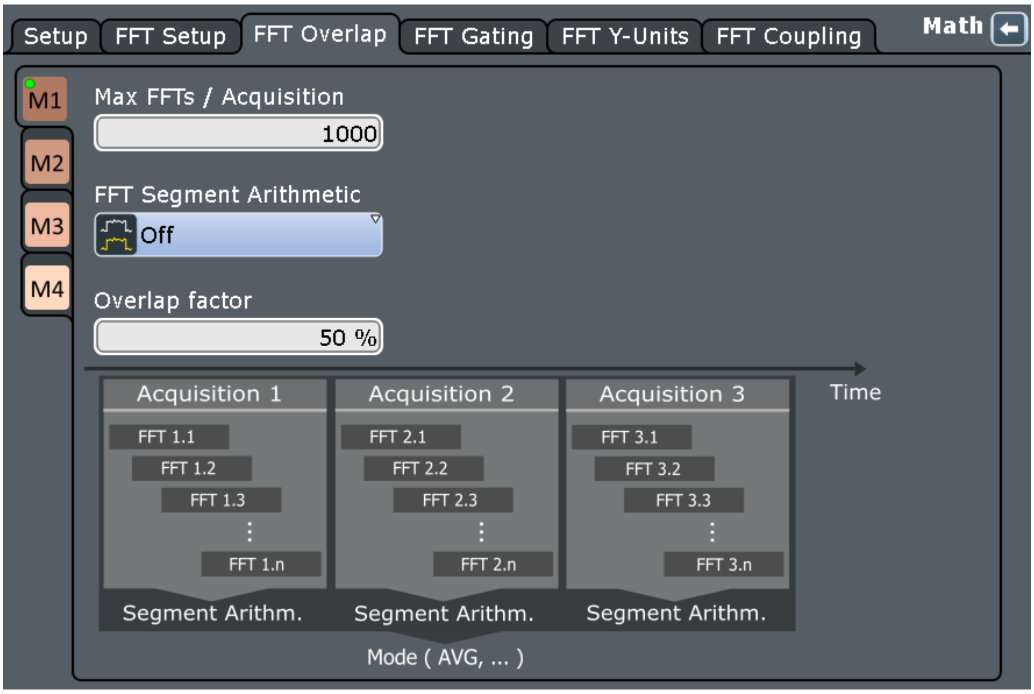
Remote command:

`CALCulate:MATH<m>:FFT:USEColtab` on page 1213

8.1.3.2 FFT Overlap

Access: [Math] > "FFT Overlap"

In this tab, you define the settings for the magnitude and phase of the frequencies.



Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:

`CALCulate:MATH<m>:STATe` on page 1114

Max FFTs / Acquisition

Restricts the maximum number of FFTs to be calculated for each data acquisition. Due to the other parameter settings, the required number of FFTs may become very high, thus slowing performance. By restricting the number of FFTs, you can avoid performance loss without changing the other parameters.

However, if the maximum number of FFTs is lower than the required number to cover the entire waveform, the waveform may only be analyzed partially. In this case, the "Frame coverage" indicates the percentage of the waveform that was analyzed, i.e. which part of the data was included in the FFT calculation.

Remote command:
`CALCulate:MATH<m>:FFT:FRAMe:MAXCount` on page 1205
`CALCulate:MATH<m>:FFT:FRAMe:COVerage?` on page 1205

FFT Segment Arithmetics

FFT analysis can only be performed on a maximum number of values at once. If more values must be calculated, the input signal is divided into segments, each of which is calculated separately. The segments need not be disjunct, that is: they may overlap, so that some values have several FFT results. In this case, the arithmetic mode defines how the final result is calculated from the individual results.

The following methods are available:

"Off" The data of only one segment is considered. In effect, no arithmetics are processed.

"Envelope" Detects the minimum and maximum values for FFT calculation over all segments. The resulting diagram shows two envelope waveforms: the minimums (floor) and maximums (roof). These envelopes indicate the range of all FFT values that occurred.

"Average" The average is calculated over all segments.

"RMS" The root mean square is calculated over all segments. The result is the average power spectrum. If you measure the channel power on this RMS spectrum, you get the same result as for the average channel power measurement on segments.

"MinHold" Determines the minimum result for each input value from the data of the current acquisition and the acquisitions before.

"MaxHold" Determines the maximum result for each input value from the data of the current acquisition and the acquisitions before.

Remote command:
`CALCulate:MATH<m>:FFT:FRAMe:ARIThmetics` on page 1204

Overlap Factor

Defines the minimum factor by which two neighboring segments overlap. If the required number of segments to cover the input values allows for more overlap, the factor is increased.

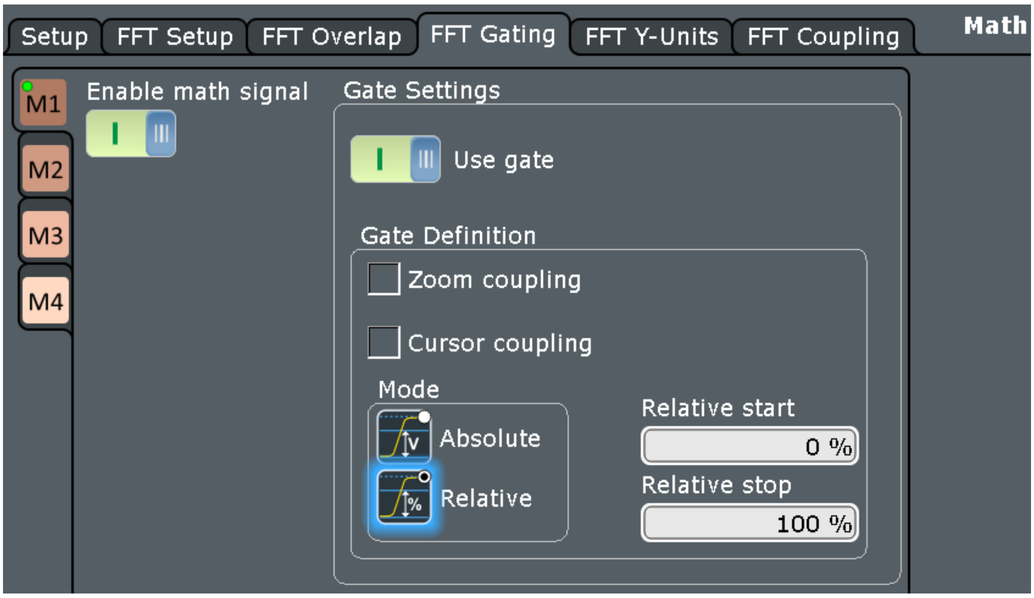
The higher the overlap factor, the more segments are used. This leads to more individual results and improves detection of transient signal effects. However, it also extends the duration of the calculation.

Remote command:
`CALCulate:MATH<m>:FFT:FRAMe:OFACtor` on page 1205

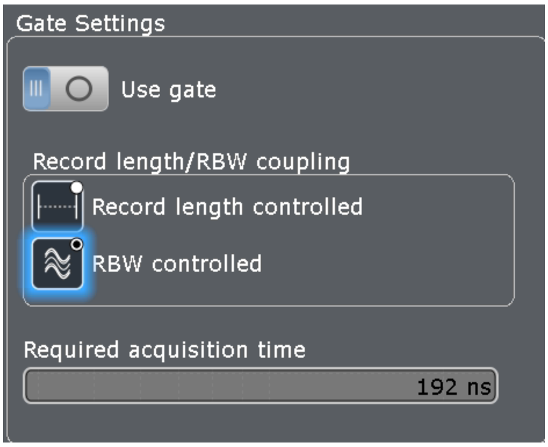
8.1.3.3 FFT Gating

Access: [Math] > "FFT Gating"

FFT gating allows you to restrict FFT analysis to a certain time base of the input signal.



If no gate is used, you can define the record length as dependent on the RBW, or the RBW as dependent on the record length (which is defined by the acquisition time).



Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:
`CALCulate:MATH<m>:STATe` on page 1114

Use Gate
Enables FFT gating and shows the gate.

If enabled, the "Gate Definition" settings are displayed.

If disabled, the relation between the record length and the RBW can be defined manually instead.

When a gate is used, the RBW is adapted, if necessary. The smaller the gate, the higher the RBW.

For details, see Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 347.

Gate Definition
Defines the gate settings for FFT gating.

Zoom coupling ← Gate Definition
Zoom coupling is available if a zoom is defined. As long as "Zoom coupling" is enabled, the gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.

If several zoom diagrams are defined, select the zoom diagram to be used for gating. The "Start" and "Stop" values of the gate are adjusted accordingly.

Zoom coupling can be set for measurement gates, FFT gates, and search gates.

Remote command:
`MEASurement<m>:GATE:ZCOupling` on page 1183
`MEASurement<m>:GATE:ZDIagram` on page 1184
`CALCulate:MATH<m>:FFT:GATE:ZCOupling` on page 1208
`SEARch:GATE:ZCOupling` on page 1263
`SEARch:GATE:ZDIagram` on page 1263

Mode ← Gate Definition
Defines whether the gate settings are configured using absolute or relative values.

"Absolute"	The gate is defined by absolute start and stop values.
"Relative"	The gate's start and stop values are defined by a percentage of the value range.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:MODE` on page 1207
`MEASurement<m>:GATE:MODE` on page 1182
`SEARch:GATE:MODE` on page 1261

(Relative) Start ← Gate Definition
Defines the starting value for the gate.

Remote command:
`CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt` on page 1206
`CALCulate:MATH<m>:FFT:GATE:RELative:STARt` on page 1207
`MEASurement<m>:GATE:ABSolute:STARt` on page 1182
`MEASurement<m>:GATE:RELative:STARt` on page 1182

SEARch:GATE:ABSolute:STARt on page 1262
SEARch:GATE:RELative:STARt on page 1262

(Relative) Stop ← Gate Definition
Defines the end value for the gate.

Remote command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP on page 1207
CALCulate:MATH<m>:FFT:GATE:RELative:STOP on page 1207
MEASurement<m>:GATE:ABSolute:STOP on page 1182
MEASurement<m>:GATE:RELative:STOP on page 1182
SEARch:GATE:ABSolute:STOP on page 1262
SEARch:GATE:RELative:STOP on page 1263

Record Length/RBW Coupling
The record length and resolution bandwidth are coupled during FFT analysis. If you change one value, the other must be adapted accordingly. You can keep either value constant, thus preventing automatic adaptation when the other parameter is changed. However, this may cause the FFT analysis to fail.

This setting is only available if gating is not enabled (otherwise the gate determines the RBW automatically).

For details, see Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 347.

"Record length controlled"	The record length remains constant. If not enough samples are available for the selected RBW, the RBW is decreased.
"RBW controlled"	The RBW is not adapted, i.e. remains as defined by the user. The required acquisition time for this RBW is indicated. If necessary and possible, the record length is extended to acquire the required number of samples.

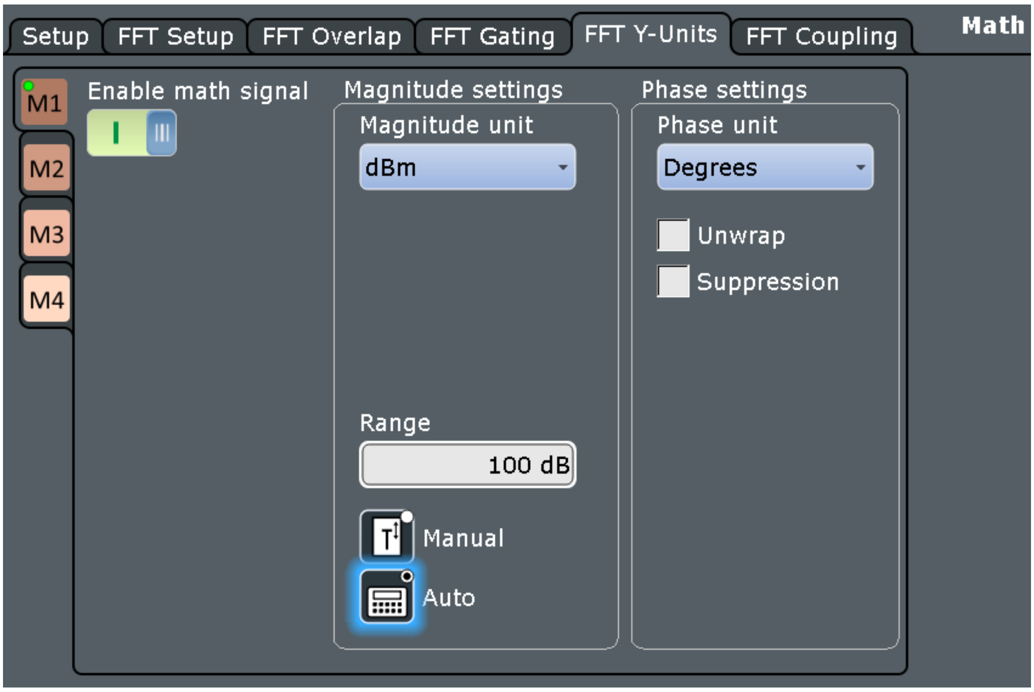
Remote command:
CALCulate:MATH<m>:FFT:GATE:COUPling on page 1206

Required acquisition time
The required acquisition time is calculated for the defined RBW value if "RBW constant" is selected, and is displayed for information only. If the required acquisition time is not available (e.g. because acquisition has already been stopped), an error message is displayed in the FFT Setup tab indicating that not enough samples are available for the defined RBW.

Remote command:
TIMebase:RACTime? on page 1206

8.1.3.4 FFT Y-Units

Access: [MATH] > "FFT Y-Units"



Enable Math Signal

If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:

`CALCulate:MATH<m>:STATe` on page 1114

Magnitude unit

Defines the scaling of the y-axis. The display values are valid for 50Ω termination impedance.

"Linear" Linear scaling; displays the RMS value of the voltage

"dBm" Logarithmic scaling; related to 1 mW

"dB" Logarithmic scaling; related to reference level

"dBµV, dBmV, dBV"

Logarithmic scaling; related to voltage 1 µV, 1 mV, 1 V, respectively

"dBps, dBns, dBµs, dBms, dBs"
Logarithmic scaling; related to time 1 ps, 1 ns, 1 µs, 1 ms, 1 s, respectively

"dBHz, dBkHz, dBMHz, dBGz"
Logarithmic scaling; related to frequency

"dBA, dBmA, µdBA"
Logarithmic scaling; related to current

Remote command:
CALCulate:MATH<m>:FFT:MAGNitude:SCALe on page 1209

Reference level

Defines the reference level for dB scaling.

Remote command:
CALCulate:MATH<m>:FFT:MAGNitude:LEVel on page 1208

Vertical scaling mode (Manual/Auto)

By default, the vertical scale is adapted to the current measurement results automatically to provide an optimal display. However, if necessary, you can define scaling values manually to suit your requirements.

Note: When you change the scaling values manually using the "Scale" rotary knob, the scale mode is set to "Manual" temporarily. When you edit the math function, scaling is automatically set back to "Auto" mode. "Manual" mode is only maintained during math function changes if you select it yourself.

"Manual" Enter the required values for "Vertical scale" and "Vertical offset". For FFT, set "Vertical range" and "Vertical maximum".

"Auto" "Vertical scale" and "Vertical offset" are read-only. For FFT, only the "Vertical maximum" is read-only.

Vertical maximum

Defines the maximum value on y-axis for spectrum displays. Only available for "Manual" scale mode.

Vertical range

Defines the range of FFT values to be displayed.

Remote command:
CALCulate:MATH<m>:VERTical:RANGe on page 1115

Range

Defines the vertical value range in spectrum mode.

Remote command:
CALCulate:MATH<m>:FFT:MAGNitude:RANGe on page 1208

Phase unit

Defines the scaling unit for phase display.

- Radians
- Degrees

Remote command:
CALCulate:MATH<m>:FFT:PHASe:SCALe on page 1210

Unwrap
If enabled, phase shifts due to a limitation of the value range are eliminated.

Remote command:
CALCulate:MATH<m>:FFT:PHASe:UNWRap on page 1210

Suppression
Enables noise suppression. Phase calculation is restricted to frequencies with a minimum magnitude, the threshold value.

Remote command:
CALCulate:MATH<m>:FFT:PHASe:SUPPression on page 1210

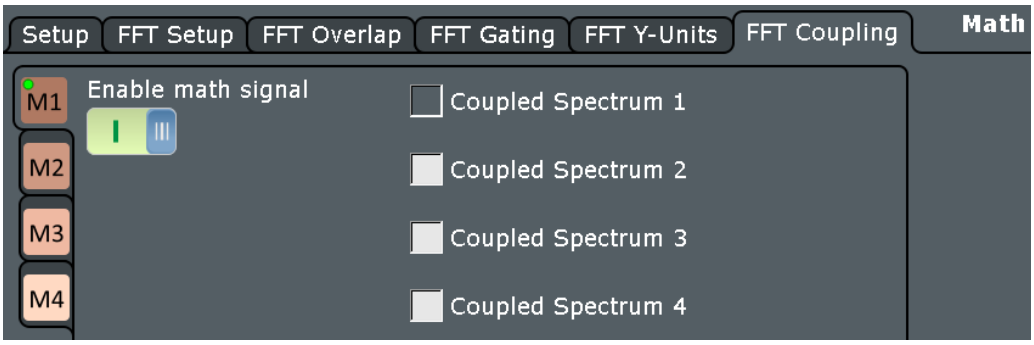
Threshold
Defines the minimum frequency magnitude for which phases are calculated. This setting is only available if "Suppression" is enabled.

Remote command:
CALCulate:MATH<m>:FFT:PHASe:THReshold on page 1210

8.1.3.5 FFT Coupling

Access: [Math] > "FFT Coupling"

Up to four spectrum displays can be shown simultaneously, one for each math waveform. The settings for one or more spectrums can be coupled. Thus, if any FFT setting for any of the coupled spectrums are changed, they are changed for all coupled spectrums.



Enable Math Signal
If activated, a diagram for the defined math waveform is displayed on the touch screen.

Remote command:
CALCulate:MATH<m>:STATe on page 1114

Coupled Spectrum 1/2/3/4

Copies the current FFT settings of the selected math waveform (M1/M2/M3/M4) to the other selected math waveforms, and couples those waveforms. Thus, if any FFT setting for any of the coupled spectrums are changed, they are changed for all coupled spectrums.

Two different sets of spectrums can be coupled at the same time, for instance Spectrum 1 can be coupled to Spectrum 2, while Spectrum 3 is coupled to Spectrum 4.

Note that the formula of the coupled math waveforms is not changed. If necessary, you must select an FFT function for the math waveform manually before the FFT settings of the coupled waveform are applied. See Chapter 6.3.1, "Displaying Math Waveforms", on page 245.

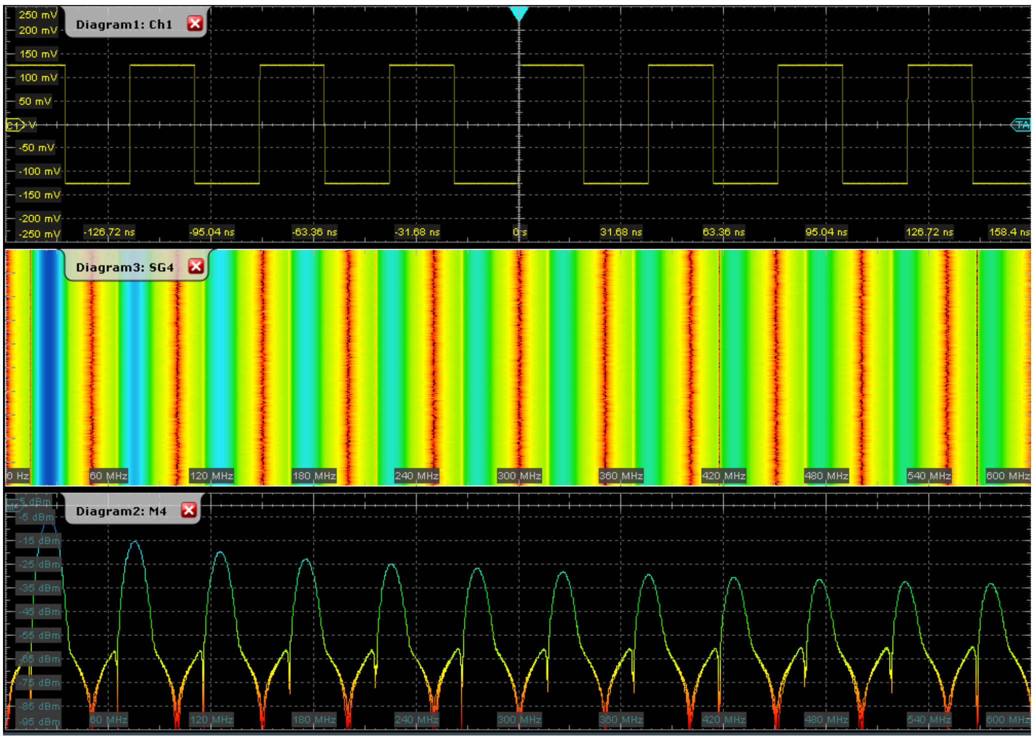
Remote command:
`CALCulate:MATH<m>:FFT:COUPled:WITH<m2>` on page 1211

8.2 Spectrogram (Option R&S RTP-K37)

This chapter describes the Spectrogram option R&S RTP-K37.

8.2.1 Spectrogram Display

The Spectrogram option provides a new diagram for spectrum waveforms: a spectrogram. When you enable a spectrogram, three windows are displayed: the power vs. time diagram at the top, the spectrogram in the middle (labeled "SG") and the power vs. frequency (=spectrum) diagram at the bottom.



A spectrogram shows how the spectral density of a signal varies over time. The x-axis shows the frequency, the y-axis shows the time. A third dimension, the power level, is indicated by different colors. Thus you can see how the strength of the signal varies over time for different frequencies.

The spectrogram is updated with each data acquisition, from top to bottom, so that the most recent trace is at the bottom. Up to two time lines can be shown at a specified position so that you can analyze the spectrum at a specific point in time.

The spectrum diagram indicates the power vs. frequency values for a single data acquisition. If a time line is enabled, the spectrum shows the results at the selected time. Otherwise, the spectrum shows the results of the most recent data acquisition.

8.2.2 Spectrogram Functions

In addition to spectrograms, the Spectrogram option also provides some new automatic measurements based on spectrum waveforms.

- A peak list measurement detects all peaks above a user-definable threshold and optionally indicates the peaks in the spectrum diagram.

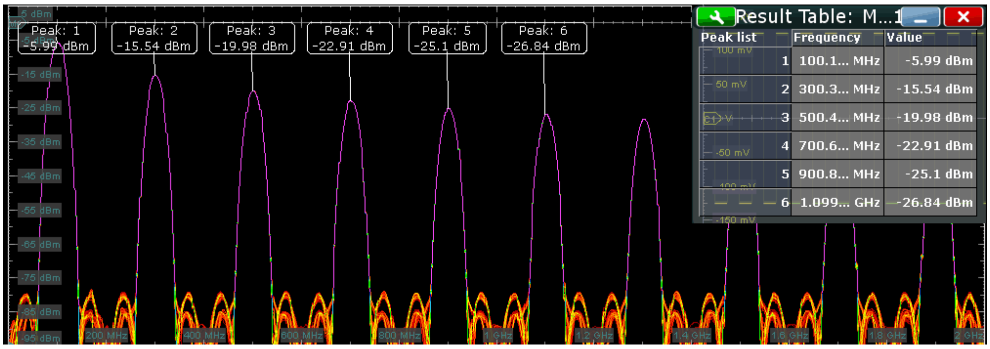


Figure 8-1: Peak list with labels for spectrum waveform

  For a description of the measurement settings, see Chapter 7.2.7.2, "Settings for Spectrum Measurements ", on page 320.
- The THD measurements are an extension to the basic THD measurement. See Chapter 7.2.7, "Spectrum Measurements", on page 319 for details.
- Cursor measurements on spectrum waveforms provide easy center definition and peak search functions, see Chapter 7.1.1.2, "Cursor Measurements on Spectrum Waveforms", on page 271.

8.2.3 Configuring Spectrograms

Spectrograms are only available if the Spectrogram option R&S RTP-K37 is activated.

1. Tap the "Spectrogram" icon on the toolbar.
2. On the sidebar, select the source of the spectrogram.

A spectrogram diagram is displayed. A new signal icon for the spectrogram is displayed on the sidebar ("SGx").
If the selected source is a channel waveform, an FFT is started, on which the spectrogram is created.
Additional settings for time lines become available in the dialog box.

3. Optionally, to display a time line and thus mark a specific waveform in the spectrogram, select "Enable" for one of the two time lines.

   A small arrow icon labeled "T1" / "T2" indicates the position of the time line in the spectrogram.
   The spectrum diagram displays the results for the selected waveforms. A new signal icon is displayed on the sidebar for each time line ("SGxTL1|2").

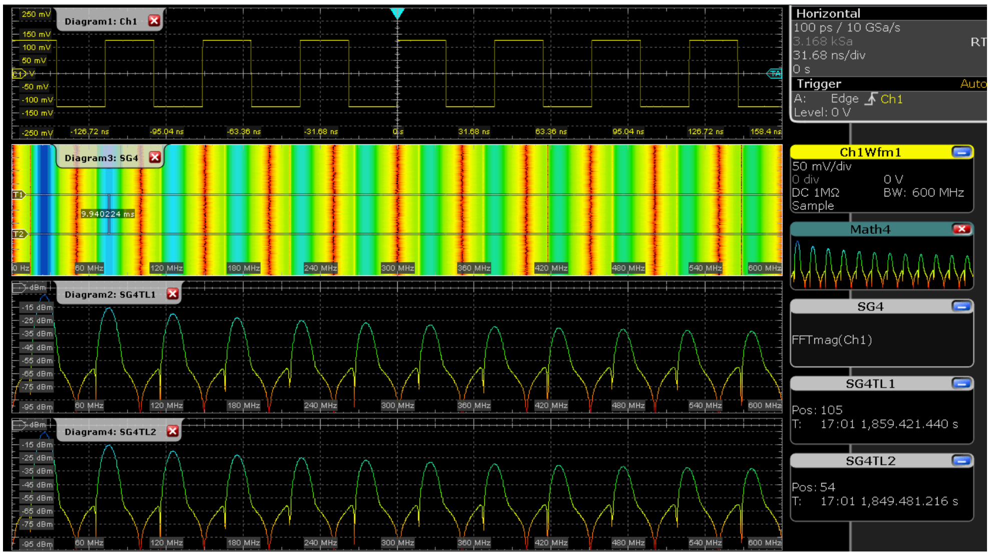


Figure 8-2: Signal icons for the spectrogram time lines

4. To view the spectrum for each time line in a separate diagram, drag the signal icon for one time line to the diagram area and drop it.

   A new window is displayed for the selected time line, and the original diagram displays the other time line.

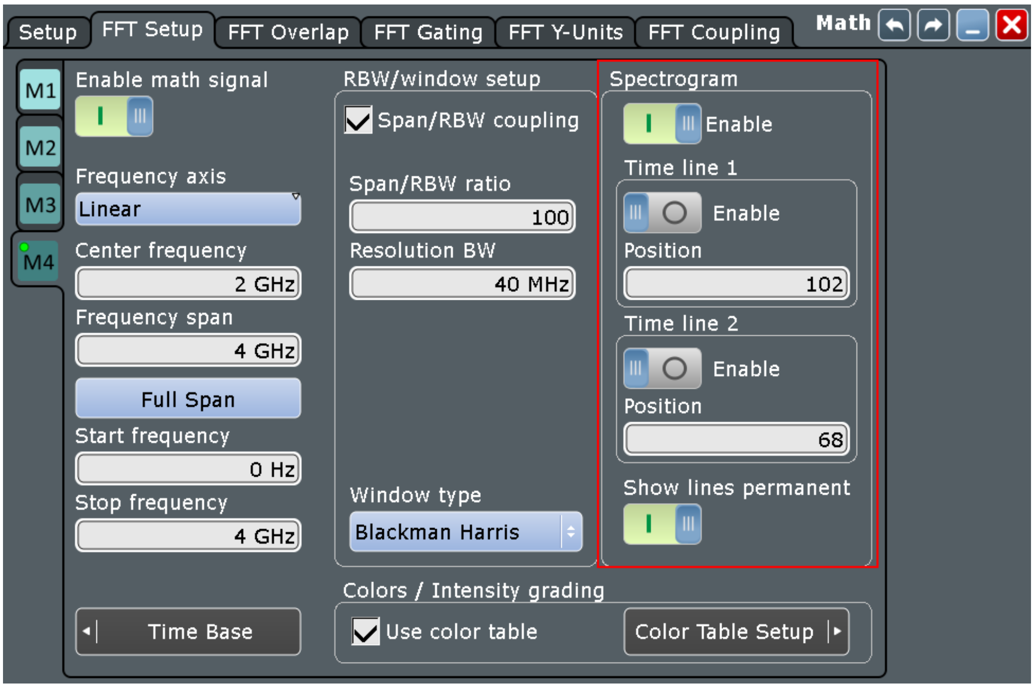
5. To view a different waveform from the spectrogram, move the time lines in the spectrogram.

8.2.4 Spectrogram Configuration Settings

Access: [Math] > "FFT Setup"

Spectrograms are only available if the option R&S RTP-K37 is activated. Furthermore, a math (FFT) waveform must be configured and enabled.

See Chapter 8.1.2, "Configuring Spectrum Waveforms", on page 351.



Enable

Enables the spectrogram display.

If enabled, a new signal icon for the spectrogram is displayed on the sidebar ("SGx").

Remote command:
`CALCulate:MATH<m>:FFT:SPECtrogram:STATe` on page 1213

Time line 1/2

A time line marks a single spectrum in the spectrogram, that is: the power vs frequency results for the data acquired at a specific time. After enabling a time line, the results for that time are displayed in the spectrum diagram. A small arrow icon labeled "T1" / "T2" indicates the position of the time line in the spectrogram. A new signal icon is displayed on the sidebar for each time line ("SGxTL1|2").

You can enable and display two time lines at the same time. This allows you to compare the results at different times.

The position of the time line is defined by the index of the data acquisition in the history. How many acquisitions are available depends on the history settings.

See "Max. acquisition count" on page 263 and Chapter 6.4.2.1, "Viewer", on page 260.

Remote command:
`CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:STATe` on page 1214
`CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:POSition` on page 1214

Show lines permanently

Displays the spectrogram time lines in the diagrams until you disable this option.

If disabled, only the small arrow icons are permanently visible. The line is only displayed temporarily when you touch the arrow.

9 Mask Testing

9.1 About Mask Testing

Masks are used to determine whether the signal remains within specified limits, e.g. to uncover signal anomalies or test compliance and stability of digital signals. The limits are specified as "mask", which is laid over the input signal in the display. Thus you can easily detect where the signal violates the mask.

Mask testing with R&S RTP has only a minor impact on the acquisition rate, thus mask violations are detected fast and reliably.

With R&S RTP, you can define own masks easily. Specific actions can be executed when mask violations occur. For error analysis, you can stop the acquisition on a failed test and use the history view to look at the previous waveforms.

Mask test

A mask test consists of:

- Mask definition
- Waveform to be tested
- Fail criteria for test
- Actions to be taken on violation or successful completion

Mask Definition

A mask can be created in several ways:

- The individual mask points are defined, either on the touch screen or as numerical values. This mask type is called *user mask*.
  For details, see Chapter 9.2.2.1, "Mask Definition: User Mask", on page 375.
- The mask is derived from an existing waveform. This mask type is called *waveform mask*.
  For details, see Chapter 9.2.2.2, "Mask Definition: Waveform Mask", on page 378.

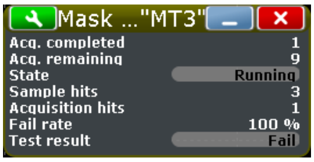
Fail Criteria for Testing

The fail criteria for a mask test is set by two parameters: "Fail condition" and "Violation tolerance". Fail condition defines if sample hits or the number of acquisitions with sample hits are considered. Violation tolerance sets the number of tolerable sample hits or acquisition hits. A test has failed if the number of sample hits or acquisition hits exceeds the limit of violation tolerance hits.

See also: "Fail condition, Violation tolerance" on page 374.

9.1.1 Results of a Mask Test

The result box of a mask test shows the following test results:



Acq. completed

Number of tested acquisitions.

Remote command:

MTESt:RESult:COUNt:WAVeforms? on page 1229

Acq. remaining

Remaining acquisitions until "Average count / Nx Single count" is reached.

The value is useful if you test a specified number of acquisitions with action "Stop acquisition" on violation. Also if the acquisition has been stopped manually before the required number of acquisitions has been acquired.

See also: Chapter 9.3.4, "Running a Mask Test", on page 391.

Remote command:

MTESt:RESult:COUNt:REMaining? on page 1229

State

Shows if the test has been completed. The state is set to "Finished" when "Nx Single count" acquisitions are tested and the number of "Acq. remaining" is 0. as long as the number of tested acquisitions is less the "Nx Single count" number, the state is "Running".

If you run the acquisition with [Run Stop], or the number of played history acquisitions exceeds "Nx Single count", the mask testing is performed according to fail criteria settings independently of the test state. The testing is not stopped when the state is set to "Finished".

Remote command:

MTESt:RESult:STATe? on page 1229

Sample hits

Number of samples that hit the mask.

Remote command:

MTESt:RESult:COUNt:FAILures? on page 1230

Acquisition hits

Number of acquisitions that contained at least one sample hit.

Remote command:

MTESt:RESult:COUNt:FWAVeforms? on page 1230

Fail rate

Ratio of acquisition hits to the number of tested acquisitions.

Remote command:

MTESt:RESult:FRATe? on page 1230

Test result
A test has failed if the number of sample hits or acquisition hits exceeds the limit of "Violation tolerance" hits.

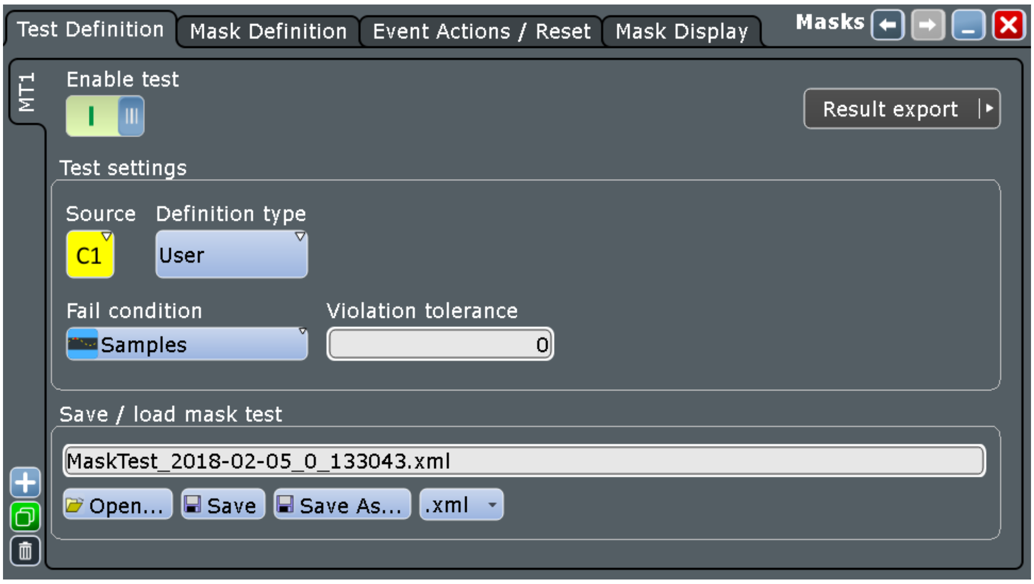
Remote command:
`MTESt:RESult[:RESult]?` on page 1229

9.2 Mask Test Settings

9.2.1 Test Definition

Access: [Mask] > "Test Definition"

The "Test Definition" tab provides all settings for the mask test itself: the waveform to be tested, pass/fail conditions, and saving/loading the mask definition.



The content of the "Test Definition" tab depends on the selected definition type. If "Waveform" is selected, the main mask settings can be set directly on the "Test Definition" tab. For a description of these settings, see Chapter 9.2.2.2, "Mask Definition: Waveform Mask", on page 378.

Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

Remote commands:

`MTESt:ADD` on page 1215

`MTESt:REMove` on page 1215

Enable test

Activates and deactivates the mask test. If the acquisition is running, the test starts immediately. Otherwise, the test starts when acquisition is started.

The testing is stopped when acquisition is stopped, or if a stop action is configured with Stop acq..

Closing the result box also disables the mask test.

Remote command:
`MTESt[:STATe]` on page 1215

Source

Selects the waveform to be tested against the mask. All channel waveforms can be tested.

Remote command:
`MTESt:SOURce` on page 1216

Definition type

Sets the method of mask definition.

"User"	The mask is created manually by tapping the mask points on the touch screen and/or by entering the numerical x- and y-values of the mask points.
"Waveform"	The mask is created from an existing waveform. The waveform builds the upper and lower limit line of the mask, and the limits are moved and stretched. The result is a tolerance tube around the waveform that is used as mask.
"Eye"	Requires jitter option R&S RTP-K12. The mask is created by selecting the shape and setting its dimensions according to the test standard. See: Chapter 9.4, "Mask Testing on Eye Diagrams", on page 393.

Remote command:
`MTESt:CTYPe` on page 1217

Fail condition, Violation tolerance

The fail criteria for a mask test is set by two parameters: "Fail condition" and "Violation tolerance".

"Fail condition" defines the kind of hits to be considered for test evaluation:

- "Samples": Considers the number of samples that hit the mask.
- "Acquisitions": Considers the number of acquisitions that contain at least one sample hit. It is not relevant how many samples hit the mask in that acquisition.

"Violation tolerance" sets the number of tolerable sample hits or acquisition hits.

A test has failed if the number of sample hits or acquisition hits exceeds the limit of violation tolerance hits.

Example:

The example test has failed when the sixth acquisition violated the mask.

Remote command:
`MTESt:CONDition` on page 1216
`MTESt:TOLerance` on page 1217

Save / load mask test

Provides all functions to store and recall a mask test. The mask definition, defined actions and fail conditions are stored in an R&S RTP-specific .xml file.

"Load, Save" Recalls or stores the specified file.

"Open, Save As" Opens a dialog box where you can select the directory the file name. See also: Chapter 11.7, "File Selection Dialog", on page 461.

"Delete" Opens a dialog box where you can select the file to be deleted.

Remote command:
`MTESt:FILE:NAME` on page 1217
`MTESt:FILE:SAVE` on page 1218
`MTESt:FILE:OPEN` on page 1218
`MTESt:FILE:DELete` on page 1218

9.2.2 Mask Definition

Access: [Mask] > "Mask Definition"

With mask definition, you define the shape of the mask - the form and position of its limit lines. The content of the "Mask Definition" tab depends on the selected "Definition type": "User" or "Waveform".

The "Definition type" is a common setting on the top of the tab, see "Definition type" on page 374.

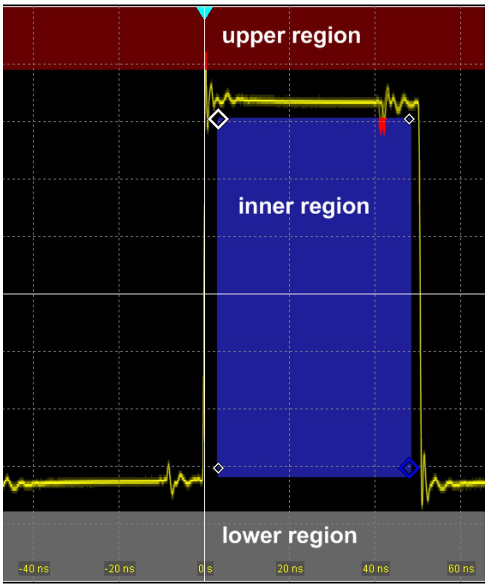
Below, you find the specific settings:

9.2.2.1 Mask Definition: User Mask

Access: [Mask] > "Mask Definition" > "Definition type" = "User"

A user mask is defined by entering the time and voltage values for all corner points of the mask segments. A user mask has at least one segment. Complex masks can have up to 16 segments.

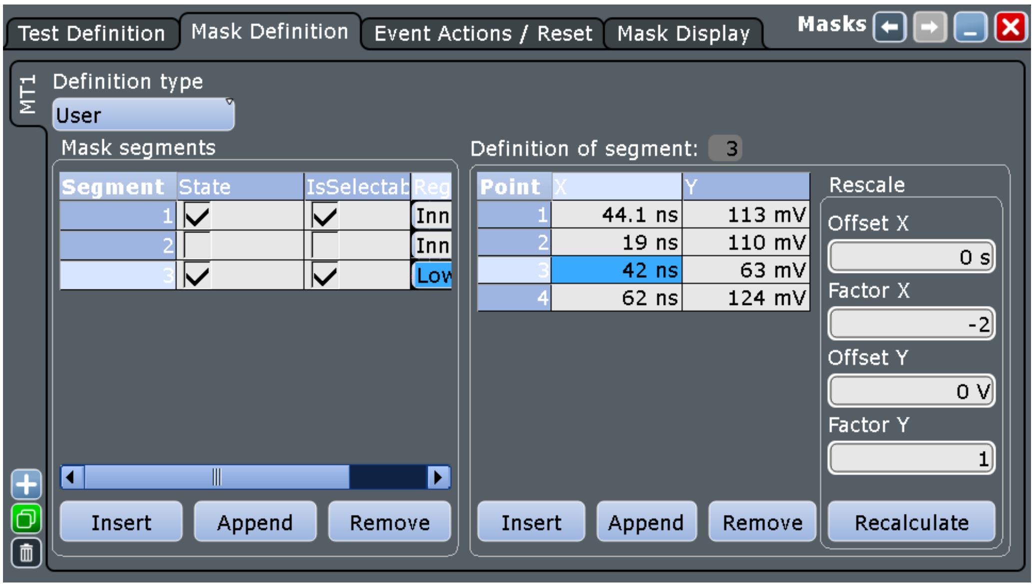
An inner segment is an area defined by three or more points. Upper and lower segments limit the signal on top and bottom of the screen. They are defined by a line, the region above or below the line is set automatically as mask segment.



Alternatively, you can set the corner points on the touch screen and adjust the values in the "Mask Definition" tab.

To save the mask, select the "Test Definition" tab and save the mask test.

Settings overview:



Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

Mask segments

Defines the number and state of mask segments for the selected mask test. Here you can:

- Insert a new segment before the selected segment.

- Append a new segment at the end of the list.
- Remove the selected mask segment from the list.
- Select the region that builds the mask.
  – Inner region: the segment points form a closed geometrical shape, which is the mask segment.
  – Upper region: the segment points are connected to a line, the display area above this line is the mask segment.
  – Lower region: the segment points are connected to a line, the display area below this line is the mask segment.
- Enable and disable the mask segments individually. Disabled segments are not considered by running tests.

Remote command:
`MTESt:SEGMent:STATe` on page 1219
`MTESt:SEGMent:ADD` on page 1219
`MTESt:SEGMent:REMove` on page 1220
`MTESt:SEGMent:INSert` on page 1219
`MTESt:SEGMent:REGion` on page 1220
`MTESt:SEGMent:COUNt?` on page 1219

Definition of segment
The number of the selected segment is shown above the table. In the definition table, the individual points of the selected mask segment are listed with exact horizontal and vertical numerical coordinates. Here you can:

- Insert a new point before the selected point.
- Append a new point at the end of the list.
- Remove the selected point from the list.
- Change the x- and y-values of each point. To scale or move the complete segment, use offset and factor values, see Rescale.

Remote command:
`MTESt:SEGMent:POINt:ADD` on page 1220
`MTESt:SEGMent:POINt:REMove` on page 1221
`MTESt:SEGMent:POINt:INSert` on page 1221
`MTESt:SEGMent:POINt:X` on page 1221
`MTESt:SEGMent:POINt:Y` on page 1222
`MTESt:SEGMent:POINt:COUNt?` on page 1221

Rescale
You can rescale and move mask segments by numerical input of factors and offsets. The values change the selected mask segment and take effect on "Recalculate".

Offset X ← Rescale
Moves the mask segment horizontally. The specified offset is added to the x-values of all points of the selected mask segment.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:XOFFset` on page 1223

Factor X ← Rescale
Stretches or compresses the selected mask segment in horizontal direction. The x-values of all points of the selected mask segment are multiplied with this factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:XFACtor` on page 1222

Offset Y ← Rescale
Moves the mask segment vertically. The specified offset is added to the y-values of all points of the selected mask segment.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:YOFFset` on page 1223

Factor Y ← Rescale
Stretches or compresses the selected mask segment in vertical direction. The y-values of all points of the selected mask segment are multiplied with this factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.

To take effect, tap "Recalculate".

Remote command:
`MTESt:SEGMent:RESCale:YFACtor` on page 1222

Recalculate ← Rescale
Multiplies and adds the given x- and y-factors and offsets to the coordinates of all points of the selected mask segment.

Remote command:
`MTESt:SEGMent:RESCale:RECalculate` on page 1222

9.2.2.2 Mask Definition: Waveform Mask

Access: [Mask] > "Mask Definition" > "Definition type" = "Waveform"

A waveform mask is created from an existing waveform. The waveform builds the upper and lower limit line of the mask, and the limits are moved and stretched. The result is a tolerance tube around the waveform that is used as mask.

During mask testing using a waveform mask, the record length is limited to 1 MSample.

The source for a waveform mask is a reference waveform. The reference waveform can be defined before mask definition, or loaded from a file, or it is created from the waveform to be tested.

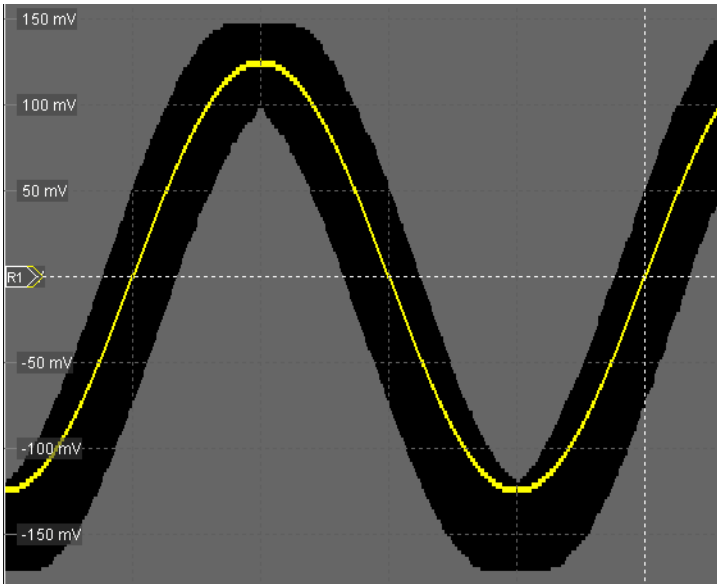
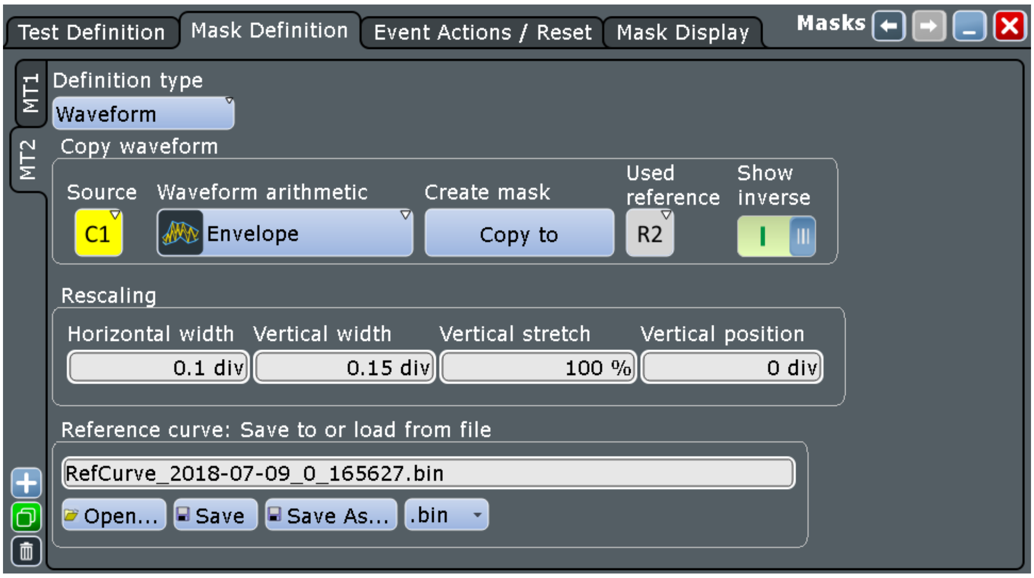


Figure 9-1: Waveform mask

Settings overview:



Common settings:

- "Definition type" on page 374
- "Source" on page 374
- "Wfm Arithmetic" on page 128

Create mask

Creates the upper and lower mask limit from the selected reference waveform. If the reference waveform was not defined before, it is created automatically from the mask test "Source" waveform which is selected in the "Test Defintion" tab.

Remote command:
MTESt:WFMLupdate on page 1224

Used reference
Sets the reference waveform from which the mask is created.

The reference waveform can be created before with "Reference Waveform Setup", or loaded from a file in the lower part of the dialog box. If the reference waveform was not defined before mask definition, it is created automatically from the mask test "Source" waveform.

Remote command:
MTESt:REFWfm on page 1224

Show inverse
If enabled, the area inside the mask is highlighted, which the signal must not exit. If disabled, the area outside the mask limits is highlighted.

Horizontal width
Sets the width of the mask in horizontal direction. The specified number of divisions is added to the positive x-values and subtracted from the negative x-values of the mask limits in relation to the source waveform of the mask. The overall mask width is twice the specified horizontal width.

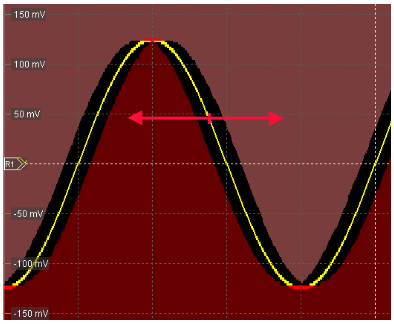


Figure 9-2: Waveform mask with horizontal width = 0.2 div

Remote command:
MTESt:WFMRescale:XWIDth on page 1224

Vertical width
Sets the width of the waveform mask in vertical direction. The specified number of divisions is added to the y-values of the upper mask limit and subtracted from the y-values of the lower mask limit. Thus, the upper half of the mask is pulled upwards, the lower half is pulled down, and the overall height of the mask is twice the vertical width.

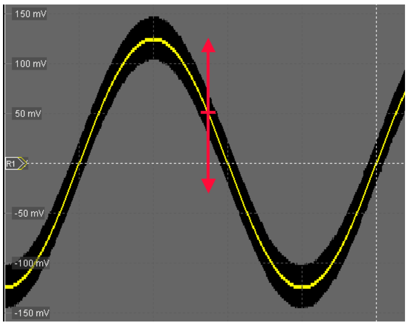


Figure 9-3: Waveform mask with vertical width = 0.5 div

Remote command:
MTESt:WFMRescale:YWIDth on page 1225

Vertical stretch
Sets the vertical scaling to stretch the mask in y-direction. The scaling axis is the horizontal line through the lowest value of the lower mask limit. Values > 100% stretch the mask, and values < 100% compress it.

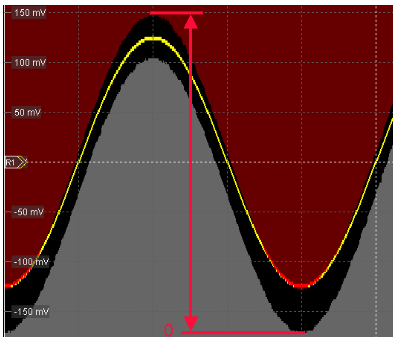


Figure 9-4: Waveform mask with vertical width = 0.5 div, vertical position = -0.5 div, vertical stretch = 110%

Remote command:
MTESt:WFMRescale:YSTRetch on page 1225

Vertical position
Moves the mask vertically within the display.

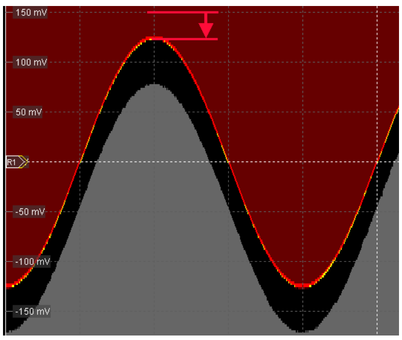


Figure 9-5: Waveform mask with vertical width = 0.5 div and vertical position = -0.5 div

Remote command:
`MTESt:WFMRescale:YPOSition` on page 1225

Reference waveform: save to or load from file
Loads the waveform from the selected file to the "Reference" and creates the mask immediately.

See also: "Save to or load from file" on page 241.

9.2.3 Event Actions /Reset

Access: [Mask] > "Event Actions /Reset "

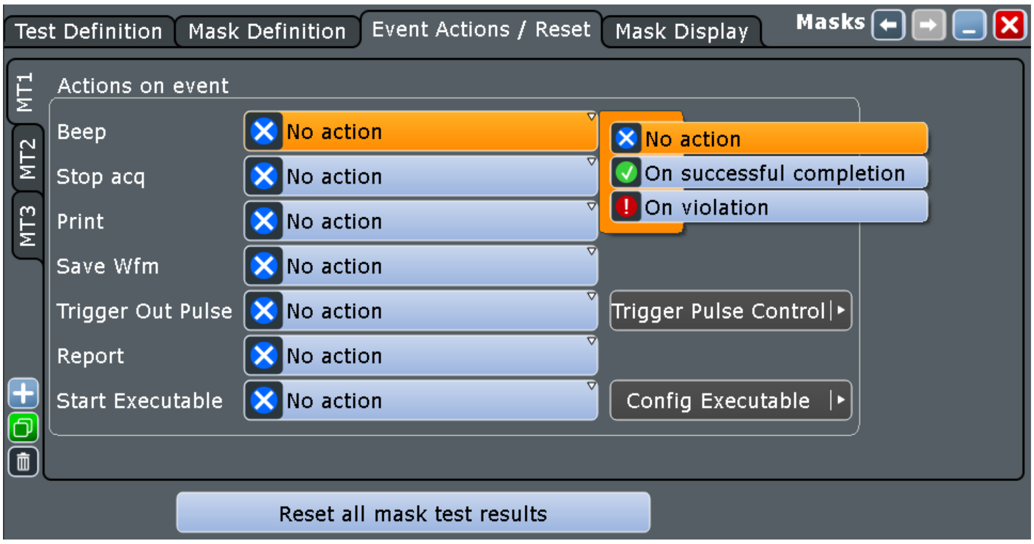
The settings in this tab define what happens when the mask test has failed or when it has passed successfully. Furthermore, you can reset all totals and results in the "Mask Test" result boxes.

Most actions can be initiated either on failure or on success:

- On violation
  The action is initiated when the fail criteria is fulfilled.
- On successful completion
  The action is initiated when the [Single] acquisition has finished and the fail criteria is not fulfilled - the fail condition and violation tolerance limit have not been reached.

There are two usual test practices:

- Testing a defined number of waveforms against the mask and initiate an action when the acquisition cycle has been completed without failure:
  – Set the number of acquisitions to be tested: "Average count (N-single count)"
  – Start [Single]
- Testing a continuous acquisition or a defined number of waveforms against the mask and initiate an action when the fail criteria is fulfilled



Make sure that the correct "Mask Test" tab is selected on the left side before you enter the settings.

Beep
Generates a beep sound.

Remote command:
MTESt:ONViolation:BEEP on page 1226

Stop acq.
Stops the waveform acquisition on mask violation.

Remote command:
MTESt:ONViolation:STOP on page 1226

Print
Prints a screenshot including the mask test results to the printer defined in the "Print" dialog box (see Printer).

Remote command:
MTESt:ONViolation:PRINt on page 1227

Save Wfm
Saves the failed waveform as a reference waveform to the file specified in [Save Recall] > "Save/Recall" > "Waveform".

Remote command:
MTESt:ONViolation:SAVewaveform on page 1227

Trigger Out Pulse
Creates a pulse on the [EXT TRIGGER OUT] connector on mask violation or successful completion of the test cycle. The minimum time difference between two trigger out pulses is 30 ms because the instrument detects mask violation at display update. Events with a higher frequency are not captured completely.

If this event is enabled and the mask test is running, the trigger control option "Enable trigger out" is disabled. Thus, the trigger out pulse is provided only on mask test result but not when a trigger occurs. The pulse is provided always with the minimum delay of 800 ns, the "Delay" cannot be set.

Remote command:
MTESt:ONViolation:TRIGgerout on page 1227

Report
Creates and saves a report using the settings defined in "File" menu > "Report Setup".

Remote command:
MTESt:ONViolation:REPort on page 1227

Start Executable
Starts an external application. Tap "Config Executable" to set the application path and parameters.

See: Chapter 3.5, "External Application", on page 102.

Remote command:
MTESt:ONViolation:RUNexec on page 1228

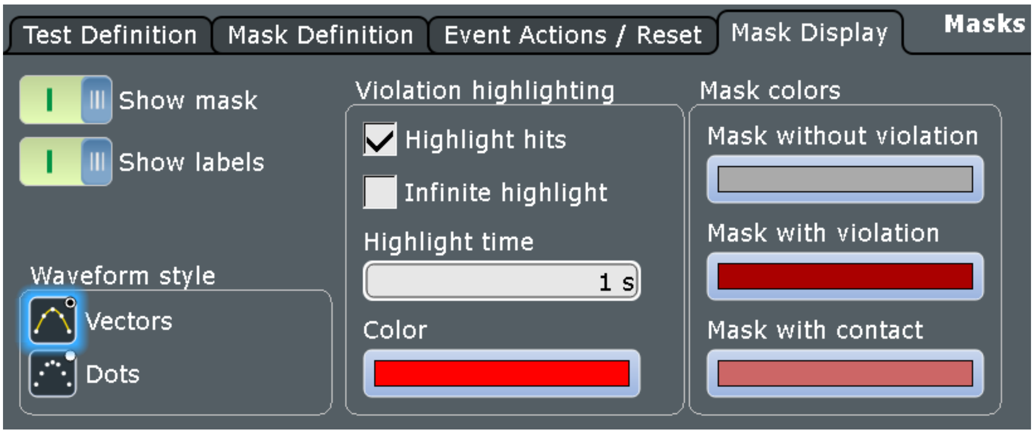
Reset
Clears all totals and results in all "Mask Test" result boxes.

Remote command:
MTESt:RST on page 1216

9.2.4 Mask Display

Access: [Mask] > "Mask Display"

The "Mask Display" tab contains all settings for mask and hit display.



Show mask
Switches the display of all mask segments on or off.

Show labels
Switches the display of the mask test name on or off.

To change the name of the mask test, open the "Test Definition" tab, double-tap the mask test subtab and enter the new mask test name.

Remote command:
MTESt:LABel on page 1228
MTESt:REName on page 1228

Waveform style
See: "Style" on page 91.

Highlight hits
If selected, the mask hits are highlighted on the screen. You can define the color and the time of the hit display.

Infinite highlight
If selected, the mask hits are highlighted for an unlimited period of time.

Highlight time
Sets the time how long the mask hits are highlighted.

Color
Sets the color of samples that violated the mask.

Mask without violation
Sets the color of masks segments that were not hit.

Mask with violation
Sets the color of mask segments the signal has entered into.

Mask with contact
Sets the color of masks segments that were touched at the border. In this case, the resolution is not sufficient to detect if the mask was really hit or not. Zoom into the concerned area to see the actual result.

9.3 Working with Masks

This chapter explains step-by-step how mask tests are setup and preformed. For the explanation of the individual settings, see Chapter 9.2, "Mask Test Settings", on page 373.

The usage of masks tests is also shown in a short video that is available on the instrument: "Tutorials > Getting Started > Mask Test".

9.3.1 Setting Up User Masks

9.3.1.1 Creating User Masks

There are two ways to create a new mask:

- Graphical way by tapping the mask points on the touchscreen,
- Numerical entry of the x- and y-values of the mask points.

You can combine both methods. For example, at first you enter the mask quickly on the touchscreen, and then modify the point coordinates with precise values.

To create a mask graphically on the touch screen

1. Tap the "Masks" icon on the toolbar.

2. Tap the corner points of the mask segment on the touch screen.

   Tip: To create an exact rectangle, draw the diagonal of the rectangle on the screen.

3. Tap "Finish segment" in the sidebar.

   Now you can enter another segment to the current mask test or add a new mask test.

4. To finish the mask definition, close the sidebar.

You can also enter only two points to create a line. When you finish the mask segment by double-tapping the second point, the display region above or below the line is defined as mask. If the line is in the upper half of the display, the region above the line becomes the mask (upper region). If the line is in the lower half, the region below the line is taken (lower region).

To create a mask numerically in the dialog box

The settings mentioned here are described in detail in Chapter 9.2.2.1, "Mask Definition: User Mask", on page 375.

1. Press the [Mask] key on the front panel.
2. Select the "Mask Definition" tab.
3. Create a mask test:
   a) Tap the "+"-icon in the lower left corner.
   b) Enter a name for the new mask test.

   A new, empty tab for the mask test appears.
4. Adjust the horizontal and vertical units if necessary.
5. In the "Mask segments" area, tap "Insert" to create a new mask segment.
6. Set the corner points of the mask segment:
   a) In the "Definition of segment" area, tap "Insert".
      Point 1 appears.
   b) Tap the X-cell and enter the X-value of the point.
   c) Tap the Y-cell and enter the Y-value of the point.
   d) To insert the next point:
      - Tap "Insert" to add a point before the selected point.
      - Tap "Append" to add a point at the end of the list.
   e) Set the X- and Y-values for this point.
   f) Repeat the last two steps until you define all points.

9.3.1.2 Modifying User Masks

To change an existing mask definition, you can also use the graphical method on the touch screen, or the numerical way, or combine both.

With the graphical method, you can:

- Move, add, and delete segments
- Move and delete points

Adding points to an existing segment graphically is not possible.

With the numerical method, in the "Mask Definition" tab, you have all modification possibilities. You can delete and add points and segments, change the coordinates, and also stretch a segment, or move it by adding an offset.

To add a mask segment on the touch screen

1. Tap a mask segment of the mask test that you want to complement.
2. Tap the "Masks" icon on the toolbar.

3. Tap the corner points of the new mask segment on the touch screen.
4. To finish the segment and mask definition, double-tap the last point, or tap the "Select" icon on the toolbar.

To delete a mask segment on the touch screen

1. On the toolbar, tap the "Delete" icon.

2. Tap the mask segment you want to delete.

To delete a point on the touch screen

1. Tap the mask segment from which you want to delete a point.

   The selected segment is now in definition mode, shown with blue color.
2. On the toolbar, tap the "Delete" icon.

3. Tap the point you want to delete.

To move a segment on the touch screen

1. Drag&drop the segment to the new position.
2. Tap outside the mask to deselect the mask segment.

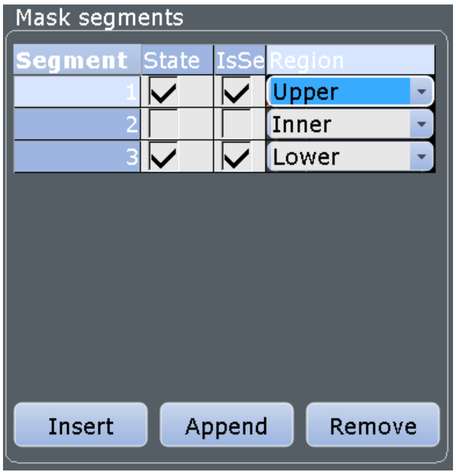
To move a point on the touch screen

1. Tap the mask segment that you want to change.
2. Drag&drop the point to the new position.
3. Tap outside the mask to deselect the mask segment.

To change the mask definition numerically

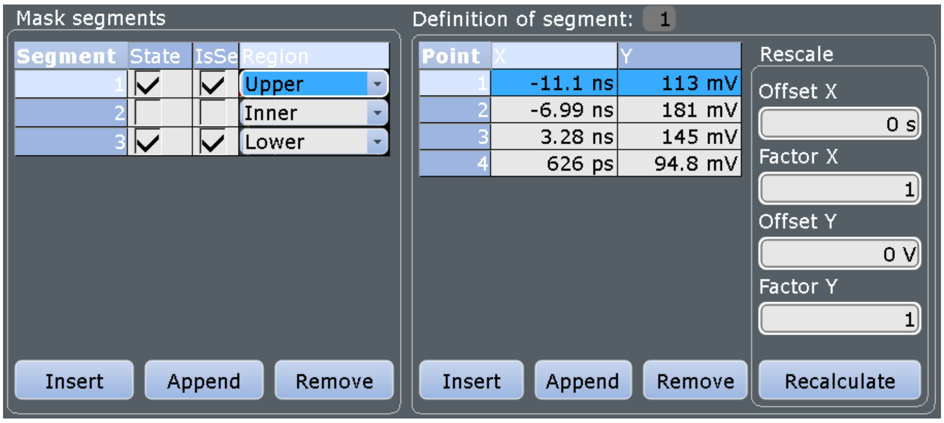
The settings mentioned here are described in detail in Chapter 9.2.2.1, "Mask Definition: User Mask", on page 375.

1. Press the [Mask] key on the front panel.
2. Select the "Mask Definition" tab.
3. On the left, select the mask test for which you want to change the mask definition.
4. To add or delete a mask segment, tap the segment's row in the "Mask segments" table and tap the required button below:
   - "Insert": to add a new segment before the selected segment.
   - "Append": to add a new segment at the end of the list.
   - "Remove": to delete the selected mask segment from the list.



5. To add, delete, or move a point of a segment:
   a) Select the segment in the "Mask segments" table.
   b) Select the point in the "Definition of segment" table.
   c) To add or delete the selected point, use the buttons below the table.
      - "Insert": to add a new point before the selected point.
      - "Append": to add a new point at the end of the list.
      - "Remove": to delete the selected point from the list.

d) To move the selected point, change the X- and Y-values.



To rescale and move a mask segment

The settings mentioned here are described in detail in Chapter 9.2.2.1, "Mask Definition: User Mask", on page 375.

1. Press the [Mask] key on the front panel.
2. Select the "Mask Definition" tab.
3. On the left, select the mask test for which you want to change the mask definition.
4. Select the required segment in the "Mask segments" table.
5. To stretch or compress the selected mask segment, enter the "X-Factor" for horizontal scaling and the "Y-Factor" for vertical scaling. The x-values and y-values of all points are multiplied with the corresponding factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.
6. To move the selected mask segment, enter the "X-Offset" for horizontal direction and the "Y-Offset" for vertical direction. The specified offset is added to the corresponding values of all points.
7. Tap "Recalculate" to perform the scaling and/or move.

9.3.2 Setting Up a Mask Test

In addition to the mask definition, the mask test contains further settings:

- the waveform to be tested
- the criteria for a failed test
- the actions to be taken if a test has failed or has been completed successfully

1. Press the [Mask] key on the front panel.
2. Select the "Test Definition" tab.
3. Select the "Source" to be tested.

4. Set the conditions for a failed test:
   a) Fail condition: select if sample hits or the number of acquisitions with sample hits are considered.
   b) Violation tolerance: number of tolerable sample hits or acquisition hits.

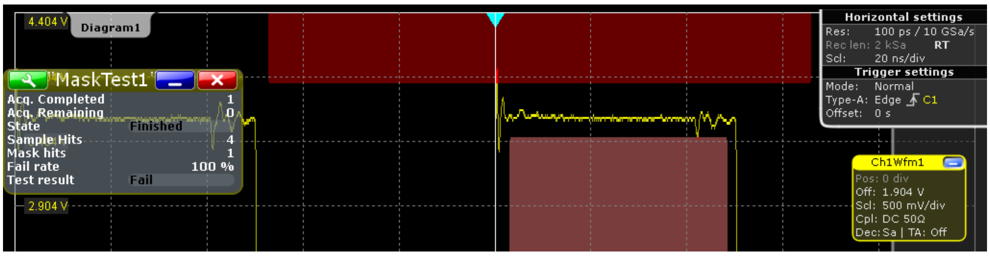
   A test has failed if the number of sample hits or acquisition hits exceeds the limit of violation tolerance hits.
5. Select the "Event Actions / Reset" tab.
6. For each action, select when the action will be executed:
   - "On violation" if the mask test has failed
   - "On successful completion"

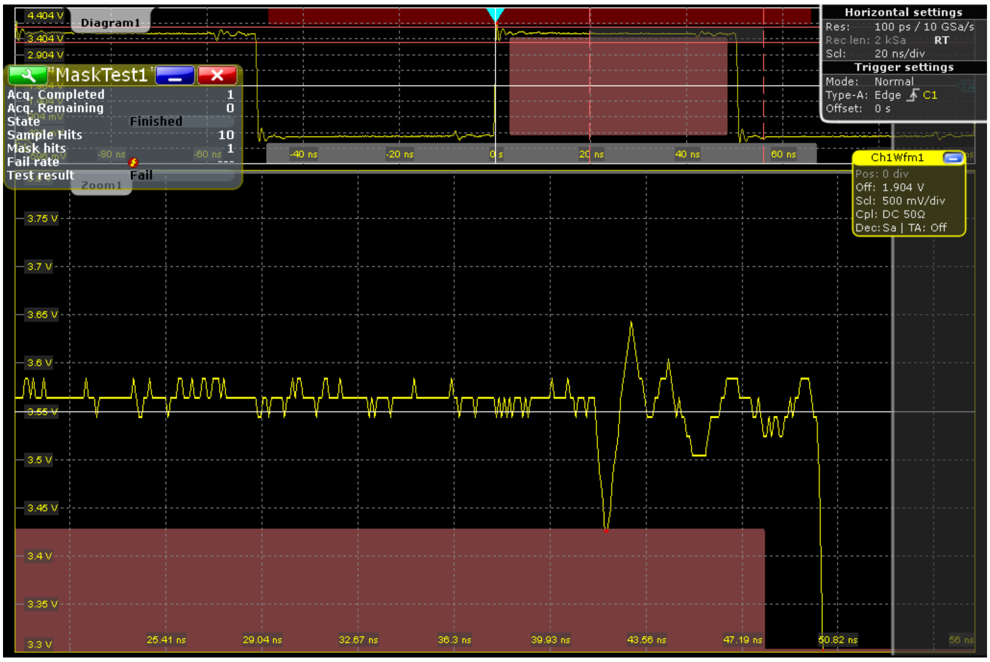
9.3.3 Configuring the Mask and Hit Display

The display of masks and mask violation is the same for all mask tests.

The settings mentioned here are described in detail in Chapter 9.2.4, "Mask Display", on page 384.

1. Press the [Mask] key on the front panel.
2. Select the "Mask Display" tab.
3. Select "Show mask" to display the masks of all enabled mask tests on the screen.
4. Define how the sample hits are displayed:
   a) Select "Highlight hits" to display the sample hits.
   b) Set the "Highlight time" or "Infinite highlight".
      Set the "Color" of the sample hits.
5. Define the color of the masks segments depending on the violation state:
   - Mask without violation
   - Mask with violation
   - Mask with contact: This color shows that the edge of the mask segment was touched. In this case, the resolution is not sufficient to detect if the mask was really hit or not. Zoom into the concerned area to see the correct result.





9.3.4 Running a Mask Test

Before you can start a mask test, make sure that the mask setup is complete:

- The mask is defined, see Chapter 9.3.1.1, "Creating User Masks", on page 385 and Chapter 9.3.1.2, "Modifying User Masks", on page 387.
- The mask test is defined, see Chapter 9.3.2, "Setting Up a Mask Test", on page 389
- The mask display is configured, see Chapter 9.3.3, "Configuring the Mask and Hit Display", on page 390.

You can perform continuous testing or test a specified number of acquisitions.

1. Press the [Mask] key on the front panel.
2. Select the "Test Definition" tab.
3. Select "Enable test".

   If the acquisition is running, the test starts immediately.
4. If the acquisition is not running, press [Run Stop].

   The test starts and runs until you stop the acquisition or the stop action is executed if defined.
5. To test a specified number of acquisitions:
   a) Press the [Acquisition] key.
   b) Set the "Average count" to the number of acquisitions.
   See also:"Acquisition/average count" on page 129
   c) Press [Single].

Note: If you run the acquisition with [Run Stop], the state of the mask test is set to "Finished" when this number of acquisitions has been captured but the mask testing continues until the acquisition is stopped.

9.3.5 Saving and Loading Masks

Mask test definitions remain on the instrument until they are changed or deleted, or [Preset] is performed. If you want to keep a mask test, you can save and reload them.

To save a mask

1. Press the [Mask] key on the front panel.
2. Select the "Test Definition" tab.
3. To save the mask file in the current directory, change the file name if needed, and tap "Save".
   You can use the automatic file name generation, see Chapter 11.5, "Autonaming", on page 456.
4. To select the directory and enter the file name, tap "Save As".

To load a mask

1. To load the specified mask file, tap "Load."
2. To load the mask from a different file, tap "Open". Select the file from the file selection dialog box.

9.3.6 Mask Testing on History Acquisitions

In the same way as for running acquisitions, you can set up and perform the mask testing also on history waveforms.

The requirements for mask testing on history waveforms are also the same:

- The mask is defined, see Chapter 9.3.1.1, "Creating User Masks", on page 385 and Chapter 9.3.1.2, "Modifying User Masks", on page 387.
- The mask test is defined, see Chapter 9.3.2, "Setting Up a Mask Test", on page 389
- The mask display is configured, see Chapter 9.3.3, "Configuring the Mask and Hit Display", on page 390.

1. Perform and finish the acquisition.
2. Press [History].
3. In the quick-access "History" dialog box, tap "Play".

   The mask testing is performed on the complete history memory, starting with the oldest acquisition. The state of the mask test is set to "Finished" when "Nx Single count" acquisitions are tested.

For details on history, see Chapter 6.4, "History", on page 259.

9.4 Mask Testing on Eye Diagrams

To perform mask testing on eye diagrams, the option R&S RTP-K12 adds a special mask definition type to the common mask definitions: the definition type "Eye".

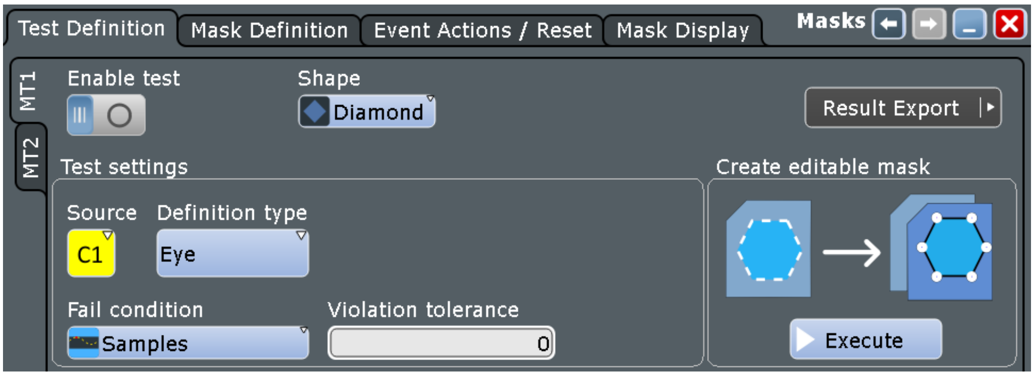
Using the "Eye" mask type, you can easily define eye masks of various shapes. You can also use "User" masks to define free mask shapes.

9.4.1 Test Definition for Eye Mask Tests

Access: "Masks" menu > "Test Definition"

1. Select the "Source": the channel waveform that is analyzed for jitter.
2. Select the "Definition type" = "Eye".
3. Adjust the "Fail condition" and "Violation tolerance".
4. Define the eye mask. See Chapter 9.4.2, "Eye Mask Definition", on page 393.

The general mask test settings are described in Chapter 9.2.1, "Test Definition", on page 373.



If the definition type "Eye" is selected, a mask copy function is available:

Create editable mask
Converts the test and mask definitions of the current mask test to a new mask test of type "User".

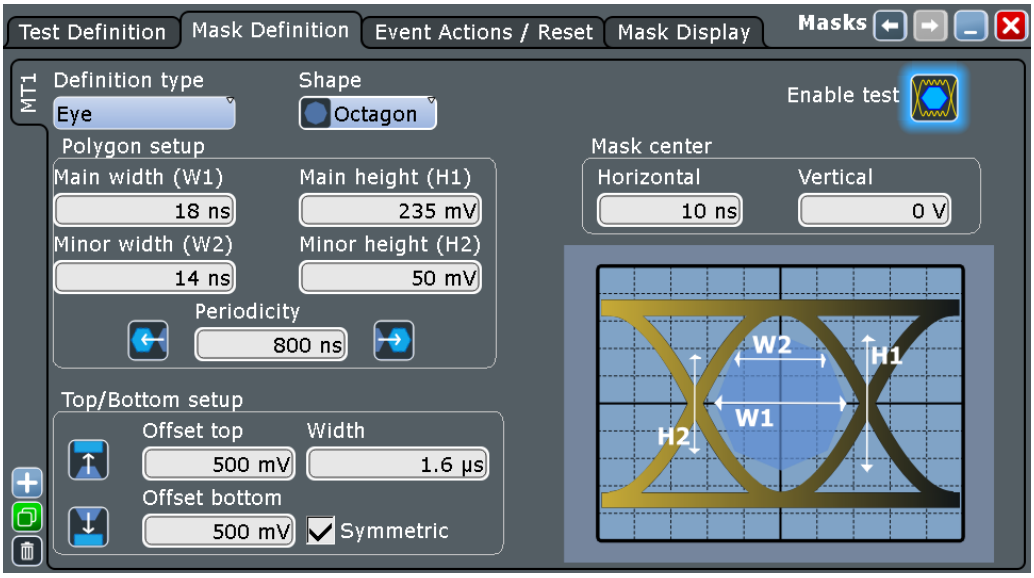
This is useful, for example, if want to run variants of a mask test in parallel.

9.4.2 Eye Mask Definition

Access: "Masks" menu > "Mask Definition"

The mask definition tab for "Definition type" = "Eye" provides all settings to define masks of different shapes.

The "Eye" mask definition type is available if option R&S RTP-K12 is activated on the instrument.



Shape

Defines the outline of the eye mask: square, diamond, hexagon or octagon.

Remote command:

`MTESt:EYEMask:TYPE` on page 1231

Main width (W1), Minor width (W2)

Main width defines the width of all eye mask shapes. Minor width defines the secondary width for hexagon and octagon mask shapes.

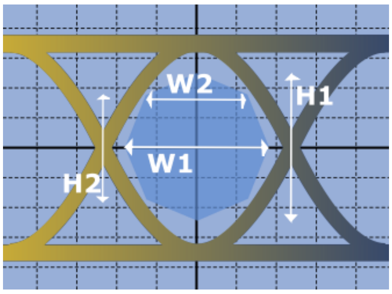


Figure 9-6: Main and minor widths and heights of an octagon eye mask

Remote command:

`MTESt:EYEMask:WIDTh<m>[:VALue]` on page 1232

Main height (H1), Minor height (H2)

Main height defines the height of all eye mask shapes. Minor height defines the secondary height for octagon mask shapes.

Remote command:
MTESt:EYEMask:HEIGht<m>[:VALue] on page 1231

Periodicity
The icons copy the eye shape to the left and to the right. The value defines the time distance between the shape centers.

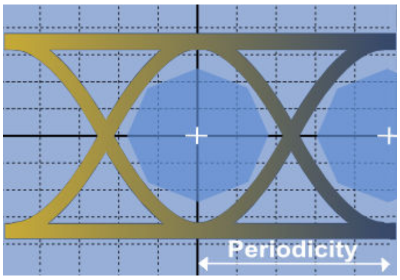


Figure 9-7: Eye mask with right periodicity

Remote command:
MTESt:EYEMask:MSKLeft on page 1232
MTESt:EYEMask:MSKRight on page 1232
MTESt:EYEMask:HPERiod on page 1232

Top/Bottom setup
The icons enable the upper and/or lower regions of the mask. Use the following settings to configure these regions:

"Offset top, Offset bottom"	Voltage distance from the eye shape center that limits the upper and lower regions.
"Symmetric"	Sets bottom and top offsets to the same value so that the outer regions are symmetric to the eye shape.
"Width"	Time width of the outer regions, symmetric to the eye shape center.

Remote command:
MTESt:EYEMask:MSKBottom on page 1233
MTESt:EYEMask:MSKTop on page 1233
MTESt:EYEMask:BOFFset on page 1233
MTESt:EYEMask:TOFFset on page 1233
MTESt:EYEMask:TBSYmmetric on page 1233
MTESt:EYEMask:TBWidth on page 1233

Mask center: Horizontal, Vertical
Set the horizontal (time) and vertical (voltage) values of the eye shape enter and thus define the position of the eye shape on the display.

Remote command:
MTESt:EYEMask:HPOSition on page 1234
MTESt:EYEMask:VPOSition on page 1234

Enable test
Starts the mask testing.

10 Search Functions

Search functions allow you to detect and analyze specific events in the acquired data quickly and simply. You can search in various waveforms for several events at once. The search area can be limited by a gate.

The events that can be searched for are basically the same events you can trigger on. Thus, the search parameters are defined in the same way as the trigger conditions. The results are displayed in a result box and optionally shown in a zoom window.

10.1 Overview: Search Definition and Results

10.1.1 Search Definition

You can define up to 8 different searches and let them run simultaneously. For each search, you define the criteria, the parameters of each criterion, the gate, and the result display.

The instrument keeps the settings until the next preset. If you save a user-defined preset, the search settings are included in the preset.

Each search is configured in a separate tab and contains:

- *Search control*
  If you enable a search and run an acquisition, the search is performed continuously on the acquired data until acquisition is stopped.
  If acquisition is stopped and you enable a search, the data of the last acquisition is searched.
  Enabling the search zoom window disables the search, stops a running acquisition, and displays the search results of the last acquisition in the zoom window.
- *Source*
  Waveform that is searched for one or more events. You can search in analog and digital signals, math or reference waveforms, and tracks. Furthermore, search in decoded data of serial buses is possible.
- *Search criteria and parameters*
  Various search criteria are available, depending on the source. Most parameters known from trigger event definition can also be configured as search conditions. Unlike triggering, you can configure several event types to be searched for simultaneously.
  If the source is an FFT spectrum, you can perform a frequency marker search by using the cursor measurement and defining the peak excursion. See Chapter 7.1.3.3, "Peak Search ", on page 279.
- *Search gate*
  Searches can be performed on the entire waveform, or only on a defined area (gate). The gate can be coupled to an existing zoom.
  Gating is not available for searches on digital signals and serial buses.

- *Result presentation*
  For each search, you define how the search results are displayed: in a result table and/or in a search zoom window.
- *Noise rejection*
  Hysteresis for the selected source is defined for each search separately, in absolute or relative values.
  Noise rejection is not available for searches on serial buses.

Remote commands:

- `SEARch:ADD` on page 1235
- `SEARch:REMove` on page 1235

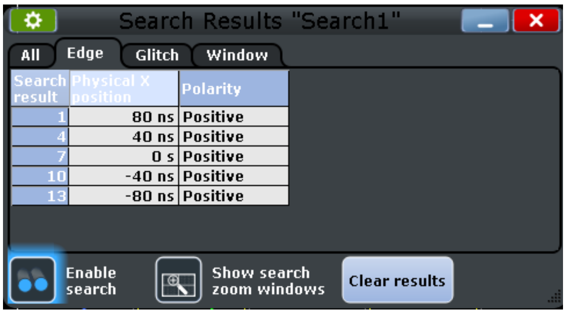
10.1.2 Search Results

The results are displayed in a "Search Results" box and optionally in a zoom window.

Search Results box

The results of each search are tabulated in a "Search Results" box.

If you search for several event types in parallel, the results are presented in several tabs - one for each search event and one for the combined results. Each tab contains a table with the position and, if available, further parameters for each result. The tables row can be sorted, and you can define a maximum number of table entries in the "Result Presentation" dialog box. As with all result boxes, you can minimize it, display it like a diagram, and define the default position.



If "Auto clear" is enabled in the "Result Presentation" dialog box, the instrument displays the search results of the last acquisition. If "Auto clear" is disabled, the first result of each acquisition is listed until the maximum number of entries in the table is reached.

Remote commands for result query:

- `SEARch:RESult[:ALL]?` on page 1270

Search zoom windows

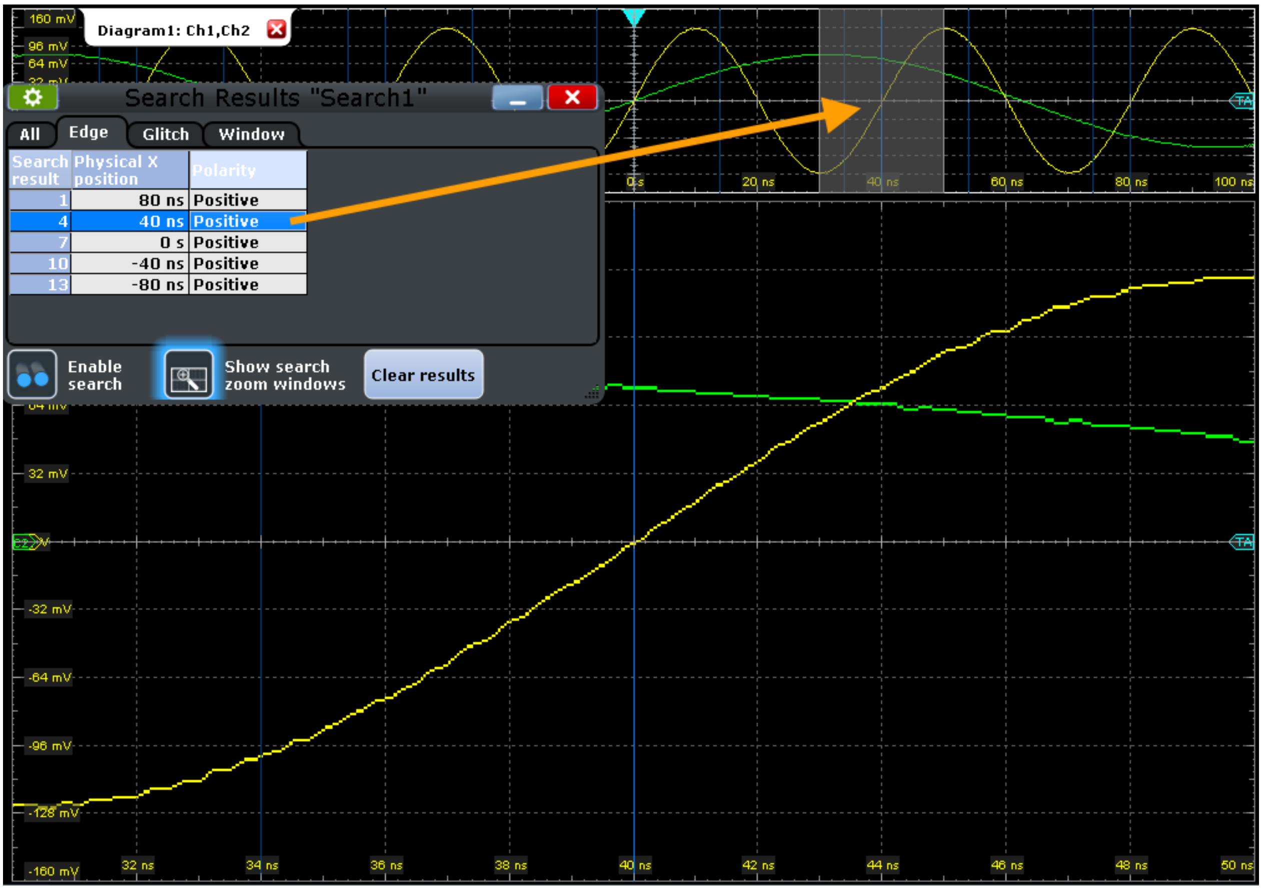
Search zoom windows allow you to analyze the search results in more detail. By default, the zoom is displayed for the selected search result. The zoom area is indicated in the diagram that displays the source waveform of the search.

Enabling the search zoom window disables the search, stops a running acquisition, and displays the search results of the last acquisition in the zoom window.

Navigating search results

If a search zoom window has been opened, it shows the first result that was found.

► To display the zoom of a specific search result, tap the result line in the result table to set the zoom to this event.



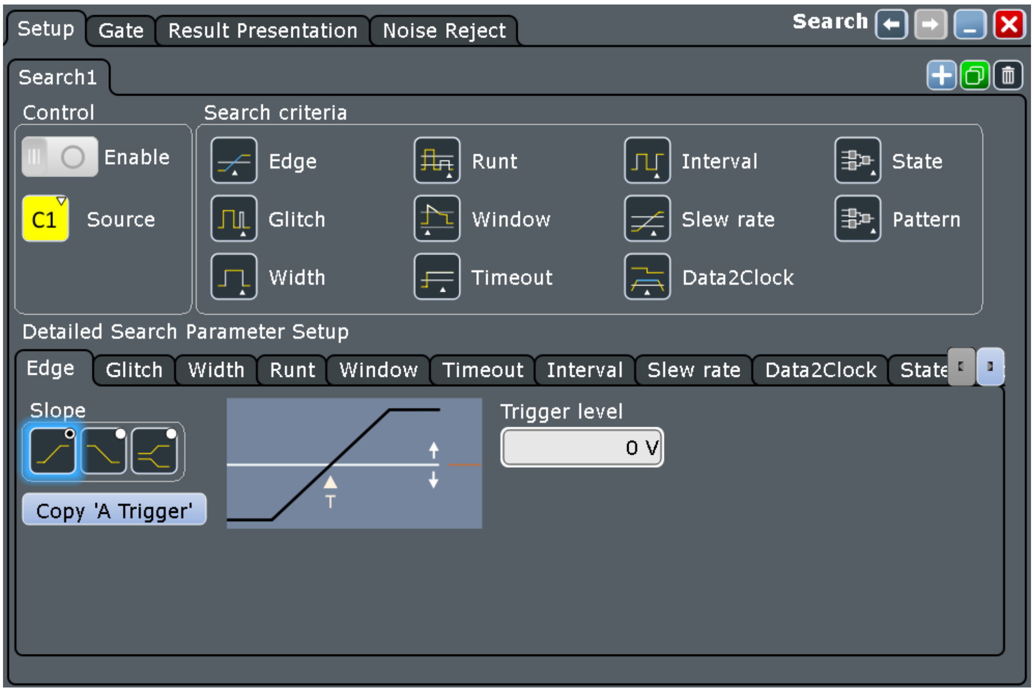
The zoom area in the source diagram moves to the selected result and the zoom is displayed.

You can change the size and the position of the search zoom area in the same way as a usual zoom. If you move the zoom area in the source diagram, the nearest search result is marked in the results table. See also: Chapter 6.1.1, "Methods of Zooming", on page 226.

10.2 Search Setup

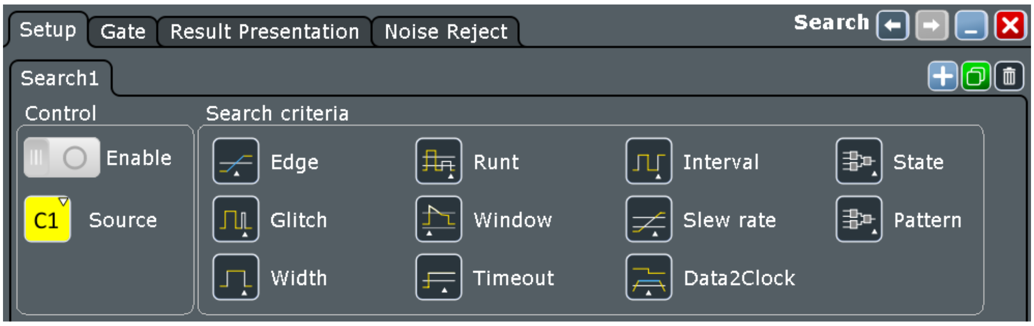
Access: [Search] > "Setup" tab

The search setup includes the source selection, the selection of search events (criteria), event-specific search conditions, and search control.



10.2.1 Search Criteria

Access: [Search] > "Setup" tab



Enable

If you enable a search and run an acquisition, the search is performed continuously on the acquired data until acquisition is stopped.

If acquisition is stopped and you enable a search, the data of the last acquisition is searched.

Remote command:

`SEARch:ONLine` on page 1236

`SEARch:ALL` on page 1236

Source
Defines the waveform to be searched. The source can be any analog and digital input signal, math or reference waveform, or track. While the instrument triggers only on real input signals, it can search also calculated and restored waveforms.

If the source is an FFT spectrum, you can perform a frequency marker search by using the cursor measurement and defining the peak excursion. See Chapter 7.1.3.3, "Peak Search ", on page 279.

For some serial protocol options, search on a serial bus is available. For details, see the relevant chapters of the "Protocol Analysis" chapter.

Depending on the selected source, different search criteria are available.

Remote command:
`SEARch:SOURce` on page 1236

Edge, Glitch, Width, Runt, Window, Timeout, Interval, Slew rate, Data2Clock, State, Pattern
Search criteria for analog and digital input signals, math and reference waveforms, and tracks. For searching on digital channels, only "Edge", "Width", "Timeout" and "Data2Clock" criteria are available.

Tap the icon to include or exclude the search criteria in the next search. You can enable several event types for simultaneous search.

Remote command:
`SEARch:TRIGger:EDGE[:STATe]` on page 1237
`SEARch:TRIGger:GLITch[:STATe]` on page 1237
`SEARch:TRIGger:WIDTh[:STATe]` on page 1238
`SEARch:TRIGger:RUNT[:STATe]` on page 1237
`SEARch:TRIGger:WINDow[:STATe]` on page 1238
`SEARch:TRIGger:TIMeout[:STATe]` on page 1237
`SEARch:TRIGger:INTerval[:STATe]` on page 1237
`SEARch:TRIGger:SLEWrate[:STATe]` on page 1237
`SEARch:TRIGger:DATatoclock[:STATe]` on page 1237
`SEARch:TRIGger:STATe[:STATe]` on page 1237
`SEARch:TRIGger:PATTern[:STATe]` on page 1237

Copy 'A Trigger'
Copies the trigger type-specific settings from the A-trigger configuration to the search settings. The source itself is not copied.

Remote command:
`SEARch:TRIGger:EDGE:ACOPy` on page 1238
`SEARch:TRIGger:GLITch:ACOPy` on page 1238
`SEARch:TRIGger:WINDow:ACOPy` on page 1238
`SEARch:TRIGger:WIDTh:ACOPy` on page 1238
`SEARch:TRIGger:RUNT:ACOPy` on page 1238
`SEARch:TRIGger:WINDow:ACOPy` on page 1238
`SEARch:TRIGger:TIMeout:ACOPy` on page 1238
`SEARch:TRIGger:INTerval:ACOPy` on page 1238
`SEARch:TRIGger:SLEWrate:ACOPy` on page 1238

SEARch:TRIGger:DATatoclock:ACOPy on page 1238
SEARch:TRIGger:STATe:ACOPy on page 1238
SEARch:TRIGger:PATTern:ACOPy on page 1238

10.2.2 Search Parameters

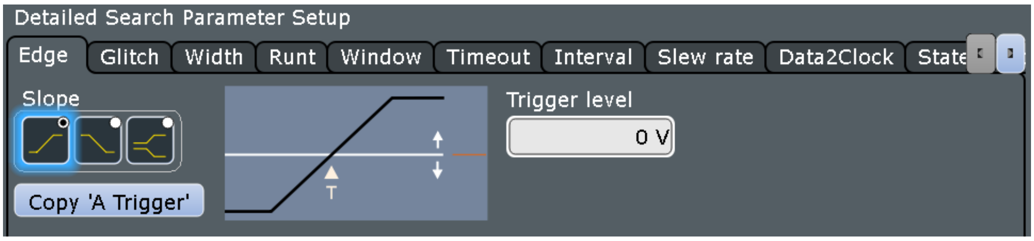
Most parameters available for trigger event definition can also be configured as search conditions. Each event type is defined in a separate subtab.

If the source is a spectrum, the instrument performs a frequency marker search.

For serial protocol options, search on a serial bus is available. These searches have protocol-specific search criteria. For details, see the relevant chapters of the "Protocol Analysis" chapter.

10.2.2.1 Edge

The edge search works the same way as the edge trigger.



Slope
Sets the edge type: rising edge ("Positive"), falling edge ("Negative"), or both.

Remote command:
SEARch:TRIGger:EDGE:SLOPe on page 1239

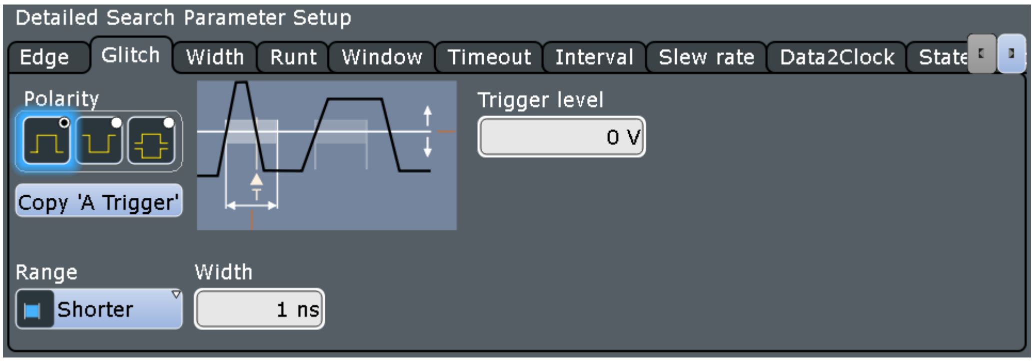
Trigger level
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1238

10.2.2.2 Glitch

The glitch search works the same way as the glitch trigger. To apply the trigger settings to search, tap Copy 'A Trigger'.

The glitch search is not available if the search source is a digital channel.



Polarity, Range, Width
See trigger settings:
- "Range" on page 188
- "Width" on page 188
- "Polarity" on page 188

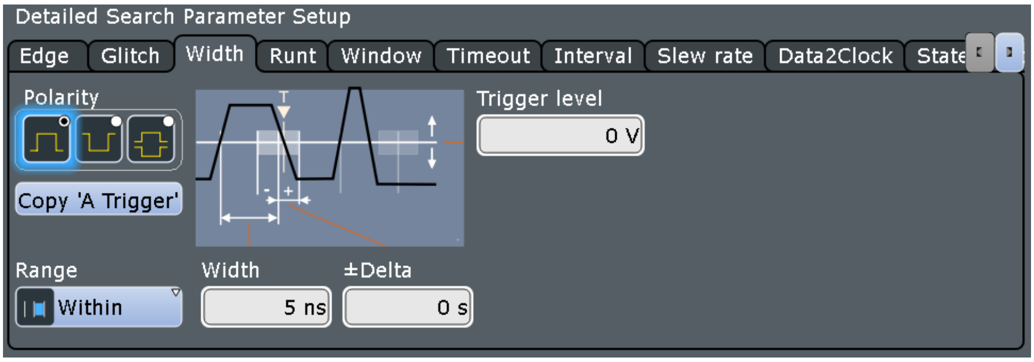
Remote command:
`SEARch:TRIGger:GLITch:POLarity` on page 1239
`SEARch:TRIGger:GLITch:RANGe` on page 1240
`SEARch:TRIGger:GLITch:WIDTh` on page 1240

Trigger level
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1238

10.2.2.3 Width

The width search works the same way as the width trigger. To apply the trigger settings to search, tap Copy 'A Trigger'.



Polarity, Range, Width, ±Delta

See trigger settings:

- "Polarity" on page 189
  While the width trigger can only analyze positive *or* negative polarity, searching for a width is also possible for both polarities at the same time ("Either").
- "Range" on page 189
- "Width" on page 190
- "±Delta" on page 190

Remote command:
`SEARch:TRIGger:WIDTh:POLarity` on page 1248
`SEARch:TRIGger:WIDTh:RANGe` on page 1248
`SEARch:TRIGger:WIDTh:WIDTh` on page 1248
`SEARch:TRIGger:WIDTh:DELTa` on page 1247

Trigger level

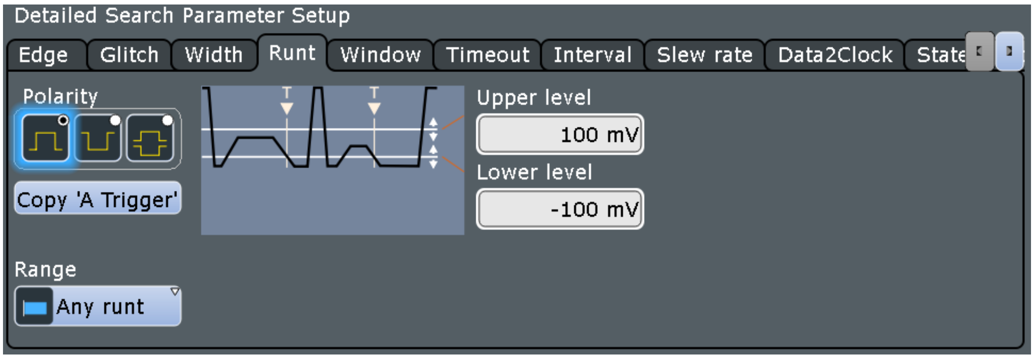
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1238

10.2.2.4 Runt

The runt search settings are the same as the runt trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.

The runt search is not available, if the search source is a digital channel.



Polarity, Range, Runt width, ±Delta
Time limit for the runt, see trigger settings:
- "Polarity" on page 188
- "Range" on page 191
- "Runt width" on page 191
- "±Delta" on page 191

Remote command:
`SEARch:TRIGger:RUNT:POLarity` on page 1242
`SEARch:TRIGger:RUNT:RANGe` on page 1243
`SEARch:TRIGger:RUNT:WIDTh` on page 1243
`SEARch:TRIGger:RUNT:DELTa` on page 1242

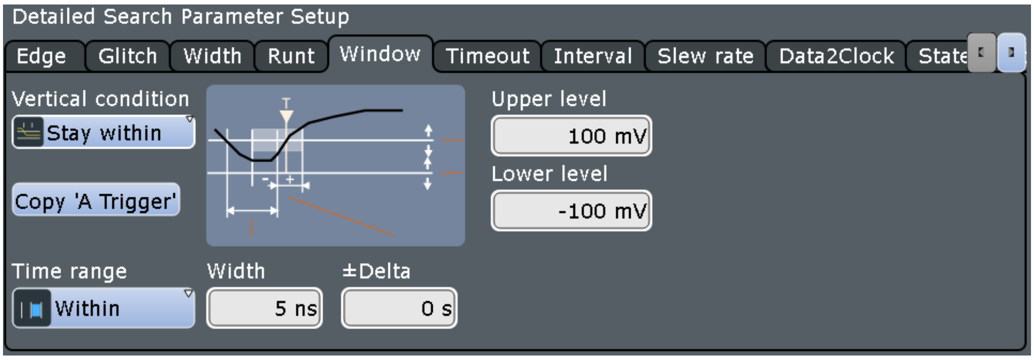
Upper level, Lower level
Set the upper and lower voltage thresholds. The amplitude of a runt crosses the first threshold twice in succession without crossing the second one.

Remote command:
`SEARch:TRIGger:LEVel:RUNT:UPPer` on page 1244
`SEARch:TRIGger:LEVel:RUNT:LOWer` on page 1244

10.2.2.5 Window

The window search settings are the same as the window trigger settings. This search type is not available if the search source is a digital channel. To apply the trigger settings to search, tap Copy 'A Trigger'.

The window search is not available if the search source is a digital channel.



Vertical condition
Defines the run of the signal relative to the window, see "Vertical condition" on page 192.

Remote command:
SEARch:TRIGger:WINDow:RANGe on page 1249

Time condition, Width, ±Delta
Set the time limit for the vertical condition, see:
- "Time condition" on page 193
- "Width" on page 193
- "±Delta" on page 193

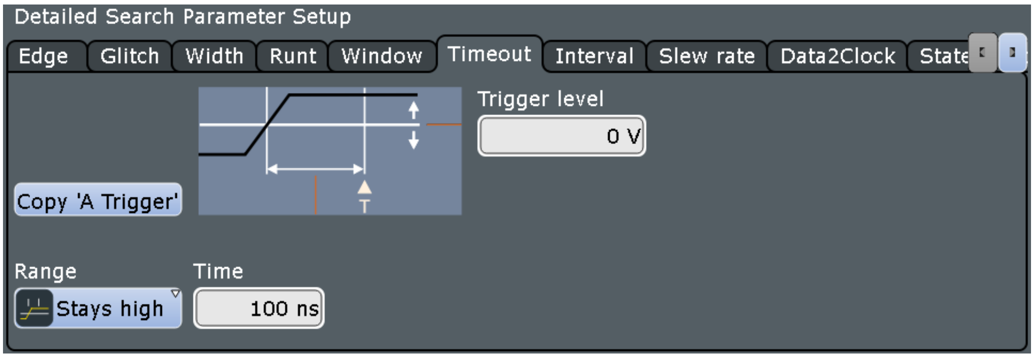
Remote command:
SEARch:TRIGger:WINDow:TIMerange on page 1250
SEARch:TRIGger:WINDow:WIDTh on page 1250
SEARch:TRIGger:WINDow:DELTa on page 1249

Upper level, Lower level
Set the upper and lower voltage thresholds. The amplitude of a runt crosses the first threshold twice in succession without crossing the second one.

Remote command:
SEARch:TRIGger:LEVel:WINDow:UPPer on page 1251
SEARch:TRIGger:LEVel:WINDow:LOWer on page 1251

10.2.2.6 Timeout

The timeout search settings are the same as the timeout trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.



Range, Time
Set the timeout condition, see:
- "Range" on page 194
- "Time" on page 194

Remote command:
SEARch:TRIGger:TIMeout:RANGe on page 1246
SEARch:TRIGger:TIMeout:TIME on page 1247

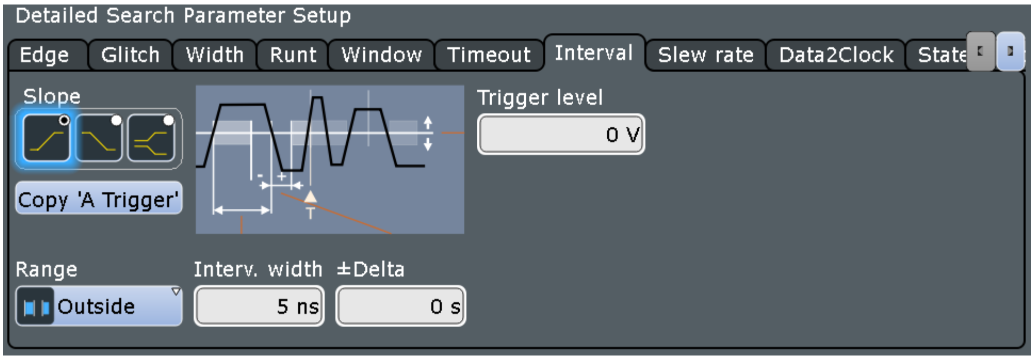
Trigger level
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
SEARch:TRIGger:LEVel[:VALue] on page 1238

10.2.2.7 Interval

The interval search settings are the same as the interval trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.

The interval search is not available if the search source is a digital channel.



Slope, Range, Interv. width, ±Delta
Set the interval condition, see:
- "Slope" on page 194
  While the interval trigger can only analyze rising or falling edges, searching for a width is possible for both edges at the same time ("Either").
- "Range" on page 195
- "Interv. width" on page 195
- "±Delta" on page 195

Remote command:
SEARch:TRIGger:INTerval:SLOPe on page 1241
SEARch:TRIGger:INTerval:RANGe on page 1241
SEARch:TRIGger:INTerval:WIDTh on page 1242
SEARch:TRIGger:INTerval:DELTa on page 1241

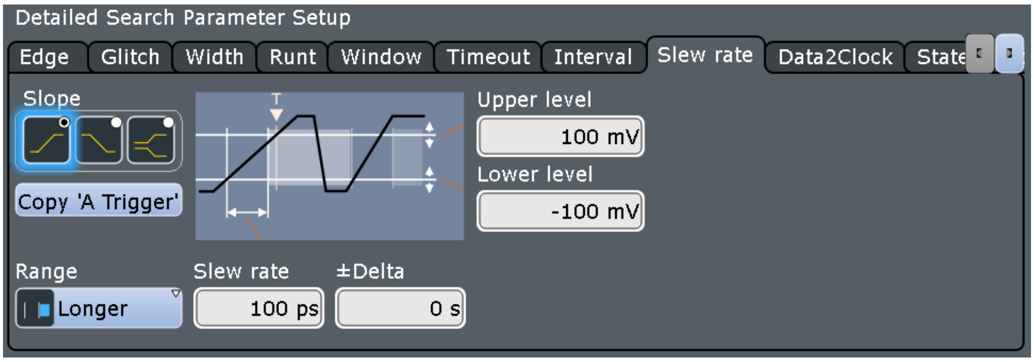
Trigger level
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
SEARch:TRIGger:LEVel[:VALue] on page 1238

10.2.2.8 Slew Rate

The slew rate search settings are the same as the slew rate trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.

The slew rate search is not available if the search source is a digital channel.



Polarity, Range, Slew rate, ±Delta

- "Slope" on page 187
- "Range" on page 196
- "Slew rate" on page 197
- "±Delta" on page 197

Remote command:
`SEARch:TRIGger:SLEWrate:SLOPe` on page 1245
`SEARch:TRIGger:SLEWrate:RANGe` on page 1245
`SEARch:TRIGger:SLEWrate:TIME` on page 1245
`SEARch:TRIGger:SLEWrate:DELTa` on page 1244

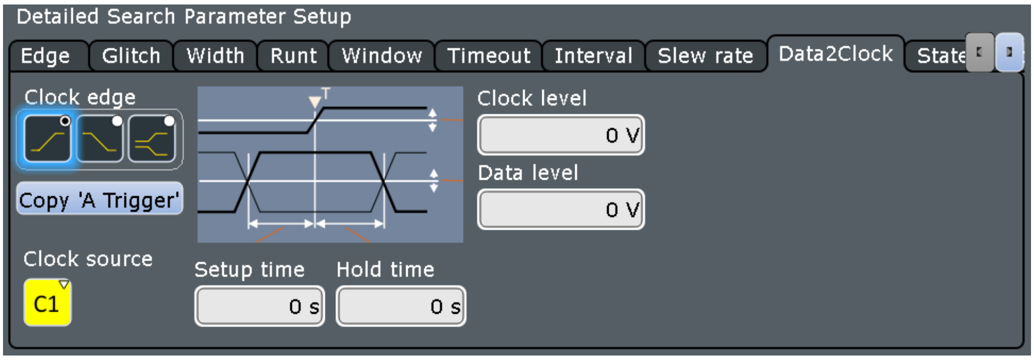
Upper level, Lower level

Set the upper and lower voltage thresholds. When the signal crosses a level, the slew rate measurement starts or stops depending on the selected slope.

Remote command:
`SEARch:TRIGger:LEVel:TRANsition:UPPer` on page 1246
`SEARch:TRIGger:LEVel:TRANsition:LOWer` on page 1246

10.2.2.9 Data2Clock

The Data2Clock search settings are the same as the Data2Clock trigger settings. To apply the trigger settings to search, tap Copy 'A Trigger'.



Clock source, Clock edge, Clock level
Set the clock settings. Both "Clock level" and "Clock edge" define the starting point for calculation of the setup and hold time.

Remote command:
`SEARch:TRIGger:DATatoclock:CSOurce` on page 1252
`SEARch:TRIGger:DATatoclock:CEDGe` on page 1251
`SEARch:TRIGger:DATatoclock:CLEVel` on page 1252

Data level
Sets the voltage level for the data signal. At this level, the setup and hold time are measured.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1238

Trigger level
Sets the voltage level for trigger search. The value is used for all search event types that require one trigger level. The search trigger level is search-specific, you can define different levels in different searches for the same event.

Remote command:
`SEARch:TRIGger:LEVel[:VALue]` on page 1238

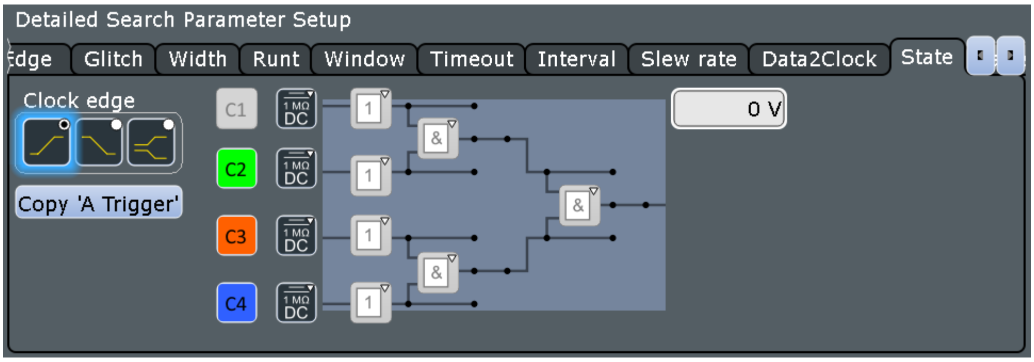
Setup time, Hold time
Sets the minimum time **before** (Setup) and **after** (Hold) the clock edge while the data signal must stay steady above or below the data level.

See also: "Setup time" on page 198 and "Hold time" on page 198.

Remote command:
`SEARch:TRIGger:DATatoclock:STIMe` on page 1253
`SEARch:TRIGger:DATatoclock:HTIMe` on page 1252

10.2.2.10 State

The state search is a qualified edge search. The state search is only available for analog channel sources (Ch1 to Ch4).



Clock source, Clock edge
Define the clock settings. The clock signal is the waveform to be searched.

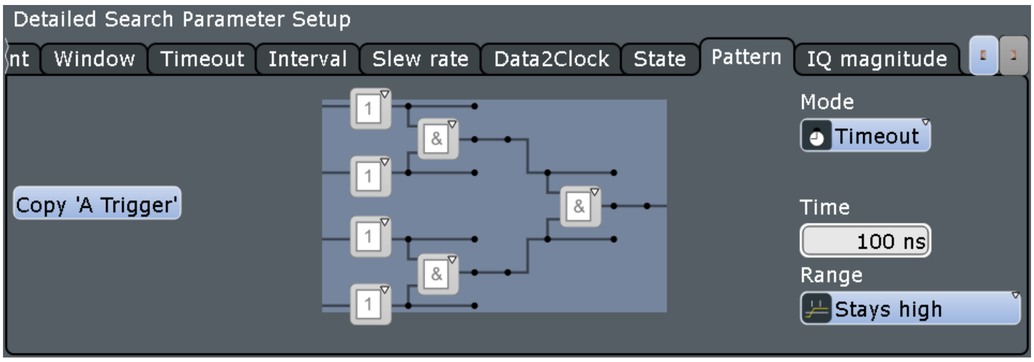
Remote command:
SEARch:TRIGger:STATe:CSOurce on page 1258
SEARch:TRIGger:STATe:CEDGe on page 1258
SEARch:TRIGger:STATe:CLEVel on page 1258

State pattern
State settings are the same as for the state trigger. See also "Pattern" on page 199.

Remote command:
SEARch:TRIGger:STATe:A[:ENABle] on page 1259
SEARch:TRIGger:STATe:A:LOGic on page 1259
SEARch:TRIGger:STATe:AB:LOGic on page 1260
SEARch:TRIGger:STATe:ABCD:LOGic on page 1260

10.2.2.11 Pattern

The pattern search combines a logical combination of the input channels with a timing condition. The pattern search is only available for analog channel sources (Ch1 to Ch4).



Pattern
Pattern search settings are the same as for the pattern trigger. See also "Pattern" on page 199.

Remote command:
SEARch:TRIGger:PATTern:A[:ENABle] on page 1254
SEARch:TRIGger:PATTern:A:LOGic on page 1254
SEARch:TRIGger:PATTern:AB:LOGic on page 1255
SEARch:TRIGger:PATTern:ABCD:LOGic on page 1255

Timing condition: Mode, Range, Time, Width, ±Delta
Additional time limitation to the pattern, see "Additional settings: Timing" on page 201.

Remote command:
SEARch:TRIGger:PATTern:MODE on page 1255
SEARch:TRIGger:PATTern:TIMeout:MODE on page 1256
SEARch:TRIGger:PATTern:TIMeout[:TIME] on page 1256
SEARch:TRIGger:PATTern:WIDTh:RANGe on page 1256
SEARch:TRIGger:PATTern:WIDTh[:WIDTh] on page 1257
SEARch:TRIGger:PATTern:WIDTh:DELTa on page 1257

10.2.3 Frequency Marker Search

When you start a search on a spectrum, a frequency marker search is performed to detect peaks in a spectrum. You can define which peaks the instrument finds by defining the noise reject settings.

Threshold
See "Threshold" on page 279.

Peak excursion
See "Peak excursion" on page 279.

10.2.4 Configuring the Search Setup

There are two ways to create a search:

- Creating a simple default search using the toolbar icon. This method is not available for search on serial buses.
- Setting up a search using the dialog box.

To perform a simple search

1. If more than one waveform is in the diagram, select the waveform to be searched for by tapping it in the diagram.
2. Select the "Search" icon on the toolbar.

3. Tap the diagram with the waveform to be searched, or drag a rectangle on the diagram to define the search area.

   The default edge search is configured as "Search<x>" and performed. The "Search Results" box is displayed.

To create a user-defined search

1. Press the [Search] key.
2. There are two ways to create a search:
   - If you want to create a new, unconfigured search, tap the "Add" icon.

   - If you want to create a new search based on an existing one, tap the "Copy" icon.

     
3. Enter a name for the search using the on-screen keyboard.

To configure a user-defined search

1. Select the "Setup" tab and the search you want to configure.
2. Select the "Source" on which you want to perform the search.
3. Select the events you want to include in the search.
4. Define the settings of the first search event.
   To use the same conditions as defined in the trigger configuration of the A-event, tap "Copy 'A-Trigger". The selected trigger settings are applied to the search settings.
5. Repeat the previous steps to define further events for the same search.
6. To perform the search only on a part of the waveform, configure the gate in the "Gate" tab as described in Chapter 10.3.2, "Defining the Search Gate", on page 414.
7. To filter out noise from the search results, configure noise rejection as described in Chapter 10.5.2, "Defining Noise Rejection for Searches", on page 419.

   Note: A-event copy, gating and noise reject are not available for search on serial buses.

10.3 Search Gate

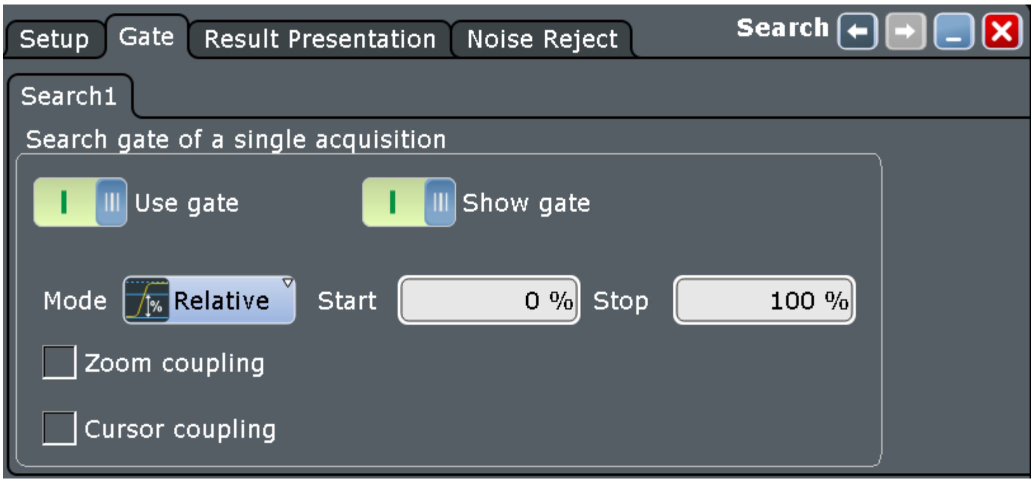
The gate defines the search area within the source waveform. You can use absolute or relative values to define the gate, or couple it to a previously defined zoom area.

10.3.1 Gate Settings

Access: [Search] > "Gate" tab

The search gate settings are identical to those for gate areas for measurements or FFT analysis.

Gating is not available if the search source is a digital channel or a serial bus.



Use Gate
Enables the gate settings and shows the gate. Search is only performed on the defined gate area of the source waveform.

Remote command:
`SEARch:GATE[:STATe]` on page 1261

Show gate
Displays the gate area in the source diagram.

Remote command:
`SEARch:GATE:SHOW` on page 1262

Mode
Defines whether the gate settings are configured using absolute or relative values.

"Absolute"	The gate is defined by absolute start and stop values.
"Relative"	The gate's start and stop values are defined by a percentage of the value range.

Remote command:
CALCulate:MATH<m>:FFT:GATE:MODE on page 1207
MEASurement<m>:GATE:MODE on page 1182
SEARch:GATE:MODE on page 1261

(Relative) Start
Defines the starting value for the gate.

Remote command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt on page 1206
CALCulate:MATH<m>:FFT:GATE:RELative:STARt on page 1207
MEASurement<m>:GATE:ABSolute:STARt on page 1182
MEASurement<m>:GATE:RELative:STARt on page 1182
SEARch:GATE:ABSolute:STARt on page 1262
SEARch:GATE:RELative:STARt on page 1262

(Relative) Stop
Defines the end value for the gate.

Remote command:
CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP on page 1207
CALCulate:MATH<m>:FFT:GATE:RELative:STOP on page 1207
MEASurement<m>:GATE:ABSolute:STOP on page 1182
MEASurement<m>:GATE:RELative:STOP on page 1182
SEARch:GATE:ABSolute:STOP on page 1262
SEARch:GATE:RELative:STOP on page 1263

Zoom coupling
Zoom coupling is available if a zoom is defined. As long as "Zoom coupling" is enabled, the gate area is defined identically to the zoom area - if you change the zoom, the gate changes as well.

If several zoom diagrams are defined, select the zoom diagram to be used for gating. The "Start" and "Stop" values of the gate are adjusted accordingly.

Zoom coupling can be set for measurement gates, FFT gates, and search gates.

Remote command:
MEASurement<m>:GATE:ZCOupling on page 1183
MEASurement<m>:GATE:ZDIagram on page 1184
CALCulate:MATH<m>:FFT:GATE:ZCOupling on page 1208
SEARch:GATE:ZCOupling on page 1263
SEARch:GATE:ZDIagram on page 1263

Cursor coupling
If enabled, the gate area is defined by the cursor lines of an active cursor measurement. If several cursor measurements are enabled, select the cursor set to be used for gating. The "Start" and "Stop" values of the gate are adjusted to the values of the cursor line positions. The measurement is limited to the part of the waveform between the cursor lines.

Remote command:
`MEASurement<m>:GATE:CCOupling` on page 1183
`MEASurement<m>:GATE:CURSor` on page 1183

10.3.2 Defining the Search Gate

If you create a search using the "Search" toolbar icon, you can directly define the gate by dragging a rectangle on the diagram. Otherwise, you define the gate in the "Gate" tab of the "Search" dialog box.

1. Press the [Search] key and select the "Gate" tab.
2. Select the search for which you want to define the gate.
3. Use one of the following methods:
   - Set the absolute or relative "Mode" and enter the start and stop values of the gate area.
   - If a zoom area has already been defined for the waveform, couple the gate area to the zoom area by selecting the "Zoom coupling" option. If several zoom diagrams are defined, select the zoom diagram you want to use for gating.
4. Tap "Use gate" to enable the gate.
5. Optionally, tap "Show gate" to display the gate area in the diagram.

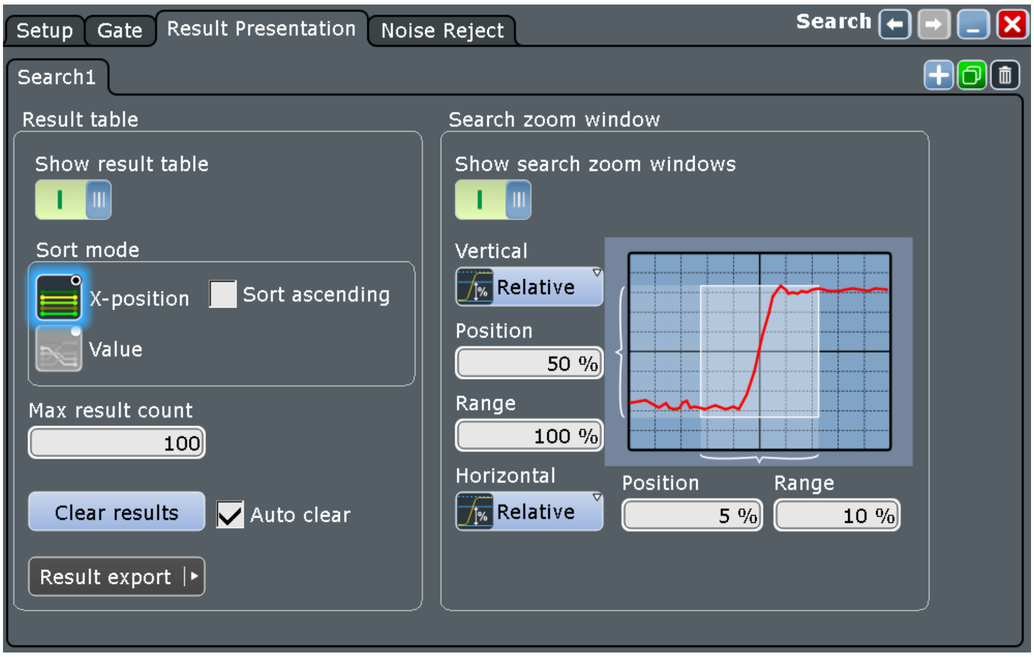
10.4 Result Presentation

Search results are displayed in a table in the "Search Results" box. In addition, a zoom window for a selected search result can be displayed so that you can analyze the result in more detail.

10.4.1 Result Presentation Settings

Access: [Search] > "Result Presentation" tab

The following settings configure the layout of the result table in the "Search Results" box and the size and position of the search zoom window. The result tables can be sorted by x-position or value. You can define a maximum number of table entries.



Result table

These settings refer to the search result table.

Show result table ← Result table

Displays or hides the search result table.

Remote command:

`SEARch:RESult:SHOW` on page 1269

Sort mode ← Result table

Sorts the search results by x-value position or value of the result.

Remote command:

`SEARch:RESult:SORT[:MODE]` on page 1270

Sort ascending ← Result table

By default, the results are listed in descending order, i.e. the largest value at the top. To change the sorting direction, enable "Sort ascending".

Remote command:

`SEARch:RESult:SORT:ASCending` on page 1269

Max result count

Defines the maximum number of entries in the search result table.

Remote command:

`SEARch:RESult:LIMit` on page 1269

Auto clear

If "Auto clear" is enabled, the instrument displays the search results of the last acquisition.

If "Auto clear" is disabled, the first result of each acquisition is listed until the maximum number of entries in the table is reached.

Clear results
Clears the search results once and starts a new search.

Remote command:
`SEARch:CLEar` on page 1235

Search zoom window
The search zoom window allows you to analyze the search results in more detail.

You can change the size and the position of the search zoom area in the same way as a usual zoom. If you move the zoom area in the source diagram, the nearest search result is marked in the results table. See also: Chapter 6.1.1, "Methods of Zooming", on page 226

The search zoom area is marked in the waveform diagram. You can change the color of the area with: "Display" menu > "Diagram layout" > "Search result gate symbol color" on page 96.

Show search zoom windows ← Search zoom window
If enabled, a zoom window is displayed for the currently selected search result. The zoom area is indicated in the diagram that displays the source waveform of the search.

Remote command:
`SEARch:RESDiagram:SHOW` on page 1267

Vertical ← Search zoom window
Defines whether absolute or relative values are used to specify the y-axis values.

Remote command:
`LAYout:ZOOM:VERTical:MODE` on page 1102
`SEARch:RESDiagram:VERT:MODE` on page 1268

Position / Relative position (vertical) ← Search zoom window
Defines the y-value of the centerpoint of the zoom area.

Remote command:
`LAYout:ZOOM:VERTical:ABSolute:POSition` on page 1102
`LAYout:ZOOM:VERTical:RELative:POSition` on page 1103
`SEARch:RESDiagram:VERT:ABSolute:POSition` on page 1267
`SEARch:RESDiagram:VERT:RELative:POSition` on page 1268

Range / Relative Range (vertical) ← Search zoom window
Defines the height of the zoom area.

Remote command:
`LAYout:ZOOM:VERTical:RELative:SPAN` on page 1103
`LAYout:ZOOM:VERTical:ABSolute:SPAN` on page 1102
`SEARch:RESDiagram:VERT:ABSolute:SPAN` on page 1268
`SEARch:RESDiagram:VERT:RELative:SPAN` on page 1268

Horizontal ← Search zoom window
Defines whether absolute or relative values are used to specify the x-axis values.

Remote command:
LAYout:ZOOM:HORZ:MODE on page 1099
SEARch:RESDiagram:HORZ:MODE on page 1266

Position / Relative position (horizontal) ← Search zoom window
Defines the x-value of the centerpoint of the zoom area.

Remote command:
LAYout:ZOOM:HORZ:ABSolute:POSition on page 1099
LAYout:ZOOM:HORZ:RELative:POSition on page 1100
SEARch:RESDiagram:HORZ:ABSolute:POSition on page 1266
SEARch:RESDiagram:HORZ:RELative:POSition on page 1267

Range / Relative Range (horizontal) ← Search zoom window
Defines the width of the zoom area.

Remote command:
LAYout:ZOOM:HORZ:ABSolute:SPAN on page 1099
LAYout:ZOOM:HORZ:RELative:SPAN on page 1101
SEARch:RESDiagram:HORZ:ABSolute:SPAN on page 1266
SEARch:RESDiagram:HORZ:RELative:SPAN on page 1267

10.4.2 Configuring the Search Results Presentation

Initially, the "Search Results" box is displayed in front of the other diagrams or as result icon on the sidebar. This depends on the default setting in the "Diagram Layout" tab. Alternatively, you can display it in its own area on the screen, like any other diagram.

For details, see Chapter 2.3.6, "Displaying Results", on page 69.

To configure the result tables

1. Press the [Search] key to open the "Search" dialog box.
2. Select the tab for the search you want to configure.
3. Select the "Result Presentation" tab.
4. Select "Show result table" to display the "Search Results" box.
5. Select the sort mode of the result table.
6. By default, the results are listed in descending order, i.e. the largest value at the top. To change the sorting direction, enable "Sort ascending".
7. Define a maximum number of results to be displayed in the result table in the "Max result count" field.

To display search zoom windows

1. In the "Search Results" box, select "Show search zoom windows".

This stops a running search and a running acquisition.
The zoom area is indicated in the diagram that displays the source waveform of the search. The zoom window is displayed for the first result that was found.

2. If you need to adjust the search zoom area, you can drag the area or their edges on the screen. You can also enter the limits of the search zoom window in the "Search > Results Presentation" tab.
   Be aware, that the zoom window size is valid for all results of a search definition. If you change the settings drastically for one result, they may not be correct for the next search result you switch to.

   See also:
   - Chapter 6.1.3, "Zooming for Details", on page 232
   - "Navigating search results" on page 398

10.5 Noise Reject

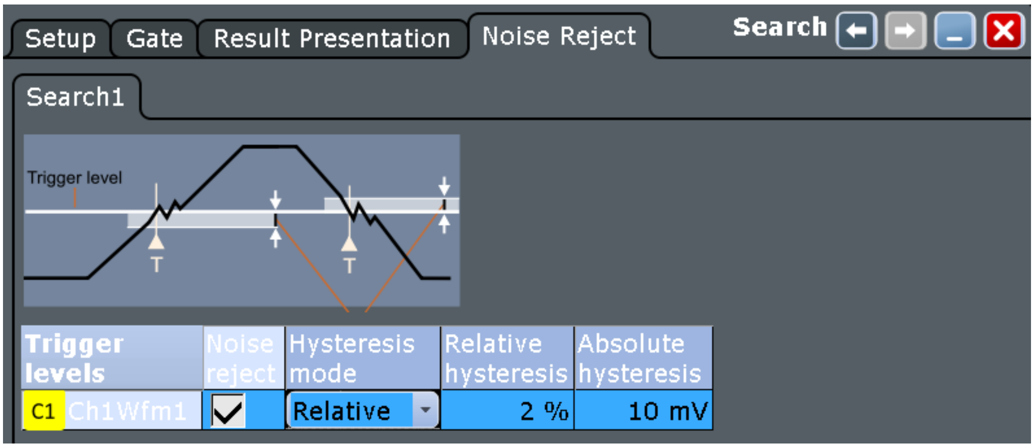
Noise rejection for searches is similar to noise rejection for triggers. You can reject noise by setting a hysteresis to avoid finding events caused by noise oscillation around the trigger level.

10.5.1 Noise Reject Settings

Access: [Search] > "Noise Reject" tab

You can select the hysteresis mode and value for each analog and digital input channel, math and reference waveform.

The noise reject settings are similar to those for triggers, see also Chapter 5.6, "Noise Reject", on page 209.



Noise reject
If enabled, the hysteresis is considered for the search.

Remote command:
SEARch:TRIGger:LEVel:NOISe[:STATe] on page 1265

Hysteresis mode
Defines whether values absolute or relative to the vertical scaling are used.

Remote command:
SEARch:TRIGger:LEVel:NOISe:MODE on page 1264

Relative / Absolute hysteresis
Defines a range in absolute or relative values around the search level. If the signal jitters inside this range and crosses the level, no search event is detected.

Absolute hysteresis values are adapted when the relative hysteresis is changed , and vice versa.

If you change the vertical scaling, either the relative or the absolute value is adjusted automatically.

Remote command:
SEARch:TRIGger:LEVel:NOISe:ABSolute on page 1264
SEARch:TRIGger:LEVel:NOISe:RELative on page 1265

10.5.2 Defining Noise Rejection for Searches

1. Press the [Search] key to open the "Search" dialog box.
2. Select the "Noise reject" tab.
3. Select the tab for the search you want to configure.
4. Define the absolute or relative hysteresis. If you change one value, the other is automatically calculated.

11 Data and File Management

This chapter describes how to manage instrument settings, and measurement results like waveform data, numeric results and screenshots.

The [Save Recall] key provides functions for saving and restoring data on the instrument. A naming pattern is available and can be adjusted to simplify a clear data storage.

The effect of the [Camera] key can be configured to save or print screenshots or reports.

11.1 Instrument Settings

To repeat measurements at different times or perform similar measurements with different test data, it is useful to save the used instrument settings and load them again later. Furthermore, it can be helpful to refer to the instrument settings of a particular measurement when analyzing the results. Therefore, you can easily save the instrument settings of a measurement. In addition to the measurement-related settings, user-specific display settings and active reference waveforms can also be saved and loaded.

Access to save instrument settings: [Save Recall] key > "Save" tab > "User settings"

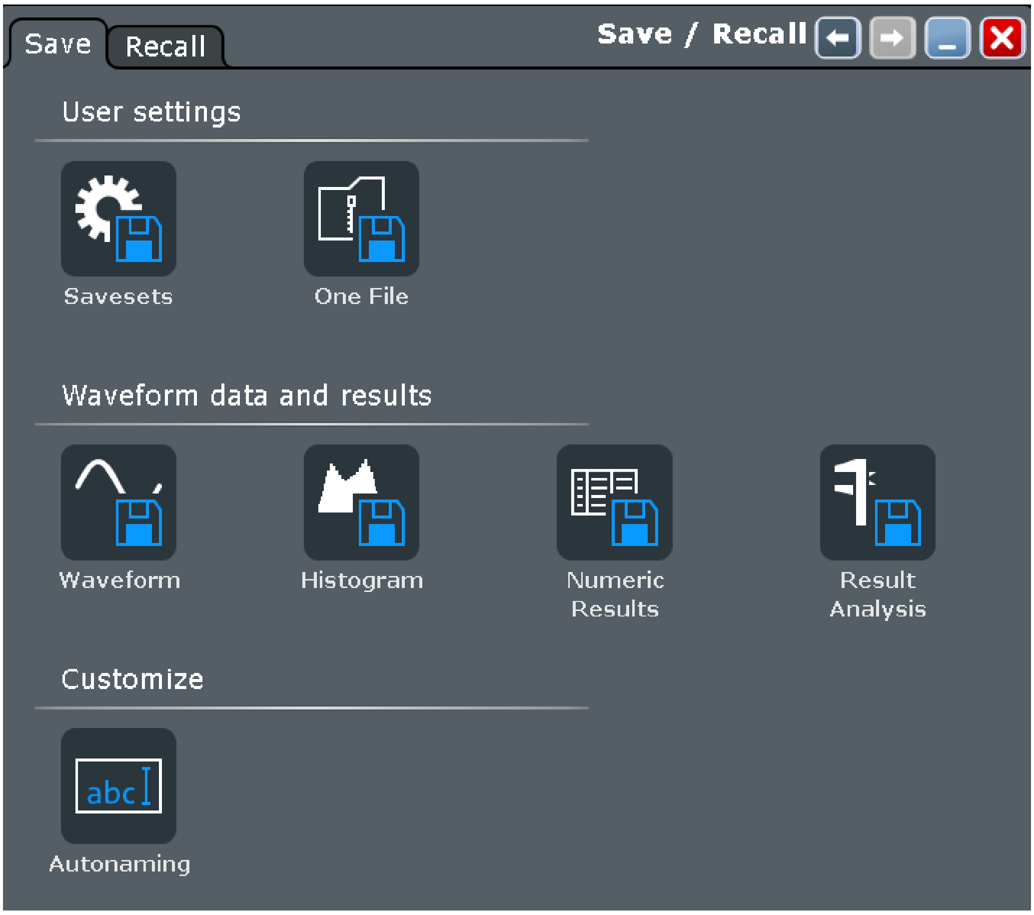


Figure 11-1: Save tab

Access to load instrument settings: [Save Recall] key > "Recall" tab > "User settings"

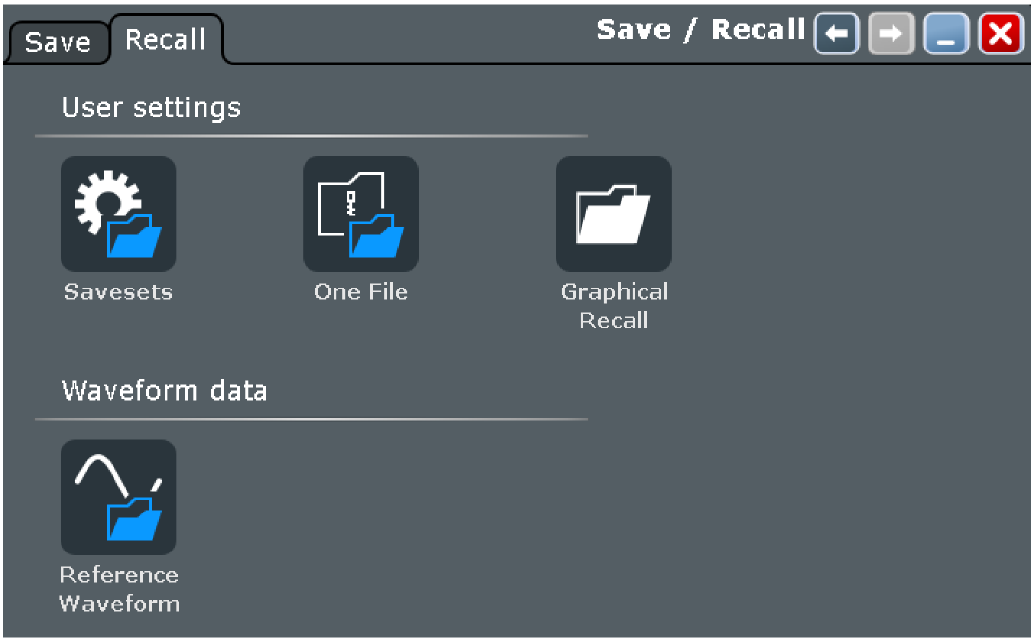


Figure 11-2: Recall tab

The R&S RTP provides three types of saving and restoring settings:

- **Savesets** contain the complete instrument and measurement configuration except for user-specific display settings.
- **One File** contains the saveset and active reference waveform files in a ZIP file.
- **User-defined presets** contain the complete instrument setup including display settings, except for transparency and intensity. These settings can be restored by pressing the [Preset] key. See Chapter 11.6, "Preset Setup", on page 459.

Access: [Save Recall] key

11.1.1 Savesets

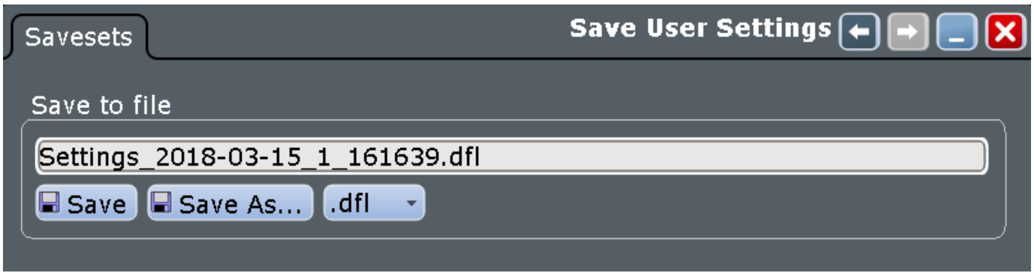
Savesets contain the complete instrument and measurement configuration including a screenshot of the current display, but except for user-specific display settings stored as user preferences. You can save an unlimited number of setting files.

To load a saveset quickly, you can use the "Load saveset" function on the toolbar. A graphical preview helps you to find the required settings file.

If you need to store the instrument settings often, you can add the "Save settings" icon to the toolbar and use the icon to store the saveset file.

11.1.1.1 Save Saveset Settings

Access: [Save Recall] key > "Save" tab > "Savesets"



Save to file

Enter the file name to save the setting data to, and select the file format with the format button on the right. Double-tap the file name to open the file selection dialog box. See also: Chapter 11.7, "File Selection Dialog", on page 461.

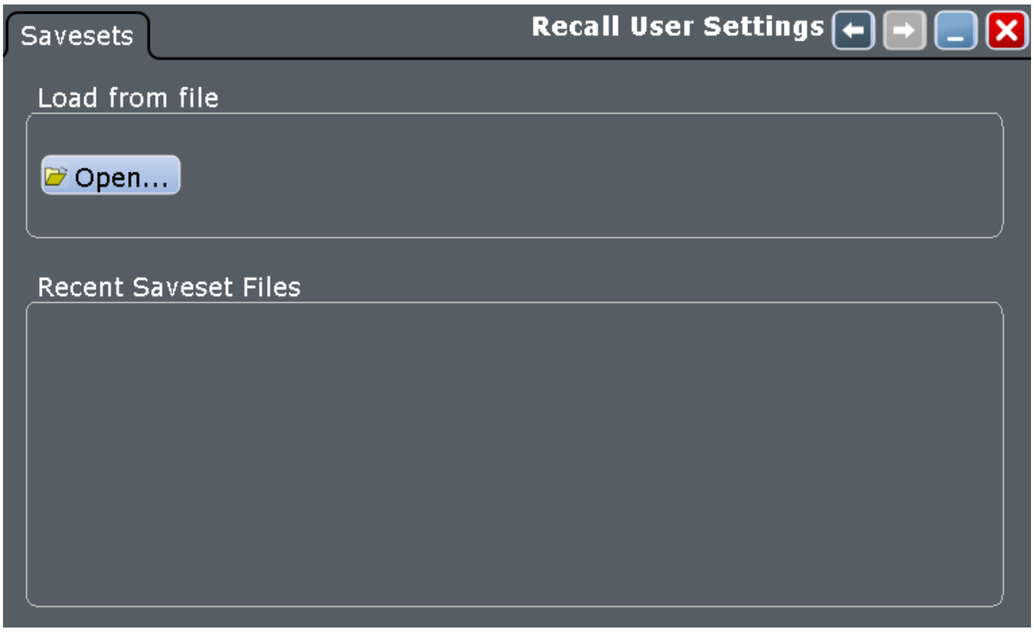
By default, saveset file names have the prefix "Settings_".

"Save"	Saves the data to the selected file.
"Save As..."	Opens the file selection dialog box and saves the data to the selected file.
".dfl/.xml"	Selects the file format.

Remote command:
`MMEMory:SAV` on page 1277

11.1.1.2 Load Saveset Settings

Access: [Save Recall] key > "Recall" tab > "Savesets"



Load from file

Enter the file name to load the setting data from, and select the file format with the format button on the right. Double-tap the file name to open the file selection dialog box.

See also: Chapter 11.7, "File Selection Dialog", on page 461.

By default, saveset file names have the prefix "Settings_".

"Open" Opens a file selection dialog box and loads the selected file.

Remote command:

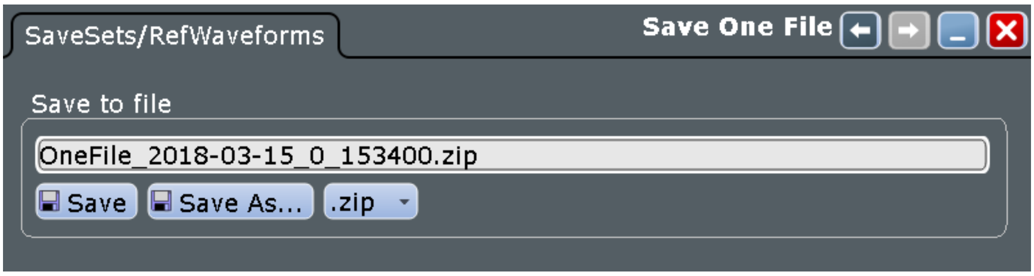
`MMEMory:RCL` on page 1277

11.1.2 One File

The One File function stores the savesets file and the data of active reference waveforms together in a ZIP file. If you want to keep channel waveform data together with the instrument settings, make sure to create a reference waveform from the channel waveform before you save the One File.

11.1.2.1 Save One File Settings

Access: [Save Recall] key > "Save" tab > "One File"



Save to file

Enter the file name to save the One File data to, and select the file format with the format button on the right. Double-tap the file name to open the file selection dialog box.

See also: Chapter 11.7, "File Selection Dialog", on page 461.

By default, saveset file names have the prefix "OneFile_".

"Save" Saves the data to the selected file.

"Save As..." Opens the file selection dialog box and saves the data to the selected file.

".zip" Shows the file format.

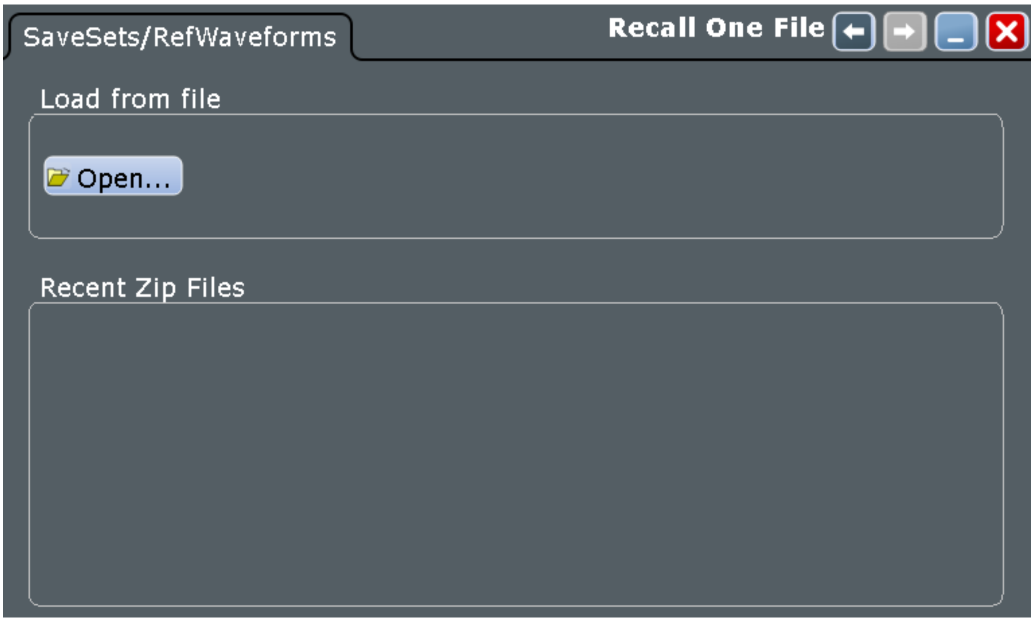
Remote command:

`SAVeset:ONEFile:NAME` on page 1278

`SAVeset:ONEFile:SAVE` on page 1279

11.1.2.2 Load One File Settings

Access: [Save Recall] key > "Recall" tab > "One File"



Load from file
Enter the file name to load the setting data from, and select the file format with the format button on the right. Double-tap the file name to open the file selection dialog box.
See also: Chapter 11.7, "File Selection Dialog", on page 461.

By default, saveset file names have the prefix "OneFile_".

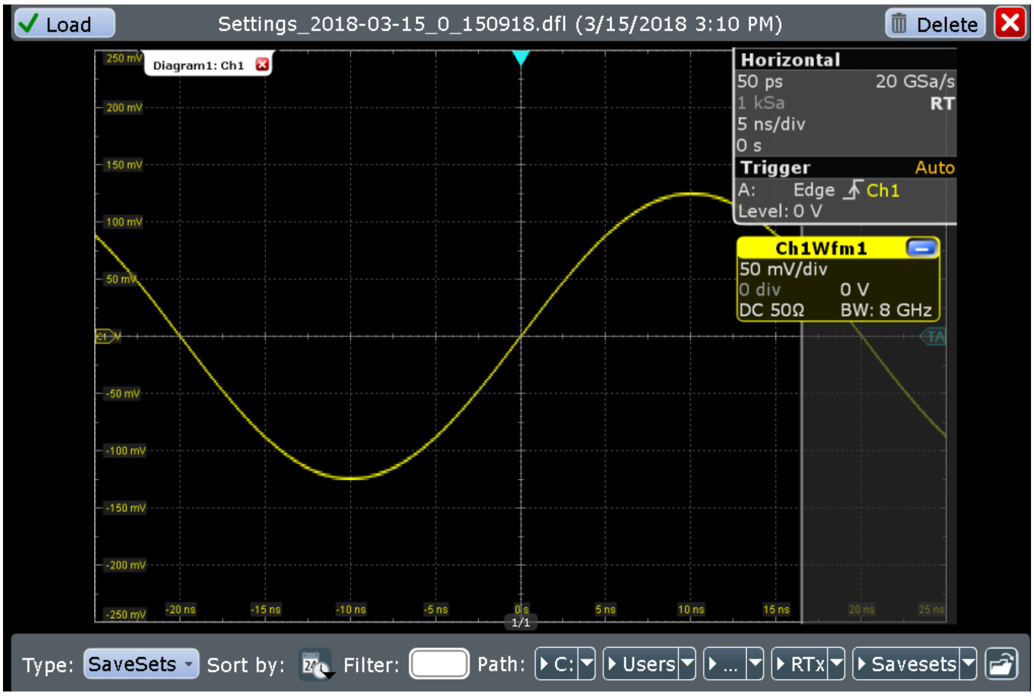
"Open" Opens a file selection dialog box and loads the selected file.

Remote command:
SAVeset:ONEFile:NAME on page 1278
SAVeset:ONEFile:OPEN on page 1278

11.1.3 Graphical Recall Function

Access: [Save Recall] key > "Recall" tab > "Graphical Recall"

The "Graphical Recall" function is also available on the toolbar. The graphical preview helps you to find the required settings file or a reference waveform.



1. On the toolbar, tap the "Graphical Recall " icon.

   A window opens and shows the screenshot of the first measurement configuration that is stored in the default directory.

2. Select if you want to display a "SaveSets" file or a reference waveform ("Ref Wfm").

3. Find the required file using one of the following methods:
   - Tap the "Next" icon on the right or the "Previous" icon on the left to scroll the savesets of the directory.

     The file name is shown on the top, and the screenshot helps to identify the settings.
   - If the saveset was stored in another directory, use the path buttons at the bottom, or tap "Open" to open the required directory.
   - Tap "Sort by" to sort the files according to the "Last modified" date or the "Filename".
   - Specify a "Filter" name to show only the files containing the filter string.

4. Tap "Load" in the upper left corner to recall the settings of the selected file.

11.1.4 Saving and Loading Settings

Settings can be stored in a file with user-defined name and location, or in a quick saveset. The settings in a saveset can be saved and retrieved quickly at the touch of a button, so savesets are ideal for frequently used measurements.

For details on save/recall instrument settings and associated remote commands, see Chapter 11.1.1, "Savesets", on page 422.

To save settings to a saveset file

Alternatively, you can add the "Save settings" icon to the toolbar and use the icon to store the saveset file to the folder and file specified in the "Settings" tab. See also Chapter 2.3.5.2, "Configuring the Toolbar", on page 64.

1. Press the [Save Recall] key.
2. In the "Save" tab, press the "Saveset" button .
3. Tap "Save" to save the settings to the specified file.
   Tap "Save As" to save the settings to a different file. Select the file and directory from the file selection dialog box.

   The current settings are saved to the selected file.

To load settings from a saveset file

Alternatively, you can use the "Load saveset" function on the toolbar, see Chapter 11.1.3, "Graphical Recall Function", on page 425.

1. Press the [Save Recall] key.
2. Select the "Recall" tab.
3. Press the "Saveset" button.
4. Tap "Load" to load the settings from the specified file.
   Tap "Open" to navigate to a different file. Select the file from the file selection dialog box and tap "Select".

   The saved settings are loaded to the R&S RTP.

To save a One File

1. If you want to save reference waveforms in the One File, create and display the reference waveforms.
2. Press the [Save Recall] key.
3. In the "Save" tab, tap the "One File".
4. Tap "Save" to save the settings to the specified file.
   Tap "Save As" to save the settings to a different file. Select the file and directory from the file selection dialog box.

   The current settings and the active reference waveforms are saved to the selected file.

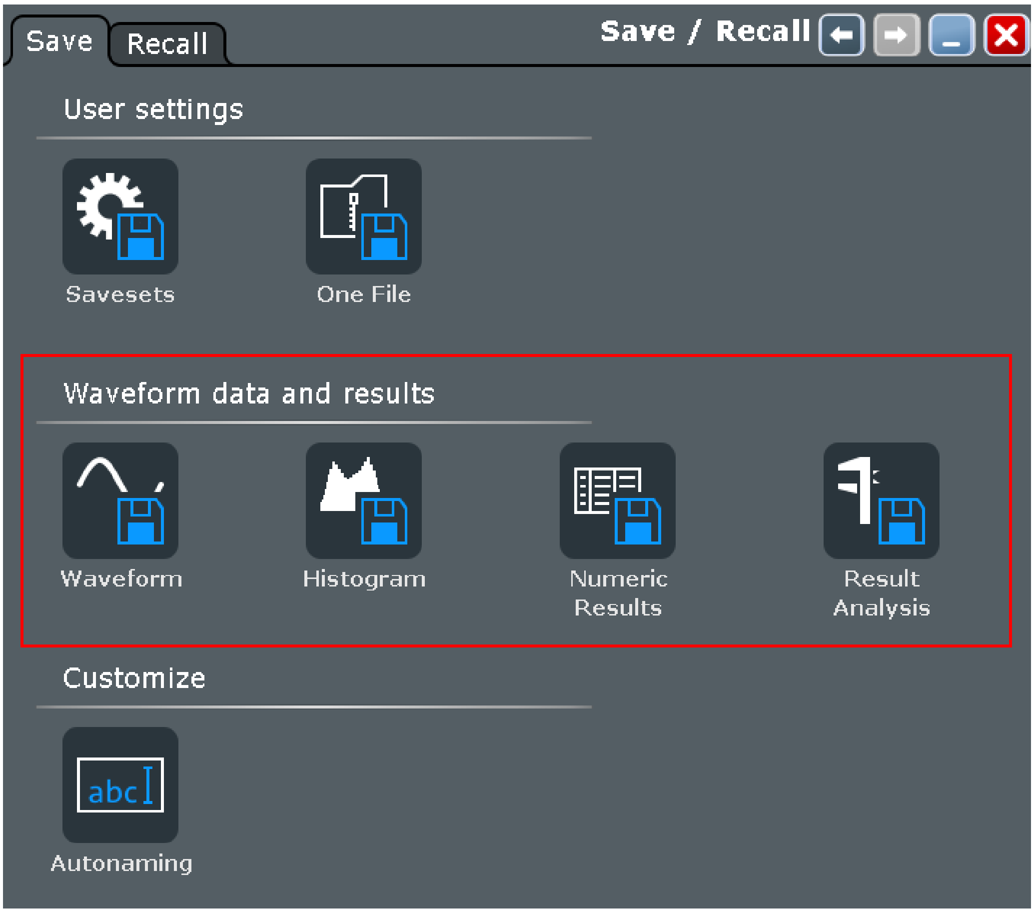
To load a One File

1. Press the [Save Recall] key.
2. Select the "Recall" tab.
3. Press the "One File" button.
4. Tap "Load" to load the settings from the specified file.
   Tap "Open" to navigate to a different file. Select the file from the file selection dialog box and tap "Select".

   The saved settings and reference waveforms are loaded to the R&S RTP.

11.2 Waveform Data and Results

Access: [Save Recall] > "Save" tab



You can export various data to file: waveform data, histograms, and measurement results.

11.2.1 Waveform Export Files

Waveforms can be stored in XML, CSV, or BIN format.

Reloading waveforms: Restrictions

In order to reload waveform data as a reference waveform, it must be stored in BIN format.

If multiple acquisitions of one waveform are exported (Data logging or Multiple waveforms), only the first acquisition can be reloaded.

If the signal is a spectrum, reloading is only possible for waveforms with "Magnitude unit" = Linear. Waveforms with logarithmic unit cannot be reloaded.

Data of all waveforms is saved in two files. One file contains the waveform data values and is indicated by `*Wfm.*` in the file name. The second file contains the header data, for example, time scale, vertical scale, vertical and horizontal positions, interpolation mode and much more. Header data is required to restore the waveform from data, or to analyze the data values of the data file.

11.2.1.1 Header Files

The header files of XML and BIN waveform files are written in XML format. The header files of CSV waveform files are written in CSV format. You can open the header files and use their information for data analysis.

CSV header files only contain the property names and values, one property per row.

```
Resolution:1e-010:
RecordLength:1000:
```

XML header files contain more information than CSV header files. The additional information is required to reload the stored waveforms with their correct settings.

```
<Prop Avail="0" ValueKey="" Name="Resolution" Value="1e-010" UserValue="0"
Step="1e-011" Default="0" Min="0" Max="1e+026" StepDefault="1e-011"
StepFactor="10" Resolution="0" UnitId="55" UnitName="s" UnitPowerProduct=""
BitGroupSize="0" Format="0"></Prop>

<Prop Avail="0" ValueKey="" Name="RecordLength" Value="1000" UserValue="1000"
Step="1" Default="1000" Min="0" Max="4294967295" StepDefault="1" StepFactor="10"
Resolution="1" UnitId="93" UnitName="Sa" UnitPowerProduct="" BitGroupSize="0"
Format="0"></Prop>
```

Header files contain the following properties:

Table 11-1: Header file properties

Value	Description
General	
FirmwareVersion	Firmware version that is installed on the R&S RTP (last entry in the header file)
Source	Name of the exported waveform
Resolution	Time between two samples *Resolution = 1 / Sample Rate*
SignalResolution	Time between two samples in this waveform. The value can differ from Resolution if the source is, for example, a spectrum, a bus signal, a correlation or a measurement. The value is determined automatically considering the waveform parameters and their dependencies. If the signal is a spectrum, the value indicates the frequency range of FFT bins.
EnhancementMode	Method to increase the sample rate if the required sample rate is higher than the ADC sample rate.
InterpolationMode	Interpolation method. The value is relevant when the enhancement mode is interpolated time.
DecimationMode	Method to reduce the number of data samples to achieve the required sample rate
DecimationFactor	Factor to the number of data samples to achieve the required sample rate *Decimation factor = ADC sample rate / Sample rate*
TraceArithmetics	Off, Envelope, or Average
InterleavedTraceCount	Number of y-values saved at each sampling time. The value is usually 1. The value is 2, if min and max values are saved for each sample, for example, for envelope waveforms.
SignalFormat	Format of the data values: • FLOAT: floating point numbers, general export format • INT (8 Bit): Integer 8 bit, used for "Raw (ADC sample)" data export. • INT (16 Bit): Integer 16 bit, used for "Raw (ADC sample)" data export in high definition mode (option R&S RTP-K17).
Timestamp	Absolute time of the waveform recording
ByteOrder	Endianess, only relevant for raw data export in high definition mode (SignalFormat = INT (16 Bit)). • LSB first: little endian, least significant byte first • MSB first: big endian, most significant byte first
NumericFormat	Number format of bus values and digital channel data (bit pattern format)
Record length	
RecordLength	Number of samples in a waveform record of one acquisition
HWRecordLength	Equivalent to the RecordLength

Value	Description
SignalRecordLength	Number of required samples in the waveform. The value can differ from RecordLength and HWRecordLength if the source is, for example, a spectrum, a bus signal, a correlation or a measurement. The value is determined automatically considering the waveform parameters and their dependencies. If the signal is a spectrum, the value indicates the number of FFT bins.
SignalHardwareRecordLength	Number of samples actually available in this waveform, including the number of required samples in the waveform and the additional samples needed for further computation
LeadingSettlingSamples	Number of additional samples before the beginning of waveform samples. These additional samples are needed for further computation, for example, for filters.
Horizontal system	
TimeScale	Horizontal scale in seconds per division
HorizontalDivisionCount	Number of horizontal divisions
RescaleCenterTime	Horizontal position, the time distance between the reference point and the zero point of the diagram
RescaleCenterPoint	Position of the reference point in % of the screen
ReferencePoint	Position of the zero point in % of the screen
TriggerOffset	Time distance from the trigger point to the zero point of the diagram
XStart	Horizontal start value of the waveform (time or frequency) *)
XStop	Horizontal stop value of the waveform (time or frequency)
HardwareXStart	Actual horizontal start value of data, including the settling time for further computation *)
HardwareXStop	Actual horizontal stop value of data, including the settling time for further computation
	*) If the waveform is a spectrum, the XStart and HardwareXStart values may be slightly smaller than the specified start frequency, or even get negative. The spectrum is centered on the center frequency, and the frequency range covered by one spectral bin is given by the SignalResolution. Hence, the spectral bin in the center of the spectrum always covers the range [CenterFrequency; CenterFrequency + SignalResolution[. As a result, the range covered by the first spectral bin in the spectrum may reach further than the start frequency specified by the user. It is ensured that the specified start frequency is included in the frequency range.
Vertical system In case of multi channel export, the values of channel1 are delivered, no matter if channel 1 is exported or not.	
VerticalScale	Vertical scale of the waveform in Volts per division, or other unit / division
VerticalDivisionCount	Number of vertical divisions
VerticalPosition	Vertical position of the waveform in divisions
VerticalOffset	Vertical offset of the waveform in Volts, or other unit

Value	Description
NofQuantisationLevels	Theoretical number of quantization levels in the signal. This value depends on the waveform format (8 bit, 16 bit, …). In case of a math waveform, it depends on the quantization levels of the operands and on the operator type.
BaseYStart	Vertical start value of the waveform
BaseYStop	Vertical stop value of the waveform
Multi channel export The header files contain strings like this: `MultiChannelVerticalOffset: 4:1.63:1.96:0:0:1e-005:0:-1e+026:1e+026:1e-005:10:0:V:`. Only the first 5 values and the unit at the end of the string are relevant for data analysis. All other values are for internal use and not explained here. Examples are in csv format.	
MultiChannelExport	Indication whether multiple channels are exported simultaneously: On | Off
MultiChannelExportState	Number of channels and export status of the individual channels, for example, 4:On:Off:On:On...: channels 1, 3 and 4 are exported.
MultiChannelVerticalOffset	Number of channels and vertical offset of the individual channels, for example, 4:0:0:0.02:0...: channel 3 has an offset of 20 mV.
MultiChannelVerticalPosition	Number of channels and vertical position of the individual channels, for example, 4:0:0:0:2...: the position of channel 4 is 2 divisions.
MultiChannelVerticalScale	Number of channels and vertical scale of the individual channels, for example, 4:0.05:0:0.03:0.04...: scale of channel is 50 mV/div, channel 3 has 30 mV/div and channel 4 has 40 mV/div.
MultiChannelBaseYStart	Number of channels and minimum value of the vertical range for each individual channel, for example, 4:-0.25:0:-0.13:-0.28...
MultiChannelBaseYStop	Number of channels and maximum value of the vertical range for each individual channel, for example, 4:0.25:0:0.17:0.12...: The range of channel 1 is -250 mV to 250 mV. The range of channel 3 is -130 mV to 170 mV. The range of channel 4 is -280 mV to 120 mV.
History	
TimestampState	State of the timestamps export. If on, the timestamps of each history waveform is written to the waveform data file.
Math waveform	
BaseUnit	Base unit of a mathematic waveform, for example, linear unit
ViewUnit	User-selected unit of a mathematic waveform, for example, logarithmic unit for a spectrum. The value is only valid if the exported waveform is a math waveform.
ViewUnitRelative	Indication of a relative unit. It is true if the math waveform has the ViewUnit "dB", for example. The value is only valid if the exported waveform is a math waveform.
ViewReferenceLevel	Reference level for a relative unit. The value is only valid if the exported waveform is a math waveform, and the unit is relative.
FFT	
CenterFreq	Center frequency of the spectrum

Value	Description
FreqSpan	Frequency span of the spectrum
FrequencyStart	Start frequency of the spectrum
FrequencyStop	Stop frequency of the spectrum
WindowType	Window used for the spectrum computation
ResolutionBW	Resolution bandwidth of the spectrum
AdjustedResolutionBW	Actual resolution bandwidth of a spectrum waveform. The value is only valid if the exported waveform is a spectrum.
GateRBWCoupling	Indication whether the record length or the resolution bandwidth is a constant for the spectrum computation
Parameters for power calculation	
Impedance	Impedance used for power calculation
NoiseBandwidth	Noise bandwidth of a spectrum waveform, required for power calculation. The value is only valid if the exported waveform is a spectrum.
Parameters for internal use	
SourceType	Source qualifier
TraceType	Waveform qualifier
ValueType	
TOADone	
BaseUnitRelative	Base unit indication
UseInterSampleTriggerOffset	
ISO_TRG SC_POST SC_TRG	

11.2.1.2 Waveform Data Files

The waveform data files - indicated by `*Wfm.*` in the file name - contain the actual waveform data. Usually only Y-values - mostly voltage values - are written subsequently. If the signal is a spectrum, the data of the last frame is written.

If the waveform consists of minimum and maximum values, two Y-values per sample are written, and the property `InterleavedTraceCount` in the header file is >1. This applies to envelope waveforms, for example.

The option "Interleaved X/Y" allows you to include horizontal values into the file.

if multi-channel export is enabled, the Y-values of the selected channels are written in interleaved order.

- One channel, single acquisition export
  - Normal waveform:
    Y_0; Y_1; Y_2; Y_3; ...

   – Envelope waveform:
     $Ymin_0$; $Ymax_0$; $Ymin_1$; $Ymax_1$; $Ymin_2$; $Ymax_2$; $Ymin_3$; $Ymax_3$; ...
   – Normal waveform, interleaved x/y data:
     X_0; Y_0; X_1; Y_1; X_2; Y_2; X_3; Y_3; ...
   – Envelope waveform, interleaved x/y data:
     X_0;$Ymin_0$; $Ymax_0$; X_1; $Ymin_1$; $Ymax_1$; X_2; $Ymin_2$; $Ymax_2$; X_3; $Ymin_3$; $Ymax_3$; ...
- Multi-channel, single acquisition export
  In the example, two channels are exported.
   – Normal waveforms:
     $YCh1_0$; $YCh2_0$; $YCh1_1$; $YCh2_1$; $YCh1_2$; $YCh2_2$; $YCh1_3$; $YCh2_3$; ...
   – Envelope waveforms, channel 1 and channel 2 are envelopes:
     $YCh1min_0$; $YCh1max_0$; $YCh2min_0$; $YCh2max_0$; $Ymin_1$; $Ymax_1$; $YCh2min_1$; $YCh2max_1$; $Ymin_2$; $Ymax_2$; $YCh2min_2$; $YCh2max_2$; $Ymin_3$; $Ymax_3$; $YCh2min_3$; $YCh2max_3$; ...
   – Normal waveforms, interleaved x/y data:
     X_0; $YCh1_0$; $YCh2_0$; X_1; $YCh1_1$; $YCh2_1$; X_2; $YCh1_2$; $YCh2_2$; X_3; $YCh1_3$; $YCh2_3$; ...
   – Envelope waveform and normal waveform, interleaved x/y data:
     X_0;$YCh1min_0$; $YCh1max_0$; $YCh2_0$; X_1; $YCh1min_1$; $YCh1max_1$; $YCh2_1$; X_2; $YCh1min_2$; $YCh1max_2$; $YCh2_2$; X_3; $YCh1min_3$; $YCh1max_3$; $YCh2_3$; ...

In XML and CSV waveform value files, the data of each sample is grouped. The example shows the values of two samples for two waveforms and interleaved x/y data. The first waveform is an envelope, the second one is a normal waveform.

In CSV files, the data values for a given sampling time is written in one row.

```
-1.96e-008    -0.0079051387     -0.0059288535     -0.1027668
-1.95e-008    -0.0098814229     -0.0079051387     -0.10474309
```

In XML format, an empty line marks the beginning of the next sample.

```
<Data>-1.96e-008</Data>
<Data>-0.0079051387 </Data>
<Data>-0.0059288535 </Data>
<Data>-0.1027668 </Data>

<Data>-1.95e-008</Data>
<Data>-0.0098814229 </Data>
<Data>-0.0079051387 </Data>
<Data>-0.1027668 </Data>
```

If multiple acquisitions (Data logging / Multiple waveforms) are exported, the first acquisition is written in the same way as with single acquisition export. The following acquisitions are appended in the same way. If the signal is a spectrum, the last frame of each acquisition is saved.

Before and after the waveform data, the instrument writes some leading and trailing settling samples. They ensure that all measurements can be performed on the reloaded waveform that could be performed on the original waveform. The number of leading settling samples is provided in the header file.

11.2.1.3 Number of Samples in the Export File

In this section, a sample is defined as one or more values acquired at a given sampling time. The number of samples for one channel and acquisition is given in the header file by the property `SignalHardwareRecordLength`. This number includes the number of required samples in the waveform and additional samples at the beginning (leading samples) and the end of the file (trailing samples).

The number of additional samples is:

No of additional samples = SignalHardwareRecordLength - SignalRecordLength

The number of leading additional samples is given in the header file: `LeadingSettlingSamples`.

The number of trailing additional samples is:

No of trailing additional samples = No of additional samples - LeadingSettlingSamples
= SignalHardwareRecordLength - SignalRecordLength - LeadingSettlingSamples

If the waveform has more than one Y-value per sample (e.g. envelope), the property `InterleavedTraceCount` is > 1, and the number of values in the file for this waveform is:

*No of values per waveform = InterleavedTraceCount * SignalHardwareRecordLength*

If multiple acquisitions are exported, the total number of values in the file is:

*No of values = InterleavedTraceCount * SignalHardwareRecordLength * No of exported acquisitions*

If "Interleaved x/y"is enabled, one horizontal value is added per sample. The total number of values in the file is:

*No of values = (1+ InterleavedTraceCount) * SignalHardwareRecordLength * No of exported acquisitions*

MSO option R&S RTP-B1:

If the data of digital channels is stored in BIN format, 1 bit is written for each sample. 8 data samples are written in 1 byte (data word). Thus, the file size is

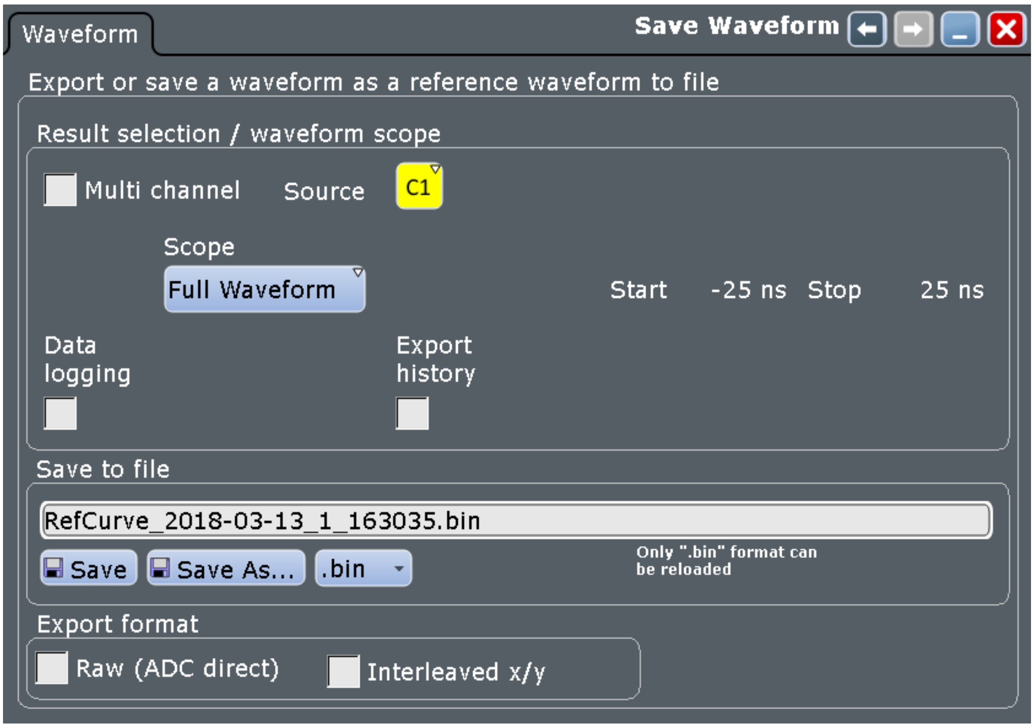
File size = Number of samples / 8

For example, 100 MSa are written into a 12.5 MByte BIN file. After reading the file, you have to extract the samples from the data words.

11.2.2 Waveforms - Export Settings

Access: [Save Recall] > "Waveform"

In this tab, the storage settings for waveform data are defined.



See also: Chapter 11.2.6, "Saving and Loading Waveform Data", on page 446.

Source

Selects the waveform to be exported if "Multichannel export" is disabled. Active waveforms of input channels, math signals and reference waveforms are available for export.

If the MSO option R&S RTP-B1 is installed, you can save also digital channels and parallel buses.

Remote command:

`EXPort:WAVeform:SOURce` on page 1281

Multi-channel export

Enables or disables the export of multiple input channels. If enabled, you can export the data of selected input channels (Selected sources) into one file.

If disabled, you can export one Source waveform.

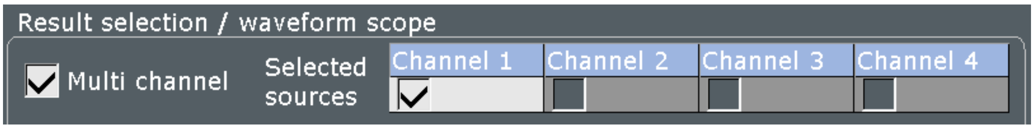
You can reload exported multiple channels if they are stored in BIN format. The import asks you to assign each stored waveform to a reference waveform.

Remote command:

`EXPort:WAVeform:MULTichannel` on page 1281

Selected sources

Select the channels to be included in data export if "Multichannel export" is enabled. Waveform1 of up to four input channels can be saved into one file.



Remote command:
`CHANnel<m>:EXPortstate` on page 1281

Scope
Defines the part of the waveform record that has to be stored.

"Full waveform"	Saves the complete waveform record.
"Zoom"	Saves the data included in the zoom area if at least one zoom is defined for the source waveform. The start and stop values of the area are shown. If several zooms are defined, select the "Zoom" to be used for export.
"Cursor"	Saves the data between the cursor lines if at least one cursor measurement is defined for the source waveform. The start and stop values of the area between the cursor lines are shown. If several cursor sets are defined, select the "Cursor set" to be used for export.
"Gate"	Saves the data included in the measurement gate if a gated measurement is defined for the source waveform. Select the "Measurement" for which the required gate is defined. The start and stop values of the gate are shown.
"Manual"	Saves the data between user-defined "Start" and "Stop" values.

Remote command:
`EXPort:WAVeform:SCOPe` on page 1282
`EXPort:WAVeform:STARt` on page 1283
`EXPort:WAVeform:STOP` on page 1283
`EXPort:WAVeform:ZOOM` on page 1283
`EXPort:WAVeform:CURSorset` on page 1284
`EXPort:WAVeform:MEAS` on page 1284

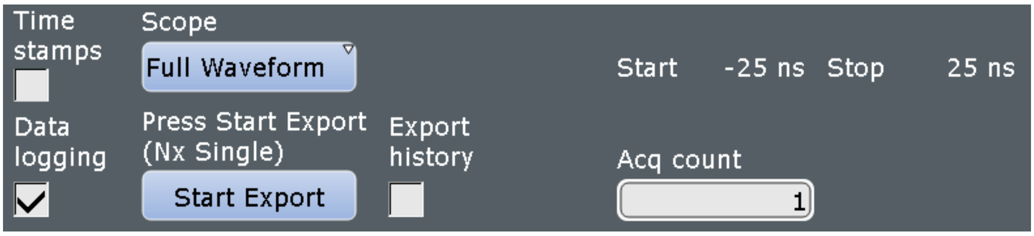
Data logging / Multiple Wfms
The "Data logging / Multiple Wfms" setting enables the export of subsequent acquisitions of the selected waveforms. If "Export history" is disabled, the setting is named "Data logging", and it exports the data of a running Nx Single acquisition. If "Export history" is enabled, the setting is named "Multiple Wfms", and it exports the history waveform data to file.

If multiple acquisitions of one waveform are exported into a BIN file, the first acquisition can be reloaded as reference waveform.

"Data logging" enables the export of all waveforms of an Nx Single acquisition into one file. The waveform records are written in historical order one after the other, either the complete records or the sections as defined in "Scope". Set the number of acquisitions to be acquired and stored with "Acq. count". The maximum amount of data that can be written is shown in "Max. file size".

Enabling "Data logging" stops a running acquisition. To start the logging, tap Start Export or press [Single].

Pressing "Run cont" disables data logging.



If "Export history" is enabled, the option "Multiple Wfms" allows you to save several or all history waveforms. Define the part of the history to be exported using "Start acq" and "Stop acq".

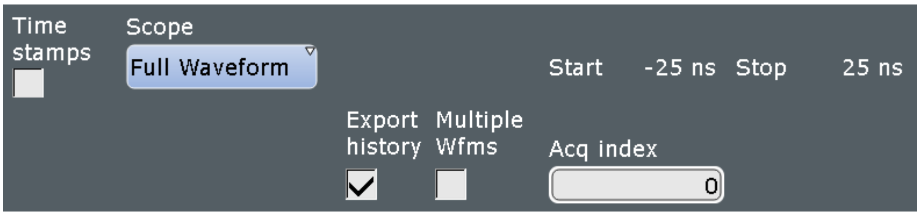
Remote command:
`EXPort:WAVeform:DLOGging` on page 1284

Start Export
Starts an Nx Single acquisition series and simultaneously saves the waveform data to a file if data logging is enabled.

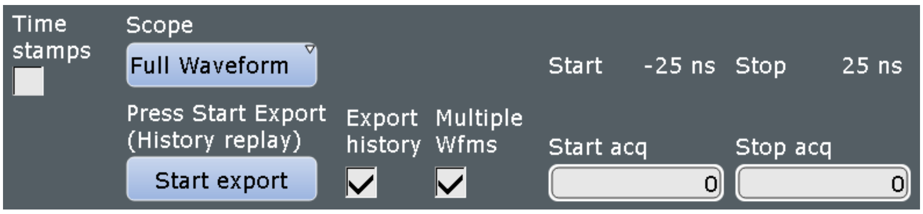
If "Export history" is enabled, the button starts the history replay and simultaneously saves the history waveforms.

Remote command:
`RUNSingle` on page 1001 (Nx Single acquisition)
`CHANnel<m>[:WAVeform<n>]:HISTory:PLAY` on page 1120 (history export)

Export history
Enables the history mode and the export of history waveforms to file. The setting is also available in the "History" dialog box under the designation"Show history".



To save one waveform from the history, enter the number of the required acquisition in "Acq index", and tap "Save".



To save several subsequent history waveforms, enable "Multiple Wfms" and define the range of the waveforms to be saved using "Start acq" and "Stop acq". These range settings are also available in the "History" dialog box. Start the history replay and simultaneous saving with "Start Export".

Remote command:
`CHANnel<m>[:WAVeform<n>]:HISTory[:STATe]` on page 1118
`CHANnel<m>[:WAVeform<n>]:HISTory:STARt` on page 1119
`CHANnel<m>[:WAVeform<n>]:HISTory:STOP` on page 1119

Timestamps
If enabled, the relative timestamps of all history waveforms are written into the waveform data file at the beginning of each waveform record.

Remote command:
`EXPort:WAVeform:TIMestamps` on page 1285

Save to file
Enter the filename to save the waveform to. Double-tap the filename to open the file selection dialog box.

By default, the filename has the prefix "RefCurves_". You can define a pattern for automatic naming in the "Autonaming" tab.

"Save"	Saves the waveform as a reference waveform in the selected file.
"Save As..."	Opens the file selection dialog box and saves the waveform to the selected file. See also Chapter 11.7, "File Selection Dialog", on page 461
".bin/.xml/.csv"	Selects the file format. Note that reference waveforms can be loaded from `.bin` files only. See also: Chapter 11.2.1, "Waveform Export Files", on page 429.

Remote command:
`EXPort:WAVeform:NAME` on page 1282
`EXPort:WAVeform:SAVE` on page 1282

Interleaved x/y
Includes horizontal values in the export data (time or frequency values, depending on the waveform). X and Y-values are written alternately to the file. If disabled, only Y-values - mostly voltage values - are written.

Interleaved x/y data cannot be exported as raw values, the "Raw (ADC direct)" option is not available.

The setting is not available for the export of digital channel data.

Remote command:
`EXPort:WAVeform:INCXvalues` on page 1285

Raw (ADC direct)
Enables the export of analog channel data in the raw sample format of the ADC. The data format is integer 8 bit (signed 8-bit binary format). This format reduces the file size (1 Byte/sample instead of 4 Bytes/sample in binary files) but decreases the precision of the values.

If the high definition mode is active (option R&S RTP-K17), the data format is integer 16 bit, except for peak detect decimation (8 bit). See "Export" on page 138.

Only y-values are exported, the "Interleaved x/y" option is not available.

Currently, the setting is not available for the export of digital channel data.

Data conversion:

To convert INT8 or INT16 data to physical quantities, e.g. voltages, use the following formulas:

*ConversionFactor = VerticalScale * VerticalDivisionCount / NofQuantisationLevels*

*PhysicalQuantity = (Value_ADC * ConversionFactor) + VerticalOffset*

The raw values are written in the `*.Wfm.*` file, all other values can be found in the corresponding header file.

	INT8	INT16, HD mode
VerticalScale	0.05	0.05
NofQuantisationLevels	253	253 * 256
VerticalDivisionCount	10	10
Value_ADC	-61	-61
ConversionFactor	0.05 * 10 / 253 = 0.00197628	0.05 * 10 / (253 * 256) = 0.0000771986
Voltage	(-61 * 0.00197628) + 0 = -120.5 mV	(-61 * 0.0000771986) + 0 = -4.7091146 mV

Remote command:
`EXPort:WAVeform:RAW` on page 1286

Byte order
Sets the endianess for INT16 data:
- LSB first: little endian, least significant byte first
- MSB first: big endian, most significant byte first

Remote command:
`FORMat:BORDer` on page 978

11.2.3 Waveform Histogram

Access: [Save Recall] > "Histogram"

The waveform histogram export saves data in two files. The `*.Wfm.*` file contains 256 or 512 absolute or relative histogram values. The other file is the header file.

Contents of the header file:
- Source waveform of the histogram
- Histogram mode: vertical or horizontal
- Incidence of exported values: absolute or relative
- Histogram range: XStart, XStop, YStart, YStop

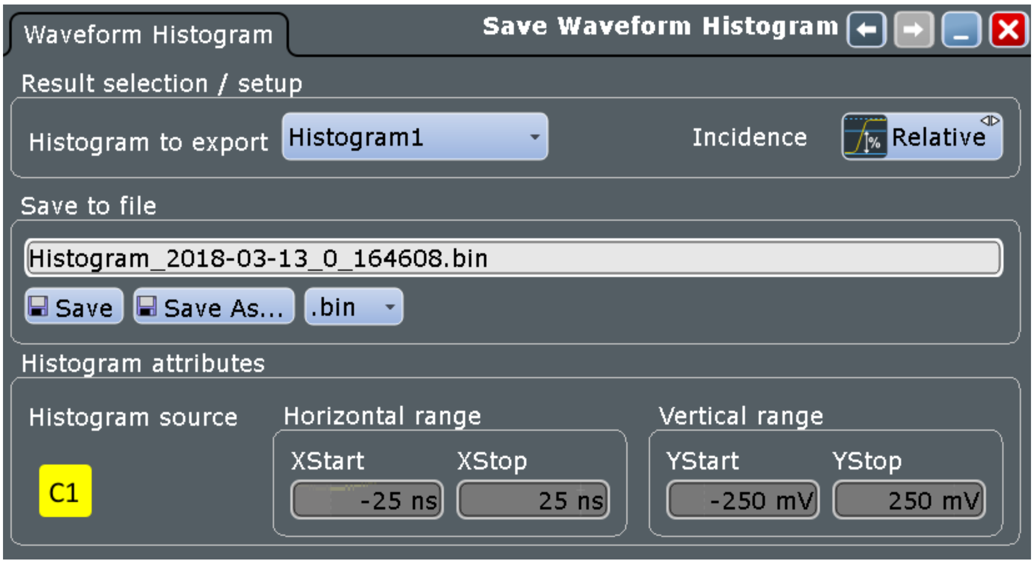
- Name of the exported histogram

Data conversion:

Using the header data, you can calculate the waveform value to which a histogram value belongs:

*YValue = (YStop - YStart) / HistogramValuesCount * HistogramValueNumber + YStart*

YStart	-0.25 V
YStop	0.25 V
HistogramValuesCount	256 (total number of written rows in a CSV file)
HistogramValueNumber	68 (number of the row in a CSV file)
Y-Value	(0.25 - (-0.25)) / 256 * 68 - 0.25 = -0.11719 V



Histogram to export
Selects the histogram to be exported. All active waveform histograms are shown in the list.

Remote command:
`EXPort:HISTogram:SELect` on page 1287

Incidence
Sets the mode of exported histogram data: relative or absolute count of values. If relative values are exported, the sum of all values is 1, and the count of each value is set in relation to the sum.

Remote command:
`EXPort:HISTogram:INCidence` on page 1287

Save to file
Enter the filename to save the waveform histogram to. Double-tap the filename to open the file selection dialog box.

By default, the filename has the prefix "Histogram_". You can define a pattern for automatic naming in the "Autonaming" tab. The default directory is:

`C:\Users\Public\Documents\Rohde-Schwarz\RTP\Histograms`

"Save"	Saves the histogram data in the selected file.
"Save As..."	Opens the file selection dialog box and saves the histogram data to the selected file. See also Chapter 11.7, "File Selection Dialog", on page 461
".bin/.xml/.csv"	Selects the file format.

Remote command:
`EXPort:HISTogram:NAME` on page 1287
`EXPort:HISTogram:SAVE` on page 1287
`EXPort:HISTogram:DATA?` on page 1288

Histogram source, Horizontal range, Vertical range
Show the source and the limits of the histogram area for information. The ranges are set in the "Histogram" dialog box ("Meas" menu > "Histogram"). See also: Chapter 7.2.8.4, "Histogram Setup", on page 328.

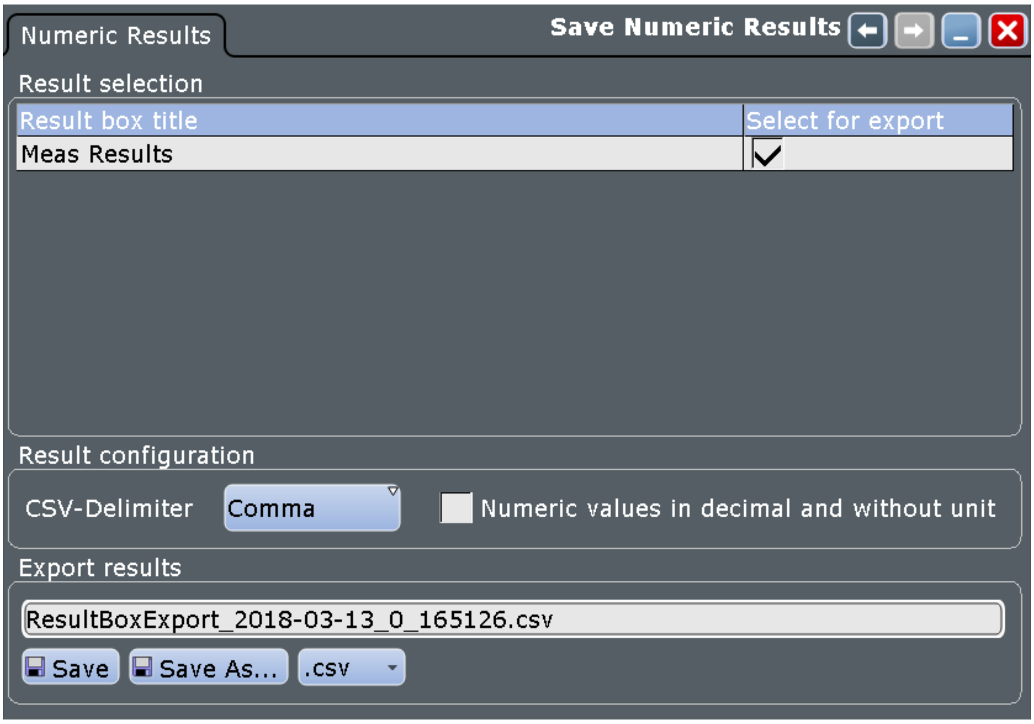
11.2.4 Numeric Results

In this tab, you can select the result boxes to be saved, and define the storage settings.

Access: [Save Recall] > "Numeric Results"

Access to the tab is available in all tabs where measurement and analysis settings are defined, for example, in the "Measurements Setup", "Cursors Setup", and "Masks Test Definition" tabs: Simply tap the "Result Export" button.

Furthermore, you can export the decode result tables of serial protocol analysis.



Result selection
The table lists all result boxes and decode tables that are currently open, including minimized boxes and docked boxes. Select the results that you want to save to file. All results are written into one file.

Note: If the result box is minimized, only the columns shown on the result icon are saved (2 columns). Statistical results are not shown on the minimized results icon, and they are not saved.

Remote command:
`EXPort:RESult:SELect` on page 1288

CSV-Delimiter
Selects the value delimiter that is used to convert the values in columns (CSV files). For MS Excel, the semicolon is recommended to be used.

Remote command:
`EXPort:RESult:DELimiter` on page 1288

Numeric values in decimal and without unit
By default, numeric result values are written with their unit to the file. If the option is enabled, the values are saved with more decimal places.

Remote command:
`EXPort:RESult:NUMeric` on page 1289

Export results
Enter the filename to save the results to. Double-tap the filename to open the file selection dialog box.

By default, the filename has the prefix "ResultBoxExport_". You can define a pattern for automatic naming in the "Autonaming" tab.

"Save" Saves the selected results to the indicated file.

"Save As..." Opens the file selection dialog box and saves the selected results to the selected file. See also Chapter 11.7, "File Selection Dialog", on page 461

".csv/.html" Selects the file format.

- CSV: comma-separated values.
  You can select the value delimiter with "CSV-Delimiter" to ensure that the file can be read by the analyzing software. The decimal separator is the point.
  Tip for using MS Excel: It is recommended that you use the semi-colon as csv delimiter. When you open the file with MS Excel, use "File > Open" and follow the wizard to set the separators correctly, or set the separator settings with "Tools > Options > International".
- HTML: Results are saved as web page for display in a browser.

Remote command:
`EXPort:RESult:NAME` on page 1289
`EXPort:RESult:SAVE` on page 1289

11.2.5 Result Analysis

Access: [Save Recall] > "Result Analysis"

You can export the data of long-term measurements, the measurement histogram and track data to file.

The measurement export saves results in two files. The `*.Wfm.*` file contains data values, and the other file is the header file.

The header file contains:

- Source waveform of the measurement
- Measurement scale
- Export type = Histogram, Long term or Track
- Exported measurement
- Histogram range: XStart, XStop, YStart, YStop
  The range is only relevant for export type = histogram. The measurement axis is the X-axis, which can be a horizontal or vertical axis depending on the histogram mode.

Long-term measurements: The `*.Wfm.*` file contains one value or value set for each long-term measurement point. The maximum number of points is defined in the "Horizontal scaling" dialog box.

- If statistics are disabled, the current result of the main measurement is written - one double value per long-term point.
- If statistics are enabled, seven values for each long-term point are saved:

– Current value of the long-term point
– Upper peak
– Lower peak
– Average
– Standard deviation
– Event count per point: number of measurement results that creates one long-term point
– Waveform count per point: number of waveforms included in one long-term point.

Measurement histogram: The `*.Wfm.*` file contains 1000 absolute or relative histogram values.

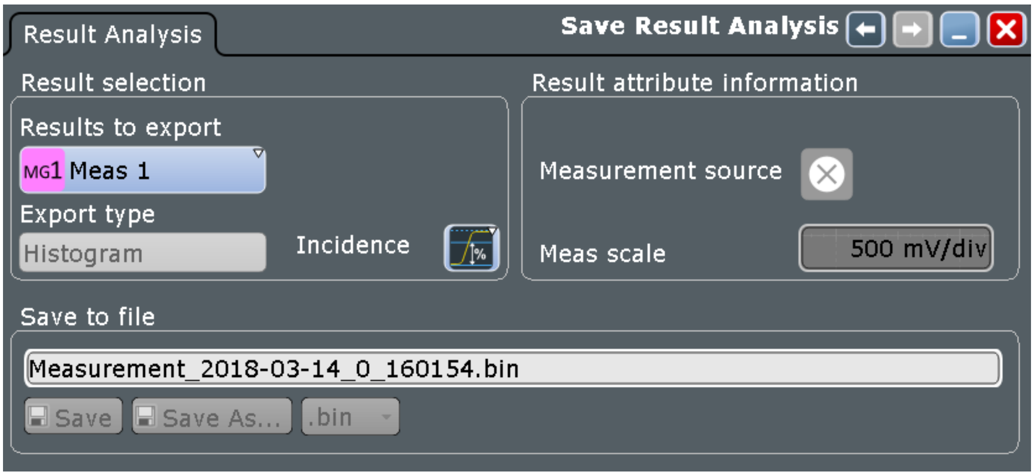
Data conversion of measurement histogram data:

Using the header data, you can calculate the measurement value to which a histogram value belongs:

*MeasValue = (XStop - XStart) / 1000 * HistogramValueNumber + XStart*

Example: The 273rd histogram value is 0.491749. That means, the relative frequency of the measurement value 0.1246 V is 0.491749.

XStart	0.07 V
XStop	0.27 V
HistogramValueNumber	273 (number of the row in a CSV file)
MeasValue	(0.27 - 0.07) / 1000 * 273 + 0.07 = 0.1246 V



Results to export
Selects the measurement to be exported.

Remote command:
`EXPort:MEASurement:SELect` on page 1289

Export type
You can export the result data of the long-term measurement, the measurement histogram or the track. To export the data, the required type must be enabled in "Measurements > Long Term/Track": "Long term Enable", "Histogram Enable" or "Track".

Remote command:
`EXPort:MEASurement:TYPE` on page 1289

Incidence
Sets the mode of exported histogram data: relative or absolute count of values. If relative values are exported, the sum of all values is 1, and the count of each value is set in relation to the sum.

Remote command:
`EXPort:HISTogram:INCidence` on page 1287

Measurement source, Meas scale
Show the measurement settings source and scale for information.

Save to file
Enter the filename to save the measurement data to. Double-tap the filename to open the file selection dialog box.

By default, the filename has the prefix "Measurement_". You can define a pattern for automatic naming in the "Autonaming" tab. The default directory is:

`C:\Users\Public\Documents\Rohde-Schwarz\RTP\Measurements`

"Save"	Saves the measurement data in the selected file.
"Save As..."	Opens the file selection dialog box and saves the measurement data to the selected file. See also Chapter 11.7, "File Selection Dialog", on page 461
".bin/.xml/.csv"	Selects the file format.

Remote command:
`EXPort:HISTogram:NAME` on page 1287
`EXPort:MEASurement:SAVE` on page 1290
`EXPort:MEASurement:DATA?` on page 1290

11.2.6 Saving and Loading Waveform Data

You can save the data of a channel, math or reference waveform to an `.xml`, `.csv`, or `.bin` file. The data export of several channels into one file is also possible. Files in `.bin` format can be reloaded to the R&S RTP as reference waveforms.

Instead of a complete waveform, you can also save a part of it, limited by a previously defined zoom, cursor lines, measurement gate or user-defined time values.

To save waveform data quickly, you can add the "Save Waveform" icon to the toolbar and use it for saving. The icon does not work for saving actions that are started with "Start export" (data logging and multiple history waveforms).

It is also possible to save history data to file. Furthermore, you can save a "live record" of a running RUN Nx SINGLE acquisition to one data file.

For details on waveform save/recall settings, see Chapter 11.2.2, "Waveforms - Export Settings", on page 435.

The following procedures are described:

- "To save a waveform or a part of a waveform to a file" on page 447
- "To save a waveform using the toolbar icon" on page 447
- "To export waveform data of a running acquisition" on page 448
- "To save the history data" on page 265
- "To load a reference waveform" on page 239
"To save a reference waveform" on page 239

To save a waveform or a part of a waveform to a file

1. Press the [Save Recall] key.
2. In the "Save" tab, tap the "Waveform" button.
3. Select the waveforms to be saved:
   - To save one waveform, tap the "Source" icon and select the waveform.
   - To save data of several channels, enable "Multi channel" and select the channels.
4. In the "Scope" list, select the part of the waveform record to be saved. Zoom, cursor and gate segments require the same setup for the selected waveform before saving. For "Manual", enter the "Start" and "Stop" time of the section.
5. Check the filename under "Save to file" and change it if needed. Usually, autonaming is used.
6. Check the file format and the "Export format" settings and change them if needed.
7. Tap "Save" to save the waveform data to the specified file.
   Tap "Save As" to save the waveform data to a different file or file type. Select the file from the file selection dialog box.

To save a waveform using the toolbar icon

1. Add the "Save Waveform" icon to the toolbar, see Chapter 2.3.5.2, "Configuring the Toolbar", on page 64.
2. Set the scope, export format, and other parameters in [Save Recall] > "Waveforms / Results" > "Waveforms".
3. If necessary, adjust the autonaming pattern and the storage path in [Save Recall] > "Autonaming".
4. To save the waveform data:

a) Tap the "Save Waveform" icon on the toolbar.

b) Tap the waveform to be saved.
If you tap the diagram background, the data of the focused waveform is saved.

To export waveform data of a running acquisition

1. Select the waveforms to be saved and the scope as described in "To save a waveform or a part of a waveform to a file" on page 447, step 1 to 5.
2. If you want to save only a section of each waveform, set the "Scope".
3. Enable "Data logging".
4. Enter the number of acquisitions to be acquired and saved in "Acq count".
5. Check the filename under "Save to file" and change it, if needed. Usually, autonaming is used.
6. Tap "Start Export" to start the acquisition and to save the acquired waveform data to the specified file.

To load waveform data as a reference waveform

To reload waveform data from a previous measurement, the waveform must have been stored as a reference waveform in a BIN file before.

The procedure is described in "To load a reference waveform" on page 239

11.3 Screenshots

To store the graphical results of the measurement, you can either print the current display on a printer or save an image to a file. The instrument saves or prints a screenshot of the graphic area. To document current settings, the open dialog box can be included in the screenshot.

The "Save Screenshot" toolbar icon saves the current display to a file according to the settings in "File" menu > "Print setup". See also Chapter 2.3.5.2, "Configuring the Toolbar", on page 64.

You can configure the [Camera] key to save or print screenshots by a single keypress. See also Chapter 3.3.2, "Hardkeys: Function Assignment", on page 85.

If a USB flash drive is connected to the instrument, the default path of the user data directory is set to the drive letter of the USB flash drive. Thus, you save data to USB flash drive automatically, and you can change the directory in the file explorer at any time.

Screenshots on a computer using the Web interface

If the R&S RTP is connected to a LAN, you can create and save screenshots of the instrument's display on a computer. See Chapter 19.3.2, "Web Browser", on page 936.

Meta information in screenshots

The meta data of the screenshot also contains instrument information. In PNG and JPEG files, meta information is saved as EXIF information and can be read, for example, using the ExifTool.

Example:

Reading meta information using the ExifTool.

Command: `# exif C:\Screenshot_2016-07-14_0_110551.png`

Result:

```
ExifTool Version Number          : 10.20
File Name                        : Screenshot_2016-07-14_0_110551.png
Directory                        : C:/
File Size                        : 37 kB
File Modification Date/Time      : 2016:07:14 11:05:51+02:00
File Access Date/Time            : 2016:07:14 11:05:51+02:00
File Creation Date/Time          : 2016:07:14 11:05:51+02:00
...
Instrument Firmware Version      : 3.30.0.46
Instrument Material Number       : 1329.7002k44
Instrument Serial Number         : 123456
Image Size                       : 1280x800
Megapixels                       : 1.0
```

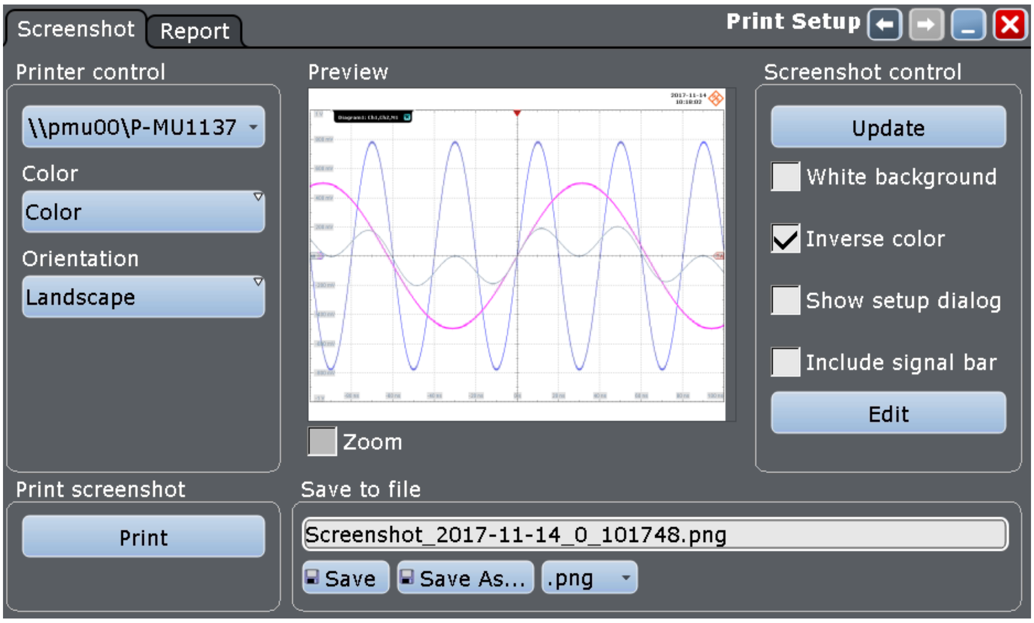
11.3.1 Screenshot Settings

Access: "File" menu > "Print setup"

In the "Screenshot" dialog box, you configure the image to be printed, saved, or included in a report. You select the printer and the storage location for screenshot files. The image is created when you open the dialog box, and can be updated at any time.

You can also edit the image before saving or printing, and include an open dialog box or the sidebar in the image.

You can print and save the image in the "Screenshot" dialog box. To save screenshots quickly, use the "Save Screenshot" toolbar icon, or configure and use the [Camera] key.



Printer

Selects a configured printer to print screenshots and reports. You can use a local printer or a network printer. The instrument firmware uses the Windows printer configuration, no additional printer setup is required. To make a printer available for R&S RTP, add and configure it in the Windows operating system: "Settings" > "Devices" > "Printers and scanners". Only users with administrator rights can fulfill this task.

Depending on the printer driver, printing to a file is also possible. By default, the Rohde & Schwarz printer drivers for BMP, JPG, PDF, PNG, and TIFF files are installed.

Remote command:
`SYSTem:COMMunicate:PRINter:SELect<1..2>` on page 1296

Color

Defines the color mode for printing. The setting affects the output on a printer and also the printing to BMP, JPG, PDF, PNG, and TIFF files.

"Black and white" Black and white output

"Color" Color output

Remote command:
HCOPy:DEVice<m>:COLor on page 1293

Orientation

Toggles the page orientation between "Landscape" and "Portrait."

Remote command:
HCOPy:PAGE:ORIentation<1..2> on page 1293

Print

Prints the current image together with saved editing changes on the selected Printer.

If the printer is configured to print to a file, "Print" is an alternative of "Save image to file".

Remote command:
HCOPy:DESTination<1..2> on page 1291
HCOPy:IMMediate<m>[:DUM] on page 1295
HCOPy:IMMediate<m>:NEXT on page 1295

Preview

Shows a preview of the screenshot. The image is created when the dialog box opens.

Zoom ← Preview

Enlarges the preview display and adds scrollbars to zoom into specific areas of the print image. Zooming does not affect the original display.

Update

Updates the preview of the screenshot with the current display view, e.g. after changes to the settings have been made, or an additional channel has been activated.

White background

Inverts the background color. So you can print waveforms with normal waveform colors on white background.

If both "White background" and Inverse color are enabled, the instrument inverts the background twice, and it appears black.

"White background"	"Inverse color"	Background	Waveform and results
On	Off	White	Screen colors
Off	On	White	Inverted colors
On	On	Black	Inverted colors
Off	Off	Black	Screen colors

Remote command:
HCOPy:WBKG on page 1294

Inverse color

Inverts the colors of the output, i.e. a dark waveform is printed on a white background.

See also: "White background" on page 451.

Remote command:
`HCOPy:DEVice<m>:INVerse` on page 1293

Show setup dialog
If you want to save dialog boxes in screenshots, enable "Show setup dialog". The currently open dialog box is included in the screenshot. Use the [Camera] key to print or save the display.

Remote command:
`HCOPy:SSD` on page 1294

Include signal bar
If enabled, the screenshot shows the sidebar beside the diagram area.

Remote command:
`HCOPy:ISBA` on page 1294

Edit
Opens the screenshot in the Paint application. Edit the image as necessary. You can store the file using "Save as" or print the file from Paint. Alternatively, save the file and close the Paint application to return to the "Print Setup" dialog, then print or save the edited image. The changes are not shown in the preview.

Save to file
Defines the filename to which screenshot is saved. By default, the filename has the prefix "Screenshot_". Double-tap the filename filed to change the name.

If a USB flash drive is connected to the instrument, the default path of the user data directory is set to the drive letter of the USB flash drive. Thus, you save data to USB flash drive automatically, and you can change the directory in the file explorer at any time.

"Save"	Saves the current screenshot to the specified file.
"Save As..."	Opens the file selection dialog box. Here you can adjust the target directory and the file name and save the current screenshot to the file. The symbols of important target folders are listed on the left of the file explorer.
"Delete"	Opens the file selection dialog box and deletes the selected file.

Remote command:
`HCOPy:DEVice<m>:LANGuage` on page 1292
`HCOPy:DESTination<1..2>` on page 1291
`MMEMory:NAME` on page 1292
`HCOPy:IMMediate<m>[:DUM]` on page 1295
`HCOPy:IMMediate<m>:NEXT` on page 1295
`MMEMory:DELete` on page 1275

11.3.2 Printing Screenshots

You can configure the format and colors used for printing, and edit the image.

1. Open the "File" menu and select "Print setup". You can use a local printer or a network printer. Depending on the printer driver, printing to a file is also possible. See also "Printer" on page 450.
2. Tap the printer selection box. Select the printer.
3. Tap the "Color" selection box to configure black and white or color images.
4. Tap the "Orientation" selection box and select the paper format.
5. To enhance the images for print on white paper, enable "White background" or "Inverse color".
6. If the current display is likely to have changed since you have opened the "Print Setup" dialog box (e.g. due to a running measurement), tap "Update image".

   The screenshot is updated.
7. To zoom into the screenshot, enable the "Zoom" option beneath the preview area.

   The image is enlarged and scrollbars are displayed to scroll through the image.
8. To edit the image in an external application and process it further from there, tap "Edit image".
9. To print the image to the selected printer, tap "Print".

11.3.3 Configuring and Saving Screenshots

You can edit the image, invert all colors, and set the background color. A preview of the current image is shown for reference.

1. Open the "File" menu and select "Print setup".
2. To enhance the images for later print on white paper, enable "White background" or "Inverse color". If you print this image later on a monochrome printer, you get a grayscaled picture. The contrast of the resulting gray lines depends on waveform colors and the used printer.
3. Select the file format: png, jpg, or another one.
4. To change the directory, tap "Save As" and configure the path.

   The symbols of often used target folders are listed on the left of the file explorer. By default, screenshots are saved in the `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\ScreenShots` directory.
5. Tap "Save".

The file is saved and the dialog box closes.

6. Check if the screenshot is saved to the desired directory.
7. To save further screenshots, use one of the following ways:
   - Configure the [Camera] key. Press the key to save a screenshot. See also Chapter 3.3, "Frontpanel Setup", on page 85.
   - Add the "Save Screenshot" icon to the toolbar. Tap the icon to save an image. See also Chapter 2.3.5.2, "Configuring the Toolbar", on page 64.
   - In the "Print setup" dialog box, tap "Save" to save the image to the specified file.
   - To save the image with a dedicated filename or to another directory, open the "Print setup" dialog box and tap "Save As". Select the path, enter a filename, and tap "Save".

Printing on a black-and-white printer

- If you use the "White background" or "Inverse color" settings and save the image to a file, you get a grayscaled picture. The contrast of the resulting gray lines on the printout depends on waveform colors and the used printer.
- To get a monochrome image, set the "Color = Black and white" and tap "Print" to start the direct printout or the print to file. See also "Printer" on page 450.

11.4 Reports

Reports document the current measurement and test results. The report contains general information, current vertical and horizontal settings, trigger settings, active channels and all current results except for zoom and search results. A screenshot is also included.

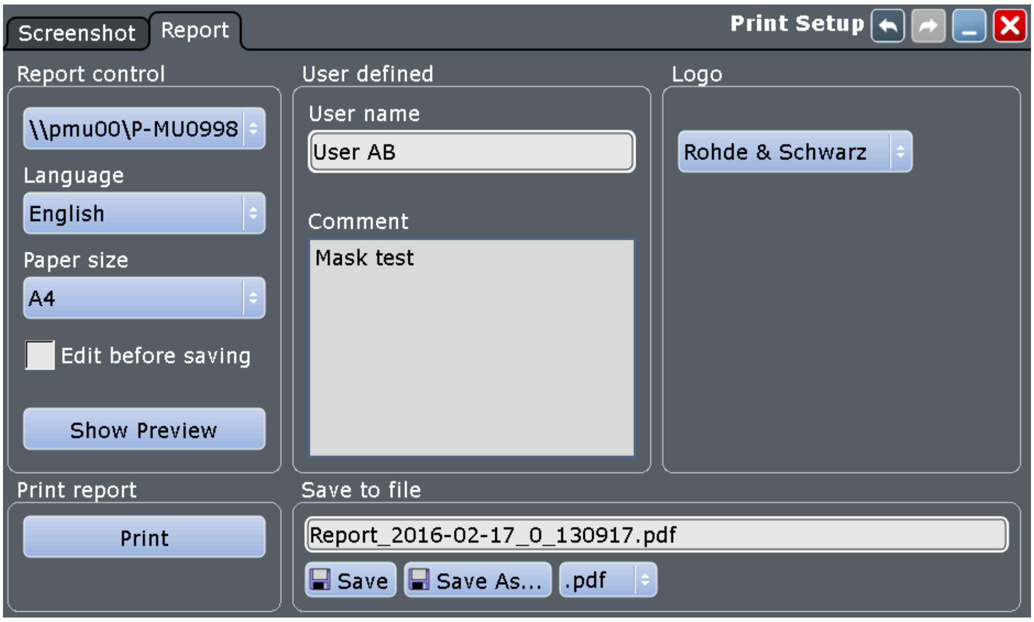
The report is configured in the "Report" tab, the screenshot is configured in the "Screenshot" tab.

You can create the report manually, or automatically on defined events:

- Press the [Camera] key. Before, configure the key to create or print reports, see Chapter 3.3, "Frontpanel Setup", on page 85
- Tap the "Create report" toolbar icon.
  Before, add the icon to the toolbar, see also Chapter 2.3.5.2, "Configuring the Toolbar", on page 64.
- Action on micro button, available on active Rohde & Schwarz probes
- Action on trigger
- Event action at mask testing
- Event action at limit checks

11.4.1 Report Settings

Access: "File" menu > "Report Setup"



Printer

See "Printer" on page 450.

Language

Selects the language to be used in the report. Available languages are listed in the data sheet.

Remote command:

`REPort:LANGuage` on page 1296

Paper size

Selects the paper size: A4 or US Letter.

Remote command:

`REPort:PAPersize` on page 1297

Edit before saving

Enables you to edit the report info when you save reports using the [Camera] key. When you press the key, a dialog box opens where you can change the user name and the comment.

Show Preview

Opens the current report in PDF format.

User name / Comment

Enter information that appears in the general information section at the beginning of the report.

Remote command:
`REPort:USER` on page 1297
`REPort:COMMent` on page 1297

Logo
By default, the Rohde & Schwarz logo is shown in the header of the report pages. You can switch the logo off, or select your logo to be shown. A preview of the selected log file is shown.

Remote command:
`REPort:LOGType` on page 1297
`REPort:LOGO` on page 1297

Print
Starts the printout to the configured printer.

Save to file
Select the file format and define the filename of the report file. By default, the filename has the prefix "Report_".

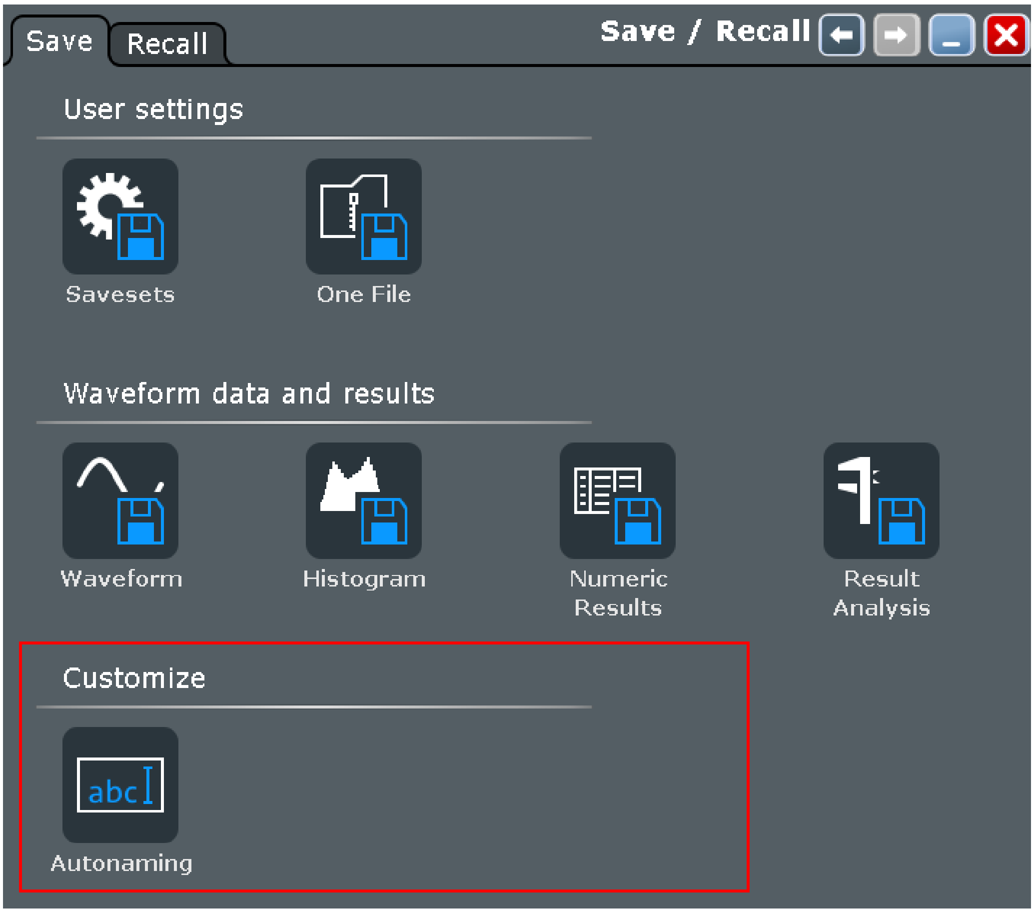
Double-tap the filename to open the file selection dialog box.

"pdf/doc/html"	Selects the report format.
"Save"	Saves the current report to the specified file.
"Save As..."	Opens the file selection dialog box and saves the report to the selected file.

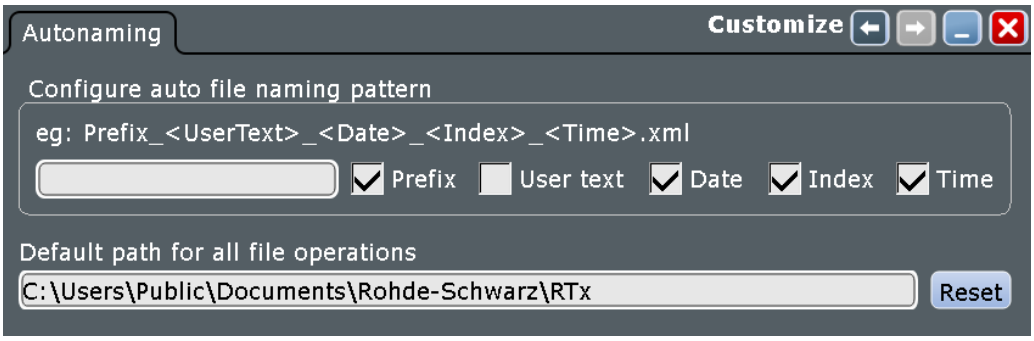
Remote command:
`REPort:FILE:NAME` on page 1297
`REPort:FILE:SAVE` on page 1298

11.5 Autonaming

Access: [Save Recall] > "Save" tab



11.5.1 Autonaming Settings



In this tab, you can define the pattern for automatic file name generation. This name is used as the default file name. The default path is the storage location for all saved files and their subdirectories.

Prefix
If enabled, inserts the default prefix in the file name. The prefix indicates the type of data that is saved, for example, Histogram, RefCurve, Settings.

Remote command:
MMEMory:AUTonaming:PREFix on page 1279

Text input
User-defined text to be inserted after the prefix.

Remote command:
MMEMory:AUTonaming:TEXT on page 1279

User text (enable)
If enabled, inserts the specified user text after the prefix.

Remote command:
MMEMory:AUTonaming:USERtext on page 1279

Date
If enabled, inserts the current date.

Remote command:
MMEMory:AUTonaming:DATE on page 1279

Index
If enabled, inserts an index.

Remote command:
MMEMory:AUTonaming:INDex on page 1279

Time
If enabled, inserts the current time.

Remote command:
MMEMory:AUTonaming:TIME on page 1279

Default path for all file operations
Defines the default path displayed in the file selection dialog box for loading and storing operations. If a USB flash drive is connected, the path is set automatically to the drive letter of the USB flash drive.

To switch the directory quickly, double-tap the input field. Use the symbols on the left of the file explorer box to change the directory.

Remote command:
MMEMory:AUTonaming:DEFaultpath on page 1279

Reset
Resets the default file path to the factory default.

Remote command:
MMEMory:AUTonaming:RESPath on page 1280
MMEMory:AUTonaming:RESall on page 1280

11.5.2 Defining Default File Paths and Names

When a save or load operation is performed, a default file name and path is provided. You can configure which path is used and how the file name is generated. In the file selection dialog box, you can change the folder and name as desired.

To define the default file path

1. Press the [Save Recall] key.
2. Select the "Save" tab.
3. Press the "Autonaming" button.
4. Double-tap the "Default path for all file operations" field.

   The directory selection dialog box is opened.
5. Select the folder in which the data is to be stored by default. Use the symbols on the left of the file explorer box to switch to often used directories.
6. To restore the factory-set default path, tap "Reset" next to the path field.

To define the automatic file name pattern

The automatic file name pattern can consist of the following elements:

<Prefix>_<UserText>_<Date>_<Index>_<Time>

The prefix depends on the data type to be stored and cannot be changed by the user. The other elements can be enabled or disabled as required.

1. Press the [Save Recall] key.
2. Select the "Autonaming" tab.
3. To insert a user-defined text after the prefix, enter the text in the edit field. and enable "User text".
4. If you want to exclude the prefix, current date, time or an index (serial number), disable the corresponding option.

   The specified elements are used to generate the default file name for the next storage operation.

11.6 Preset Setup

A user-defined preset contains the complete instrument setup including display settings, except for transparency and intensity. You can save the current configuration to a preset file, and load a previously saved preset file. You can then specify that these settings are to be applied with the [Preset] key.

11.6.1 User-defined Preset - Settings

Access: "File" menu > "Preset setup"

Save to or load from file
The file name with extension `.dfl` to load or to save the settings to.

For details, see the Save to file function in the "Settings" tab.

Enable user-defined preset
If enabled, the settings from the selected preset file are restored when the [Preset] key is pressed.

If disabled, [Preset] sets the instrument to the factory defaults.

Factory defaults
Resets the instrument to the factory default settings, to the initial state. Factory settings comprise all instrument settings, including display, intensity and transparency settings. After loading factory defaults, perform a self-alignment to synchronize the signal data ("File" menu > "Selfalignment").

Remote command:
`SYSTem:PRESet` on page 981

11.6.2 Restoring Settings

When you have changed many different settings on the instrument and are no longer sure which settings are causing which effect in the measurement, you may want to restore the default settings and start anew. The following methods are available:

- Saving instrument settings to a user-defined preset and restoring the instrument settings to user-defined default values
- Restoring all settings on the R&S RTP to the factory-defined values

- Restoring settings from a file (see "To load settings from a saveset file" on page 427)

For details on save/recall instrument settings and associated remote commands, see Chapter 11.1.1, "Savesets", on page 422.

To save a user-defined preset

1. Press the "File" menu > "Preset setup".
2. Enter a name for the preset file. Select the file format.
3. Tap Save.

   Note: If you want to store the file in another directory than the default one, select "Save As". See also: Chapter 11.7, "File Selection Dialog", on page 461

To restore the instrument settings to user-defined default values

1. Press the "File" menu > "Preset setup".
2. Tap "Open" and select the preset file that contains the required settings.

   The instrument settings are restored to values that are stored in the file.
3. To use these settings as preset values, select "Enable user-defined preset".
4. Press the [Preset] key.

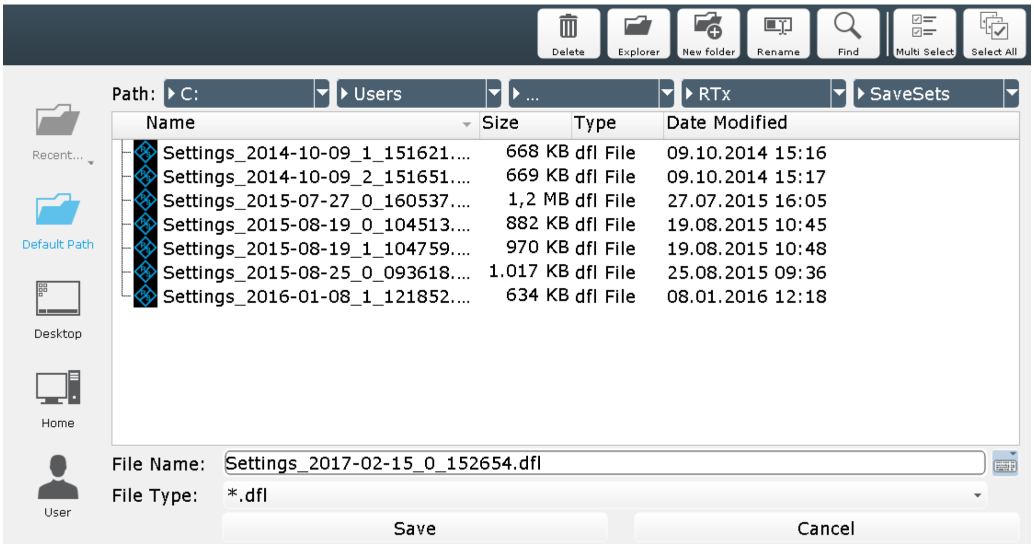
To restore all settings to the factory defaults

1. Press the "File" menu > "Preset setup".
2. Tap the "Factory defaults" button.

   All settings on the R&S RTP are reset to their factory-defined values. As long as no user-defined preset file is loaded and Enable user defined preset is disabled, the [Preset] key also resets the instrument settings to factory defaults.

11.7 File Selection Dialog

The file selection dialog provides a file explorer from which you can select a file to load or to save data to. You can also manage your files in this dialog.



Path

Tap the path elements to change the current folder. The default folder is defined in Default path for all file operations.

You can save the data in a local folder on the instrument, to an external storage device (usually a USB flash drive), or to a folder on a connected network drive. The path list provides all available drives and folders.

On the left, shortcut icons provide access to often used folders.

Toolbar

The toolbar on the top provides various functions for file management.

File Name

The file name to be loaded or stored to. Double-tap the file name, or tap the keyboard icon to enter the file name using the online keyboard.

The default file name for new files is defined in the "Autonaming" tab, see Chapter 11.5, "Autonaming", on page 456.

File Type

The file extension of the file to be loaded or stored to.

Save, Select

Selects the specified file for the open or save operation and closes the dialog box.

Cancel

Closes the dialog box without selecting a file.

12 Protocol Analysis

Using the serial protocol options for the R&S RTP, you can analyze various serial protocols.

12.1 Basics of Protocol Analysis

Before you can analyze a serial signal, the bus has to be configured according to the protocol and specifics of the signal. The configuration contains:

- Assignment of the data and clock lines to the input channels
- Logical thresholds
- Protocol-specific settings

Serial data can be analyzed in several ways:

- Triggering: You can trigger on various events that are typical for the selected protocol type, for example, on start and stop of messages, or on specified data patterns in the message.
  Triggering on a trigger event sequence is not supported, and holdoff settings are not available.
- Protocol decoding: The digitized signal data is displayed on the screen together with the decoded content of the messages in readable form, and the decode results are listed in a table.
- Search on decoded signal data: For most serial protocols, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, because several event types can be combined. Thus, you get the results for the complete acquisition cycle.

12.1.1 Decode - General Settings

For all protocols, configuration starts with the selection of the serial bus and the protocol. The "Trigger Setup" button leads directly to the trigger configuration.

Table 12-1: Configuration settings are protocol-specific. They are described in the related chapters:

CAN, CAN FD	Chapter 12.5.1, "CAN and CAN-FD Configuration", on page 511
Custom: Manchester / NRZ	Chapter 12.12.2, "Custom: Manchester / NRZ Configuration", on page 687
I²C	Chapter 12.2.2, "I²C Configuration", on page 473
LIN	Chapter 12.6.2, "LIN Configuration", on page 550
MDIO	Chapter 12.14.2, "MDIO Configuration", on page 736
MIPI D-PHY	Chapter 12.10.2, "D-PHY Configuration", on page 630
MIPI M-PHY	Chapter 12.11, "M-PHY and USB SSIC (Option R&S RTP-K44 and -K64)", on page 647
MIPI RFFE	Chapter 12.9.2, "RFFE Configuration", on page 606
SPI	Chapter 12.3.2, "SPI Configuration", on page 489
UART	Chapter 12.4.2.1, "UART Configuration Settings", on page 502
USB 3.1	Chapter 12.15.2, "USB 3.1 Configuration", on page 759
USB PD	Chapter 12.16.2, "USBPD Configuration", on page 774
USB SSIC	Chapter 12.11.2, "M-PHY Configuration", on page 649
8b/10b	Chapter 12.13.2, "8b/10b Configuration", on page 722
DDR3	Chapter 12.18.1, "DDR3 Configuration", on page 818

Make sure that the tab of the correct serial bus is selected on the left side.

Protocol

Defines the protocol type of the selected serial bus.

Remote command:

BUS<m>:TYPE on page 1299

Decode

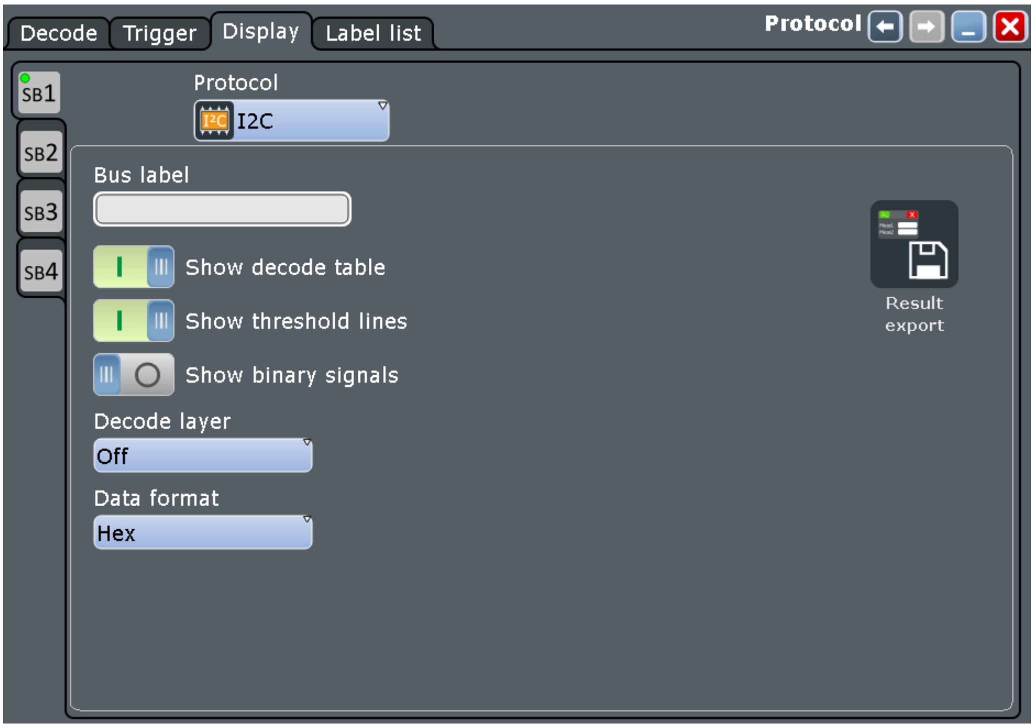
Enables the decoding of the selected bus. The signal icon of the bus appears on the sidebar.

Remote command:

BUS<m>[:STATe] on page 1299

12.1.2 Display

For all protocols, you can select to display the decoded signal as a table and to show the binary signal on the screen. Optionally, you can assign a label to the bus.



For some protocols, the result table provides a button to show the details of the selected frame.

Bus label

Defines a label to be displayed with the bus.

Remote command:

BUS<m>:LABel on page 1299

Show decode table

Opens a table with decoded data of the serial signal. The function requires the option for the analyzed protocol.

Table 12-2: Decode results are protocol-specific. They are described in the related chapters:

CAN, CAN FD	Chapter 12.5.4, "CAN and CAN FD Decode Results", on page 530
Custom: Manchester / NRZ	Chapter 12.12.5, "Custom: Manchester / NRZ Decode Results", on page 715
I²C	Chapter 12.2.5, "I²C Decode Results", on page 482
LIN	Chapter 12.6.5, "LIN Decode Results", on page 557
MDIO	Chapter 12.14.5, "MDIO Decode Results", on page 743
MIPI D-PHY	Chapter 12.10.4, "D-PHY Decode Results", on page 640

MIPI M-PHY	Chapter 12.11.4, "M-PHY Decode Results", on page 667
MIPI RFFE	Chapter 12.9.5, "RFFE Decode Results", on page 620
SPI	Chapter 12.3.4, "SPI Decode Results", on page 496
UART	Chapter 12.4.4, "UART Decode Results", on page 508
8b/10b	Chapter 12.13.4, "8b/10b Decode Results", on page 729
DDR3	Chapter 12.18.3, "DDR3 Decode Results", on page 824

Remote command:
`BUS<m>:RESult` on page 1300

Show binary signals
For each configured line, the binary signal is displayed additionally to the decoded signal.

Show threshold lines
If selected, the threshold levels are displayed in the diagram.

Remote command:
`BUS<m>:THReshold` on page 1300

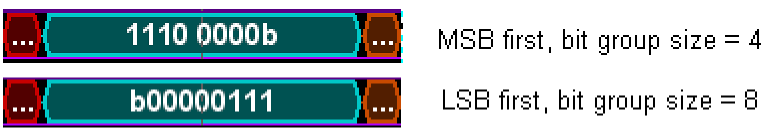
Data format
Sets the data format for decoded data values of the selected bus in the "Decode results" box and in the combs of the decoded signal.

Remote command:
`BUS<m>:FORMat` on page 1301

Binary bit order
Select MSB or LSB to define the data bit order in the combs of the decoded signal. The setting is only available for the binary data format, and only for protocols sending data LSB first.

If the "Binary bit order" is LSB, you can read the bits of an LSB first signal in LSB first order in the combs, while the results table displays the correct values MSB first.

Binary bit group size
Sets the number of bits that forms a bit group in the comb display of the selected bus. The setting is only available for the binary data format, and only for protocols sending data LSB first.



Result export
Opens the "File" dialog box. Select the "Waveforms/Results" tab > "Numeric" subtab to save the decode results to file.

Show details
Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Remote command:
`BUS<m>:RESDetail` on page 1300

12.1.3 Label Lists

For all protocols using ID or address identification, it is possible to create label lists containing addresses or IDs, a symbolic name for each node (symbolic label), and some protocol-specific information.

You can load label lists, and activate its usage for decoding. As a result, an additional "Label" column appears in the "Decode results" table, containing the symbolic label. The frame captions of the decoded signal show the symbolic label instead of the ID or address values. Hence it is easy to identify the messages of the different bus nodes.

You can also use the label list to trigger on an identifier or address. Instead of entering the value, you select the name, which is defined in the label list.

Available file formats are PTT, CSV, DBC (CAN only), and XML (FIBEX files, FlexRay only).

Label lists are protocol-specific. Their contents are described in the corresponding protocol chapters:

- Chapter 12.2.4, "I²C Label List", on page 480
- Chapter 12.5.3, "CAN / CAN FD Label List", on page 528
- Chapter 12.6.4, "LIN Label List", on page 556
- Chapter 12.9.4, "RFFE Label List", on page 618

12.1.3.1 Content and Format of the PTT File

Label lists are stored as PTT (protocol translation table) files. The PTT file format is an extension of the CSV format (comma-separated values). You can edit it with standard editors, for example, with MS Excel or a text editor.

The PTT file has three types of lines:

- Comment lines begin with a hash character #. A hash character at any other position in the line is treated like a standard character.
- Command lines begin with a commercial at character @. An @ character at any other position in the line is treated like a standard character.
- Standard lines are the lines that not qualify as comment or command lines. They build the core of the label list.

Command lines

Command lines define the version of the PTT file and the protocol name:

- @FILE_VERSION: must appear exactly once in the file

- @PROTOCOL_NAME: must appear at least once in the file. Thus, one file can contain several label lists for different protocols.

```
# --- Start of PTT file
@FILE_VERSION  = 1.0
@PROTOCOL_NAME = i2c
[... Label list for I2C]
@PROTOCOL_NAME = can
[... Label list for CAN]
# --- End of PTT file
```

Standard lines

Standard lines define the contents of the label list. The rules for standard lines follow the csv convention, they are:

- Values are separated by commas
- Space characters following a delimiter are ignored
- Values with a special character (comma, newline, or double quote) must be enclosed in double quotes
- Text in double quotes must be escaped by double quote characters

The format of the numeric value is indicated by a suffix. The following formats are supported:

Format	Suffix	Example
Decimal	<empty> d	`106, DeviceName` `106d, DeviceName`
Hexadecimal	h	`6Ah, DeviceName` or prefix: `0x6A, DeviceName`
Octal	o	`152o, DeviceName`
Binary	b	`01101010b, DeviceName`

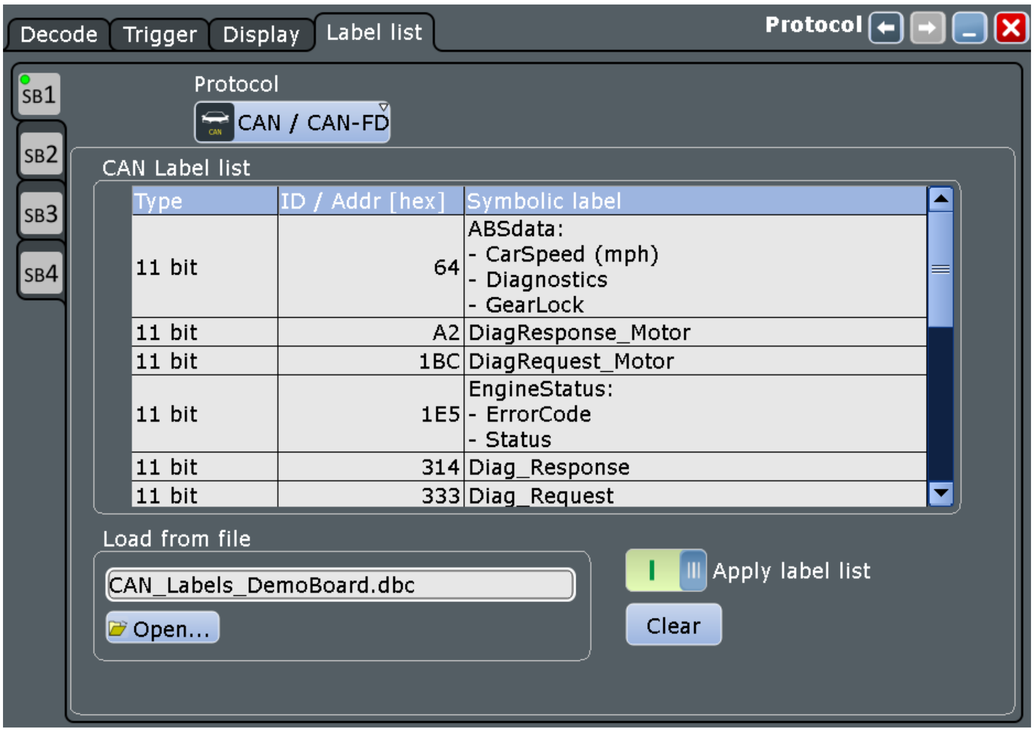
The maximum supported word size for (unsigned) integers is 64 bits.

```
# --- Start of PTT file
@FILE_VERSION  = 1.0
@PROTOCOL_NAME = i2c
#    Following two lines are equal:
7,01h,Temperature
7,01h, Temperature
#    A comma must be enclosed in double quotes:
7,01h,"Temperature, Pressure, and Volume"
#    A double quote must also be enclosed in double quotes:
7,7Fh,"Highspeed ""Master"" 01"
#    Following lines yield the same result:
7d,0x11,Pressure
7h,11h,Pressure
0x7,17d,Pressure
```

```
7,17,Pressure
```

12.1.3.2 Label List - General Settings

In the "Label List" tab, you can load, read and activate label list files.



The common settings for all protocols are:

Save to or load from file
Selects and loads a label list file. Available file formats are PTT, CSV, DBC (CAN only), and XML (FIBEX files, FlexRay only).

Label lists are protocol-specific. Their contents are described in the corresponding protocol chapters:
- Chapter 12.2.4, "I²C Label List", on page 480
- Chapter 12.5.3, "CAN / CAN FD Label List", on page 528
- Chapter 12.6.4, "LIN Label List", on page 556
- Chapter 12.9.4, "RFFE Label List", on page 618

Remote command:
`BUS<m>:NEWList` on page 1301

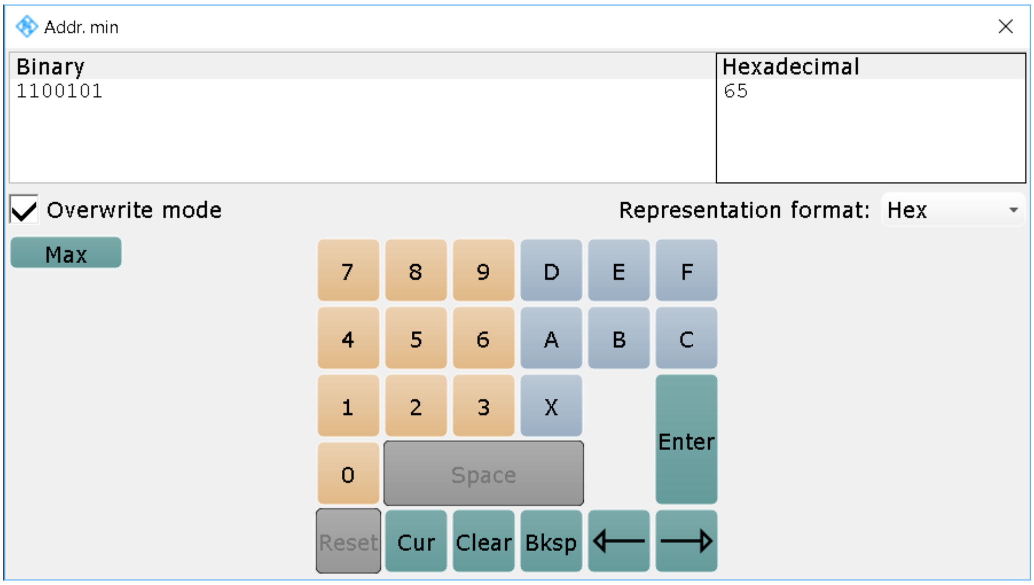
Clear
Deletes the label list from the instrument.

Apply label list
Activates the label list to be used for decoding. The "Label" appear in the "Decode results" table and in the frame captions of the decoded signal.

Remote command:
BUS<m>:SYMBols on page 1302

12.1.4 Bit Pattern Editor

If you want to enter a specified address or data pattern, the bit pattern editor helps you to enter the pattern in various formats - decimal, hexadecimal, octal, binary and ASCII.



The editor displays the pattern in two columns. The left column always shows binary data. For the right column, you can select the format, the default depends on the data specifics. You can edit data in the left or right column. The keypad adapts itself to the column format, only keys appropriate to the format are enabled.

The data is grouped and converted in bit groups. The size of a bit group depends on the address or data specifics and is set by the instrument. Groups are automatically separated by blanks. The maximum size of a bit group is 64 bit, the most common group size is 1 byte.

"Overwrite mode": If disabled, the data behind the new digit is shifted to the right. Bit groups are rearranged automatically.

Format-specific information:

- Unsigned: Decimal data format without sign. It is available for I²C, SPI, UART, CAN, LIN and FlexRay protocols. If you enter a decimal number that is too large for the defined bit group, the number is truncated and a message appears. X (do not care) in the decimal column sets all binary digits of the bit group to X.
- Signed: Signed decimal format, available for audio protocols. The first bit represents the sign. You can use the 2's complement or 1's complement format.
- Binary: 0, 1 and X (do not care) is allowed.
- Hex: most common format in the right column.
- Octal: Each digit represents 3 bit.

- ASCII: In the ASCII column, "X" is the character X. The binary X (do not care) is not allowed. If an X is included in the binary value in the left column, the ASCII columns displays "§" to indicate that the value is not defined.

Where applicable, frequently used values are provided in a "Predefined values" list below the pattern table, for example, reserved end words of data packets in the UART protocol.

12.2 I²C (Option R&S RTP-K1

The Inter-Integrated Circuit is a simple, low-bandwidth, low-speed protocol used for communication between on-board devices.

12.2.1 The I²C Protocol

This chapter provides an overview of protocol characteristics, data format, address types and trigger possibilities. For detailed information, read the "I2C-bus specification and user manual" available on the NXP manuals web page at http://www.nxp.com/.

I²C characteristics

Main characteristics of I²C are:

- Two-wire design: serial clock (SCL) and serial data (SDA) lines
- Master-slave communication: the master generates the clock and addresses the slaves. Slaves receive the address and the clock. Both master and slaves can transmit and receive data.
- Addressing scheme: each slave device is addressable by a unique address. Multiple slave devices can be linked together and can be addressed by the same master.
- Read/write bit: specifies if the master reads (=1) or writes (=0) the data.
- Acknowledge: takes place after every byte. The receiver of the address or data sends the acknowledge bit to the transmitter.

The R&S RTP supports all operating speed modes: high-speed, fast mode plus, fast mode, and standard mode.

Data transfer

The format of a simple I²C message (frame) with 7-bit addressing consists of the following parts:

- Start condition: a falling slope on SDA while SCL is high

- 7-bit address of the slave device that either is written to or read from
- R/W bit: specifies if the data is written to or read from the slave
- ACKnowledge bits: is issued by the receiver of the previous byte if the transfer was successful
  Exception: At read access, the master terminates the data transmission with a NACK bit after the last byte.
- Data: several data bytes with an ACK bit after every byte
- Stop condition: a rising slope on SDA while SCL is high

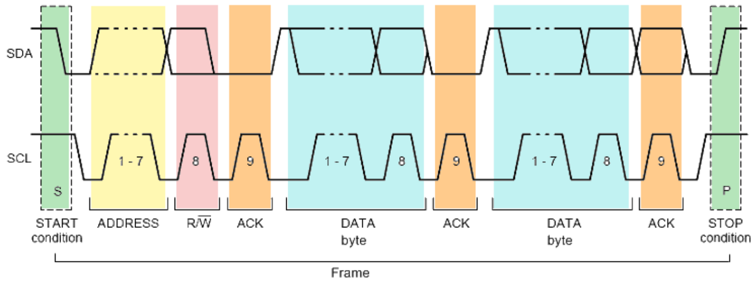


Figure 12-1: I2C writes access with 7-bit address

Address types: 7-bit and 10-bit

Slave addresses can be 7 bits or 10 bits long. A 7-bit address requires 1 byte, 7 bits for the address followed by the R/W bit.

A 10-bit address for write access requires 2 bytes: the first byte starts with the reserved sequence 11110, followed by the two MSB of the address and the write bit. The second byte contains the remaining 8 LSB of the address. The slave acknowledges each address byte.

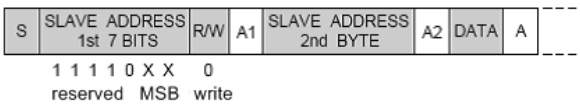


Figure 12-2: 10-bit address, write access

A 10-bit address for read access requires 3 bytes. The first 2 bytes are identical to the write access address. The third byte repeats the address bits of the first byte and sets the read bit.

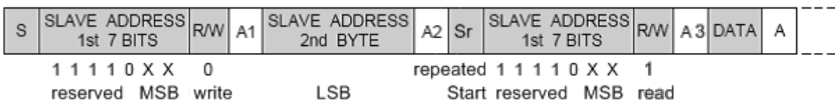


Figure 12-3: 10-bit address, read access

Trigger

The R&S RTP can trigger on various parts of I²C messages. The data and clock lines must be connected to the input channels, triggering on math and reference waveforms is not possible.

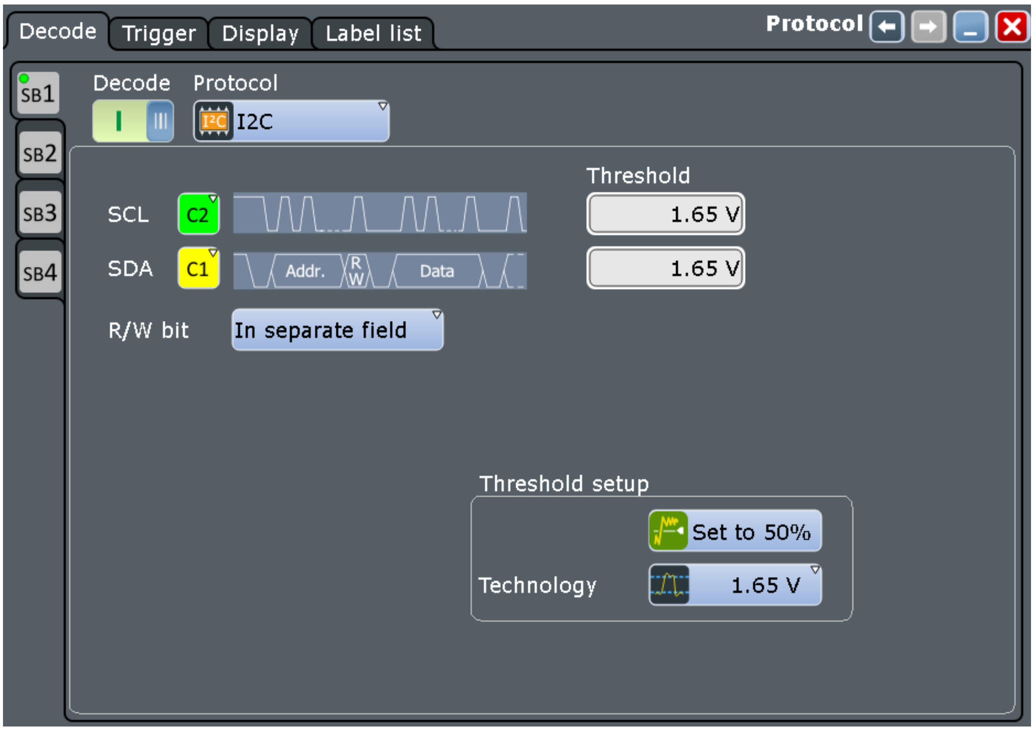
You can trigger on:
- Start or stop condition
- Repeated start condition
- Transfer direction (read or write)
- Bytes with missing acknowledge bit
- Specific slave address or address range
- Specific data pattern in the message

12.2.2 I²C Configuration

12.2.2.1 I²C Configuration Settings

Access: [Protocol] > "Decode" tab > "Protocol" = *I2C*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

SDA, SCL
Set the waveforms of the data line (SDA) and clock line (SCL).

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Alternatively, digital channels can be used if MSO option R&S RTP-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:I2C:SDA:SOURce` on page 1304
`BUS<m>:I2C:SCL:SOURce` on page 1304

Threshold
Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high (1 or true for the Boolean logic). Otherwise, the signal state is considered low (0 or false) if the signal value is below the threshold.

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:I2C:SCL:THReshold` on page 1304
`BUS<m>:I2C:SDA:THReshold` on page 1305
`BUS<m>:I2C:TECHnology` on page 1305
`BUS<m>:SETReflevels` on page 1299

R/W bit
Defines if the R/W bit is considered separately or as part of the address. The setting affects the Address setup of the trigger conditions.

Remote command:
`BUS<m>:I2C:RWBit` on page 1306

12.2.2.2 Configuring I²C Protocol

The configuration of the I²C is simple - assign the two lines to input channels, and set the thresholds.

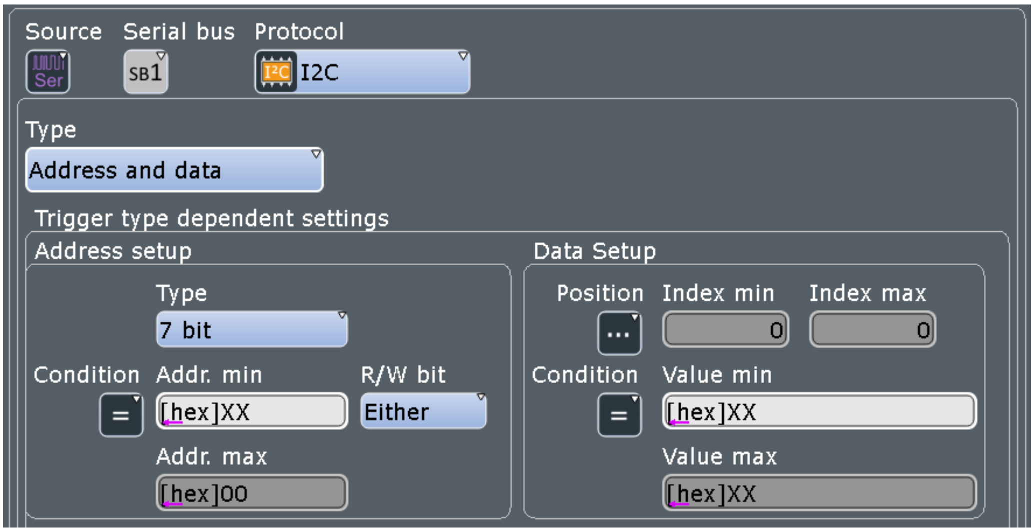
For details on configuration settings, see Chapter 12.2.2, "I²C Configuration", on page 473.

1. Press the [Protocol] key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Decode" tab.
4. Tap the "Protocol" button and select the protocol: "I2C".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "SDA" button, and select the waveform of the data line.
7. Tap the "SCL" button, and select the waveform of the clock line.
8. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fields.
9. Enable "Decode", if available.

12.2.3 I²C Trigger

12.2.3.1 I²C Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = I2C"



Make sure that:
- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Serial bus
Selects the serial bus to be triggered on. Make sure to select the correct bus before you enter the settings.

To trigger on a serial bus, the signals sources must be channel signals. If the data or clock source is a math or reference waveform, you cannot trigger on that bus.

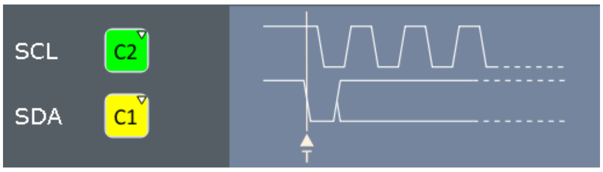
Remote command:
`TRIGger<m>:SOURce:SBSelect` on page 1303

Protocol
Defines the protocol type of the selected serial bus.

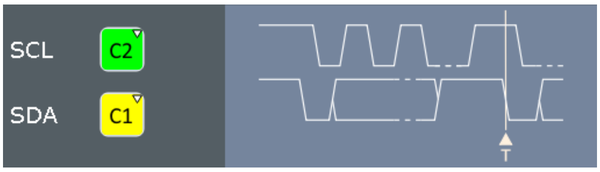
Remote command:
`BUS<m>:TYPE` on page 1299

Trigger type
Selects the trigger type for I²C analysis.

"Start" Sets the trigger to the start of the message. The start condition is a falling edge on SDA while SCL is high. The trigger instant is the falling edge of the SDA line.
You can change the SDA and SCL lines here if necessary.



"Repeated start" Sets the trigger to a repeated start - when the start condition occurs without previous stop condition. Repeated start conditions occur when a master exchanges multiple messages with a slave without releasing the bus.



"Stop" Sets the trigger to the end of the message. The stop condition is a rising slope on SDA while SCL is high.

"No Ack (Missing Ack)" Missing acknowledge bit: the instrument triggers if the data line remains HIGH during the clock pulse following a transmitted byte.
You can also localize specific missing acknowledge bits by setting the No Ack conditions.

"Address" Sets the trigger to one specific address condition or a combination of address conditions. The trigger time is the falling clock edge of the acknowledge bit after the address.
- Address type
- Specified address or address range
- Read/Write bit

Description of trigger type specific settings: "Address setup" on page 478.

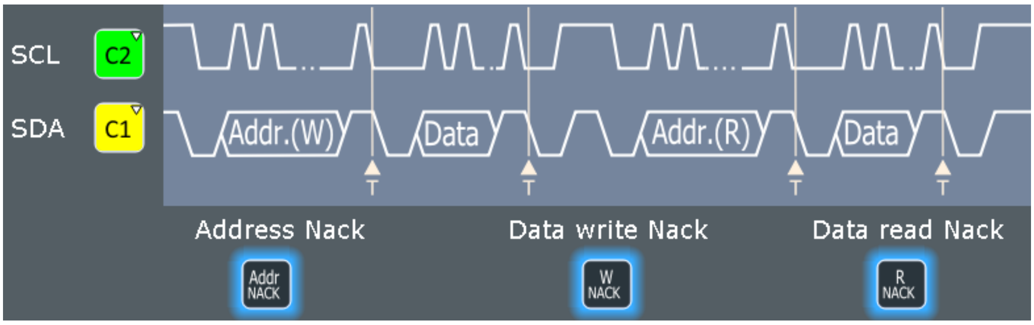
"Address OR" Triggers on one to four address conditions.
Description of trigger type specific settings: "Address OR conditions" on page 479.

"Address and data" Sets the trigger to a combination of address and data condition. The address conditions are the same as for the "Address" trigger type, see "Address setup" on page 478 and "Data setup" on page 479.

Remote command:
`TRIGger<m>:I2C:MODE` on page 1307

No Ack conditions

Selects which missing acknowledge bits is detected if the trigger type is set to "Missing Ack".



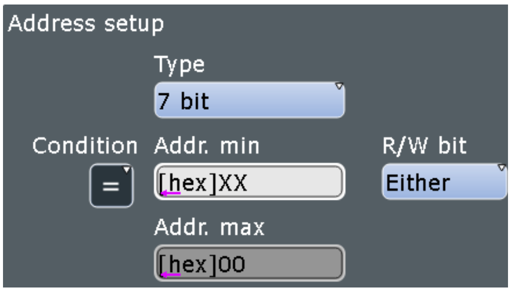
"Address Nack" No slave recognizes the address.

"Data write Nack" The addressed slave does not accept the data.

"Data read Nack"	Marks the end of the read process when the master reads data from the slave. This Nack is sent according to the protocol definition, it is not an error.

Remote command:
TRIGger<m>:I2C:ADNack on page 1307
TRIGger<m>:I2C:DWNack on page 1308
TRIGger<m>:I2C:DRNack on page 1308

Address setup
Specifies the address conditions:



Type ← Address setup
Sets the address length to be triggered on: 7 bit, 7+1 bit, or 10 bit. Available settings depend on the R/W bit setting of the bus configuration.

For "7 bit" and "10 bit", enter the address bits in the Addr. min / Addr. max field, and use the "R/W bit" on page 479 field to select the transfer direction.

For "7+1 bit", enter the seven address bits and also the R/W bit in the "Address" field.

If the trigger type is "Address + data", you can set the address type "Any" to trigger on data only, regardless of the address.

Remote command:
TRIGger<m>:I2C:AMODe on page 1308

Addr. min / Addr. max ← Address setup
Defines the bit pattern of the slave device address. The length of the entry is adjusted to the selected address type. In binary format, use the following characters: 1; 0; or X (any bit). The use of X is restricted to the "Address operator"s "Equal" and "Not equal".

The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

Depending on the Condition, a specific address or an address range must be defined.

To trigger on any address, set the "Address operator" to "Equal" and enter *X* for each address bit.

Remote command:
TRIGger<m>:I2C:ADDRess on page 1309
TRIGger<m>:I2C:ADDTo on page 1309

Condition ← Address setup
Sets the operator to set a specific address ("Equal" or "Not equal") or an address range. The address values are set with Addr. min / Addr. max.

Remote command:
TRIGger<m>:I2C:ACONdition on page 1309

R/W bit ← Address setup

Toggles the trigger condition between Read and Write access of the master. Select "Either" if the transfer direction is not relevant for the trigger condition.

Remote command:
TRIGger<m>:I2C:ACCess on page 1307

Address OR conditions

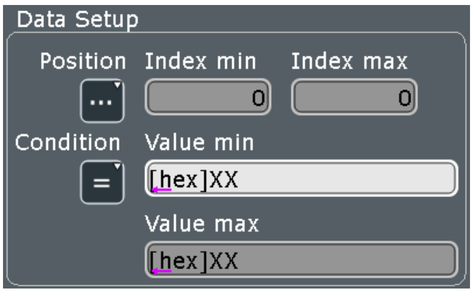
Triggers on one to four address conditions. For each condition to be used, select "Monitor".

Each condition requires an exact address. The definition of address ranges is not possible here. X (do not care) can be used.

Remote command:
TRIGger<m>:I2C:ADOR<n>:ENABle on page 1309
TRIGger<m>:I2C:ADOR<n>:ADRType on page 1309
TRIGger<m>:I2C:ADOR<n>[:VALue] on page 1310
TRIGger<m>:I2C:ADOR<n>:RWBit on page 1310

Data setup

Specifies the data conditions:



Position ← Data setup

Operator for the data position within a frame. You can define an exact position, or a position range. Select "Any", if the position of the required pattern is not relevant.

Remote command:
TRIGger<m>:I2C:DPOPerator on page 1310

Index min, Index max ← Data setup
Sets the number of data bytes to be skipped after the address. The index 0 is associated with the first data byte. If the Position defines a range, the first and the last byte of interest are defined.

Remote command:
`TRIGger<m>:I2C:DPOSition` on page 1311
`TRIGger<m>:I2C:DPTO` on page 1311

Condition ← Data setup
Selects the operator for the "Data" pattern: "Equal", "Not equal", or a range definition.

Remote command:
`TRIGger<m>:I2C:DCONdition` on page 1311

Value min / Value max ← Data setup
Specifies the data bit pattern. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

The instrument ensures that the max value is always ≥ the min value, and X bits (do not care) are at the same position in both values.

The bit pattern editor helps you to enter the pattern, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

Remote command:
`TRIGger<m>:I2C:DMIN` on page 1311
`TRIGger<m>:I2C:DMAX` on page 1312

12.2.3.2 Triggering on I²C Signals

Prerequisites: An I²C bus is configured, see Chapter 12.2.2.2, "Configuring I²C Protocol", on page 474.

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Select the serial bus that is set to I²C.
5. Select the "Trigger type".
6. For more complex trigger types, enter the address and/or data conditions: address, acknowledge bits, R/W bit, and data pattern.
   For details, see Chapter 12.2.3, "I²C Trigger", on page 475

12.2.4 I²C Label List

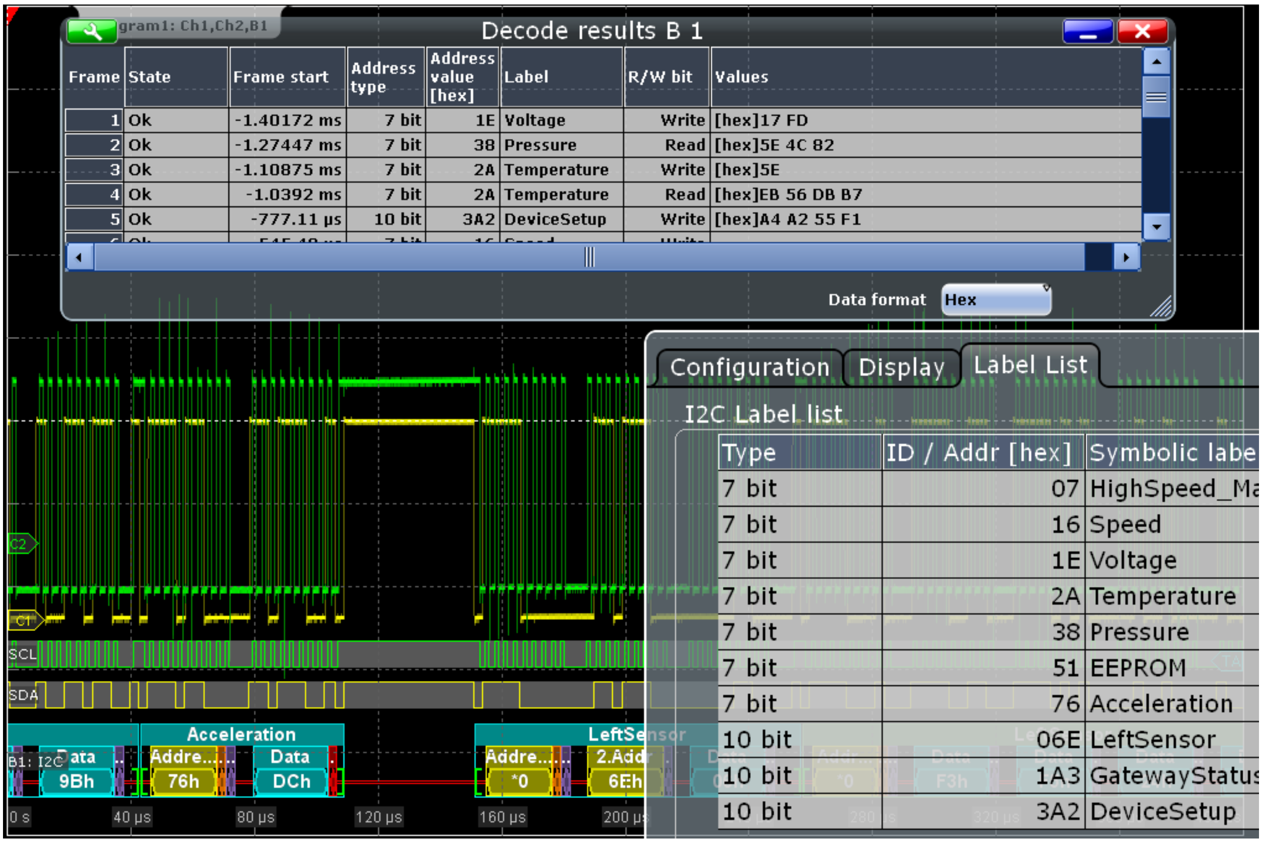
Label lists are protocol-specific. Label lists for I²C are available in CSV and PTT format.

An I²C label file contains three values for each address:

- Address type, 7-bit or 10-bit long
- Address value
- Symbolic label: name of the address, specifying its function in the bus network.

Example: I²C PTT file

```
# ----------------------------------------------------------------------------
@FILE_VERSION  = 1.00
@PROTOCOL_NAME = i2c
# ---------------------------------------------------------------------------
# Labels for I2C protocol
#   Column order: Identifier type, Identifier value, Label
# ---------------------------------------------------------------------------
7,0x1E,Voltage
7,38h,Pressure
7,2Ah,Temperature
7,16h,Speed
7,118,Acceleration
7,07h,HighSpeed_Master_0x3
7,51h,EEPROM
10,3A2h,DeviceSetup
10,1A3h,GatewayStatus
10,06Eh,LeftSensor
# ----------------------------------------------------------------------------
```



For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 467.

Remote command:

- BUS<m>:I2C:FRAMe<n>:SYMBol? on page 1317

12.2.5 I²C Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

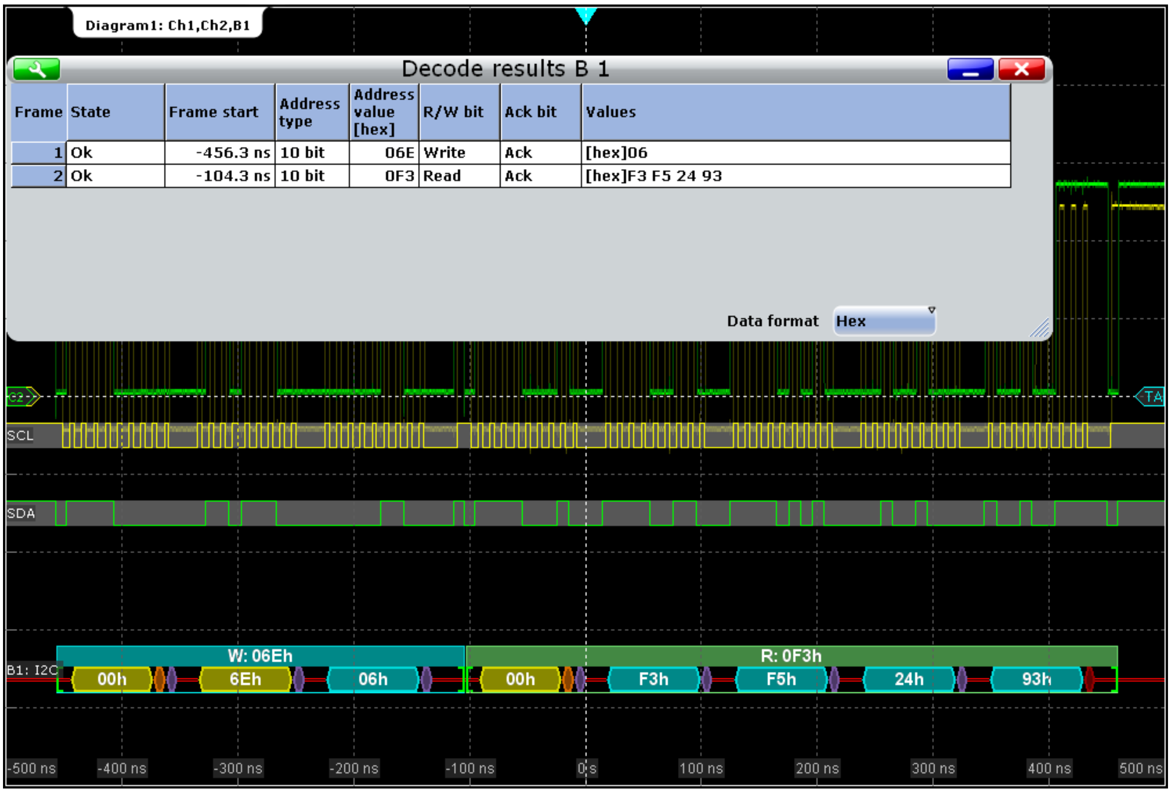


Figure 12-4: Decoded and binary I2C signal, and decode results

green brackets [...] = start and end of frame
blue frame header = write frame ok, with transfer direction and address value
green frame header = read frame ok, with transfer direction and address value

yellow	= address
blue	= correct data
light orange	= R/W bit
purple	= acknowledge bit
red	= No ack (missing acknowledge bit)

The signal in Figure 12-4 shows a write access followed by a read access, both with 10bit address. The decoded data shows a No Ack bit at the end of the read data. This No Ack bit is sent according to the protocol definition and is not an error. Thus, the decode results in the table indicate "Ack" for the second frame.

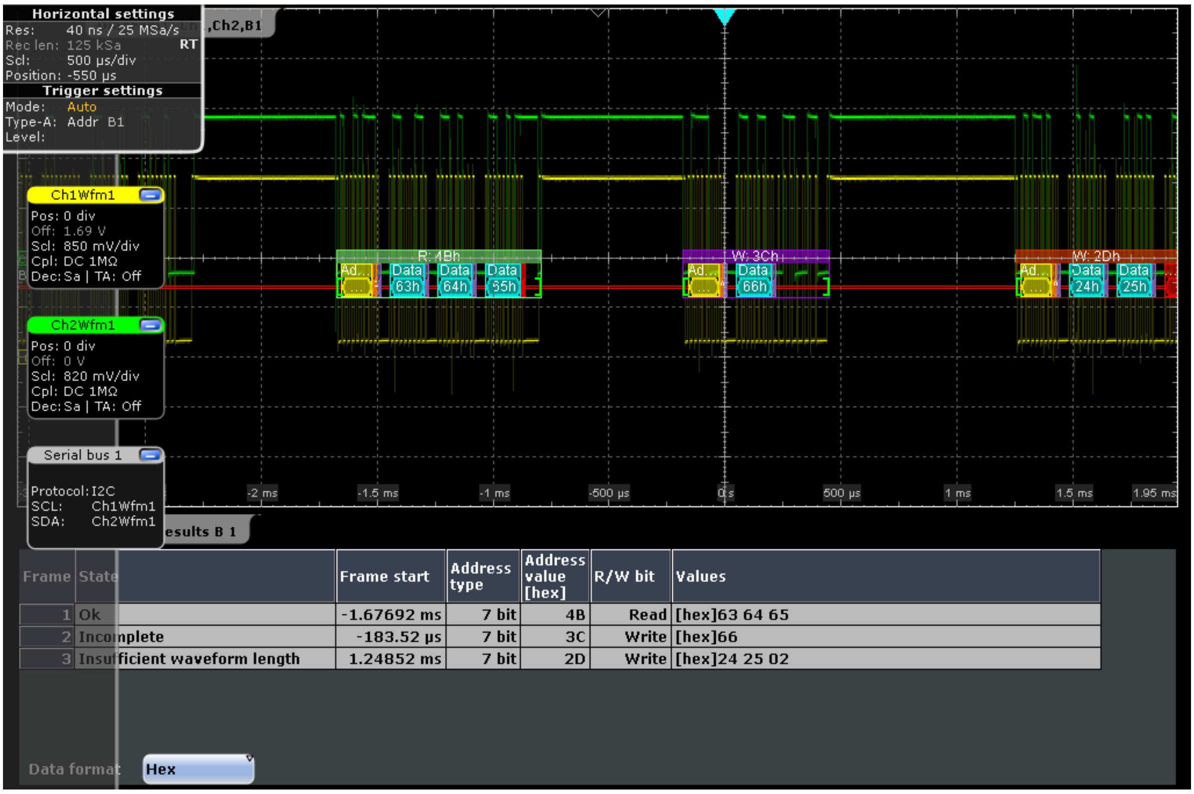


Figure 12-5: Decoded I2C signal with incomplete data, and decode results

magenta frame header	= incomplete frame, missing bits in data words
dark orange frame header	= insufficient frame (end of acquisition before decoding has been completed), with transfer direction and address value
red	= insufficient data word (end of acquisition before end of word)

The "Decode results" box shows the detailed decoded data for each data frame.

Table 12-3: Content of the "Decode results" table

Column	Description
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Frame start	Time of frame start

Column	Description
Address type	Address length, 7 bit or 10 bit
Address value (hex)	Hexadecimal value of the address
Label	Symbolic label name defined in the label list
R/W bit	Value of the R/W bit
Ack bit	Value of the address acknowledge bit
Values	Value of all data bytes of the frame. The data format is selected below the table.

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.3.3, "Decode Results", on page 1312.

12.2.6 Search on Decoded I²C Data

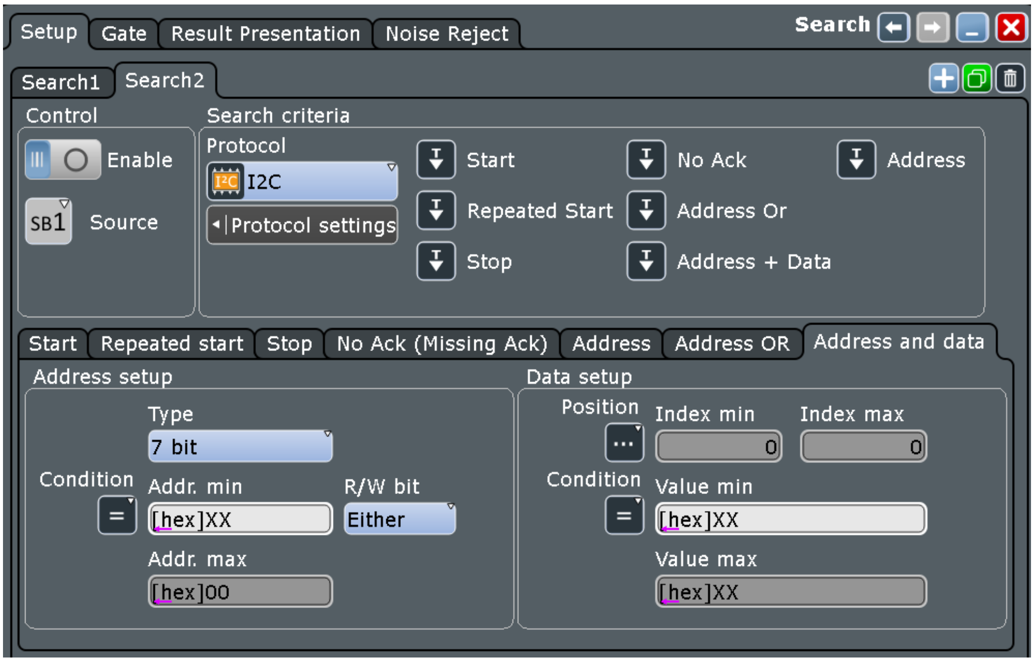
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 396.

12.2.6.1 I²C Search Setup

Access: [Search] > "Setup" tab



Search criteria

Enable the events to be searched for. Unlike triggering, where you can trigger only on one defined event, you can search for various different events in one search.

"Start"	Searches for the start of the message. The start condition is a falling edge on SDA while SCL is high. The event is the falling edge of the SDA line. You can change the SDA and SCL lines here if necessary.
"Repeated start"	Searches for a start condition without previous stop condition. Repeated start conditions occur when a master exchanges multiple messages with a slave without releasing the bus.
"Stop"	Searches for the end of the message. The stop condition is a rising slope on SDA while SCL is high.
"No ACK (Missing ACK)"	Searches for a missing acknowledge bit: an event is found if the data line remains HIGH during the clock pulse following a transmitted byte. For details, see "No Ack conditions" on page 477.
"Address"	Searches for one specific address condition or a combination of address conditions. The event is the falling edge of the acknowledge bit after the address.
"Address OR"	Searches for one to four address conditions. See "Address OR conditions" on page 479.
"Address and data"	Searches for a combination of address and data conditions.

Remote command:

`SEARch:TRIGger:I2C:SCONdition` on page 1321

`SEARch:TRIGger:I2C:RCONdition` on page 1321

`SEARch:TRIGger:I2C:STCNdition` on page 1321

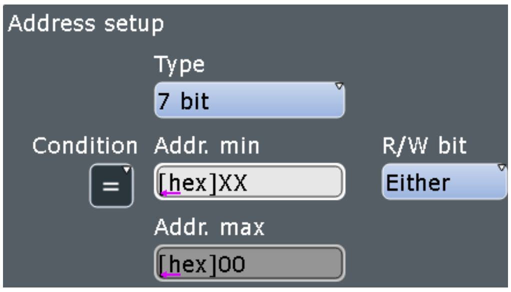
`SEARch:TRIGger:I2C:NACKnowledge` on page 1321

SEARch:TRIGger:I2C:SADDress on page 1322
SEARch:TRIGger:I2C:ADOR on page 1322
SEARch:TRIGger:I2C:ADData on page 1322

Address setup: Condition, Type, Addr. min, Addr. max, R/W bit

The address setup consists of the condition, type, R/W bit and one or two address patterns.

The address setup settings are the same as in the I2C trigger setup, see "Address setup" on page 478.

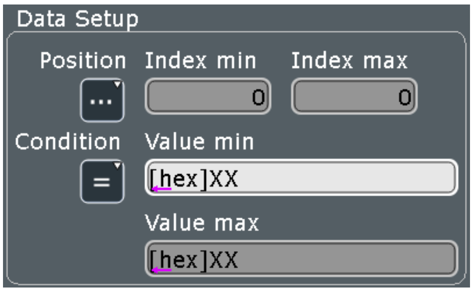


Remote command:
SEARch:TRIGger:I2C:ACONdition on page 1323
SEARch:TRIGger:I2C:ADDRess on page 1324
SEARch:TRIGger:I2C:ADDTo on page 1324
SEARch:TRIGger:I2C:AMODe on page 1323
SEARch:TRIGger:I2C:ACCess on page 1324

Data setup: Condition, Position, Index min, Index max, Value min, Value max

The data setup consists of the condition, position, and one or two index/value patterns.

The data setup settings are the same as in the I2C trigger setup, see "Data setup" on page 479.



Remote command:
SEARch:TRIGger:I2C:DPOPerator on page 1326
SEARch:TRIGger:I2C:DPOSition on page 1326
SEARch:TRIGger:I2C:DPTO on page 1327
SEARch:TRIGger:I2C:DCONdition on page 1327
SEARch:TRIGger:I2C:DMIN on page 1327
SEARch:TRIGger:I2C:DMAX on page 1328

Address OR setup: Monitor, Address type, Address, R/W bit

The address OR setup consists of the monitor, address type, address and an R/W bit.

The address OR setup settings are the same as in the I2C trigger setup, see "Address OR conditions" on page 479.

Remote command:

`SEARch:TRIGger:I2C:ADDO<m>:ENABle` on page 1324

`SEARch:TRIGger:I2C:ADDO<m>:ADRType` on page 1325

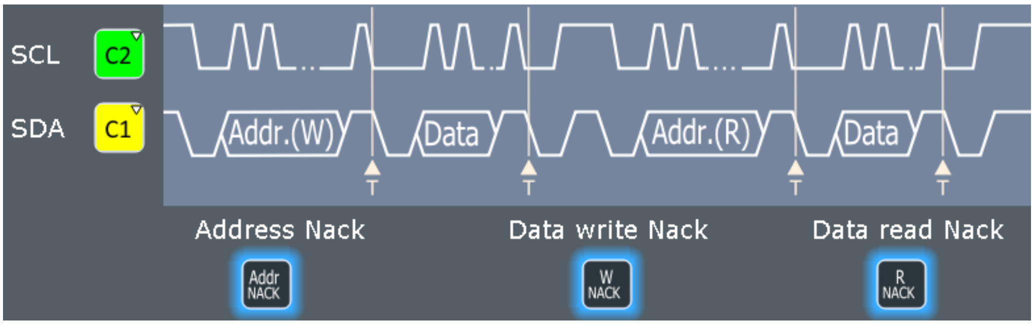
`SEARch:TRIGger:I2C:ADDO<m>[:VALue]` on page 1325

`SEARch:TRIGger:I2C:ADDO<m>:RWBit` on page 1326

No ACK setup: Addr/W/R NACK

The no ACK setup consists of the Addr/W/R NACK.

The no ACK setup settings are the same as in the I2C trigger setup, see "No Ack conditions" on page 477.



Remote command:

`SEARch:TRIGger:I2C:DRNack` on page 1328

`SEARch:TRIGger:I2C:DWNack` on page 1328

`SEARch:TRIGger:I2C:NACKnowledge` on page 1321

12.2.6.2 I²C Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

The columns in the search result table are the same as in the decoding table, see Chapter 12.2.5, "I²C Decode Results", on page 482.

Remote commands:

- `SEARch:RESult:I2C:FCOunt?` on page 1329
- `SEARch:RESult:I2C:FRAMe<m>:STATus?` on page 1329
- `SEARch:RESult:I2C:FRAMe<m>:STARt?` on page 1330
- `SEARch:RESult:I2C:FRAMe<m>:STOP?` on page 1330
- `SEARch:RESult:I2C:FRAMe<m>:SYMBol?` on page 1333
- `SEARch:RESult:I2C:FRAMe<m>:DATA?` on page 1333
- `SEARch:RESult:I2C:FRAMe<m>:ADDRess?` on page 1331
- `SEARch:RESult:I2C:FRAMe<m>:AACCess?` on page 1330
- `SEARch:RESult:I2C:FRAMe<m>:ACCess?` on page 1331
- `SEARch:RESult:I2C:FRAMe<m>:ACOMplete?` on page 1331
- `SEARch:RESult:I2C:FRAMe<m>:ADBStart?` on page 1331
- `SEARch:RESult:I2C:FRAMe<m>:ADEVice?` on page 1332
- `SEARch:RESult:I2C:FRAMe<m>:AMODe?` on page 1332
- `SEARch:RESult:I2C:FRAMe<m>:ASTart?` on page 1332
- `SEARch:RESult:I2C:FRAMe<m>:BCOunt?` on page 1333
- `SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACCess?` on page 1334
- `SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACKStart?` on page 1334
- `SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:COMPlete?` on page 1334
- `SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:STARt?` on page 1335
- `SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:VALue?` on page 1335

12.3 SPI Bus (Option R&S RTP-K1)

12.3.1 The SPI Protocol

A 4-channel instrument is required for full support of the SPI protocol, or the MSO option R&S RTP-B1.

The Serial Peripheral Interface SPI is used for communication with slow peripheral devices, in particular, for transmission of data streams.

Main characteristics of SPI are:

- Master-slave communication
- No device addressing; The slave is accessed by a chip select, or slave select line.
- No acknowledgement mechanism to confirm receipt of data
- Duplex capability

Most SPI buses have four lines, two data and two control lines:

- Clock line to all slaves (SCLK)
- Slave Select or Chip Select line (SS or CS)
- Master data output, slave data input (MOSI or SDI)
- Master data input, slave data output (MISO or SDO)

When the master generates a clock and selects a slave device, data may be transferred in either or both directions simultaneously.

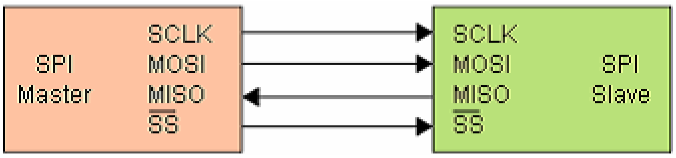


Figure 12-6: Simple configuration of SPI bus

The data bits of a message are grouped by following criteria:

- A word contains a number of successive bits. The word length is defined in the protocol configuration.
- A frame contains a number of successive words, at least one word.

For SPI buses, the R&S RTP provides the following trigger possibilities:

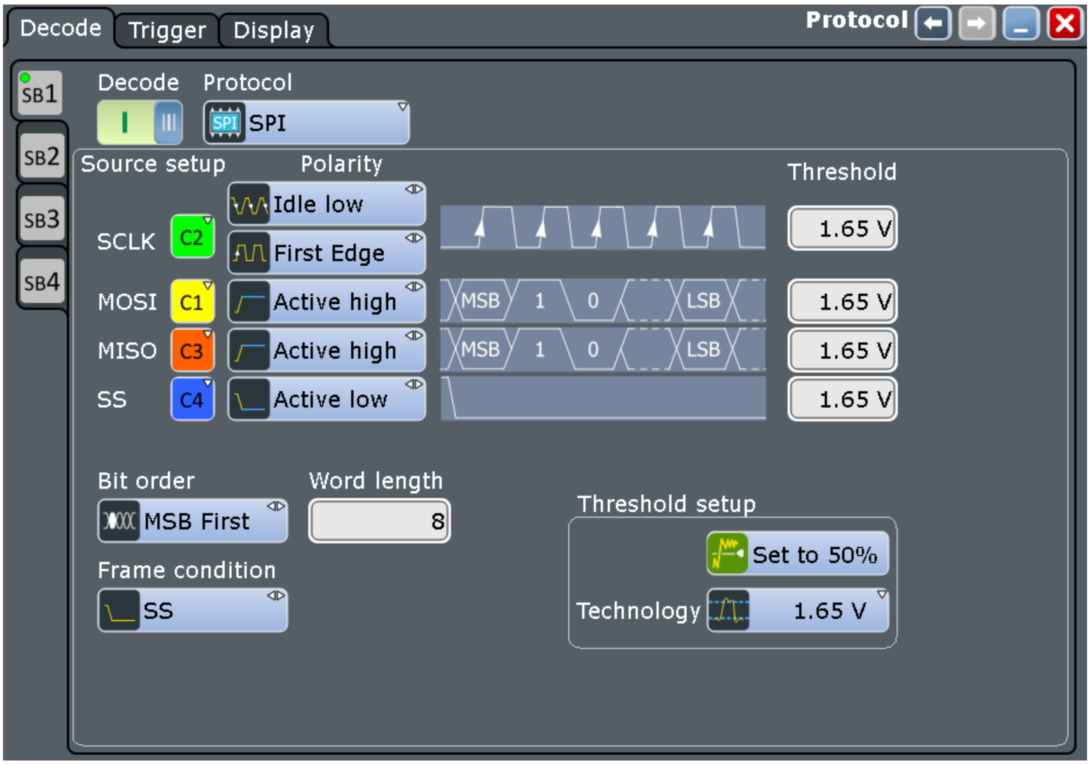
- On frame start
- On a serial pattern at a specified position

12.3.2 SPI Configuration

12.3.2.1 SPI Configuration Settings

Access: [Protocol] > "Configuration" tab > "Protocol" = *SPI*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

SCLK

Defines the settings for the clock line.

SCLK source ← SCLK

Sets the input channel of the clock line. Waveform 1 of channel signals, math waveforms, and reference waveforms can be used for decoding.

Alternatively, digital channels can be used if MSO option R&S RTP-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:

`BUS<m>:SPI:SCLK:SOURce` on page 1336

Polarity ← SCLK

Two settings define the clock mode: the clock polarity and the clock phase. Together, they determine the edges of the clock signal on which the data are driven and sampled. A master/slave pair must use the same parameter pair values to communicate.

The clock polarity is "Idle low" (idle = 0) or "Idle high" (idle = 1).

The clock phase defines the slope. It selects if data is stored with the rising or falling slope of the clock. The slope marks the begin of a new bit.

SS, MISO, MOSI
Configures the Slave Select, MISO and MOSI lines.

Source ← SS, MISO, MOSI
Sets the input channel of the selected line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Alternatively, digital channels can be used if MSO option R&S RTP-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:SPI:SSELect:SOURce` on page 1337
`BUS<m>:SPI:MISO:SOURce` on page 1337
`BUS<m>:SPI:MOSI:SOURce` on page 1338

Polarity ← SS, MISO, MOSI
Selects whether transmitted data or the slave select signal is high active (high = 1) or low active (low = 1).

Remote command:
`BUS<m>:SPI:SSELect:POLarity` on page 1337
`BUS<m>:SPI:MISO:POLarity` on page 1338
`BUS<m>:SPI:MOSI:POLarity` on page 1338

Threshold
Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold. The interpretation of HIGH and LOW is defined by the Polarity.

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:SPI:SCLK:THReshold` on page 1339
`BUS<m>:SPI:MISO:THReshold` on page 1339

BUS<m>:SPI:MOSI:THReshold on page 1339
BUS<m>:SPI:SSELect:THReshold on page 1339
BUS<m>:SPI:TECHnology on page 1339
BUS<m>:SETReflevels on page 1299

Bit order

Defines if the data of the messages starts with msb (most significant bit) or lsb (least significant bit). The display of the decoded signal considers this setting, results are displayed in the specified order.

Remote command:
BUS<m>:SPI:BORDer on page 1336

Word length

Sets the number of bits in a word. The maximum length is 32 bit.

Remote command:
BUS<m>:SPI:WSIZe on page 1336

Frame condition

Defines the start of a frame. A frame contains a number of successive words, at least one word.

"SS"	Start and end of the frame is defined by the active state of the slave select signal.
"CLK timeout"	Defines a timeout on the clock line SCLK as limiter between two frames. The timeout condition is used for SPI connections without an SS line. Enter the minimum clock idle time in the field.

Remote command:
BUS<m>:SPI:FRCondition on page 1340

Timeout

Sets the minimum clock idle time if a timeout on the clock line SCLK is used as limiter between two frames.

See also: "Frame condition" on page 492.

Remote command:
BUS<m>:SPI:TIMeout on page 1340

12.3.2.2 Configuring SPI Signals

For configuration, assign the lines to the input channels, and define the active states and the logical thresholds.

For details on configuration settings, see Chapter 12.3.2, "SPI Configuration", on page 489.

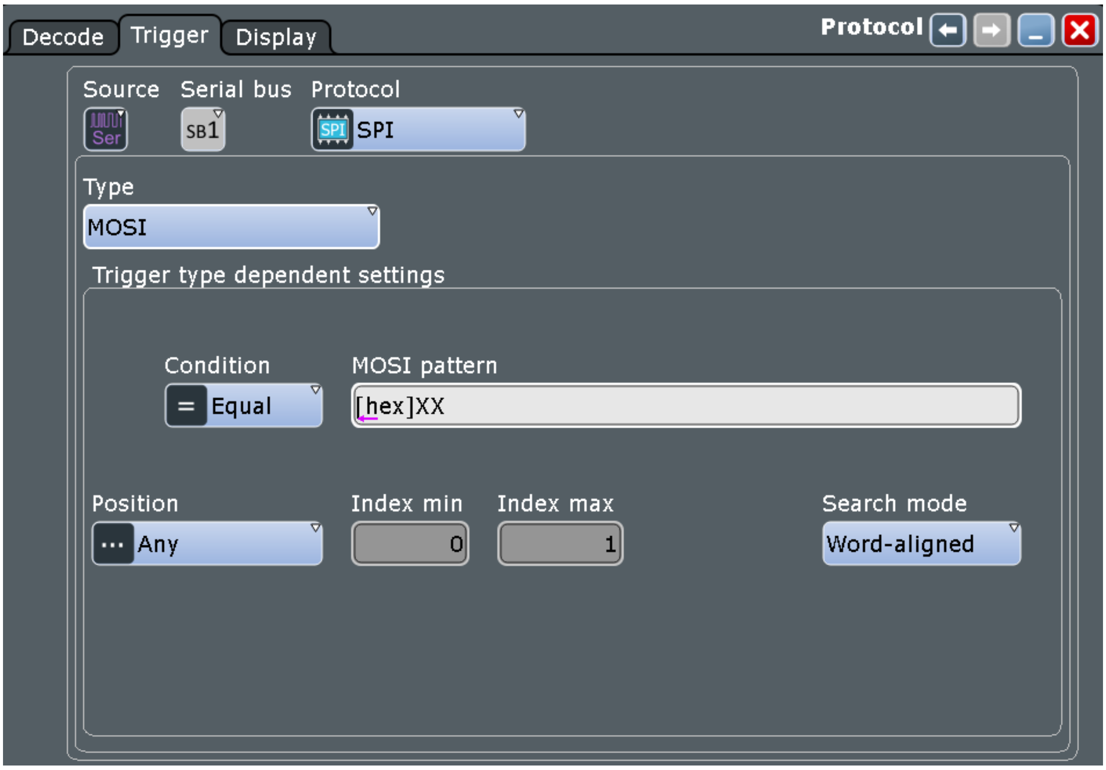
1. Press the [Protocol] key on the front panel.
2. At the left hand-side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.

4. Tap the "Protocol" button and select the protocol: "SPI".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Tap the "SCLK Source" button, and select the waveform of the clock line.
7. Set the polarity (clock mode) for SCLK.
8. For each of the available SS, MISO and MOSI lines, assign the waveform. Define the polarity (active state) of the line.
9. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fields.
10. Set the "Bit order", "Word length", and "Frame condition" according to your signal.

12.3.3 SPI Trigger

12.3.3.1 SPI Trigger

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = SPI"



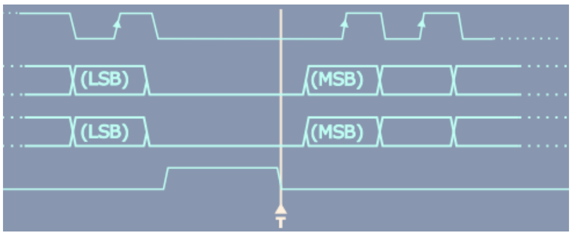
Make sure that:

- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

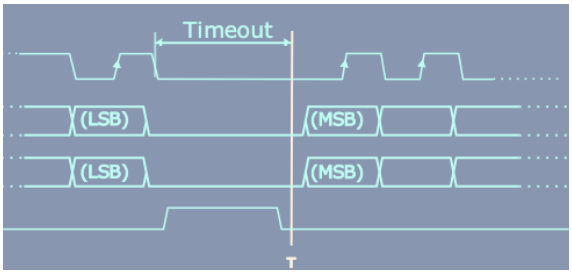
Trigger type

Selects the trigger type for SPI analysis.

"Frame start (SS)" Trigger on the start of the frame when the slave select signal SS changes to the active state. This trigger type is available if Frame condition is set to "SS".



"Frame start (Timeout)" Triggers on the start of the frame when the clock idle time exceeds the "Timeout" time. This trigger type is available if Frame condition is set to "CLK timeout".



"MOSI" Sets the trigger to a specified data pattern expected on the MOSI line.
See: "MOSI and MISO data conditions" on page 494.

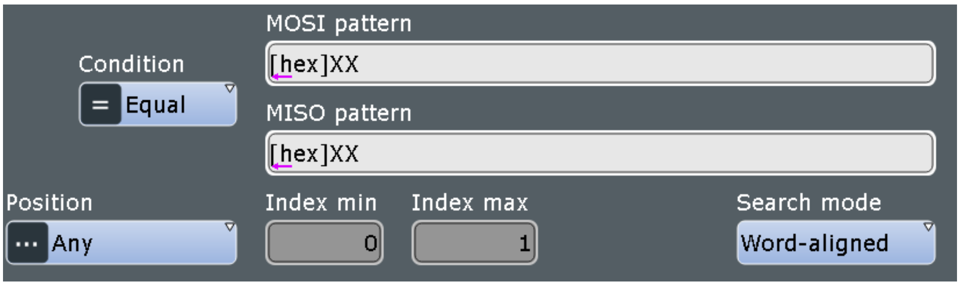
"MISO" Sets the trigger to a specified data pattern expected on the MISO line.
See: "MOSI and MISO data conditions" on page 494.

"MOSI/MISO" Sets the trigger to specified data patterns expected on the MOSI and MISO lines on the same time.

Remote command:
`TRIGger<m>:SPI:MODE` on page 1341

MOSI and MISO data conditions

The trigger on MOSI and MISO patterns is defined in the same way:



Condition ← MOSI and MISO data conditions
Selects the operator for the "Data" pattern: "Equal" or "Not equal".

Remote command:
`TRIGger<m>:SPI:FCONdition` on page 1342

MOSI pattern, MISO pattern ← MOSI and MISO data conditions
Specify the data patterns to be found on the MOSI and/or MISO line.

If the trigger type is "MOSI" or "MISO" (one pattern is defined), the maximum pattern length is 256 bit. If the trigger type is "MOSI/MISO", two patterns must be found at the same time. Thus, both patterns must have the same length, and the maximum pattern length of each pattern is 128 bit.

Enter the words in msb first bit order. The starting point of the pattern is defined by Index min, Index max and Search mode.

The bit pattern editor helps you to enter the pattern, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

Remote command:
`TRIGger<m>:SPI:MOSipattern` on page 1343
`TRIGger<m>:SPI:MISopattern` on page 1343

Position ← MOSI and MISO data conditions
Operator for the data position. You can define an exact position, a position range, or let the position undefined ("Any").

Remote command:
`TRIGger<m>:SPI:DPOPerator` on page 1342

Index min, Index max ← MOSI and MISO data conditions
The effect of data positioning depends on the Search mode. It sets the number of bits or words before the first word of interest. These offset bits/words are skipped. If the position operator defines a range, the first and the last bit/word of interest are defined. The index 0 is associated with the first data bit or word.

Remote command:
`TRIGger<m>:SPI:DPOSition` on page 1342
`TRIGger<m>:SPI:DPTO` on page 1342

Search mode ← MOSI and MISO data conditions
Defines how the specified data pattern is searched:

"Word-aligned" The pattern is matched only at word boundaries.

"Bit-aligned" Bit-by-bit: the pattern can start at any position in the message.

Remote command:
`TRIGger<m>:SPI:PALignment` on page 1341

12.3.3.2 Triggering on SPI

Prerequisites: A bus is configured for the SPI signal to be analyzed.

1. Press the [Protocol] key and select the "Trigger" tab.
2. Tap the "Source" button and select the "Serial bus" trigger source.
3. Select the serial bus that is set to SPI.
4. Select the "Trigger type".
5. For more complex trigger types, enter the data pattern conditions
   For details, see Chapter 12.3.3, "SPI Trigger", on page 493

12.3.4 SPI Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The decoding process considers the "Bit order" configuration setting of the signal and displays the binary result MSB first. Binary values in the combs of the decoded signal also consider the "Binary bit order" setting in the "Display" tab. Thus, you can read the bits of an LSB first signal in LSB first order in the combs while the results table displays the correct values MSB first.

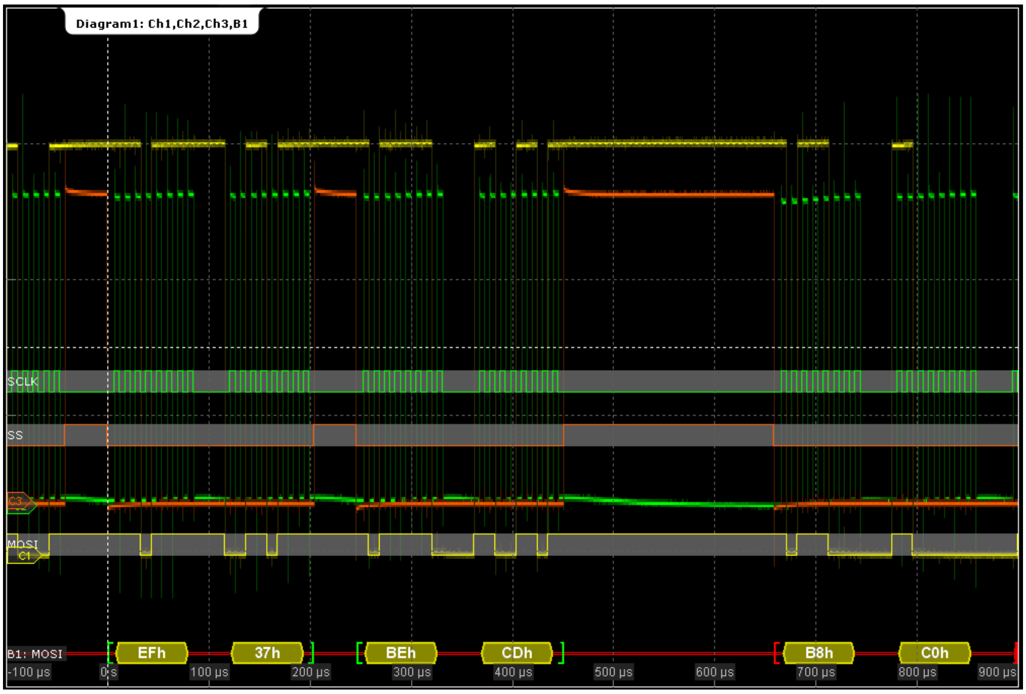
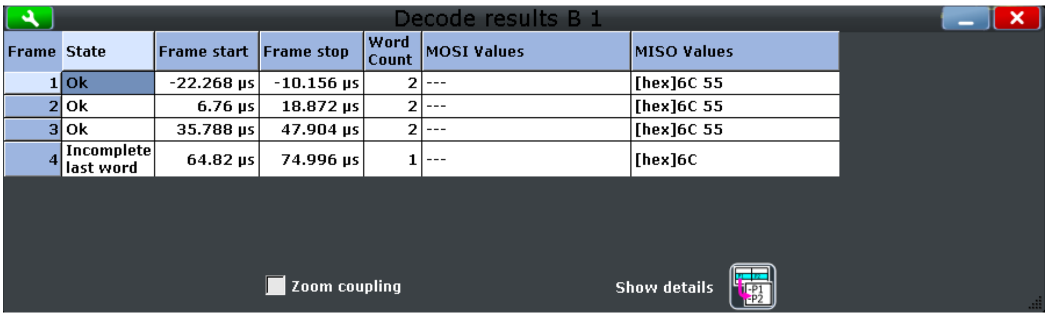


Figure 12-7: Decoded and binary SPI signal with SCLK, MOSI, and SS line

green brackets [...] = start and end of complete frame
red brackets [...] = start and end of incomplete frame
yellow = word
red = error

The "Decode results" box shows the detailed decoded data for each data frame.

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).



Frame	State	Frame start	Frame stop	Word Count	MOSI Values	MISO Values
1	Ok	-22.268 µs	-10.156 µs	2	---	[hex]6C 55
2	Ok	6.76 µs	18.872 µs	2	---	[hex]6C 55
3	Ok	35.788 µs	47.904 µs	2	---	[hex]6C 55
4	Incomplete last word	64.82 µs	74.996 µs	1	---	[hex]6C

Figure 12-8: Decode results

In the figure above, the first three frames contain two words each. The fourth frame is incomplete, only one word of the frame was recognized

Table 12-4: Content of the "Decode results" table

Column	Description
State	Overall state of the frame
Frame start , Frame stop	Times of frame start and frame end

Column	Description
Word count	Number of words in the frame
MOSI values	Value of the MOSI data words. The data format is selected below the table.
MISO values	Value of the MISO data words. The data format is selected below the table.

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:

- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.4.3, "SPI Decode Results", on page 1343.

12.3.5 Search on Decoded SPI Data

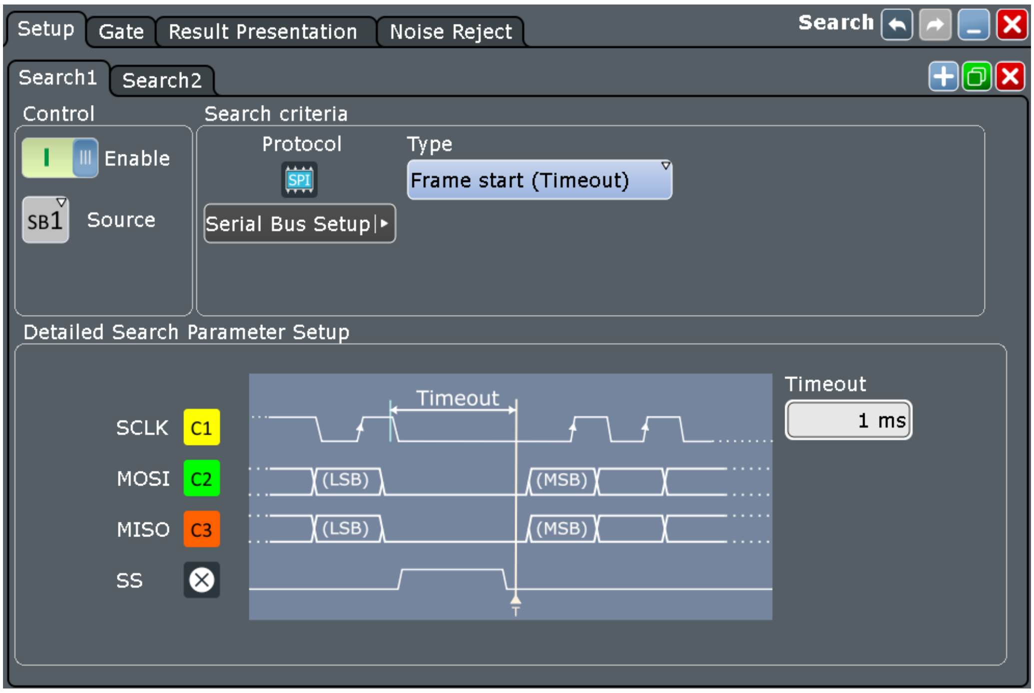
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 396.

12.3.5.1 SPI Search Setup

Access: [Search] > "Setup" tab



Type

Sets the event to be searched for.

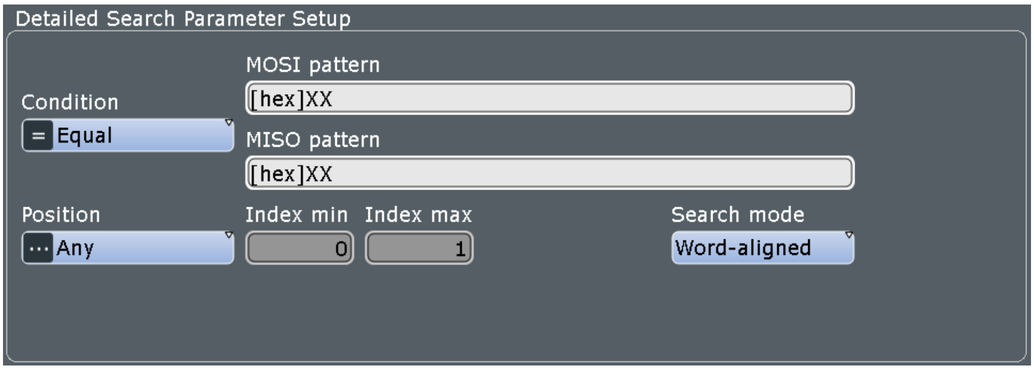
"Frame start (SS)"	Searches for the start of the frame when slave select signal SS changes to the active state. This type is available if the slave select line is configured in the bus setup, and the frame condition is "SS".
"Frame start (Timeout)"	Searches for the start of the frame when the clock idle time exceeds the timeout. This trigger type is available if frame condition is set to "CLK timeout".
"MOSI"	Searches for a specified data pattern expected on the MOSI line.
"MISO"	Searches for a specified data pattern expected on the MISO line.
"MOSI / MISO"	Searches for specified data patterns expected on the MOSI and MISO lines.

Remote command:
`SEARch:TRIGger:SPI:MODE` on page 1348

MOSI and MISO data search

The MOSI and MISO setup consists of the condition, position, MOSI pattern, MISO pattern, search mode (word-aligned, bit-aligned) and one or two index patterns.

The MOSI and MISO setup settings are the same as in the SPI trigger setup. For details, see "MOSI and MISO data conditions" on page 494.



Remote command:
`SEARch:TRIGger:SPI:FCONdition` on page 1349
`SEARch:TRIGger:SPI:MISopattern` on page 1349
`SEARch:TRIGger:SPI:MOSipattern` on page 1349
`SEARch:TRIGger:SPI:DPOPerator` on page 1349
`SEARch:TRIGger:SPI:DPOSition` on page 1350
`SEARch:TRIGger:SPI:DPTO` on page 1350
`SEARch:TRIGger:SPI:PALignment` on page 1350

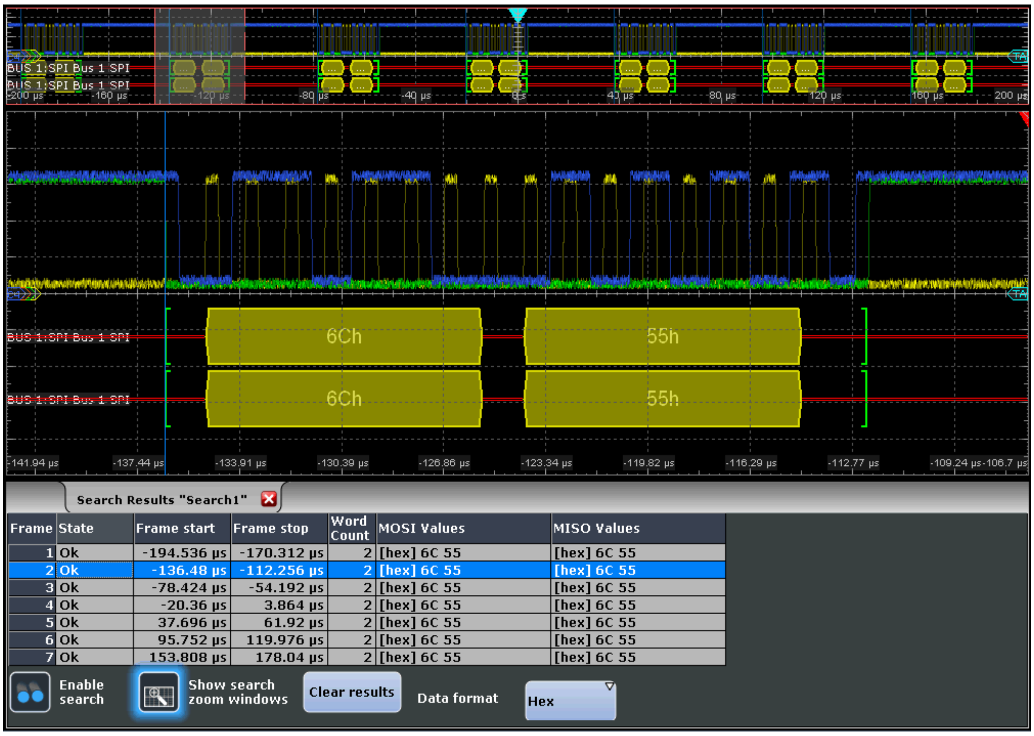
12.3.5.2 SPI Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414



Remote commands are listed in Chapter 20.17.4.5, "SPI Search Results", on page 1351.

12.4 UART/RS-232/RS-422/RS-485 (Option R&S RTP-K2)

12.4.1 The UART / RS232 Interface

The Universal Asynchronous Receiver/Transmitter UART converts a word of data into serial data, and vice versa. It is the base of many serial protocols like of RS-232. The UART uses only one line, or two lines for transmitter and receiver.

Data transfer

The data is transmitted in words, also referred to as symbols or characters. Each word consists of a start bit, several data bits, an optional parity bit, and one or more stop bits. Several words can form a package, or frame. The end of a package is marked with a reserved word or by a pause between two words.

Start	Data0	Data1	Data2	Data3	Data4	[Data5]	[Data6]	[Data7]	[Data8]	[Parity]	Stop

Figure 12-9: Bit order in a UART word (symbol)

- The start bit is a logic 0.
- The stop bits and the idle state are always logic 1.

The UART protocol has no clock for synchronization. The receiver synchronizes by means of the start and stop bits, and the bit rate that must be known to the receiver.

Trigger

The R&S RTP can trigger on specified parts of UART serial signals:

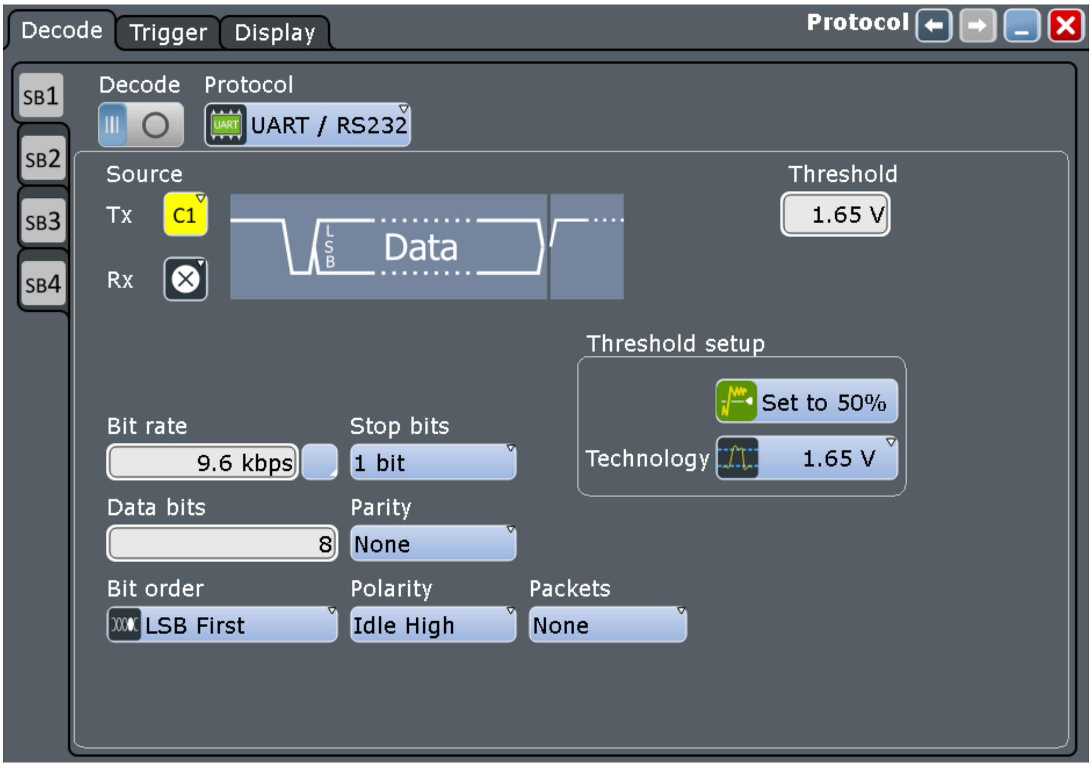
- Start bit
- Packet start
- Parity errors, and breaks
- Stop errors
- A serial pattern at any or a specified position

12.4.2 UART Configuration

12.4.2.1 UART Configuration Settings

Access: [Protocol] > "Configuration" tab > "Protocol" = *UART / RS232*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Source: Tx, Rx
Select the input channels for the transmitter and receiver signals.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Do not combine a reference waveform with channel or math waveform because the time correlation of these waveforms might differ.

Alternatively, digital channels can be used if MSO option R&S RTP-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
`BUS<m>:UART:TX:SOURce` on page 1355
`BUS<m>:UART:RX:SOURce` on page 1355

Threshold
Sets the threshold value for digitization of signals for each line. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold. The interpretation of HIGH and LOW is defined by the Polarity.

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:UART:RX:THReshold` on page 1356
`BUS<m>:UART:TX:THReshold` on page 1356
`BUS<m>:UART:TECHnology` on page 1356
`BUS<m>:SETReflevels` on page 1299

Polarity
Defines the logic levels of the bus. The idle state corresponds to a logic 1. the start bit to a logic 0. "Idle high" (high=1) is used, for example, for control signals, while "Idle low" (low=1) is defined for data lines (RS-232).

Remote command:
`BUS<m>:UART:POLarity` on page 1358

Bit rate

Sets the number of transmitted bits per second. To select a bit rate from list of predefined values, tap the icon beside the "Bit rate" field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

Remote command:
`BUS<m>:UART:BITRate` on page 1357
`BUS<m>:UART:BAUDrate` on page 1357

Data bits

Sets the number of data bits of a word in a range from 5 bits to 8 bits. If no parity bit is used, then 9 data bits are possible.

Remote command:
`BUS<m>:UART:SSIZe` on page 1358

Bit order

Defines if a word starts with msb (most significant bit) or lsb (least significant bit). The display of the decoded signal considers this setting, results are displayed in the specified order.

Stop bits

Sets the number of stop bits: 1 or 1.5 or 2 stop bits are possible.

Remote command:
`BUS<m>:UART:SBIT` on page 1358

Parity

Defines the optional parity bit that is used for error detection.

"None"	No parity bit is used.
"Odd"	The parity bit is set to "1" if the number of data bits set to "1" is even.
"Even"	The parity bit is set to "1" if the number of data bits set to "1" is odd.
"Mark"	The parity bit is always a logic 1.
"Space"	The parity bit is always a logic 0.
"Don't care"	The parity is ignored.

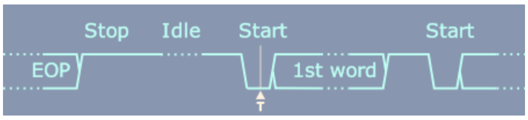
Remote command:
`BUS<m>:UART:PARity` on page 1357

Packets

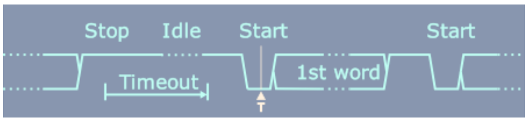
Allows you to define packets of several words in the data stream.

"None"	Packets are not considered.

"End word" Defines a pattern as end condition of a packet, for example, a reserved word like CR or LF. The bit pattern editor provides frequently used values in the "Predefined values" list below the pattern table.
A new packet starts with the first start bit after the defined end pattern.



"Timeout" Defines a timeout between a stop bit and the next start bit. Enter the minimum time that marks the end of a packet.
A new packet starts with the first start bit after the timeout.



Remote command:
BUS<m>:UART:PACKets on page 1359
BUS<m>:UART:TOUT on page 1359
BUS<m>:UART:EWORd on page 1360

12.4.2.2 Configuring UART Protocol

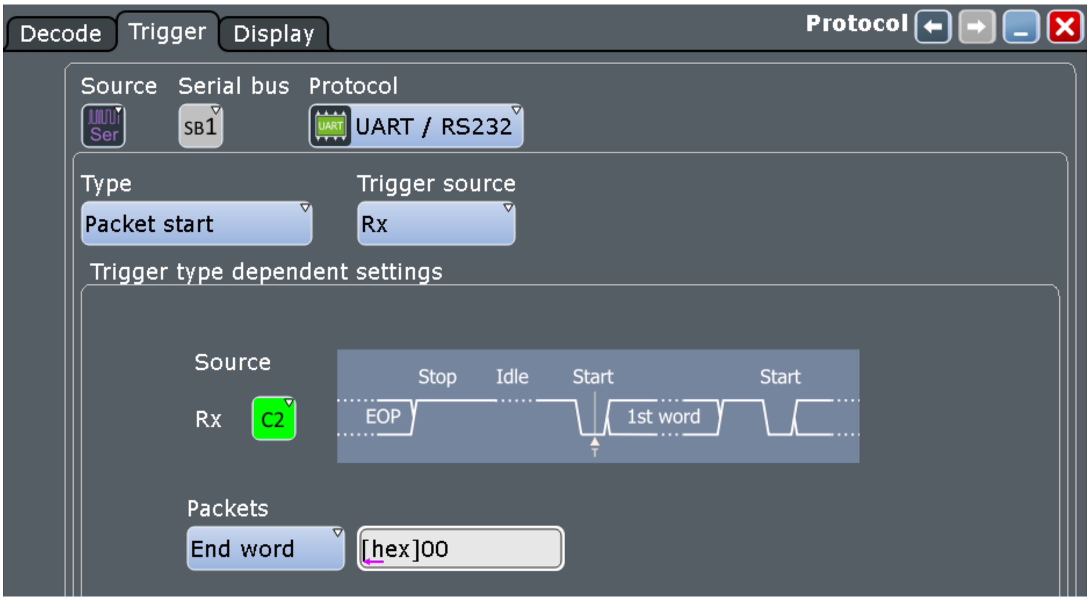
For details on configuration settings, see Chapter 12.4.2.1, "UART Configuration Settings", on page 502.

1. Press the [Protocol] key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Decode" tab.
4. Tap the "Protocol" button and select the protocol: "UART".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "TX" button, and select the waveform of the transmitter line.
7. Tap the "Rx" button, and select the waveform of the receiver line.
8. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels with "Set to 50%", or enter a user-defined value directly in the "Threshold" fields.
9. Set the "Bit rate" and "Stop bits".
10. Set the "Data bits" and "Parity".
11. Set the "Bit order", "Polarity" and "Packets".
12. Enable "Decode", if available.

12.4.3 UART Trigger

12.4.3.1 UART Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = UART / RS232"



Make sure that:

- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Type
Selects the trigger type for UART analysis.

"Start bit"	Triggers on a start bit. The start bit is the first low bit after a stop bit.
"Packet start"	Triggers on the begin of a data packet. The frame start is configured with "Packets" on page 504.
"Data"	Trigger on a serial pattern at a defined position in the data packet. The pattern can include several subsequent symbols (data frames). See "Data conditions" on page 507.
"Parity error"	Triggers on a parity error indicating a transmission error. This trigger type is only available if a parity is configured for the UART bus.
"Break condition"	Triggers if a start bit is not followed by a stop bit, the data line remains at logic 0 for longer than a UART word.

"Stop error" Triggers if the stop bit is a logic 0.

Remote command:
TRIGger<m>:UART:TYPE on page 1361

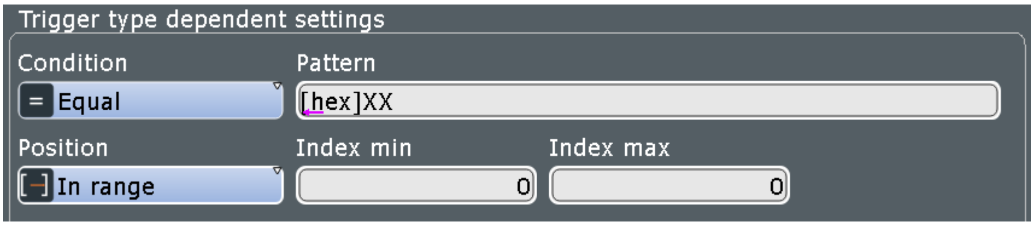
Trigger source

Selects the transmitter or receiver line as trigger source.

Remote command:
TRIGger<m>:UART:SOURce on page 1361

Data conditions

Specify the data conditions if the trigger type is set to "Data".



Condition ← Data conditions

Selects the operator for the "Data" pattern: "Equal" or "Not equal".

Remote command:
TRIGger<m>:UART:FCONdition on page 1362

Pattern ← Data conditions

Specifies the data pattern to be found on the specified trigger source, in binary or hex format. Enter the words in msb first bit order. The starting point of the pattern is defined by Position and Index min, Index max.

The bit pattern editor helps you to enter the pattern, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

Remote command:
TRIGger<m>:UART:DATA on page 1362

Position ← Data conditions

Operator for the data position. You can define an exact position, or a position range.

The setting is available if packet detection is enabled in the protocol configuration.

Remote command:
TRIGger<m>:UART:DPOPerator on page 1361

Index min, Index max ← Data conditions

Sets the number of words before the first word of interest. These offset words are ignored. If the Position defines a range, the first and the last words of interest are defined.

The setting is available if packet detection is enabled in the protocol configuration.

Remote command:
TRIGger<m>:UART:DPOSition on page 1361
TRIGger<m>:UART:DPTO on page 1362

12.4.3.2 Triggering on UART Signals

Prerequisites: An UART bus is configured, see Chapter 12.4.3.1, "UART Trigger Settings", on page 506.

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Select the serial bus that is set to UART.
5. Select the "Trigger type" and "Trigger source".
6. For more complex trigger types, enter the data conditions: pattern, position, index. For details, see Chapter 12.2.3, "I²C Trigger", on page 475

12.4.4 UART Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The decoding process considers the "Bit order" configuration setting of the signal and displays the binary result MSB first. Binary values in the combs of the decoded signal also consider the "Binary bit order" setting in the "Display" tab. Thus, you can read the bits of an LSB first signal in LSB first order in the combs while the results table displays the correct values MSB first.

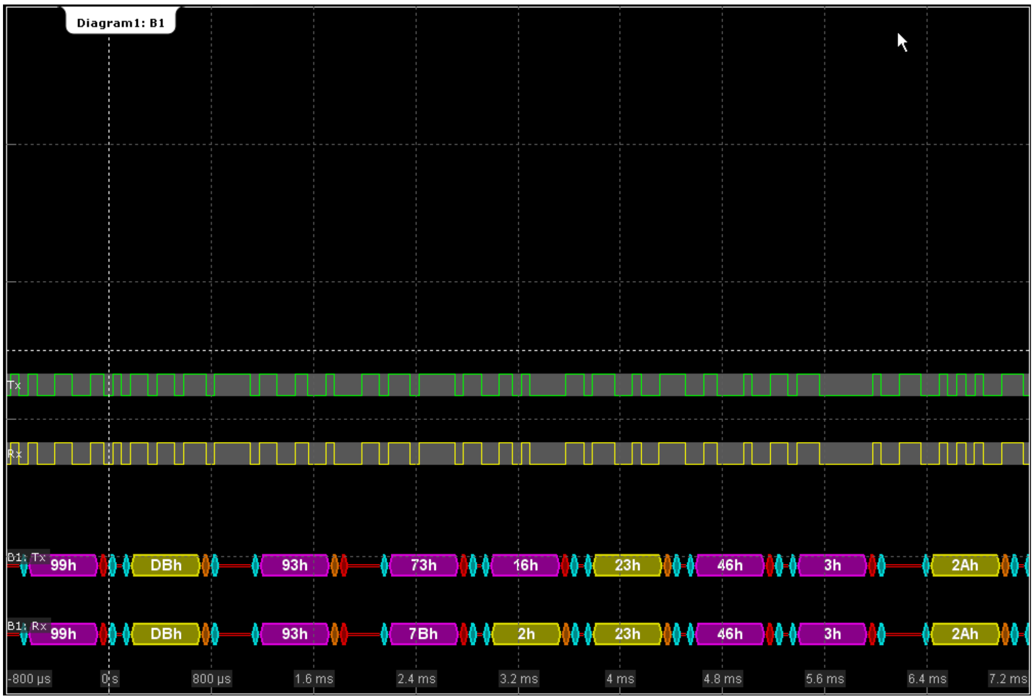


Figure 12-10: Decoded and binary UART signal

blue = start and stop bits if ok
red = start error, stop error, parity error
orange = parity bit if ok
yellow = word ok
magenta = word contains error

The "Decode results" box shows the detailed decoded data for each word.

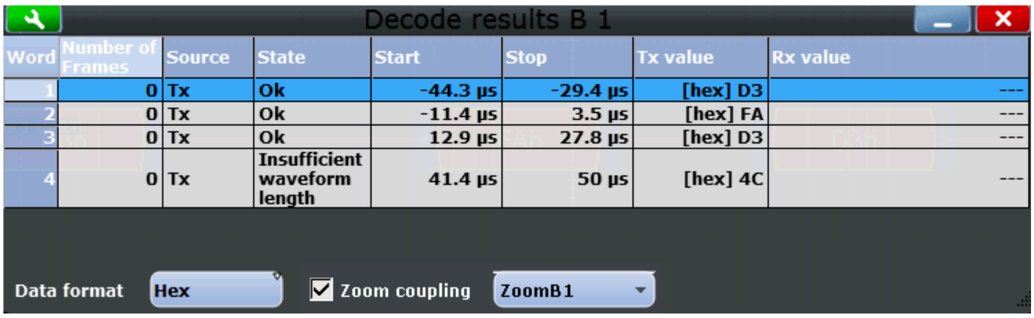


Figure 12-11: Decode results of the UART signal

Table 12-5: Content of the "Decode results" table

Column	Description
Number of Frames	
Source	Line, Tx or Rx

Column	Description
State	Decoding state of the word. "Insuffcient waveform length" indicates that the word is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of the word start (start bit)
Stop	Time of the word stop (stop bit)
Tx value	Value of the Tx word. The data format is selected below the table.
Rx value	Value of the Rx word. The data format is selected below the table.

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:
- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.5.3, "Decode Results", on page 1362.

12.5 CAN and CAN FD (Options R&S RTP-K3 and -K9)

CAN is the Controller Area Network, a bus system designed by Bosch for use within automotive network architecture, for example, for brake, power train and engine management. Today, it is also used in many other systems, for example, in industrial machines, aerospace, subsea, merchant marine etc..

More than 20 years after the invention of CAN, communication needs have increased, and CAN has reached it's bandwidth limits in some application fields. Therefore, Bosch specified an improved CAN protocol with flexible data rate - CAN FD. It introduces a higher bit rate in the data phase up to 15 Mbit/s and an extended data field from up to 64 bytes.

The R&S RTP provides decoding, triggering and searching CAN and CAN FD signals with following options:

- CAN: option R&S RTP-K3
- CAN FD: option R&S RTP-K9, requires CAN option R&S RTP-K3

12.5.1 CAN and CAN-FD Configuration

Access: [Protocol] key > "Decode" tab > "Protocol" = "CAN" or "CAN/CAN-FD"

Make sure that the tab of the correct serial bus is selected on the left side.

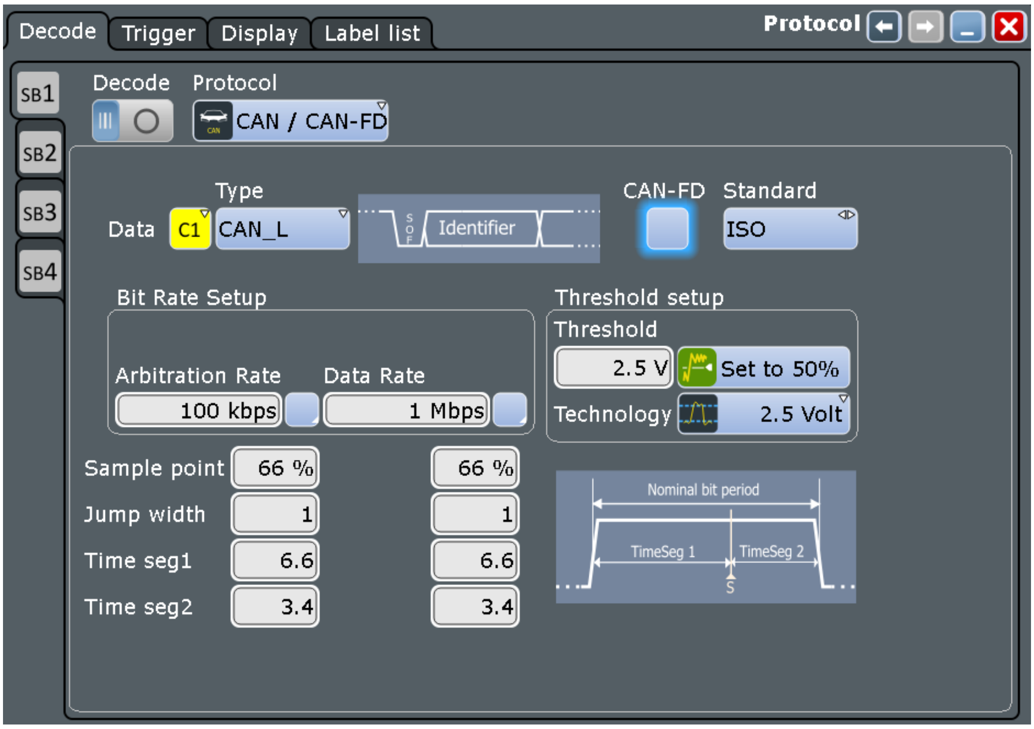


Figure 12-12: Configuration for CAN FD

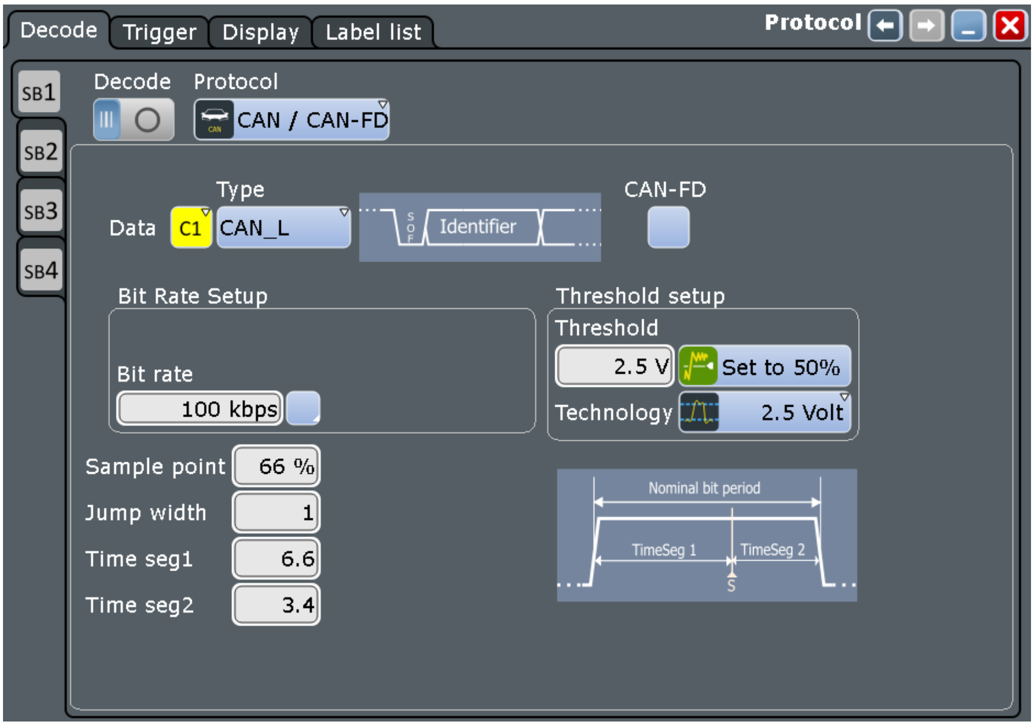


Figure 12-13: Configuration for CAN

See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Protocol

Defines the protocol type of the selected serial bus.

Remote command:

`BUS<m>:TYPE` on page 1299

Decode

Enables the decoding of the selected bus. The signal icon of the bus appears on the sidebar.

Remote command:

`BUS<m>[:STATe]` on page 1299

Data

Sets the source of the selected data line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTP-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

A math waveform can be used, for example, if you probe on CAN-High and CAN-Low using two single-ended probes, and the difference between high and low is calculated and displayed using a math waveform.

Remote command:
BUS<m>:CAN:DATA:SOURce on page 1365

Type
Selects the CAN-High or CAN-Low line. CAN uses both lines for differential signal transmission.

If you measure with a differential probe, connect the probe to both CAN-H and CAN-L lines, and select the data "Type" = *CAN-H*.

If you use a single-ended probe, connect the probe to either CAN_L or CAN_H, and select the data type accordingly.

Remote command:
BUS<m>:CAN:TYPE on page 1365

CAN-FD
Enables the CAN FD protocol configuration and displays additional CAN FD parameters.

The setting is available in CAN FD option R&S RTP-K9.

Remote command:
BUS<m>:CAN:FDATa:ENABle on page 1367
BUS<m>:CAN:FDATa:FRAMe<n>:STANdard? on page 1378

Standard
Only available for CAN FD buses.

"Non-ISO"	Signals are decoded according to the the Bosch CAN FD protocol.
"ISO"	Signals are decoded according to the the ISO CAN FD protocol. This protocol has an additional stuff count field before the CRC sequence.

Remote command:
BUS<m>:CAN:FDATa:PSTandard on page 1365

Threshold
Sets the threshold value for digitization of the signal. If the signal value on the line is higher than the threshold, the signal state is high (1 or true for the boolean logic). Otherwise, the signal state is considered low (0 or false).

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:CAN:DATA:THReshold` on page 1366
`BUS<m>:CAN:TECHnology` on page 1366
`BUS<m>:SETReflevels` on page 1299

Bit rate (CAN) / Arbitration rate (CAN FD)
For CAN buses, the "Bit rate" sets the number of transmitted bits per second.

For CAN FD buses, this parameter is called "Arbitration rate" and sets the bit rate of the arbitration phase.

The maximum value of this rate is 1 Mbit/s. The bit rate is uniform and fixed for a given CAN or CAN FD bus.

To select a bit rate from the list of predefined values, tap the button beside the field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

Remote command:
`BUS<m>:CAN:BITRate` on page 1367

Data rate
The setting is available in CAN FD option R&S RTP-K9.

Sets the bit rate of the data phase. The data rate can be equal or higher than the arbitration rate; and it is uniform and fixed for a given CAN FD bus.

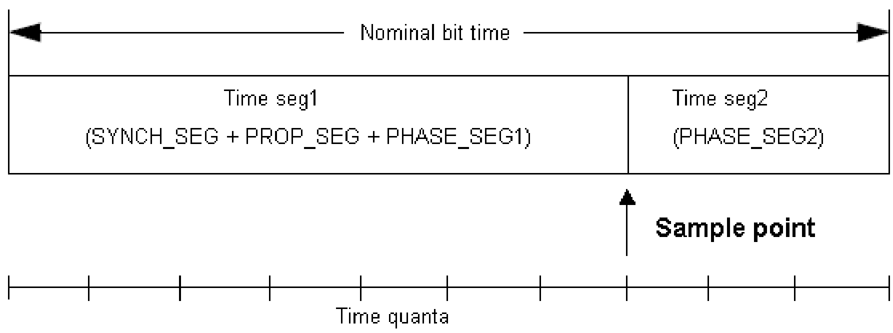
To select a data rate from the list of predefined values, tap the button beside the field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

Remote command:
`BUS<m>:CAN:FDATa:DBITrate` on page 1367

Synchronization: Sample point, Time segments, Jump width
The CAN bus interface uses an asynchronous transmission scheme. The standard specifies a set of rules to resynchronize the local clock of a CAN node to the message.

The sample point divides the nominal bit period into two distinct time segments. The length of the time segments is defined in time quanta according to network and node conditions during CAN development.

For CAN FD signals, you can define the sysnchronization settings separately for the arbitration phase and data phase.



To specify the bit timing, enter either "Time seg1" and "Time seg2", or directly the "Sample point". Additionally, set the "Jump width".

"Time seg1, Time seg2"
: Set the number of time quanta before the sample point (Time seg1) and after the sample point (Time seg2). The "Sample point" percentage value is adjusted accordingly.
Time seg1 comprises the segments Synch_seg, Prop_seg, and Phase_seg1 which are specified in the CAN standard. Time seg2 matches Phase_seg2 from the standard.
The maximum sum of Time seg1 and Time seg2 is 24.

"Sample point"
: Sets the position of the sample point within the bit in percent ot the nominal bit time.
The time quanta values "Time seg1, Time seg2" are adjusted accordingly.

"Jump width"
: Time segment1 may be lengthened or time segment2 may be shortened due to resynchronization. Resynchronization corrects the phase error of an edge caused by the drift of the oscillators. The jump width defines the maximum number of time quanta for phase correction.
The maximum value of the jump width is 4, or *Time seg1 - Time seg2* if this difference is lower than 4.

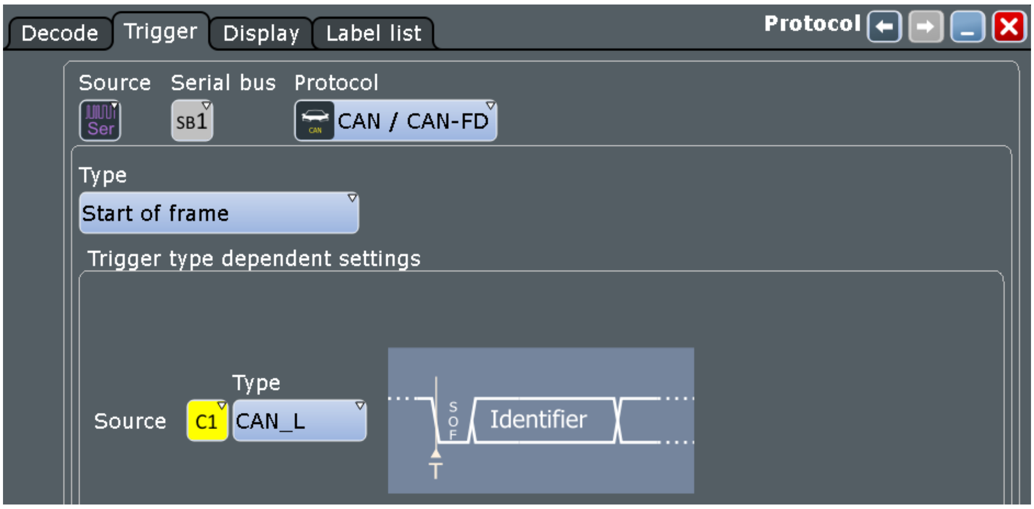
Remote command:
`BUS<m>:CAN:T1Segment` on page 1368
`BUS<m>:CAN:T2Segment` on page 1368
`BUS<m>:CAN:SAMPlepoint` on page 1367
`BUS<m>:CAN:JWIDth` on page 1369
`BUS<m>:CAN:FDATa:T1Segment` on page 1368
`BUS<m>:CAN:FDATa:T2Segment` on page 1368
`BUS<m>:CAN:FDATa:SAMPlepoint` on page 1367
`BUS<m>:CAN:FDATa:JWIDth` on page 1369

12.5.2 CAN / CAN FD Trigger

The R&S RTP can trigger on various events in a CAN or CAN FD frame. Trigger conditions include start of frame, frame ID, data pattern, or error conditions.

12.5.2.1 Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = CAN/CAN-FD"



Make sure that:

- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Serial bus
Selects the serial bus to be triggered on. Make sure to select the correct bus before you enter the settings.

To trigger on a serial bus, the signals sources must be channel signals. If the data or clock source is a math or reference waveform, you cannot trigger on that bus.

Remote command:
`TRIGger<m>:SOURce:SBSelect` on page 1303

Protocol
Defines the protocol type of the selected serial bus.

Remote command:
`BUS<m>:TYPE` on page 1299

Trigger type
Selects the trigger type for CAN analysis.

"Start of frame" Triggers on the first edge of the dominant SOF bit (synchronization bit).

"Frame type" Triggers on a specified frame type (data, remote, error, or overload). For data and remote frames, also the identifier format is considered.

For details, see:
- "Frame type" on page 517
- "ID type" on page 518

"Identifier"	Sets the trigger to a specific message identifier or an identifier range. See "Identifier setup: Condition, Identifier min, Identifier max" on page 518.
"Identifier + Data"	Sets the trigger to a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern. The identifier conditions are the same as for the "Identifier" trigger type, see "Identifier setup: Condition, Identifier min, Identifier max" on page 518. Data conditions are set with "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 519.
"Error condition"	Identifies various errors in the frame, see "Error conditions" on page 522.
"Symbolic"	The "Symbolic" trigger type is available if a DBC label list file is loaded and applied. It allows you to trigger on a specific data message, or a signal and its value that appears inside the message, see Chapter 12.5.6.1, "Symbolic Trigger", on page 542.

Remote command:
`TRIGger<m>:CAN:TYPE` on page 1370

Standard

Selects the CAN standard: "CAN", "CAN FD", or "Any".

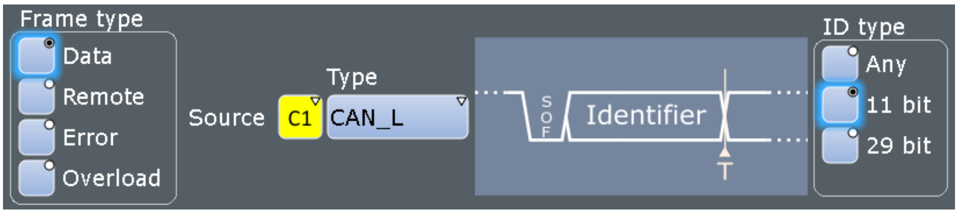
The setting is available in CAN FD option R&S RTP-K9.

Use "Any" to trigger on either CAN or CAN-FD frame. In this case, the trigger configuration provides all possible settings, for CAN as well as for CAN FD.

Remote command:
`TRIGger<m>:CAN:FDATa:STANdard` on page 1371

Frame type

CAN has four frame types which can be used as trigger condition.



For data and remote frames, the identifier format has to be set with ID type.

"Data"	The data frame is the only frame for actual data transmission.
"Remote"	Remote frames are only available in the CAN protocol. The remote frame initiates the transmission of data by another node. The frame format is the same as of data frames but without the data field.

"Error" When a node recognizes an error, it cancels transmission by sending an error frame.
The instrument triggers seven bit periods after the end of the error flag that is marked by a dominant-recessive edge.
The ID type is irrelevant for error frames.

"Overload" When a node needs a delay between data and/or remote frames, it sends and overload frame.
The instrument triggers seven bit periods after the end of the overload flag that is marked by a dominant-recessive edge.
The ID type is irrelevant for overload frames.

Remote command:
TRIGger<m>:CAN:FTYPe on page 1371

ID type
Selects the length of the identifier:

"11 bit" Identifier length of the CAN base frame format. The instrument triggers on the sample point of the IDE bit (identifier extension flag).

"29 bit" Identifier length of the CAN extended frame format. The instrument triggers on the sample point of the RTR bit.

"Any" The ID type and ID pattern are not relevant for the trigger condition.
If the trigger type is "Identifier", the instrument triggers on any identifier in the specified frame type.
If the trigger type is "Identifier + Data", set the "ID type" to "Any" if you want to trigger only on data.

Remote command:
TRIGger<m>:CAN:ITYPe on page 1371

Identifier setup: Condition, Identifier min, Identifier max
The identifier setup consists mainly of the condition and one or two identifier patterns. Additionally, ID type and frame type may qualify the identifier.

The trigger point depends on the ID type.

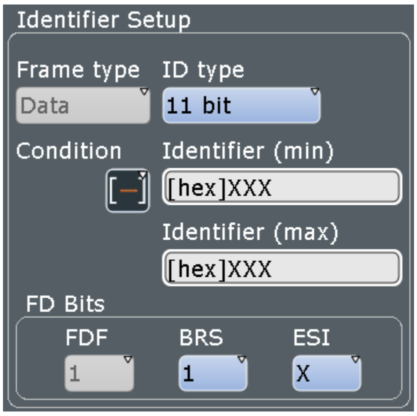


Figure 12-14: Identifier setup for CAN FD

"Frame type" Data frames and remote frames contain an identifier. Select the frame type to be triggered on, or select "Any" if the frame type is not relevant.
In CAN FD, only "Data" frames are available.

"ID type" See: "ID type" on page 518.

"Condition" Defines the operator to set a specific identifier ("Equal" or "Not equal") or an identifier range.

"Identifier min" Defines the bit pattern of the message identifier. In binary format, use the following characters: 1; 0; or X (any bit). The use of X is restricted to the conditions "Equal" and "Not equal".
The length of the bit patterns is restricted to the selected "ID type".
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Identifier max" The second identifier pattern is required to specify a range with conditions "In range" and "Out of range".

"FD bits" See: "FD bits" on page 519.

Remote command:
`TRIGger<m>:CAN:ICONdition` on page 1372
`TRIGger<m>:CAN:IMIN` on page 1372
`TRIGger<m>:CAN:IMAX` on page 1372

FD bits
For standard settings "CAN FD" and "Any", you can trigger on CAN FD-specific bits.

"FDF" The bit determines whether a frame is CAN or CAN-FD. It corresponds to the EDL bit (extended data length), which only exists in CAN FD format. If you do not know if the signal is CAN or CAN FD, you can use this bit to identify the format: FDF = 1 is CAN FD, and FDF = 0 is CAN. Set "X" if the format is not relevant.

"BRS" is the bit rate switch bit. Value 1 means that the bit rate switches from the "Arbitration rate" to the faster "Data rate".

"ESI" is the error state indicator. Set "X" if the bit is not relevant.

Remote command:
`TRIGger<m>:CAN:FDATa:FDF` on page 1373
`TRIGger<m>:CAN:FDATa:BRS` on page 1373
`TRIGger<m>:CAN:FDATa:ESI` on page 1373

Data setup: DLC, NDB, Transfer, Condition, Data min, Data max
The data setup consists of the transfer direction, the number of bytes, the condition, and one or two data patterns.

To trigger only on data, set the "ID type" of the identifier setup to "Any".

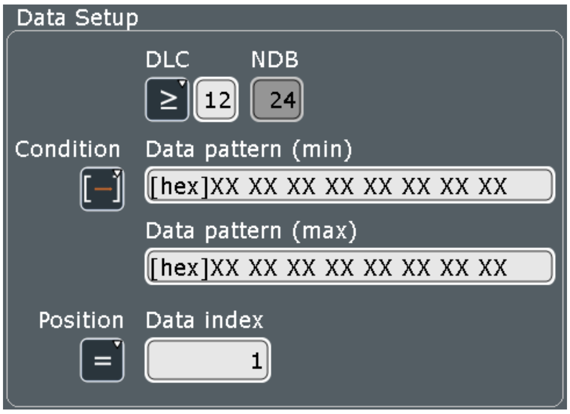


Figure 12-15: Data setup for CAN FD

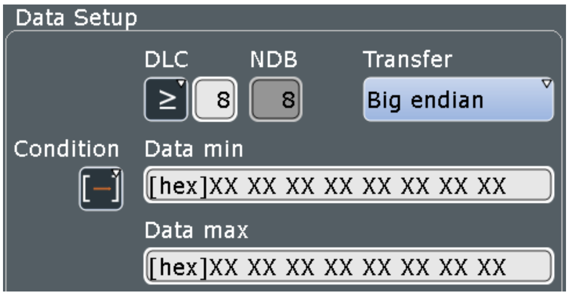


Figure 12-16: Data setup for CAN

"Transfer" CAN only:

Sets the byte order (endianness) of the data transfer. With "Big endian", the data is analyzed and evaluated in the order of reception. With "Little endian", the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

"DLC, NDB" "DLC" sets the Data Length Code, which defines the number of data bytes to be found.
"NDB" shows the number of data bytes that is set by the DLC. DLC and NDB are different in CAN FD for DLCs > 8.
CAN:

For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set.
Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*.
With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*.
CAN FD:
The data field can have up to 64 bytes, the DLC is defined in the standard. For example, DLC = 9 defines that the data field has 12 bytes, and DLC = 15 sets a 64 byte data field.

"Condition" Sets the operator to set a specific data pattern ("Equal" or "Not equal") or a data range.

"Data min" Defines the data pattern. The pattern length is adjusted to the DLC setting (and vice versa). Enter the pattern MSB first and with big endian byte order.
In binary format, use the following characters: 1; 0; or X (any bit). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:CAN:BORDer` on page 1374
`TRIGger<m>:CAN:DCONdition` on page 1373
`TRIGger<m>:CAN:DMIN` on page 1374
`TRIGger<m>:CAN:DMAX` on page 1374
`TRIGger<m>:CAN:DLCCondition` on page 1374
`TRIGger<m>:CAN:DLC` on page 1375
`TRIGger<m>:CAN:NDBYtes?` on page 1375

Data position

The data position sets the location in the data field where the instrument looks for the specified data pattern.

The setting is available in CAN FD option R&S RTP-K9.

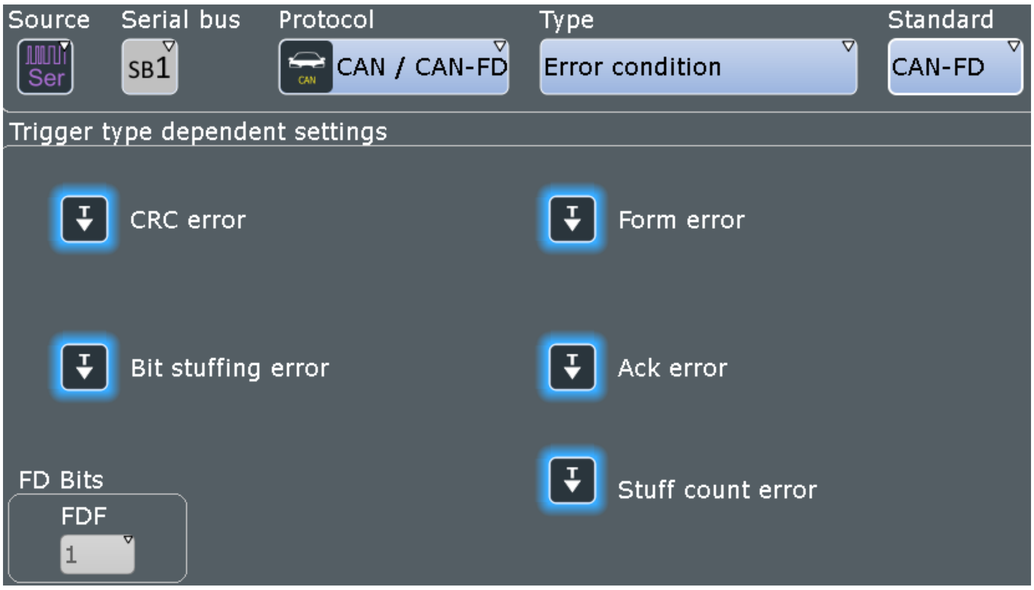
The position can be defined if the data field of the frame is longer than 8 bytes - if DLC ≥9.

"Position" Sets the operator to define an exact position ("Equal") or a data range.
Use "Any", if the data position is not relevant for the trigger condition.

"Data index (min)"	Defines the number of the first data byte at which the data pattern may start.
"Data index (max)"	Sets the number of the last byte at which the required data pattern may start if the "Position" operator is "In range".

Remote command:
`TRIGger<m>:CAN:FDATa:DPOPerator` on page 1375
`TRIGger<m>:CAN:FDATa:DPOSition` on page 1375
`TRIGger<m>:CAN:FDATa:DPTO` on page 1376

Error conditions
If a CAN detects an error, it transmits an error flag at the next bit. The R&S RTP detects errors in the message and triggers on these errors even if no CAN node sends an error flag.



- CRC error
  CAN uses the Cyclic Redundancy Check, which is a complex checksum calculation method. The transmitter calculates the CRC and sends the result in the CRC sequence. The receiver calculates the CRC in the same way. A CRC error occurs when the calculated result differs from the received value in the CRC sequence.
- Bit stuffing error
  The frame segments Start Of Frame, Arbitration Field, Control Field, Data Field and CRC Sequence are coded by the bit stuffing method. The transmitter automatically inserts a complementary bit into the bit stream when it detects five consecutive bits of identical value in the bit stream to be transmitted. A stuff error occurs when the 6th consecutive equal bit level in the mentioned fields is detected.
- Form error
  A form error occurs when a fixed-form bit field contains one or more illegal bits.
- Ack error
  An acknowledgement error occurs when the transmitter does not receive an acknowledgment - a dominant bit during the Ack Slot.
- Stuff count error

A stuff count error occurs if th received stuff count value does not match the value calculated from the own stuff bit count. Only relevant for CAN FD signals in ISO standard.

Remote command:
`TRIGger<m>:CAN:CRCerror` on page 1376
`TRIGger<m>:CAN:BITSterror` on page 1376
`TRIGger<m>:CAN:FORMerror` on page 1377
`TRIGger<m>:CAN:ACKerror` on page 1376
`TRIGger<m>:CAN:FDATa:SCERror` on page 1377

12.5.2.2 Triggering on CAN FD Data

The "Identifier + Data" trigger type supports triggering on data bytes of specific value at specific location in the data field of a frame. The "Data Pattern" field provides 8 data bytes to define the data pattern. For data fields longer than 8 byte, you can define the position where the specified pattern starts.

The following examples demonstrate how the data pattern and data position are defined.

To set up the trigger

1. Set the basic trigger events:
   a) Select the source: "Serial bus".
   b) Select the serial bus.
   c) Select the protocol: "CAN/CAN FD".
   d) Select the trigger type: "Identifier + Data".
   e) Select the standard:"CAN FD" or "Any".
2. In this example, the identifier does not matter. Set the "ID type = Any".
3. Define the data setup as described in the examples.

Example: Triggering on the second data byte

The CAN FD frame has 2 or more data bytes, where the value of the second data byte should be E7.

- Set "DLC ≥ 2".
- Set the data pattern: "= XX E7".

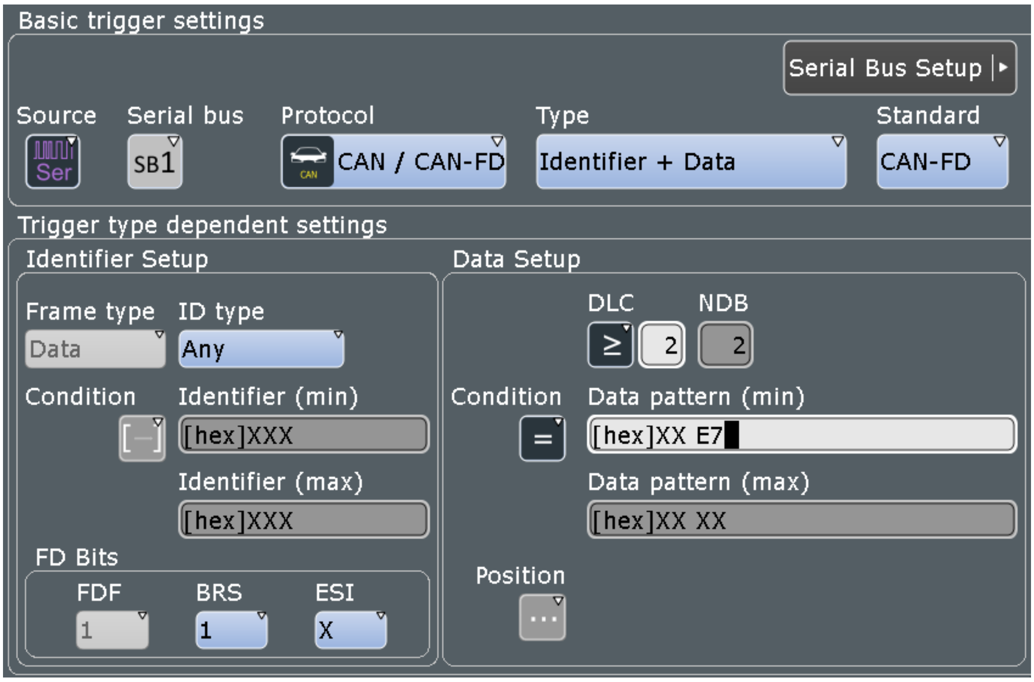
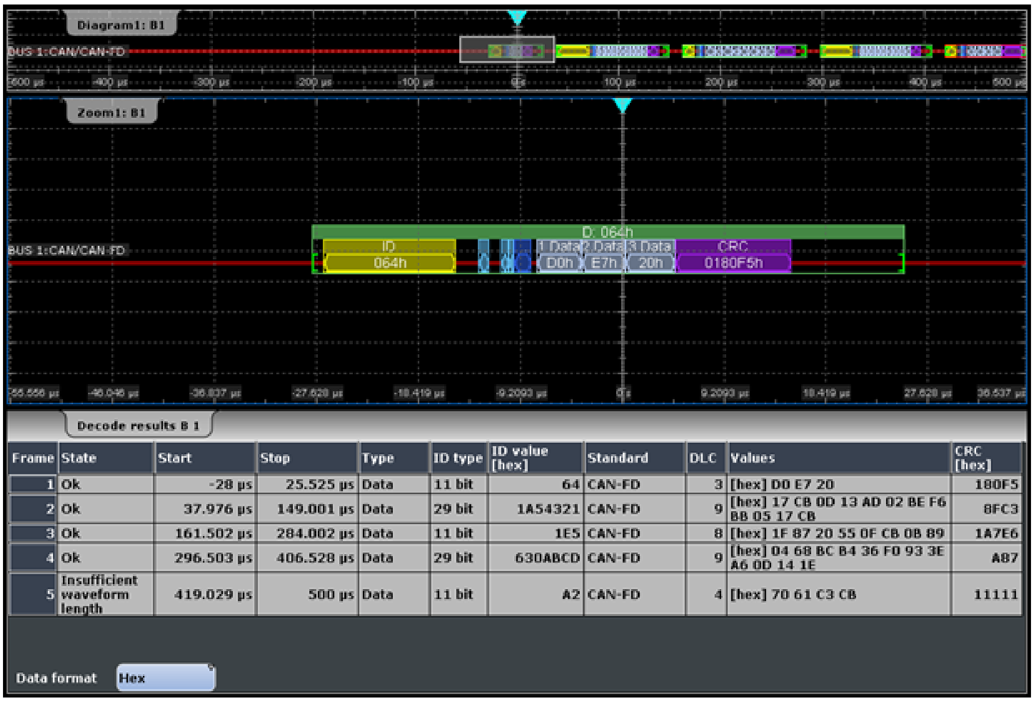


Figure 12-17: Trigger setup to trigger on the 2nd data byte with value = E7



Frame	State	Start	Stop	Type	ID type	ID value [hex]	Standard	DLC	Values	CRC [hex]
1	Ok	-28 µs	25.525 µs	Data	11 bit	64	CAN-FD	3	[hex] D0 E7 20	180F5
2	Ok	37.976 µs	149.001 µs	Data	29 bit	1A54321	CAN-FD	9	[hex] 17 CB 0D 13 AD 02 BE F6 BB 05 17 CB	8FC3
3	Ok	161.502 µs	284.002 µs	Data	11 bit	1E5	CAN-FD	8	[hex] 1F 87 20 55 0F CB 08 89	1A7E6
4	Ok	296.503 µs	406.528 µs	Data	29 bit	630ABCD	CAN-FD	9	[hex] 04 68 BC B4 36 F0 93 3E A6 0D 14 1E	A87
5	Insufficient waveform length	419.029 µs	500 µs	Data	11 bit	A2	CAN-FD	4	[hex] 70 61 C3 CB	11111

Figure 12-18: Data type trigger on 2nd data byte with value = E7

Example: Triggering on the seventh or later data byte

The CAN FD frame has 12 or more data bytes, where the value of the seventh or later data byte should be 17.

- Set "DLC ≥ 9".
- Set the data pattern: "= XX XX XX XX XX XX 17 XX".

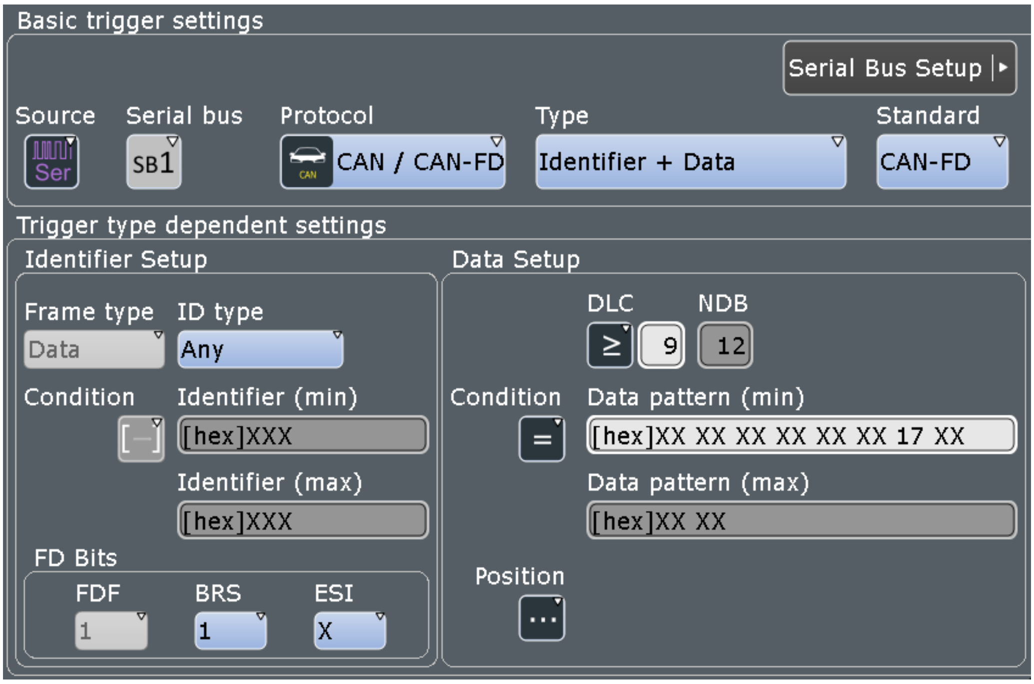


Figure 12-19: Trigger setup to trigger on the 7th or later data byte with value = 17

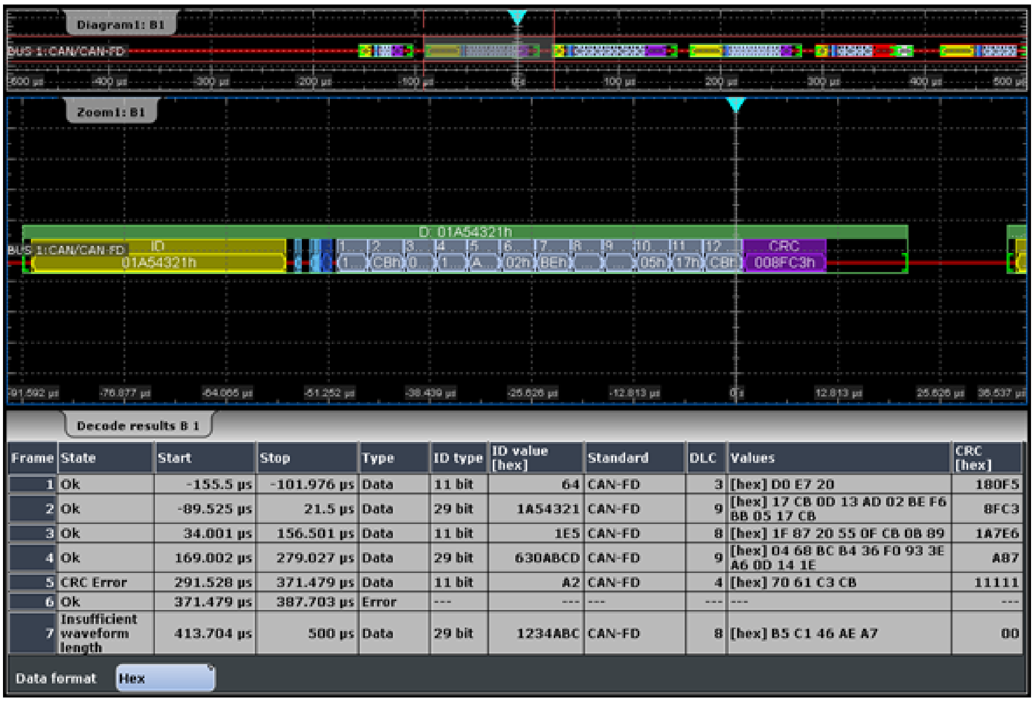


Figure 12-20: Data type trigger on data byte with the 7th or later byte value = 17

Example: Triggering on a data byte at a given position

The CAN FD frame has 12 or more data bytes. the trigger is set at the 8th data byte starting at the 4th data byte or later, with data byte value = 17.

- Set "DLC ≥ 9".
- Set the data pattern: "= XX XX XX XX XX XX XX 17 ".
- Set the position of the data pattern: "In range", "4" to "12".

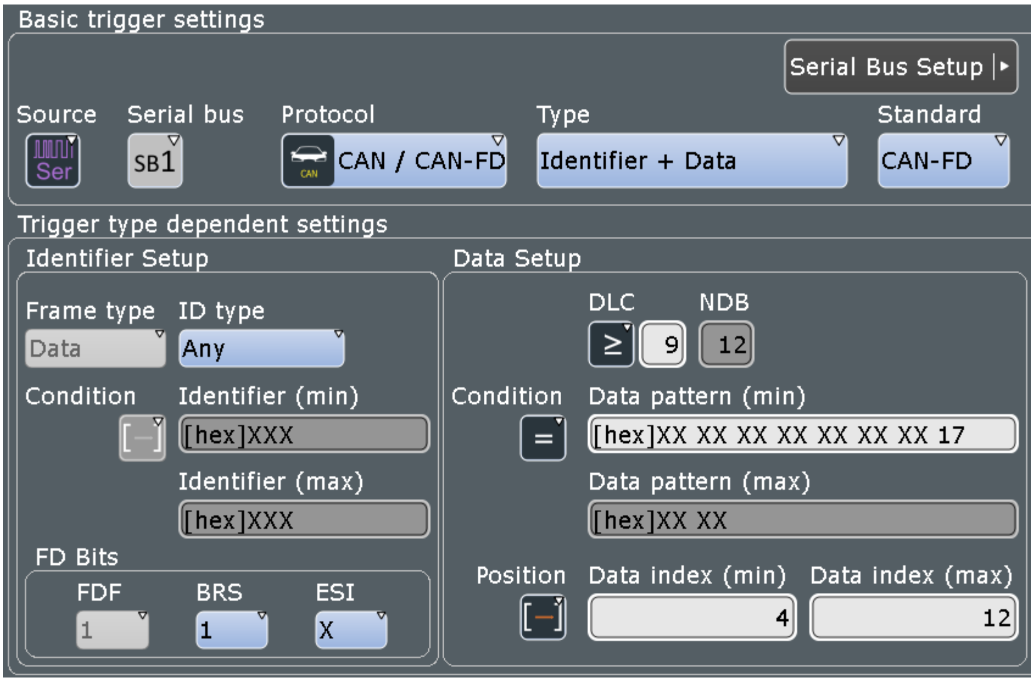


Figure 12-21: Trigger setup to trigger on data byte with value = 17 at 11th data byte location

The instrument skips the first 3 data bytes and starts comparing the data pattern with the 4th data byte. So, the byte with value 17 can be found between the 11th and the 19th data byte.

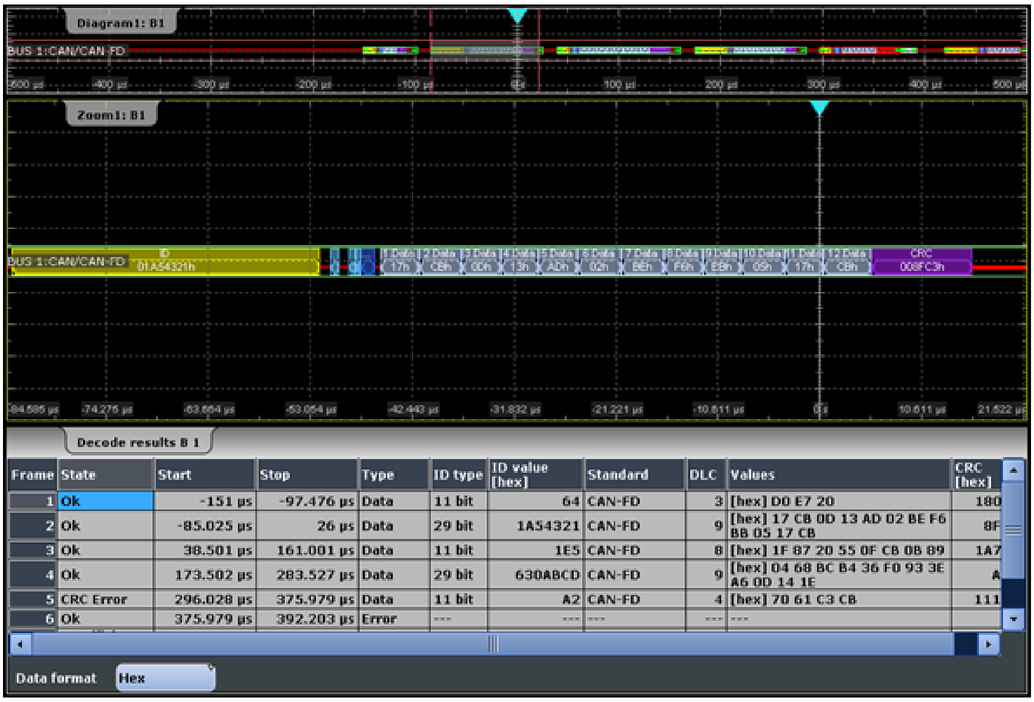


Figure 12-22: Data type trigger on data byte with value = 17 at 11th data byte location

12.5.3 CAN / CAN FD Label List

Label list files (symbolic data files) for CAN and CAN FD protocols are available in PTT and CSV file formats, similar to other serial protocols. In addition, the R&S RTP can read and apply DBC files to the decoded signal and provides settings for symbolic triggering and symbolic search.

Note: In the following, CAN means both protocols: CAN, and CAN FD.

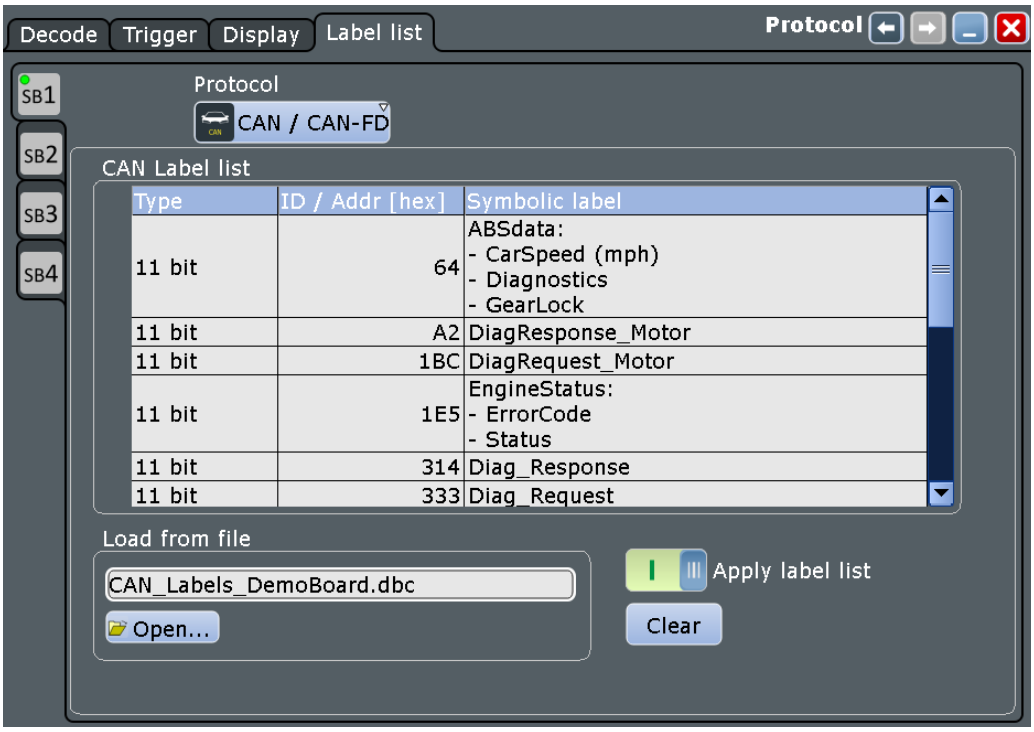
12.5.3.1 DBC Files for CAN / CAN FD

Industry-standard DBC files contain more information than PTT and CSV files and translate the abstract decode results to human language. For each frame, the frame ID and the symbolic name of the ID are given; the frames are also called messages in CAN. The data of a CAN message can consist of several "signals". The DBC file provides the label, unit, start bit, length and other indicators for each signal. For state-encoded signals, the meaning of the states is given.

In the demo example, the message "EngineData" has the decimal ID 2,166,573,756 and consists of 8 data bytes. These 8 bytes are defined as 6 signals. The first one, "PetrolLevel", starts at bit #24, has a length of 8 bit, and the unit is liter. The signal "IdleRunning" is state-encoded. It has only one bit. The binary value 0 means "Running", and the binary value 1 means "Idle".

Example: CAN DBC file section

```
BO_ 2166573756 EngineData: 8 Engine
 SG_ PetrolLevel : 24|8@1+ (1,0) [0|255] "l" ...
 SG_ EngPower : 48|16@1+ (0.01,0) [0|350] "kW" ...
 SG_ EngForce : 32|10@1+ (1,0) [0|1000] "N" ...
 SG_ IdleRunning : 23|1@1+ (1,0) [0|1] "" ...
 SG_ EngTemp : 16|7@1+ (2,-50) [-50|150] "degC" ....
 SG_ EngSpeed : 0|13@1+ (1,0) [0|8000] "rpm" ...
....
 VAL_ 2166573756 IdleRunning 0 "Running" 1 "Idle" ;
```



The usage of DBC files is described in Chapter 12.5.6, "Symbolic Trigger, Decode and Search", on page 542.

12.5.3.2 PTT and CSV Files for CAN / CAN FD

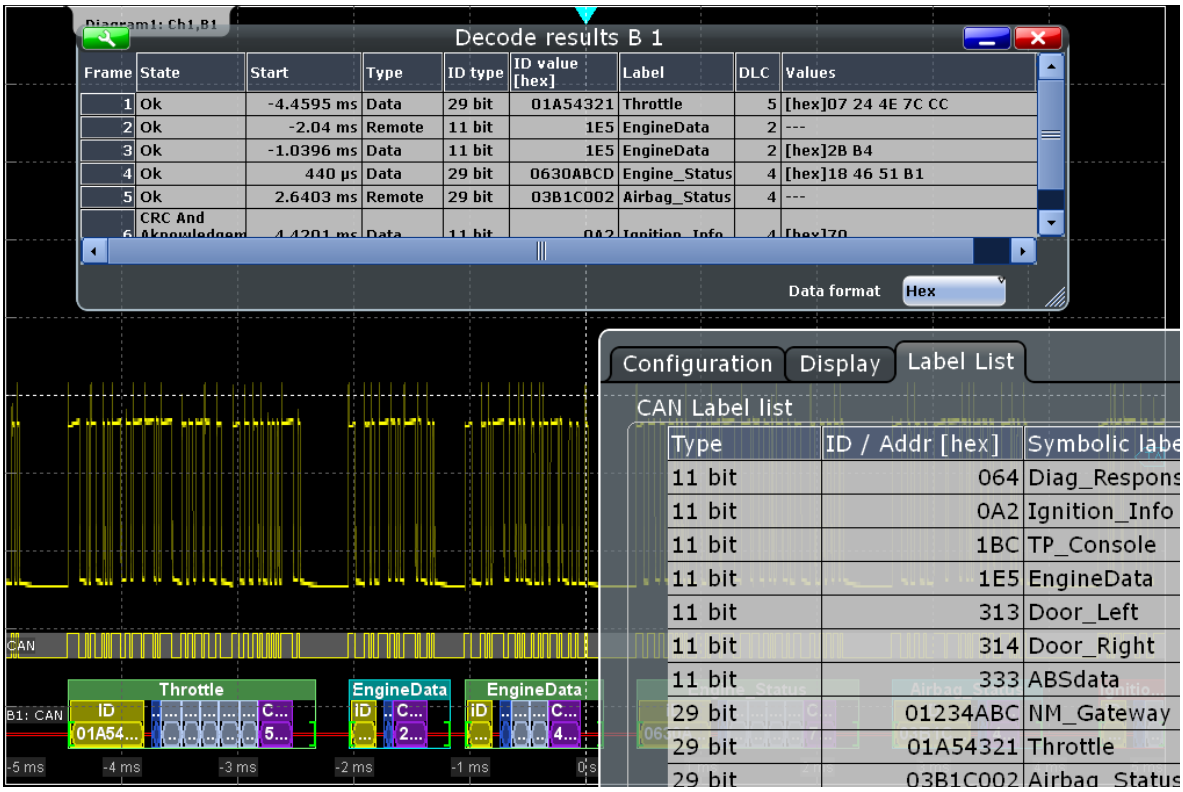
Label list files are protocol-specific. A PTT label file for CAN protocols contains three values for each identifier:

- Identifier type, 11-bit or 29-bit long
- Identifier value
- Label, symbolic name of the identifier, specifying its function in the bus network.

Example: CAN PTT file

```
# ----------------------------------------------------------------------------
@FILE_VERSION  = 1.00
@PROTOCOL_NAME = can
# ---------------------------------------------------------------------------
# Labels for CAN protocol
#   Column order: Identifier type, Identifier value, Label
# ---------------------------------------------------------------------------
11,064h,Diag_Response
11,1E5h,EngineData
11,0A2h,Ignition_Info
11,1BCh,TP_Console
11,333h,ABSdata
11,313h,Door_Left
11,314h,Door_Right
```

```
29,01A54321h,Throttle
29,13A00FA2h,LightState
29,0630ABCDh,Engine_Status
29,03B1C002h,Airbag_Status
29,01234ABCh,NM_Gateway
# --------------------------------------------------------------------------
```



For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 467.

Remote command:
- BUS<m>:CAN:FRAMe<n>:SYMBol? on page 1380

12.5.4 CAN and CAN FD Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

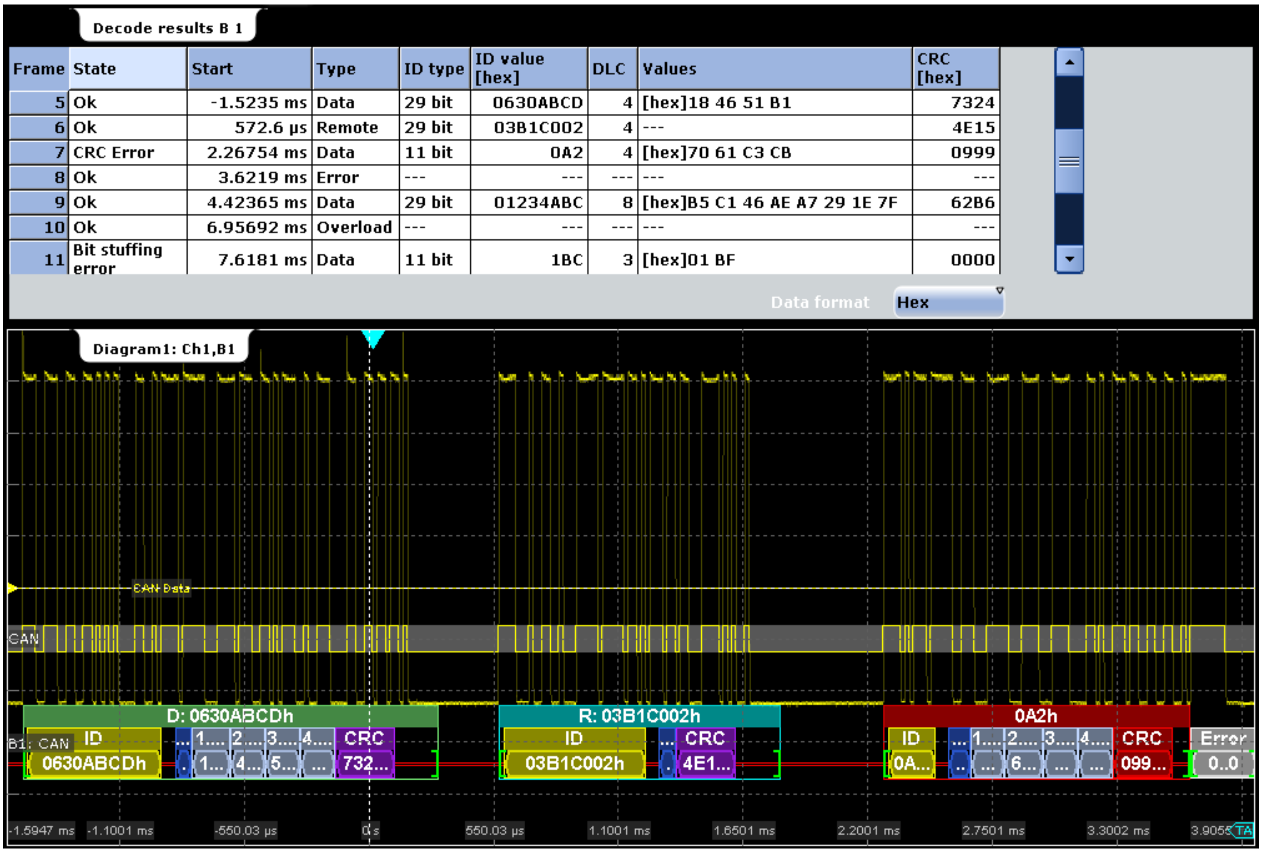
1. In the "Protocol" dialog > "Decode" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The binary results of data bytes are displayed MSB first.

For CAN protocol, the endianness setting ("Transfer") is a trigger setting and not considered for decoding.



Decode results B 1

Frame	State	Start	Type	ID type	ID value [hex]	DLC	Values	CRC [hex]
5	Ok	-1.5235 ms	Data	29 bit	0630ABCD	4	[hex]18 46 51 B1	7324
6	Ok	572.6 µs	Remote	29 bit	03B1C002	4	---	4E15
7	CRC Error	2.26754 ms	Data	11 bit	0A2	4	[hex]70 61 C3 CB	0999
8	Ok	3.6219 ms	Error	---	---	---	---	---
9	Ok	4.42365 ms	Data	29 bit	01234ABC	8	[hex]B5 C1 46 AE A7 29 1E 7F	62B6
10	Ok	6.95692 ms	Overload	---	---	---	---	---
11	Bit stuffing error	7.6181 ms	Data	11 bit	1BC	3	[hex]01 BF	0000

Figure 12-23: Decoded and binary CAN signal, and decode results

green brackets [...]	=	Start and end of frame
green frame header	=	Data frame, ok
cyan frame header	=	Remote frame, ok
magenta frame header	=	Overload frame, ok
red frame header	=	Frame contains an error
no frame header	=	Error frame
yellow	=	Identifier
blue	=	DLC
gray-blue	=	data
purple	=	CRC (checksum)
gray	=	Error frame
red	=	Error occurred

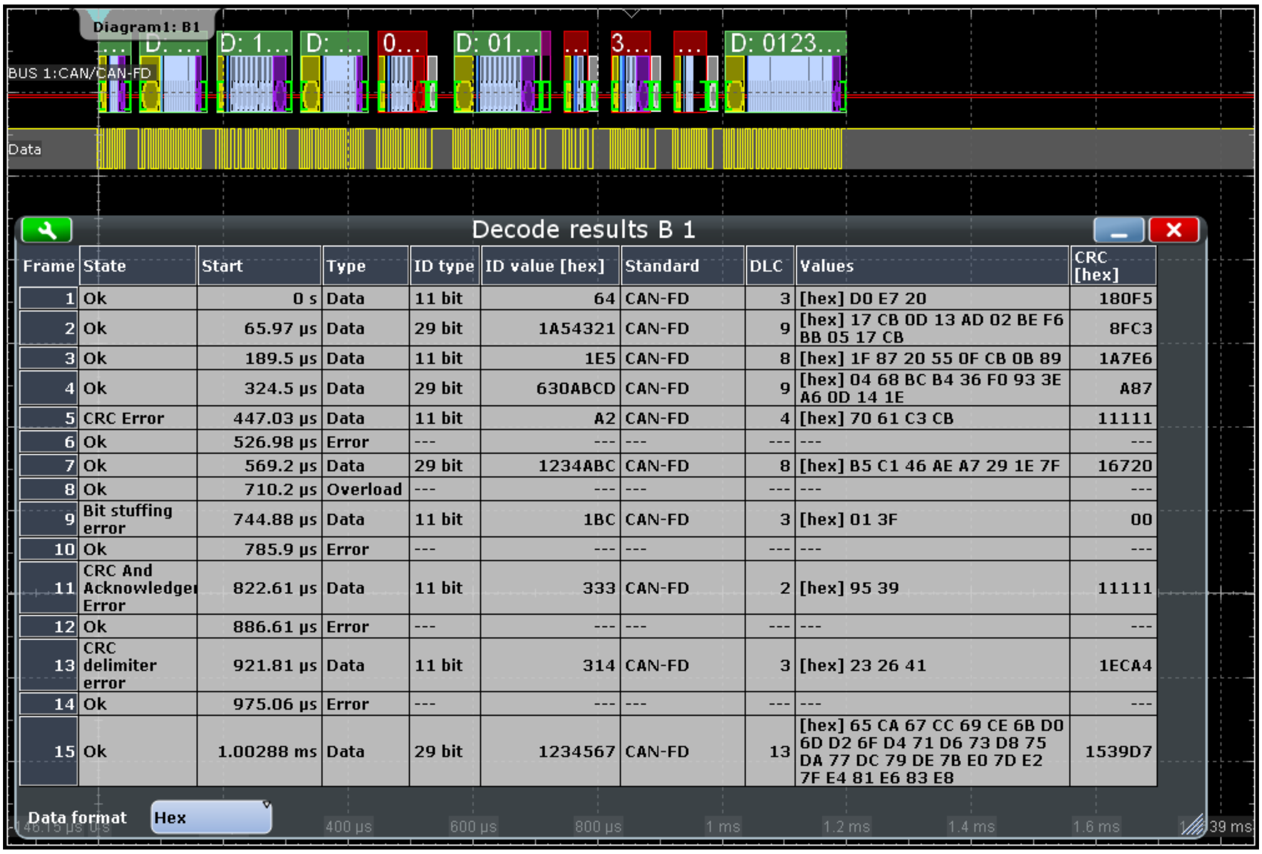


Figure 12-24: Decoded CAN FD signal with data type = CAN_L, arbitration rate = 1 Mbps and data rate = 2 Mbps

You can also load and apply industry-standard DBC files. The symbolic names from the file are applied to the display of the decoded data, see Chapter 12.5.6.2, "Symbolic Decode Waveform", on page 544.

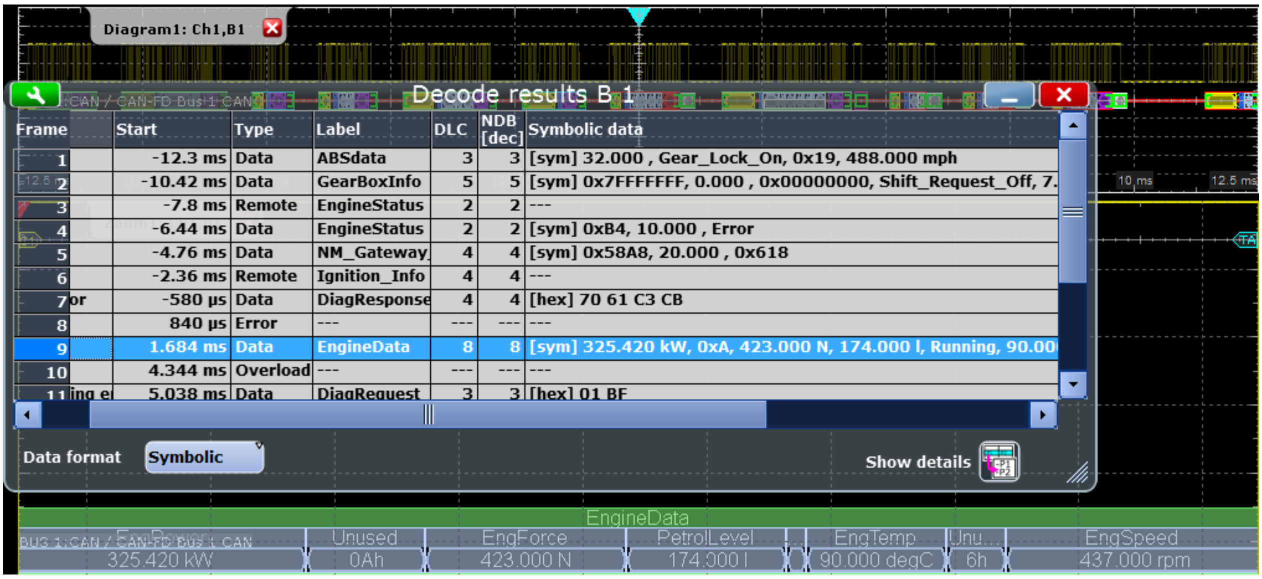


Figure 12-25: Decoded CAN signal with applied DBC file and "Symbolic" data in the result table

Table 12-6: Content of the "Decode results" table

Column	Description
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of frame start
Type	Frame type: Data, Remote, Error, or Overload
ID type	11-bit standard format or 29-bit extended format
ID value (hex)	Identifier value, hexadecimal value
Standard	Frame format, CAN or CAN FD. Only available in CAN FD option R&S RTP-K9.
Label	Symbolic label name defined in the label list
DLC	Data length code, coded number of data bytes
NDB	Actual number of data bytes
Values	Value of the data frame. The data format is selected below the table. Remote frames do not transmit data, therefore "- - -" is displayed.
Symbolic data	Values of the individual signals that are part of a message. The column is shown instead of the "Values" column, if a DBC file is loaded and the "Data format" is "Symbolic".
SC (dec)	Stuff count value, decimal value. Only available for CAN FD ISO signals, option R&S RTP-K9.
CRC (hex)	Value of the Cyclic Redundance Check (checksum), hexadecimal value
Form error cause	Reason of a form error if a form error occurred

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:

- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.6.3, "Decode Results", on page 1377.

12.5.5 Search on Decoded CAN or CAN FD Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

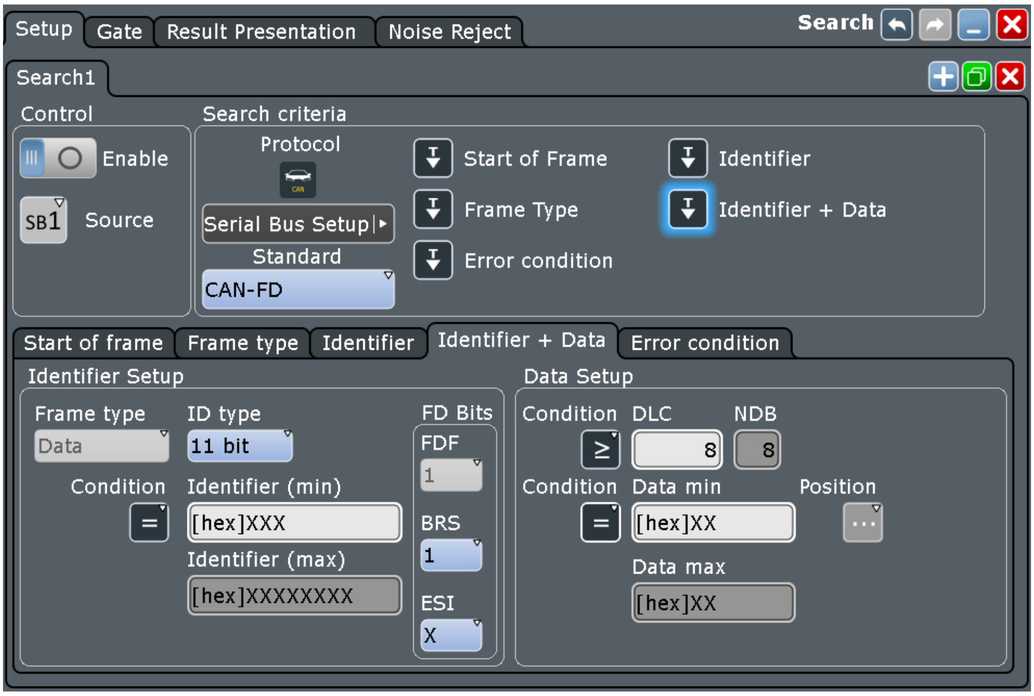
Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 396.

12.5.5.1 Search Settings

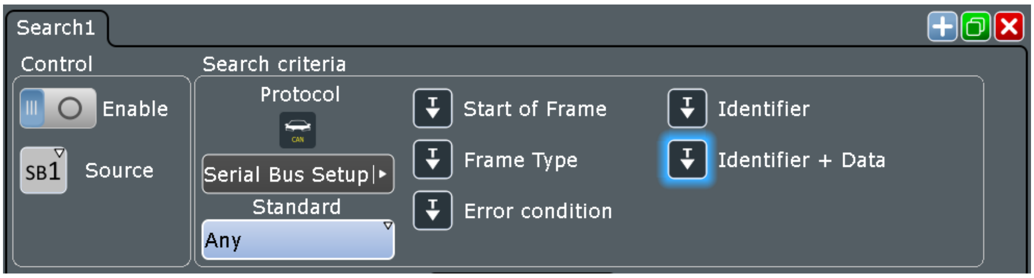
Access: [Search] > "Setup" tab



Search Criteria

Sets one criterion or an AND-combination of criteria to be searched for. If more than one criterion is selected, all criteria must be fulfilled by a frame for it to be shown in the search results.

If a DBC label list file is applied, an additional criterion "Symbolic" is provided, see Chapter 12.5.6.3, "Symbolic Search", on page 545.



"Start of frame"
: Searches for the first edge of the dominant SOF bit (synchronization bit).

"Frame type"
: Searches for a specified frame type (data, remote, error, or overload). For data and remote frames, also the identifier format is considered.
For details, see:
- "Frame type" on page 536
- "ID type" on page 536

"Identifier"
: Searches for a specific message identifier or an identifier range. See "Identifier setup: Condition, Identifier min, Identifier max" on page 536.

"Identifier + Data"
: Searches for a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern.
The identifier conditions are the same as for the "Identifier" search criteria, see "Identifier setup: Condition, Identifier min, Identifier max" on page 536. Data conditions are set with "Data setup: DLC, NDB, Condition, Data min, Data max" on page 537.

"Error condition"
: Identifies various errors in the frame, see "Error conditions" on page 522.

"Symbolic"
: The "Symbolic" search criteria is available if a DBC label list file is loaded and applied. It allows you to search for specific data messages, or a signal and its value that appears inside the message. Symbolic search is an alternative to the other search criteria, you can either search for symbolic values or for an AND-combination of the other 5 criteria.
For details, see Chapter 12.5.6.3, "Symbolic Search", on page 545.

Remote command:
`SEARch:TRIGger:CAN[:SSOFrame]` on page 1386
`SEARch:TRIGger:CAN:SFTYpe` on page 1386
`SEARch:TRIGger:CAN:SFIDentifier` on page 1386
`SEARch:TRIGger:CAN:SIDData` on page 1386
`SEARch:TRIGger:CAN:SERRor` on page 1387
`SEARch:TRIGger:CAN:SSYMbolic` on page 1403

Standard

Selects the CAN standard: "CAN", "CAN FD", or "Any".

The setting is available in CAN FD option R&S RTP-K9.

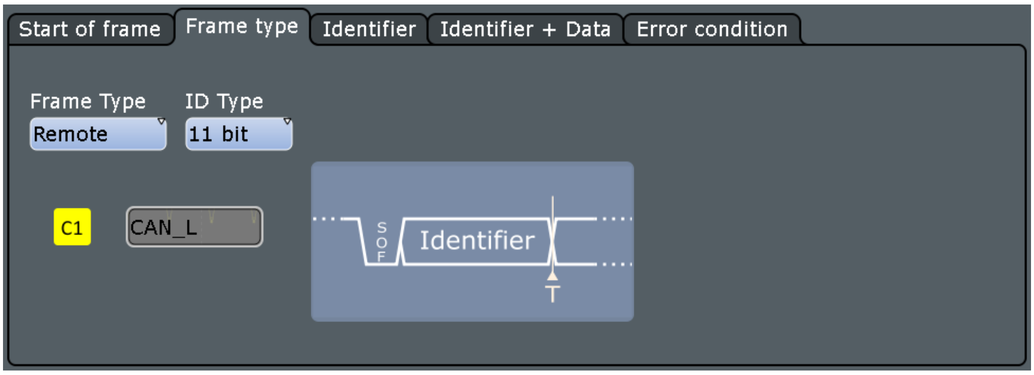
Use "Any" to search for both CAN and CAN-FD frames. In this case, the search configuration provides all possible settings, for CAN as well as for CAN FD.

Remote command:
`SEARch:TRIGger:CAN:FDATa:STANdard` on page 1387

Frame type

Selects the frame type.

Remote frames are only available in the CAN protocol.



The frame types are the same as in the CAN trigger setup, see "Frame type" on page 517.

Remote command:
`SEARch:TRIGger:CAN:FTYPe` on page 1387

ID type

Selects the length of the identifier.

"11 bit" Identifier length of the CAN base frame format. The instrument triggers on the sample point of the IDE bit.

"29 bit" Identifier length of the CAN extended frame format. The instrument triggers on the sample point of the RTR bit.

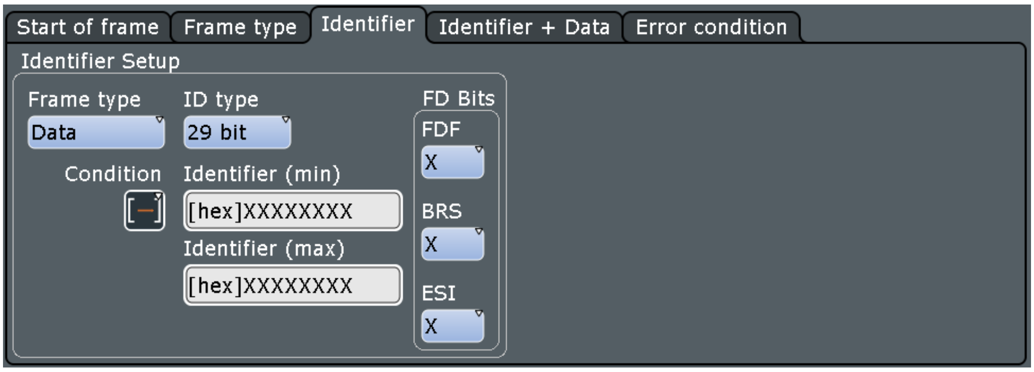
"Any" The ID type is not relevant. If the trigger type is "Identifier + Data", set the "ID type" to "Any" if you want to search only for data.

Remote command:
`SEARch:TRIGger:CAN:ITYPe` on page 1388

Identifier setup: Condition, Identifier min, Identifier max

The identifier setup consists mainly of the condition and one or two identifier patterns. Additionally, ID type and frame type may qualify the identifier.

The identifier setup settings are the same as in the CAN trigger setup, see "Identifier setup: Condition, Identifier min, Identifier max" on page 518.



FD bits: see "FD bits" on page 537.

Remote command:
`SEARch:TRIGger:CAN:ICONdition` on page 1388
`SEARch:TRIGger:CAN:IMIN` on page 1389
`SEARch:TRIGger:CAN:IMAX` on page 1388

FD bits
For standard settings "CAN FD" and "Any", you can search for CAN FD-specific bits.

For details, see "FD bits" on page 519.

The setting is available in CAN FD option R&S RTP-K9.

Remote command:
`SEARch:TRIGger:CAN:FDATa[:FDF]` on page 1393
`SEARch:TRIGger:CAN:FDATa:BRS` on page 1393
`SEARch:TRIGger:CAN:FDATa:ESI` on page 1394

Data setup: DLC, NDB, Condition, Data min, Data max
The data setup consists of the number of bytes, the condition, and one or two data patterns.

The data setup settings are the same as in the CAN trigger setup, see "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 519.

The data condition setting is also used for symbolic signal search, see Chapter 12.5.6.3, "Symbolic Search", on page 545.

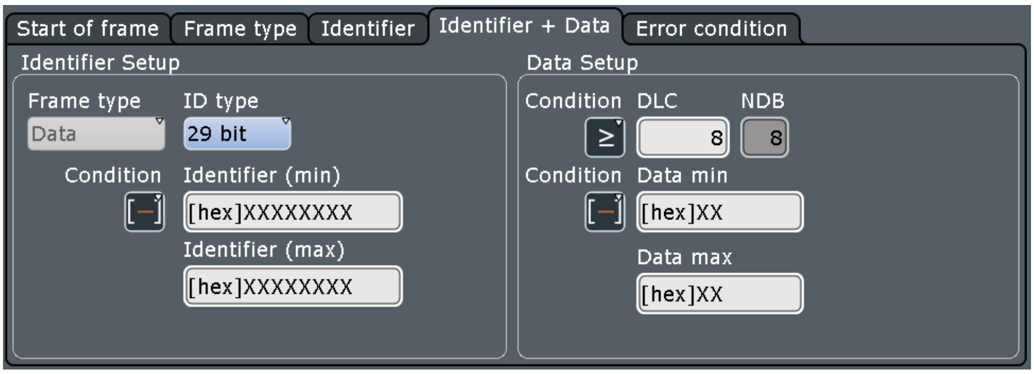


Figure 12-26: Identifier + Data search setup for CAN signals

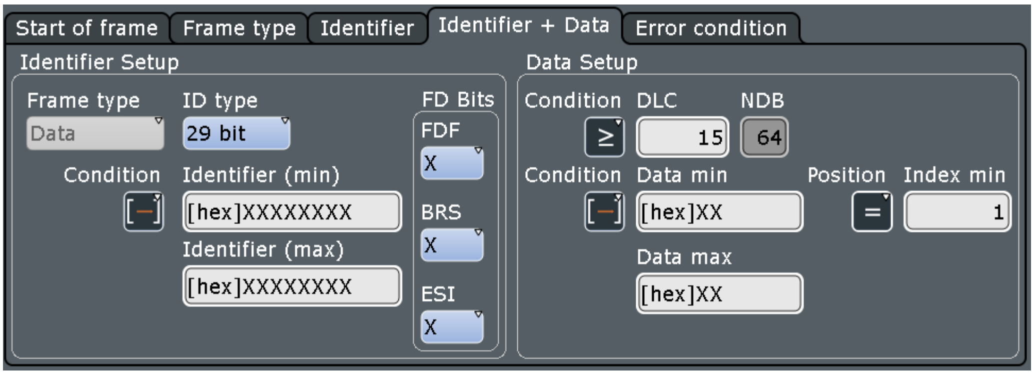


Figure 12-27: Identifier + Data search setup for CAN FD signals

Remote command:
SEARch:TRIGger:CAN:DCONdition on page 1389
SEARch:TRIGger:CAN:DMIN on page 1389
SEARch:TRIGger:CAN:DMAX on page 1390
SEARch:TRIGger:CAN:DLCCondition on page 1390
SEARch:TRIGger:CAN:DLC on page 1390
SEARch:RESult:CAN:FRAMe<m>:NDBYtes? on page 1390

Data position

The data position sets the location in the data field where the instrument looks for the specified data pattern.

The setting is available in CAN FD option R&S RTP-K9.

The position can be defined if the data field of the frame is longer than 8 bytes - if DLC ≥9.

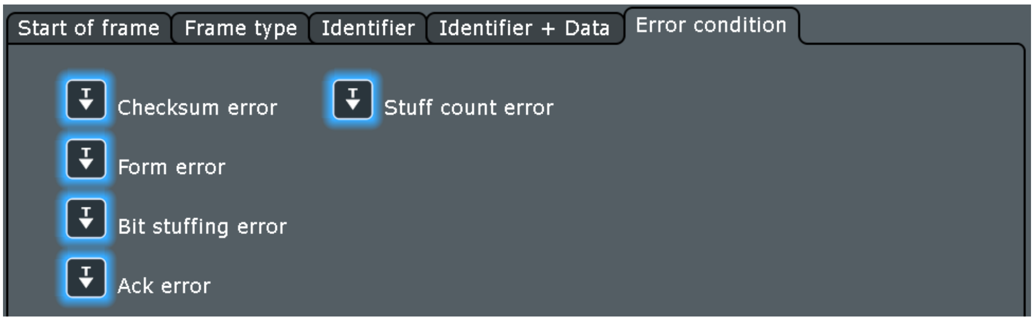
For details, see "Data position" on page 521.

Remote command:
SEARch:TRIGger:CAN:FDATa:DPOPerator on page 1391
SEARch:TRIGger:CAN:FDATa:DPOSition on page 1391
SEARch:TRIGger:CAN:FDATa:DPTO on page 1392

Error Condition

Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the CAN trigger setup, see "Error conditions" on page 522.



Remote command:
SEARch:TRIGger:CAN:CRCerror on page 1392
SEARch:TRIGger:CAN:BITSterror on page 1392
SEARch:TRIGger:CAN:FORMerror on page 1393
SEARch:TRIGger:CAN:ACKerror on page 1392
SEARch:TRIGger:CAN:FDATa:SCERror on page 1393

12.5.5.2 Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:
- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

Remote commands:
- SEARch:RESult:CAN:FCOunt? on page 1395
- SEARch:RESult:CAN:FRAMe<m>:STATus? on page 1399
- SEARch:RESult:CAN:FRAMe<m>:FERCause? on page 1397
- SEARch:RESult:CAN:FRAMe<m>:ACKState? on page 1396
- SEARch:RESult:CAN:FRAMe<m>:ACKValue? on page 1395
- SEARch:RESult:CAN:FRAMe<m>:BSEPosition? on page 1395
- SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:STATe? on page 1395
- SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:VALue? on page 1396
- SEARch:RESult:CAN:FRAMe<m>:CSSTate? on page 1396
- SEARch:RESult:CAN:FRAMe<m>:CSValue? on page 1396
- SEARch:RESult:CAN:FRAMe<m>:DATA? on page 1397
- SEARch:RESult:CAN:FRAMe<m>:DLCState? on page 1396
- SEARch:RESult:CAN:FRAMe<m>:DLCValue? on page 1397
- SEARch:RESult:CAN:FRAMe<m>:IDSTate? on page 1396

- `SEARch:RESult:CAN:FRAMe<m>:IDTYpe?` on page 1398
- `SEARch:RESult:CAN:FRAMe<m>:IDValue?` on page 1398
- `SEARch:RESult:CAN:FDATa:FRAMe<m>:STANdard?` on page 1398
- `SEARch:RESult:CAN:FRAMe<m>:STARt?` on page 1399
- `SEARch:RESult:CAN:FRAMe<m>:STOP?` on page 1399
- `SEARch:RESult:CAN:FRAMe<m>:SYMBol?` on page 1400
- `SEARch:RESult:CAN:FRAMe<m>:TYPE?` on page 1400

12.5.5.3 Searching CAN FD Data

The "Identifier + Data" search supports the search for data bytes of specific value at a specific location in the data field of a frame. The "Data Pattern" field provides 8 data bytes to define the pattern. For data fields longer than 8 byte, you can define the position where the specified pattern starts.

The following example demonstrates how the data pattern and data position is defined.

To set up the search

1. Set the "Source", the signal to be searched: "SerBus". Select the bus that is configured for CAN FD.
2. Set the search criteria:
   a) Select the standard: "CAN FD".
   b) Select the search type: "Identifier + Data".
3. In this example, the identifier does not matter. Set the "ID type = Any".
4. Define the data setup as described in the example.

Example: Searching for a specific byte anywhere in the frame

The CAN FD frame has 8 or more data bytes, containing at least one data byte with value = CB anywhere in the data field.

- Set "DLC ≥ 8".
- Set the data pattern: "= CB".

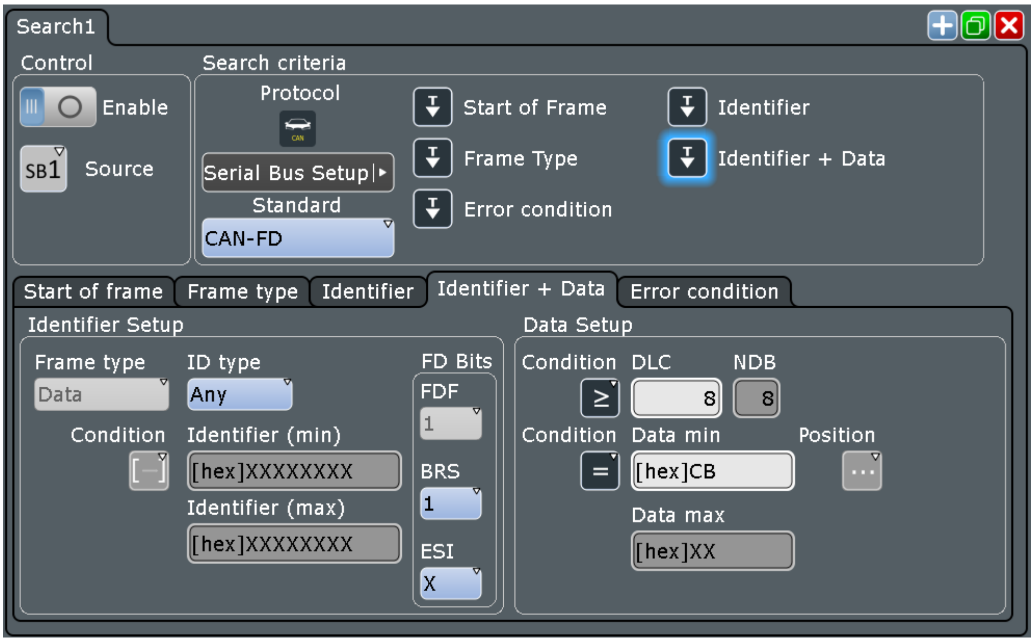


Figure 12-28: Search setup to find all data bytes with value = CB

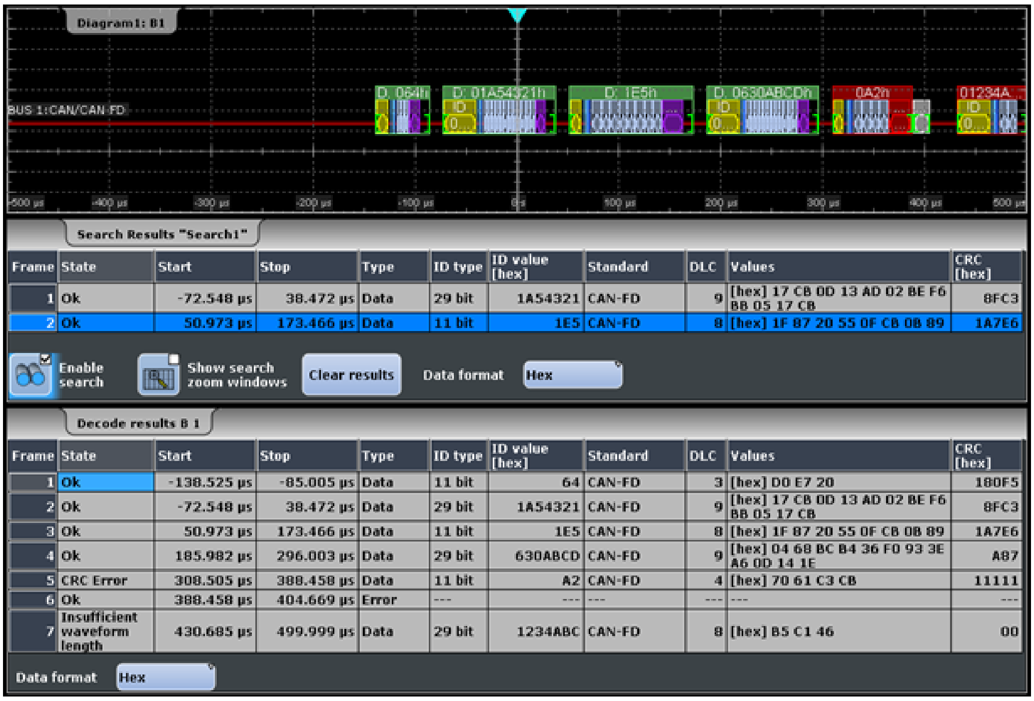


Figure 12-29: Search result

12.5.6 Symbolic Trigger, Decode and Search

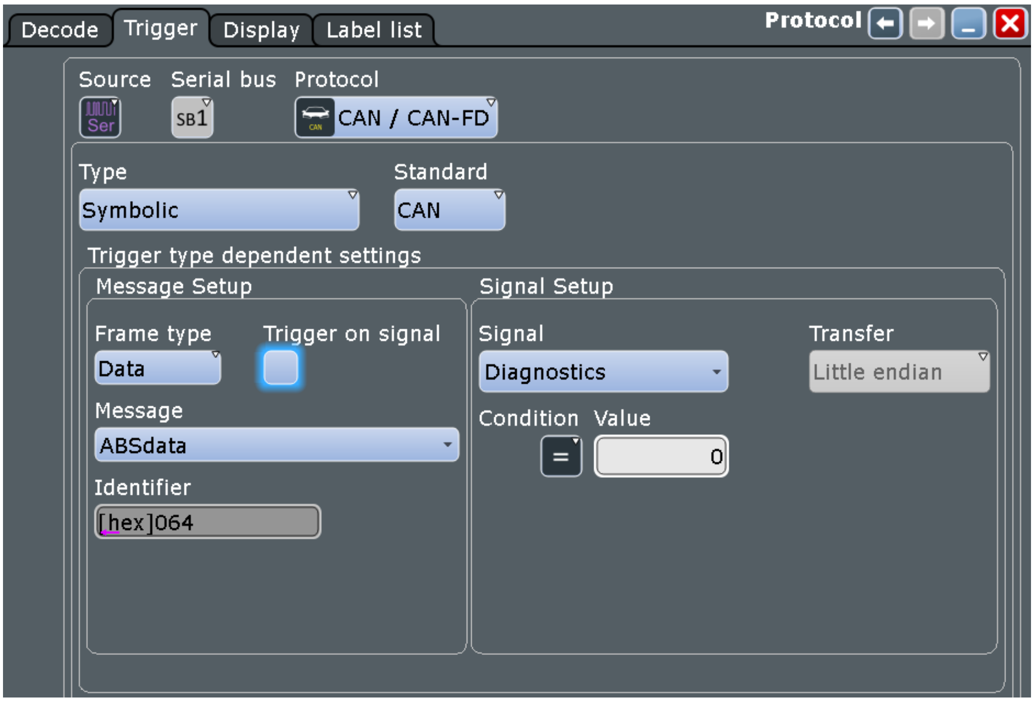
The R&S RTP can read and apply industry-standard DBC files to the decoded signal and provides settings for symbolic triggering and symbolic search.

For a description of DBC files, see Chapter 12.5.3.1, "DBC Files for CAN / CAN FD", on page 528.

12.5.6.1 Symbolic Trigger

The "Symbolic" trigger type is available if a DBC label list file is loaded and applied, see Chapter 12.5.3, "CAN / CAN FD Label List", on page 528. It allows you to trigger on a specific data message, or a signal and its value that appears inside the message.

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = CAN/ CAN-FD" and "Type" = "Symbolic"



The "Frame type" is automatically set to "Data", and the "Identifier" is shown for information.

Specific settings for the symbolic trigger are:

Message

Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

Remote command:

`TRIGger<m>:CAN:SYMBolic:MSGValue` on page 1401

Trigger on signal

Enables the trigger on a specific signal value that is part of the selected message.

Remote command:

`TRIGger<m>:CAN:SYMBolic:TSIGnals` on page 1401

Signal

Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

Remote command:
`TRIGger<m>:CAN:SYMBolic:SIGValue` on page 1401

Condition
Sets the operator to set a specific data pattern or symbolic value ("Equal" or "Not equal") or a data range.

Remote command:
`TRIGger<m>:CAN:DCONdition` on page 1373

Value, Value min
Defines the data pattern or selects a symbolic data value.

Remote command:
`TRIGger<m>:CAN:SYMBolic:DMIN` on page 1401
`TRIGger<m>:CAN:SYMBolic:SGEValue` on page 1402

Value max
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:CAN:SYMBolic:DMAX` on page 1401

12.5.6.2 Symbolic Decode Waveform

If a DBC file is applied, the symbolic names from the file are applied to the display of the decoded data. The result table lists the signal values and units in the "Symbolic Data" column, and the comb display shows the signal names in addition to the signal values and units.

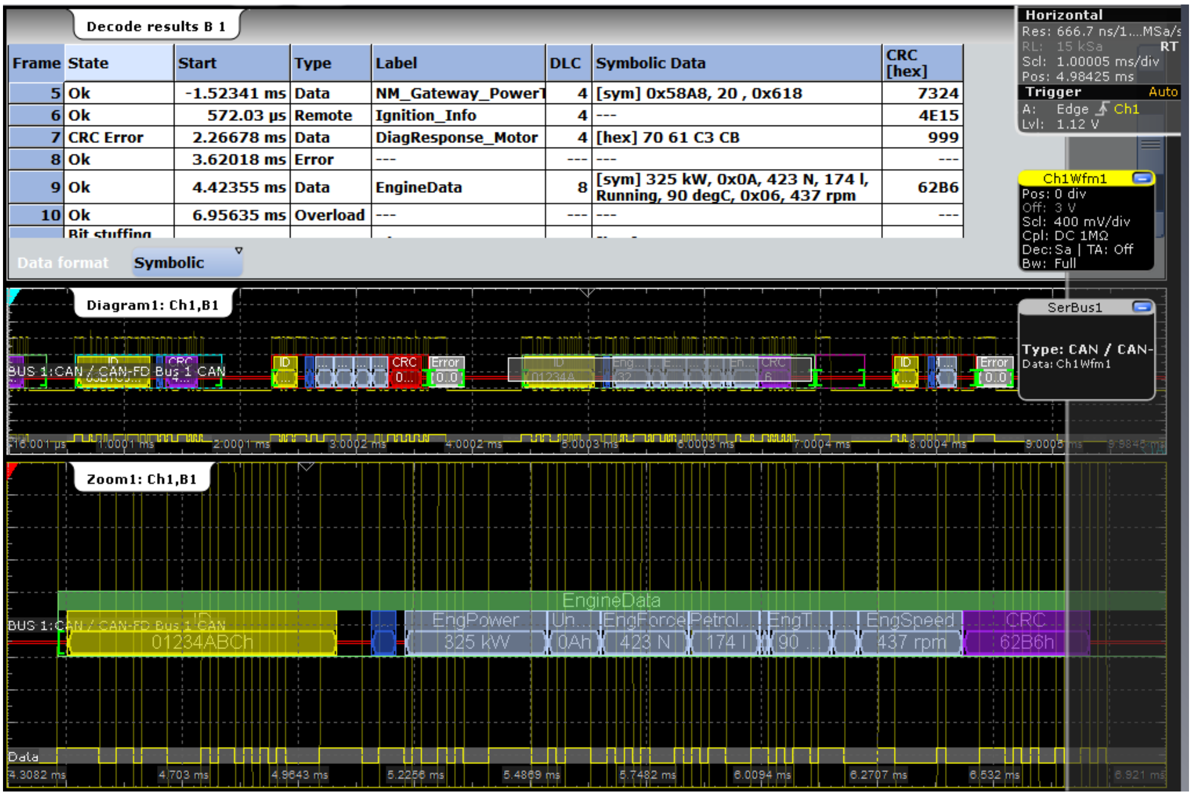


Figure 12-30: Result table and decoded CAN signal with applied DBC file and zoom on EngineData message

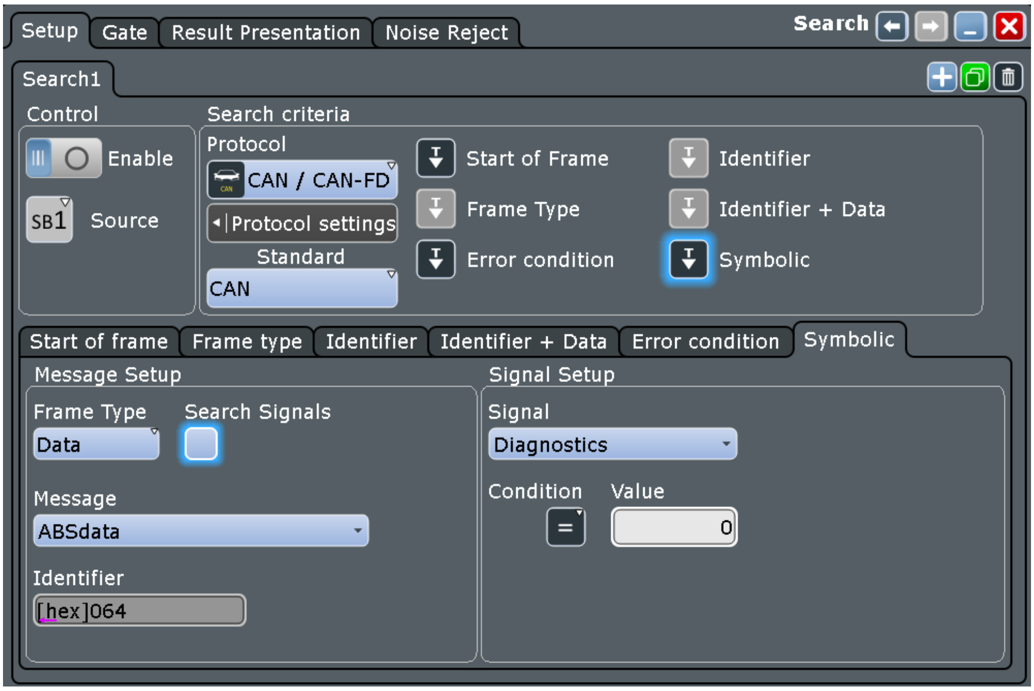
Remote command:

- BUS<m>:CAN:FRAMe<n>:SDATa? on page 1402

12.5.6.3 Symbolic Search

Access: [Search] > "Setup" tab > "Symbolic" = on

If a DBC file is applied, the symbolic search for messages and signal, which are defined in the DBC file, is available. Symbolic search is an alternative to the other search criteria, you can either search for symbolic values or for an AND-combination of the other 5 criteria.



If symbolic search is active, the "Frame type" is automatically set to "Data", and the "Identifier" is shown for information.

Symbolic

Enables the symbolic search and disables all other search criteria.

Remote command:

`SEARch:TRIGger:CAN:SSYMbolic` on page 1403

Message

Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

Remote command:

`SEARch:TRIGger:CAN:SYMBolic:MSGValue` on page 1403

Search signals

Enables the search for a specific signal value that is part of the selected message.

Remote command:

`SEARch:TRIGger:CAN:SYMBolic:SSIGnals` on page 1404

Signal

Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:SIGValue` on page 1404

Condition
Sets the operator to set a specific data pattern or symbolic value ("Equal" or "Not equal") or a data range.

This condition is also used to search for data, see "Data setup: DLC, NDB, Condition, Data min, Data max" on page 537.

Remote command:
`SEARch:TRIGger:CAN:DCONdition` on page 1389

Value, Value (min)
Defines the data pattern or selects a symbolic data value.

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:DMIN` on page 1404
`SEARch:TRIGger:CAN:SYMBolic:SGEValue` on page 1405

Value (max)
The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:CAN:SYMBolic:DMAX` on page 1404

12.5.6.4 Symbolic Search Results

If a DBC file is applied, you can search for symbolic messages and signals as described in Chapter 12.5.6.3, "Symbolic Search", on page 545. As ususal, the search results are shown in a table. You can enable the search zoom window to view the frame with the selected result in more detail.

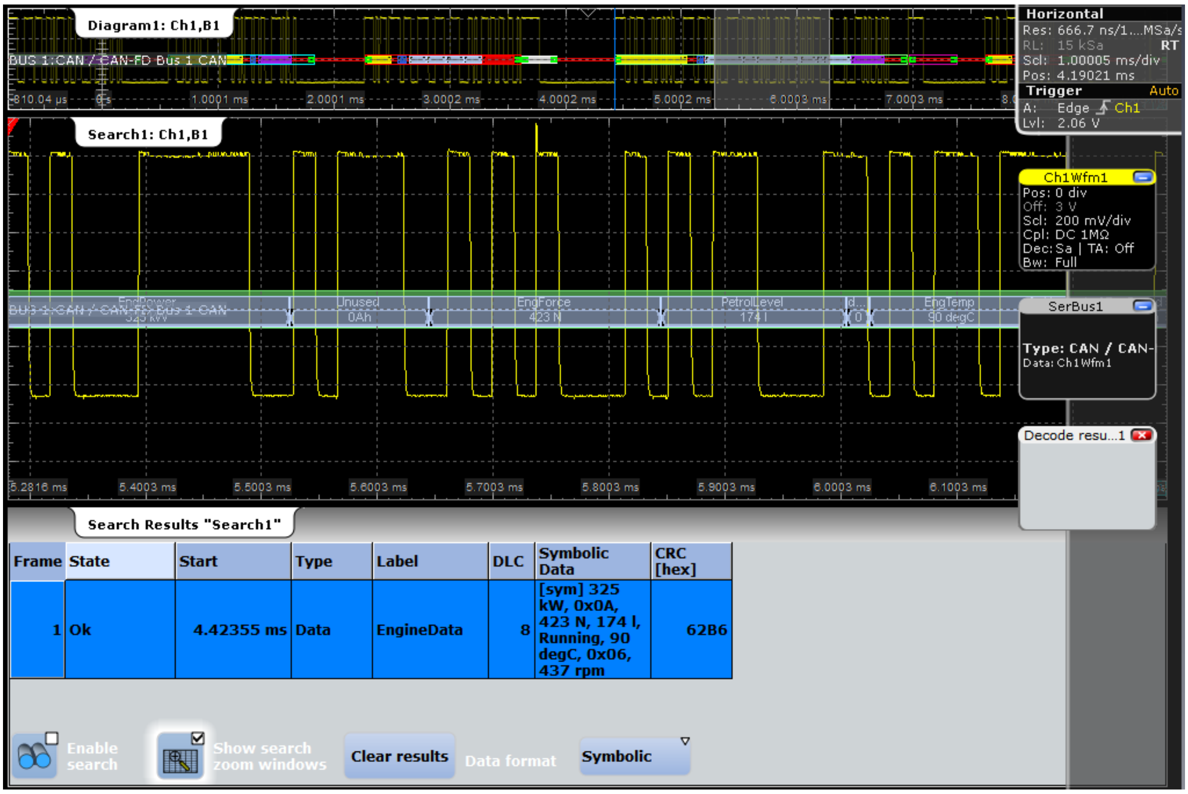


Figure 12-31: Search results table and search zoom window. Search for signal "IdleRunning" with value "Running" (bit value = 0)

The figure shows the result of a search for an "EngineData" message and the signal "IdleRunning = Running" inside the message. The result marker (blue line) is set to the start of the frame that fulfills the search condition. The search zoom window Search1 is active. It has been moved to the right until the "IdleRunning" bit with value 0 is visible in the zoom.

Remote command:

- `SEARch:RESult:CAN:FRAMe<m>:SDATa?` on page 1403

12.6 LIN (Option R&S RTP-K3)

The Local Interconnect Network (LIN) is a simple, low-cost bus system used within automotive network architectures. LIN is usually a subnetwork of a CAN bus. The primary purpose of LIN is the integration of uncritical sensors and actuators with low-bandwidth requirements. Common applications in a motor vehicle are the control of doors, windows, wing mirrors, and wipers.

12.6.1 The LIN Protocol

This chapter provides an overview of protocol characteristics, frame format, identifiers and trigger possibilities. For detailed information, order the LIN specification on http://www.lin-subbus.org/ (free of charge).

LIN characteristics

Main characteristics of LIN are:

- Single-wire serial communications protocol, based on the UART byte-word interface
- Single master, multiple slaves - usually up to 12 nodes
- Master-controlled communication: master coordinates communication with the LIN schedule and sends identifier to the slaves
- Synchronization mechanism for clock recovery by slave nodes without crystal or ceramics resonator

The R&S RTP supports several versions of the LIN standard: v1.3, v2.0, v2.1 and the American SAE J2602.

Data transfer

Basic communication concept of LIN:

- Communication in an active LIN network is always initiated by the master.
- Master sends a message header including the synchronization break, the synchronization byte, and the message identifier.
- The identified node sends the message response: one to eight data bytes and one checksum byte.
- Header and response form the message frame.

The data is transmitted in bytes using the UART byte-word interface without the parity bit. Each byte consists of a start bit, 8 bits and a stop bit.

Start bit	Bit 0 LSB	Bit 1						Bit 7 MSB	Stop bit

Byte field

Figure 12-32: Structure of a byte field

Data bytes are transmitted LSB first.

The identifier byte consists of 6 bits for the frame identifier and two parity bits. This combination is known as protected identifier.

Trigger

The R&S RTP can trigger on various parts of LIN frames. The data line must be connected to an input channel, triggering on math and reference waveforms is not possible.

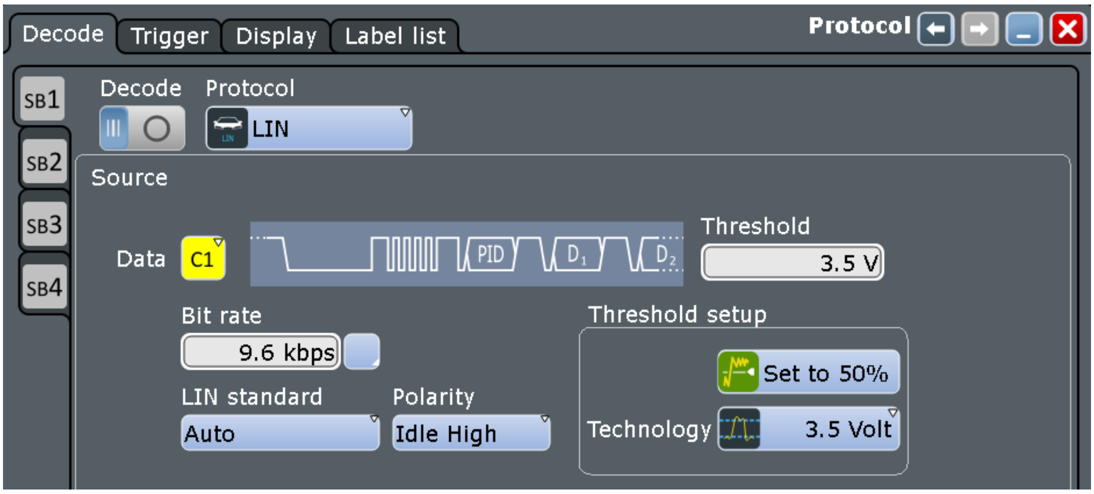
You can trigger on:

- Frame start (synchronization field)
- Specific slave identifier or identifier range
- Data pattern in the message
- Wake up signal
- Checksum error (error in data), parity error (error in identifier)

12.6.2 LIN Configuration

Access: [Protocol] > "Decode" tab > "Protocol" = *LIN*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Data

Sets the source waveform of the data line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTP-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:

`BUS<m>:LIN:DATA:SOURce` on page 1405

Threshold
Sets the threshold value for digitization of the signal. If the signal value on the line is higher than the threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the threshold. The interpretation of HIGH and LOW is defined by the Polarity.

There are three ways to set the threshold:
- "Threshold"
  Enter the value directly in the field.
- "Set to 50%"
  Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Technology"
  Selects the default threshold voltage for various signal technologies from a list. The value is set to "Manual" if the threshold was set with "Set to 50%", or was entered directly.

Note: If the sources are digital channels, the same threshold values are used for the parallel and the serial buses. You can set the thresholds either in the parallel bus configuration or in the serial bus configuration.

Remote command:
`BUS<m>:LIN:DATA:THReshold` on page 1406
`BUS<m>:LIN:TECHnology` on page 1406
`BUS<m>:SETReflevels` on page 1299

Bit rate
Sets the number of transmitted bits per second. The maximum bit rate for LIN is 20 kbit/s.

To select a bit rate from list of predefined values, tap the icon beside the "Bit rate" field. To enter a specific value, open the keypad. The list of predefined values is also available in the keypad.

If the "LIN standard" is "J2602", the bit rate is 10.417 kbit/s and cannot be changed.

Remote command:
`BUS<m>:LIN:BITRate` on page 1407

LIN standard
Selects the version of the LIN standard that is used in the DUT. The setting mainly defines the checksum version used during decoding.

The most common version is LIN 2.x. For mixed networks, or if the standard is unknown, set the LIN standard to "Auto".

Remote command:
`BUS<m>:LIN:STANdard` on page 1407

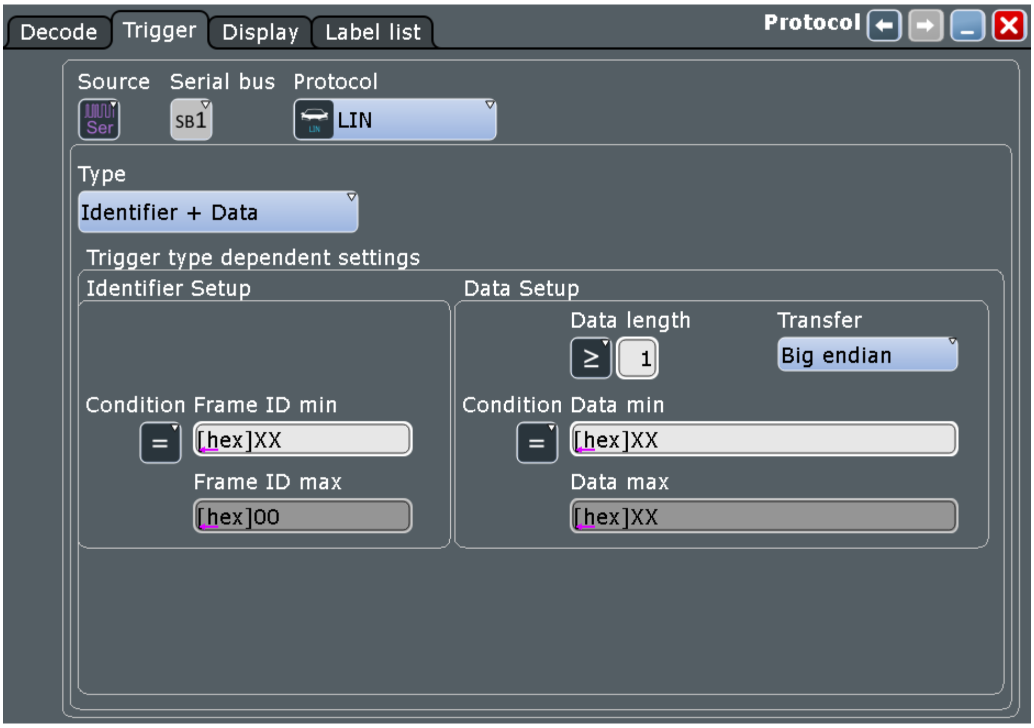
Polarity
Defines the idle state of the bus. The idle state is the recessive state and corresponds to a logic 1.

Remote command:
`BUS<m>:LIN:POLarity` on page 1407

12.6.3 LIN Trigger

12.6.3.1 LIN Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = LIN"



Make sure that:
- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Trigger type
Selects the trigger type for LIN analysis.

"Start of frame (Sync)"
Triggers on the stop bit of the sync field.

"Identifier"
Sets the trigger to one specific identifier or an identifier range. Enter only the 6-bit identifier without parity bits, not the protected identifier.
Description of trigger type specific settings: "Identifier setup: Condition, Frame ID min, Frame ID max" on page 553.

"Identifier OR" Sets the trigger to a combination of up to four identifiers.
Description of trigger type specific settings: "Identifier OR setup: Monitor, Frame ID" on page 553

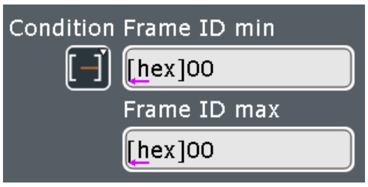
"Identifier + Data" Sets the trigger to a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern.
The identifier conditions are the same as for the "Identifier" trigger type, see Identifier setup: Condition, Frame ID min, Frame ID max.
Data conditions are set with Data setup: Data length, Transfer, Condition, Data min, Data max.

"Wakeup frame" Triggers after a wakeup frame.

"Error condition" Identifies various errors in the frame, see "Error conditions" on page 555.

Remote command:
`TRIGger<m>:LIN:TYPE` on page 1408

Identifier setup: Condition, Frame ID min, Frame ID max
The identifier setup consists of the condition and one or two identifier pattern.



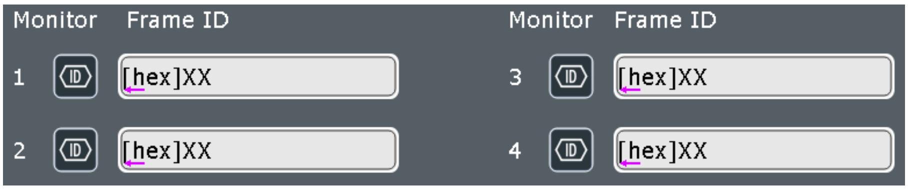
"Condition" Defines the operator to set a specific identifier ("Equal" or "Not equal") or an identifier range.

"Frame ID min / Frame ID" Defines the bit pattern of the slave identifier. Enter only the 6-bit identifier without parity bits, not the protected identifier.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Frame ID max" The second identifier pattern is required to specify a range with conditions "In range" and "Out of range".

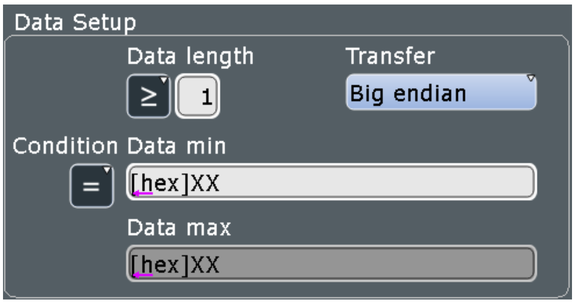
Remote command:
`TRIGger<m>:LIN:ICONdition` on page 1409
`TRIGger<m>:LIN:IMIN` on page 1409
`TRIGger<m>:LIN:IMAX` on page 1409

Identifier OR setup: Monitor, Frame ID
Sets the trigger to a combination of up to four identifiers. Enter the patterns in the "Frame ID" fields. In binary and hex format, characters 1, 0, and X (do not care) are allowed. For each identifier pattern to be triggered on, enable "Monitor".



Remote command:
TRIGger<m>:LIN:IDOR<n>:ENABle on page 1411
TRIGger<m>:LIN:IDOR<n>[:VALue] on page 1412

Data setup: Data length, Transfer, Condition, Data min, Data max
The data setup consists of the transfer direction, the number of bytes, the condition, and one or two data patterns.



"Transfer" Sets the byte order (endianness) of the data transfer. With "Big endian", the data is analyzed and evaluated in the order of reception. With "Little endian", the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.
According to the standard, LIN data is transmitted in little endian transfer order. The "Little endian" setting allows you to enter the required data word directly into "Data min", and the instrument triggers correctly.

"Data length" Sets the length of the bit pattern to be found, in bytes.

For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set.
Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*. With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*.

"Condition" Sets the operator to define a specific data pattern ("Equal" or "Not equal") or an data range.

"Data min" Defines the data pattern. The pattern length is adjusted to the data length setting (and vice versa), maximum is 8 bytes.
Enter the pattern MSB first and with big endian byte order, and set the correct "Transfer" direction. The data is compared byte by byte.
In binary format, use the following characters: 1; 0; or X (do not care).
The use of X is restricted to the operators "Equal" and "Not equal".

"Data max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:LIN:BORDer on page 1410
TRIGger<m>:LIN:DLECondition on page 1411
TRIGger<m>:LIN:DLENgth on page 1411
TRIGger<m>:LIN:DCONdition on page 1409
TRIGger<m>:LIN:DMIN on page 1410
TRIGger<m>:LIN:DMAX on page 1410

Error conditions
Triggers if one or more of the following errors occur:

- Checksum error
  The checksum verifies the correct data transmission. It is the last byte of the frame response. The checksum includes not only the data but also the protected identifier (PID). To identify checksum errors caused by data, additional settings are required: Enter the bit pattern of the slave identifier ("Frame ID"), the number of data bytes ("Data length"), and select the used "LIN standard". See also: "LIN standard" on page 551.
- Identifier parity error
  Parity bits are the bits 6 and 7 of the identifier. They verify the correct transmission of the identifier.
- Sync error
  Synchronization error

Remote command:
TRIGger<m>:LIN:CHKSerror on page 1412
TRIGger<m>:LIN:ERRPattern on page 1413
TRIGger<m>:LIN:CRCDatalen on page 1413
TRIGger<m>:LIN:STANdard on page 1413
TRIGger<m>:LIN:IPERror on page 1412
TRIGger<m>:LIN:SYERror on page 1412

12.6.3.2 Triggering on LIN Signals

Prerequisites: An LIN bus is configured, see Chapter 12.2.2.2, "Configuring I²C Protocol", on page 474.

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Select the serial bus that is set to LIN.
5. Select the "Trigger type".
6. For more complex trigger types, enter the address and/or data conditions: address, identifier, frame ID.
   For details, see Chapter 12.6.3.1, "LIN Trigger Settings", on page 552.

12.6.4 LIN Label List

Label lists are protocol-specific. Label lists for LIN are available in CSV and PTT format.

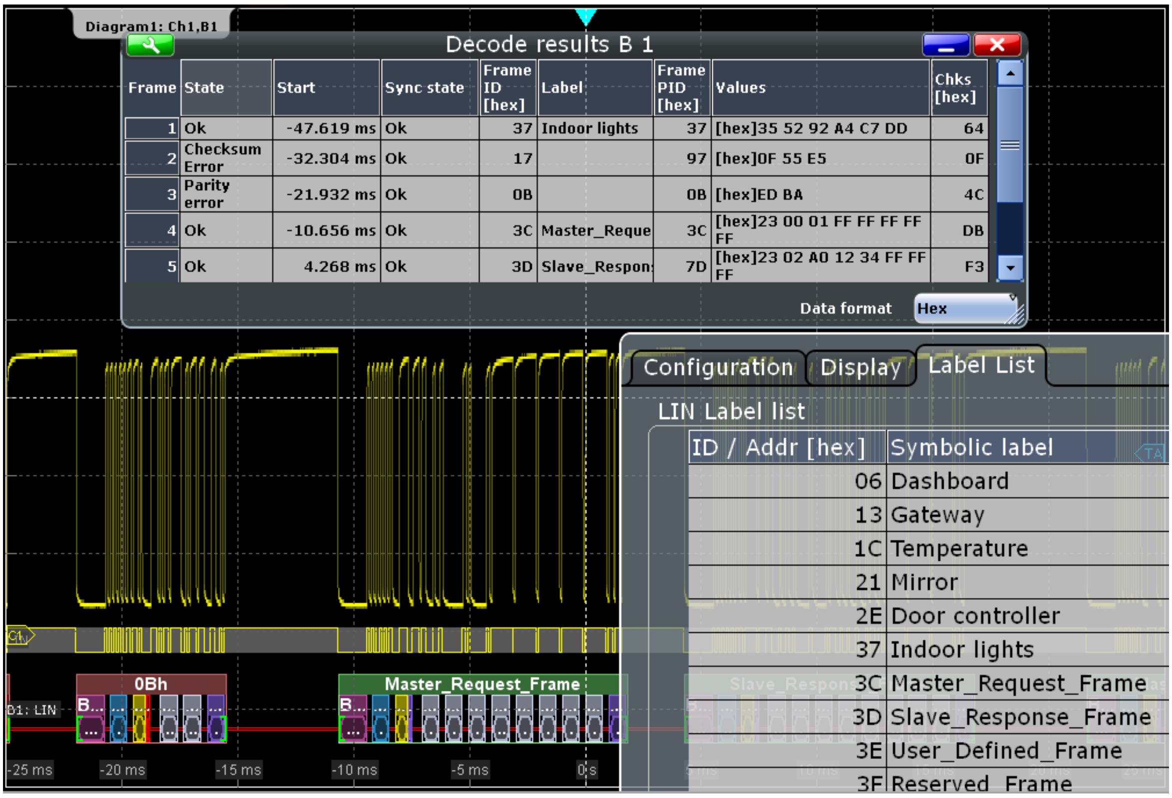
A LIN label file contains two values for each identifier:

- Identifier value
- Symbolic name for the identifier

Example of a LIN PTT file

```
# ----------------------------------------------------------------------------
@FILE_VERSION = 1.0
@PROTOCOL_NAME = lin
# ----------------------------------------------------------------------------
# Labels for LIN protocol
#   Column order: Identifier, Label
# ----------------------------------------------------------------------------
# Labels for standard addresses
0x3F,Temperature
1Ch,Left brake
20h,Right brake
# Following ID is provided as integer
33,Mirror
0x37,Indoor lights
# Labels for reserved addresses
0x3C,Master_Request_Frame
0x3D,Slave_Response_Frame
# ----------------------------------------------------------------------------
```

For general information on label lists, see Chapter 12.1.3, "Label Lists", on page 467.



For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 467.

Remote command:

- `BUS<m>:LIN:FRAMe<n>:SYMBol?` on page 1415

12.6.5 LIN Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The endianness setting ("Transfer") is a trigger setting and not considered for decoding. The binary results of data bytes are displayed MSB first.

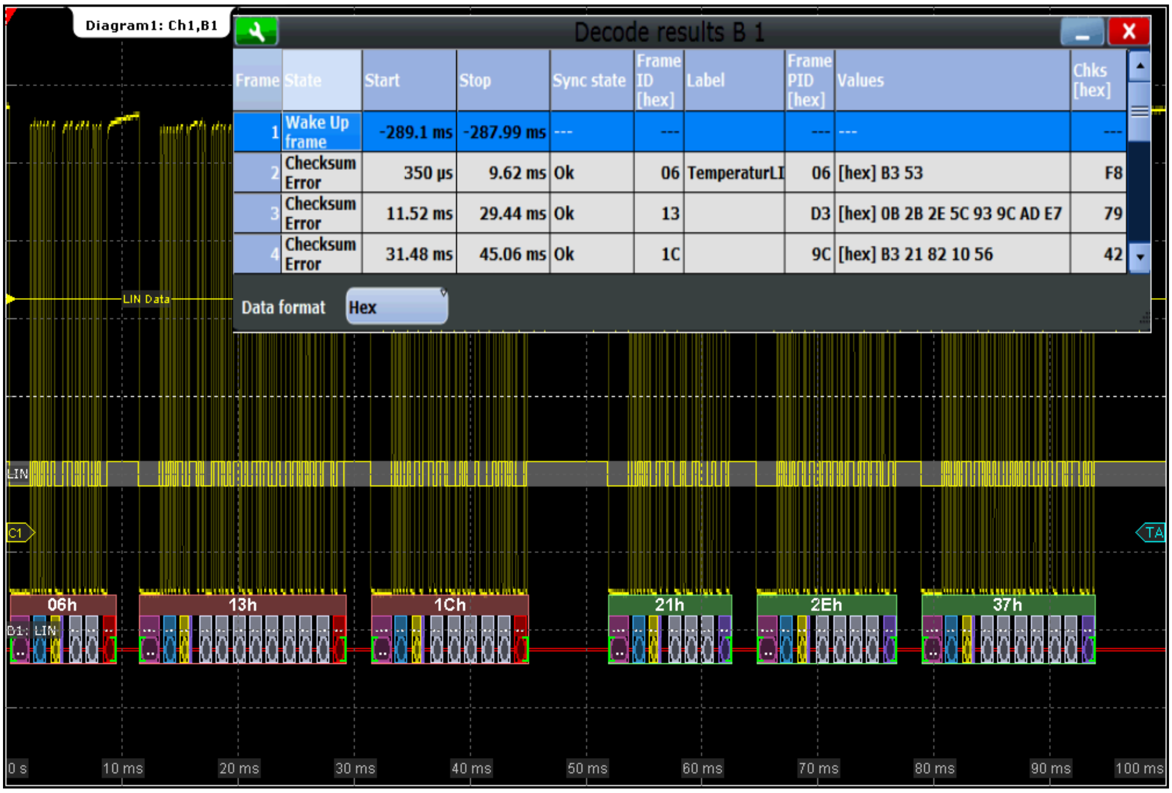


Figure 12-33: Decoded and binary LIN signal, and decode results

green brackets [...]	= start and end of frame
green frame header	= frame state is ok
red frame header	= error in frame
magenta frame header	= wakeup frame
magenta	= break
blue	= sync
yellow	= frame ID ok
grey	= data bytes
purple	= parity bit, or checksum ok
red	= error in frame ID, or checksum, or parity bit

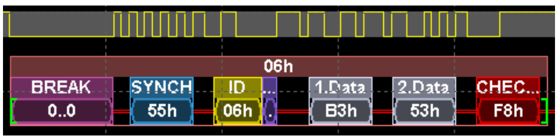


Figure 12-34: Decoded frame with checksum error (frame No 1 in figure above)

Table 12-7: Content of the "Decode results" table

Column	Description
State	Overall state of the frame.
Start	Time of frame start
Stop	Time of frame stop
Label	Symbolic label name defined in the label list

Column	Description
Sync state	Result of synchronization
Frame ID (hex)	Identifier value
Label	Symbolic label name defined in the label list
Frame PID (hex)	Protected identifier
Values	Value of the data bytes. The data format is selected below the table.
Chks (hex)	Checksum value

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.7.3, "Decode Results", on page 1414.

12.6.6 Search on Decoded LIN Data

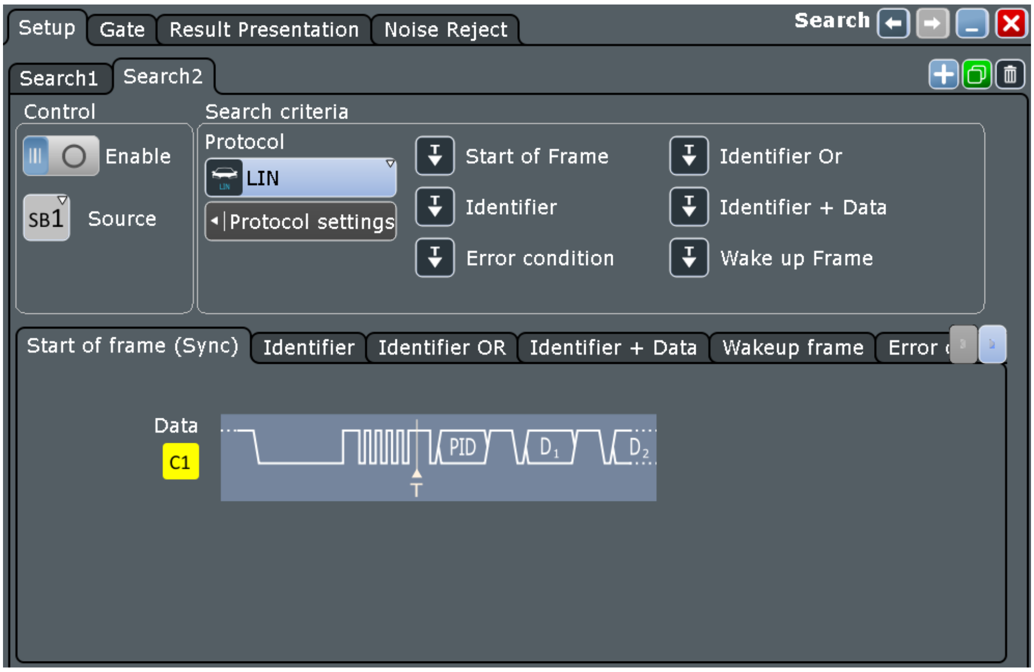
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 396.

12.6.6.1 LIN Search Setup

Access: [Search] > "Setup" tab



Search criteria

Sets the type to be searched for.

"Start of frame (Sync)" Searches for the stop bit of the sync field.

"Identifier" Searches for one specific identifier or an identifier range.
See "Identifier setup: Condition, Frame ID min, Frame ID max" on page 561

"Identifier OR" Searches for a combination of up to four identifiers.
See "Identifier OR setup: Monitor, Frame ID" on page 561

"Identifier + Data" Searches for a combination of identifier and data condition. The instrument triggers at the end of the last byte of the specified data pattern.
The identifier conditions are the same as for the "Identifier" trigger type, see "Identifier setup: Condition, Frame ID min, Frame ID max" on page 553.
Data conditions are set with "Data setup: Data length, Transfer, Condition, Data min, Data max" on page 554.

"Wakeup frame" Searches for wakeup frames.

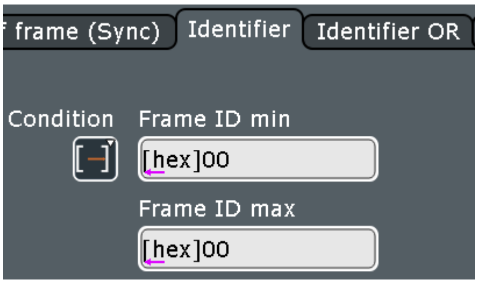
"Error condition" Identifies various errors in the frame, see "Error conditions" on page 555.

Remote command:
`SEARch:TRIGger:LIN:SSOFrame` on page 1421
`SEARch:TRIGger:LIN:SFIDentifier` on page 1421
`SEARch:TRIGger:LIN:IDENtifieror` on page 1421
`SEARch:TRIGger:LIN:SIDData` on page 1421

SEARch:TRIGger:LIN:WUFRame on page 1422
SEARch:TRIGger:LIN:SERRor on page 1422

Identifier setup: Condition, Frame ID min, Frame ID max
The identifier setup consists of the condition and one or two frame ID patterns.

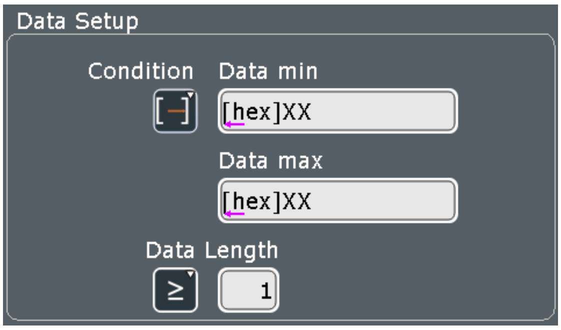
The identifier setup settings are the same as in the LIN trigger setup, see "Identifier setup: Condition, Frame ID min, Frame ID max" on page 553.



Remote command:
SEARch:TRIGger:LIN:ICONdition on page 1422
SEARch:TRIGger:LIN:IMIN on page 1422
SEARch:TRIGger:LIN:IMAX on page 1423

Data setup: Condition, Data min, Data max, Data length, Transfer
The data setup consists of the transfer direction, the data length, the condition, and one or two data patterns.

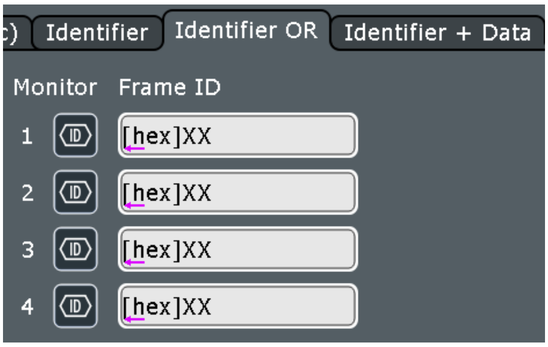
The data setup settings are the same as in the LIN trigger setup, see "Data setup: Data length, Transfer, Condition, Data min, Data max" on page 554.



Remote command:
SEARch:TRIGger:LIN:DCONdition on page 1424
SEARch:TRIGger:LIN:DMIN on page 1424
SEARch:TRIGger:LIN:DMAX on page 1424
SEARch:TRIGger:LIN:DLECondition on page 1425
SEARch:TRIGger:LIN:DLENgth on page 1425
SEARch:TRIGger:LIN:BORDer on page 1425

Identifier OR setup: Monitor, Frame ID
The identifier OR setup consists of the monitor and frame ID.

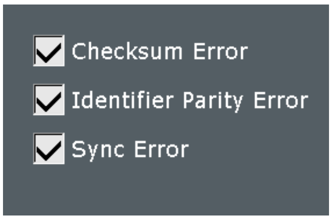
The identifier OR setup settings are the same as in the LIN trigger setup, see "Identifier OR setup: Monitor, Frame ID" on page 553



Remote command:
`SEARch:TRIGger:LIN:IDOR<m>:ENABle` on page 1423
`SEARch:TRIGger:LIN:IDOR<m>[:VALue]` on page 1423

Error Condition
Selects the error type to be searched for. You can select one or more error types as search condition.

The error types are the same as in the LIN trigger setup, see "Error conditions" on page 555.



Remote command:
`SEARch:TRIGger:LIN:IPERror` on page 1426
`SEARch:TRIGger:LIN:SYERror` on page 1426
`SEARch:TRIGger:LIN:CHKSerror` on page 1426
`SEARch:TRIGger:LIN:ERRPattern` on page 1427
`SEARch:TRIGger:LIN:CRCDatalen` on page 1427
`SEARch:TRIGger:LIN:STANdard` on page 1427

12.6.6.2 LIN Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397

- Chapter 10.4, "Result Presentation", on page 414

The columns in the search result table are the same as in the decoding table, see Chapter 12.6.5, "LIN Decode Results", on page 557.

Remote commands:
- SEARch:RESult:LIN:FCOunt? on page 1428
- SEARch:RESult:LIN:FRAMe<m>:STATus? on page 1428
- SEARch:RESult:LIN:FRAMe<m>:STARt? on page 1428
- SEARch:RESult:LIN:FRAMe<m>:STOP? on page 1429
- SEARch:RESult:LIN:FRAMe<m>:DATA? on page 1429
- SEARch:RESult:LIN:FRAMe<m>:CSSTate? on page 1429
- SEARch:RESult:LIN:FRAMe<m>:CSValue? on page 1430
- SEARch:RESult:LIN:FRAMe<m>:IDSTate? on page 1430
- SEARch:RESult:LIN:FRAMe<m>:IDValue? on page 1430
- SEARch:RESult:LIN:FRAMe<m>:IDPValue? on page 1431
- SEARch:RESult:LIN:FRAMe<m>:SYMBol? on page 1431
- SEARch:RESult:LIN:FRAMe<m>:SYSTate? on page 1431
- SEARch:RESult:LIN:FRAMe<m>:VERSion? on page 1431
- SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:STATe? on page 1432
- SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:VALue? on page 1432

12.7 Ethernet 10BASE-T and 100BASE-TX (Option R&S RTP-K8)

Twisted-pair Ethernet technologies are based on the family of standards IEEE 802.3, issued by the Institute of Electrical and Electronics Engineers (IEEE).

R&S RTP-K8 is a firmware option that enables the R&S RTP to analyze Ethernet protocol variants 10BASE-T and 100BASE-TX, by decoding the signal and searching within the decoded events. It is possible to trigger on 10BASE-T signals. To trigger 100BASE-TX signals, use the edge trigger on the source channel. The option is compatible with the standards IEEE 802.3i of 1990 (10BASE-T) and IEEE 802.3u of 1995 (100BASE-TX).

12.7.1 The Ethernet Protocol

The two Ethernet protocol variants that R&S RTP-K8 can process have the following features:

- 10BASE-T uses Manchester coding (or phase encoding, PE). In terms of a logical Boolean operation, the Manchester value of each bit is the exclusive disjunction (XOR) of the original data value and the clock value. A "0" is expressed by a high-to-low transition, a "1" by a low-to-high transition. These transitions, which occur at the middle of each bit period, make the signal self-clocked.
- 100BASE-TX uses a 4B5B Multi-Level Transmit (MLT-3) encoding. The protocol sequentially cycles through a sequence of the voltage levels -1 V, 0 V, +1 V, and 0 V. To transmit a "1" bit, MLT-3 moves to the next state; to transmit a "0" bit, it stays in the same state. 4B5B block coding is used to map groups of four bits onto groups of five bits. Also, the signal is scrambled.

All Ethernet-over-twisted-pair technologies use wires with four twisted pairs of cables (and 8P8C connectors), but 10BASE-T and 100BASE-TX only require two pairs of wires.

12.7.2 Ethernet Configuration

12.7.2.1 Ethernet Configuration Settings

Access: [Protocol] > "Decode" tab > "Protocol" = *Ethernet*

Make sure that the tab of the correct serial bus is selected on the left side.

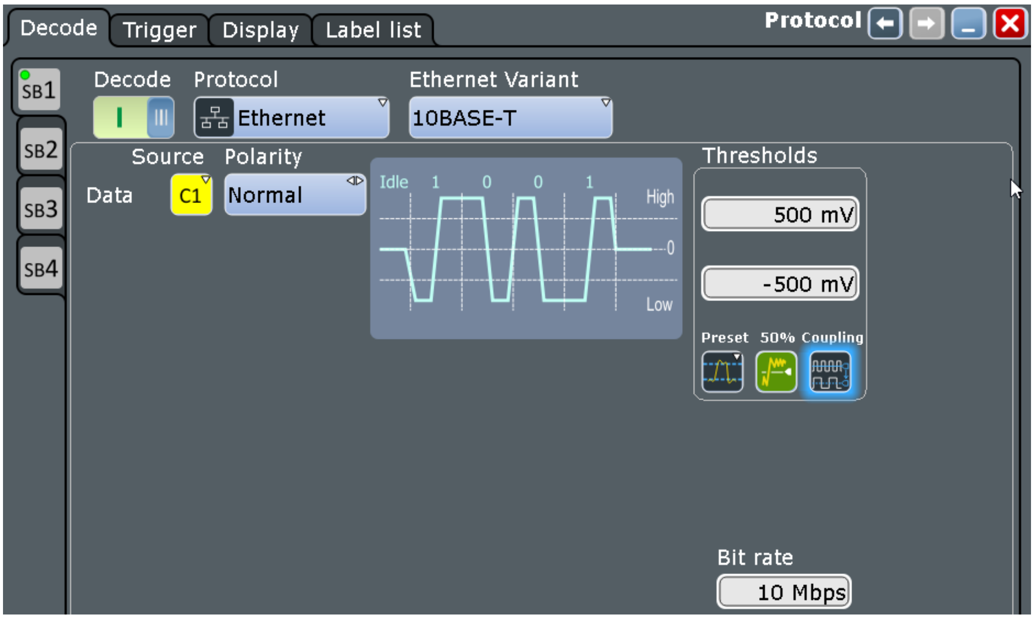


Figure 12-35: Serial bus protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Protocol
Defines the protocol type of the selected serial bus.

Remote command:
`BUS<m>:TYPE` on page 1299

Decode
Enables the decoding of the selected bus. The signal icon of the bus appears on the sidebar.

Remote command:
`BUS<m>[:STATe]` on page 1299

Ethernet Variant
Defines the Ethernet protocol variant and transmission speed.

Note: Note that no triggering on the serial bus is available.
To trigger the signal, use the edge trigger on the source channel.

"10BASE-T"

Selects the Ethernet protocol variant 10BASE-T (standard data rate 10 Mbit/s).

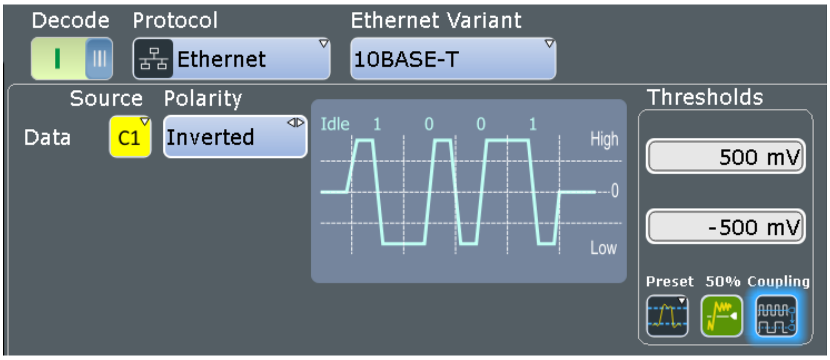


Figure 12-36: Ethernet 10BASE-T protocol configuration (here with inverted polarity)

"100BASE-TX"

Selects the Ethernet protocol variant 100BASE-TX, which provides 100 Mbit/s use data rate. Due to 4b/5b encoding, the raw data rate on the line is 125 Mbit/s. This value is used by R&S RTP-K8 as the bit rate default for 100BASE-TX.

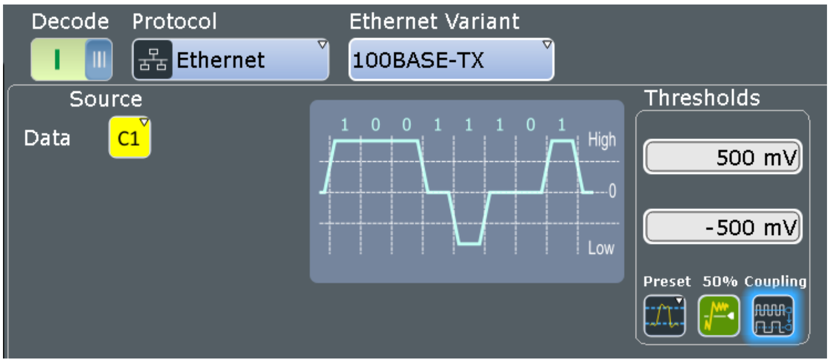


Figure 12-37: Ethernet 100BASE-TX protocol configuration

Remote command:
BUS<m>:ETHernet:VARiant on page 1433

Source

Defines the source settings for the data signal.

Permitted source selections are the analog, mathematical, and reference channels.

Remote command:
BUS<m>:ETHernet:SOURce on page 1433

Polarity

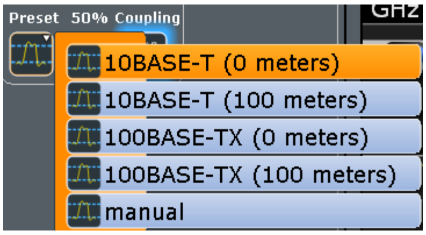
Defines the polarity ("Normal" or "Inverted") of the data signal. This setting is only available in 10BASE-T.

Remote command:
BUS<m>:ETHernet:POLarity on page 1433

Thresholds
Sets the threshold value for the digitization of each signal line. If the signal value on the line is higher than the upper threshold, the signal state is high. Otherwise, if the signal value is below the lower threshold, the signal state is considered low.

There are four ways to set the threshold:

- "Thresholds"
  Enter the values directly: upper threshold in the upper field, lower threshold in the lower field.
- "Preset"
  Either sets individual voltages by selecting "Manual", or sets the voltages to one out of four pre-defined levels:
  – 10BASE-T (0 meters): *±1.25 V*
  – 10BASE-T (100 meters): *±750 mV*
  – 100BASE-TX (0 meters): *±500 mV*
  – 100BASE-TX (100 meters): *±350 mV*

  The "Preset" levels depend on:
  – the Ethernet variant
  – the distance from the transmitter. "0 meters" represents "voltage at transmitter" and "100 meters" represents "voltage at the maximum cable length", according to the standard.

  When any non-predefined threshold is set, the "Preset" value automatically changes to manual (without affecting anything else).
- "50%"
  Executes a measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Coupling"
  Couples threshold settings between upper and lower threshold.

Remote command:
`BUS<m>:ETHernet:THReshold:HIGH` on page 1434
`BUS<m>:ETHernet:THReshold:LOW` on page 1434
`BUS<m>:ETHernet:PRESet` on page 1434

Bit rate
Defines the transmission speed setting for the data signal:

- 10BASE-T: default bit rate 10 Mbps
- 100BASE-TX: default bit rate 125 Mbps

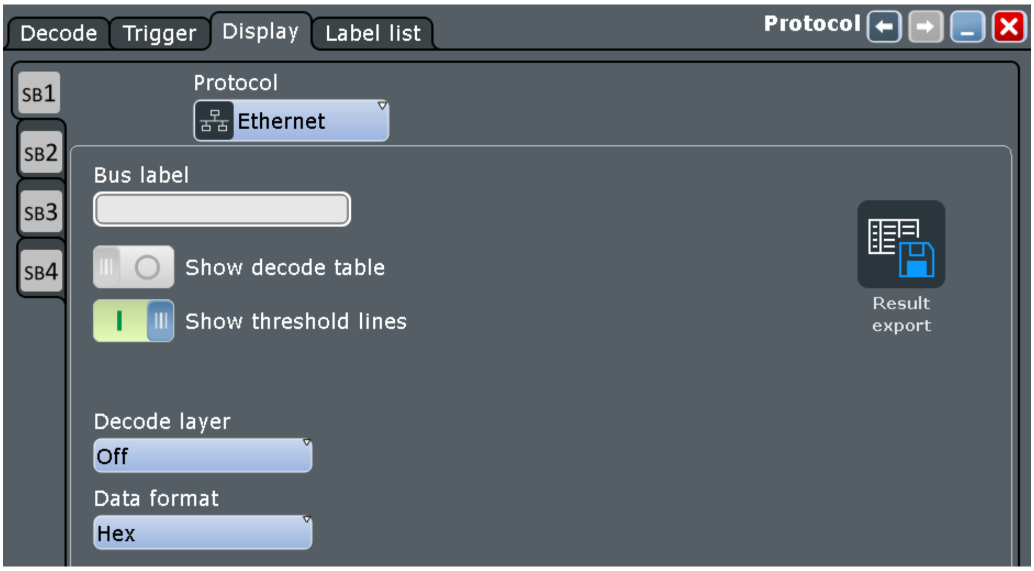
In both variants, the permitted bit rates range from 10 kbps to 150 Mbps. Switching the variant adjusts the bit rate, independent of the previous setting.

Remote command:
`BUS<m>:ETHernet:BITRate` on page 1435

12.7.2.2 Ethernet Display Settings

Access: [Protocol] > "Configuration" tab > "Protocol = Ethernet" > "Display" tab

To enhance the decode possibilities of the Ethernet protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 465.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

12.7.2.3 Configuring Ethernet Signals

For configuration, assign the lines to the input channels and define the active states and the logical thresholds.

1. Press the [Protocol] key on the front panel.
2. At the left hand-side, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Select the "Configuration" tab.
4. Tap "Protocol" and select the protocol: "Ethernet".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Tap "Ethernet Variant" and select the variant ("10BASE-T" or "100BASE-TX") you want to set up.

   Note: Note that no triggering on the serial bus is available.

To trigger the signal, use the edge trigger on the source channel.

7. For the variant "10BASE-T", select the polarity ("Normal" or "Inverted") of the data signal.
8. Set the logical thresholds, see "Thresholds" on page 567.
9. In the protocol "Configuration" tab, select "Decode" to activate the decode functionality.

For details on configuration settings, see Chapter 12.7.2.1, "Ethernet Configuration Settings", on page 564.

12.7.3 Ethernet Trigger

If you need information on how to get started with triggering on Ethernet 10BASE-T signals, see Chapter 12.7.3.2, "Triggering on Ethernet", on page 571. Otherwise proceed with the Ethernet trigger settings.

12.7.3.1 Ethernet Trigger Settings

Access: [Trigger] > "Source = Serial Bus" > select "Serial bus" > "Protocol = Ethernet"

In this section, all trigger settings are described. Their availability on the instrument depends on the selected trigger type. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to data sheet.

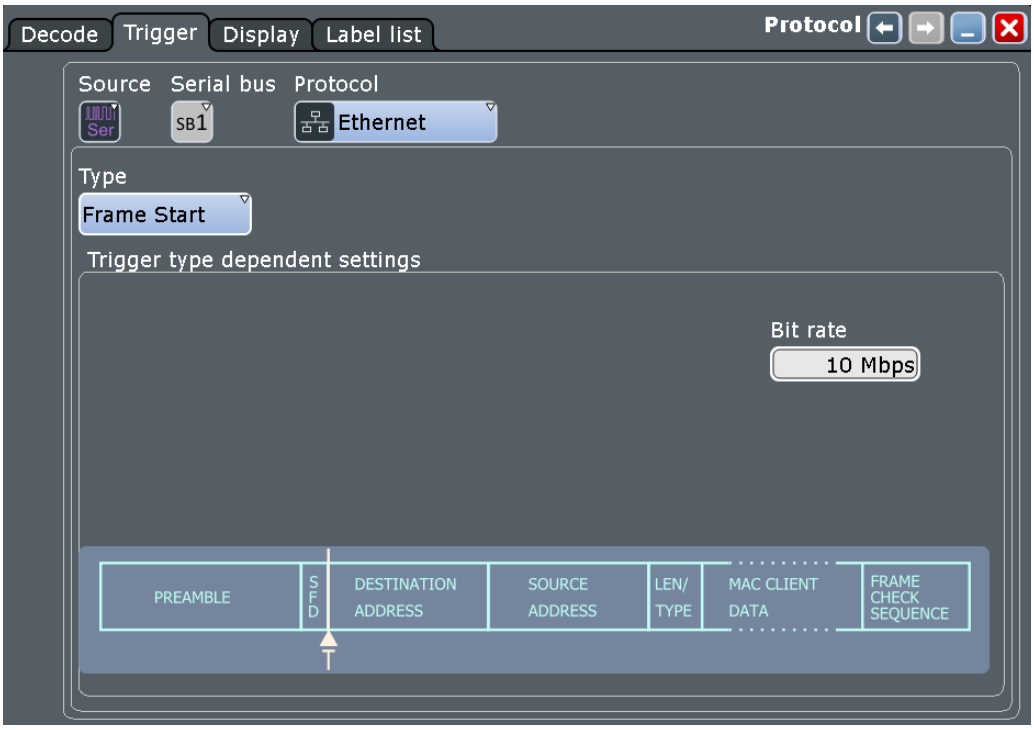


Figure 12-38: Ethernet trigger event settings dialog

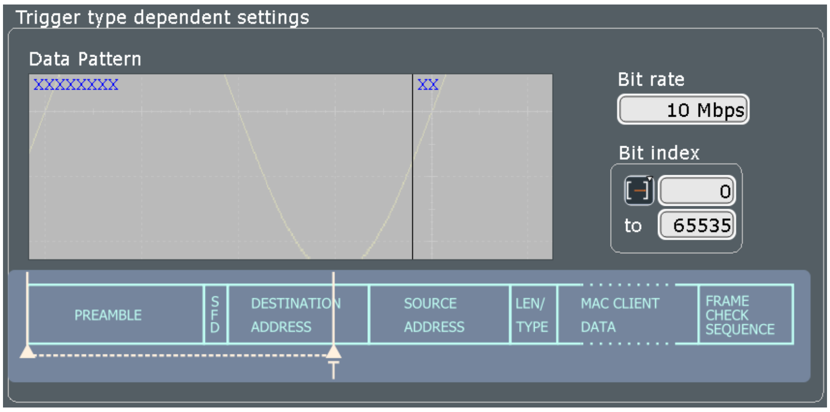
Make sure that:
- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Type

Selects the trigger type for 10BASE-T analysis.

"Frame Start" Sets the trigger to the start frame delimiter (SFD). The start of frame (SOF) condition is the occurrence of the preamble; the trigger instant is after the SFD.

"Pattern" Sets the trigger to any bit pattern (data) that can be freely specified, starting from the beginning of the frame. The trigger instant is after the last bit of the specified data pattern.



Remote command:
TRIGger<m>:ETHernet:TYPE on page 1435

Data Pattern
Specifies the data pattern that is to be triggered.

Remote command:
TRIGger<m>:ETHernet:PATTern on page 1436

Bit rate
Defines the transmission speed setting for the data signal:

- 10BASE-T: default bit rate 10 Mbps
- 100BASE-TX: default bit rate 125 Mbps

In both variants, the permitted bit rates range from 10 kbps to 150 Mbps. Switching the variant adjusts the bit rate, independent of the previous setting.

Remote command:
BUS<m>:ETHernet:BITRate on page 1435

Bit index
Defines the position of the first bit of the data pattern.

"Bit index operator" Sets the operator ("Equal", "Greater or equal", or "In range").

"Bit index" Sets the bit index (data position), or the start value of a bit index range.

"Bit index to" Sets end value of a bit index range (data position range). Available only, if the "Bit index operator" is set to "In range".

12.7.3.2 Triggering on Ethernet

Prerequisite: A bus is configured for the Ethernet signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press [Trigger] or, if coming from the serial bus protocol configuration dialog (Chapter 12.7.2.1, "Ethernet Configuration Settings", on page 564), tap on "Trigger Setup".
2. Tap "Source" and select "Serial bus" as the trigger source (unless already selected):
   
3. Tap "Serial bus" and select the serial bus that is set to Ethernet, e.g.:
   
   The "Protocol" selection is then automatically set to "Ethernet".
4. Tap "Type" and select the trigger type to be used for Ethernet protocol analysis. Available trigger types are "Frame Start" and "Pattern".
5. Depending on the selected Ethernet variant, more setup conditions have to be specified.

Note that there is no trigger available for Ethernet 100BASE-TX. If prompted for this fact, tap on "Serial Bus Setup" or press [Protocol], then select Ethernet variant 10BASE-T instead of 100BASE-TX.

For information on how to proceed with the configuration settings, see Chapter 12.7.3.1, "Ethernet Trigger Settings", on page 569.

12.7.4 Ethernet Label List

Label lists are protocol-specific. An Ethernet label file contains two values for each identifier:

- "Ethernet Header Display": the Ethernet header display value
- "Symbolic label": symbolic name of the header, specifying its function

```
# ----------------------------------------------------------------------------
@FILE_VERSION  = 1.00
@PROTOCOL_NAME = ethernet
# ---------------------------------------------------------------------------
# Labels for Ethernet protocol
#   Column order: Ethernet Header Display, Label
#-----------------------------------------------------------------------------
# Supported MAC Address Format
# xx:xx:xx  standard 24 bit manufactory header
```

```
# xx:xx:xx:xx:xx:xx/yy  support other length headers
# yy should be the header length in decimal
# yy should be between 24 - 48
# ---------------------------------------------------------------------------
00:00:0C, Cisco
00:01:13, Olympus
00:01:14, KandaTsu
00:04:07, TopconPo
00:0B:64, KiebackP
00:1B:C5:06:C0:00/36, LuxconSy
00:1B:C5:06:D0:00/36, TesElect
00:1B:C5:06:E0:00/36, TwoDimen
00:1B:C5:06:F0:00/36, LlcEmzio
00:1F:BE, Shenzhen
00:21:8F, Avantgar
00:21:90, GoliathS
00:21:91, D-Link
00:21:92, BaodingG
00:50:C2:5F:60:00/36, Cambridg
00:50:C2:5F:70:00/36, Metrolog
00:50:C2:5F:80:00/36, GrupoEpe
18:42:2F, AlcatelL
18:44:62, RiavaNet
18:46:17, SamsungE
18:8E:D5, TpVision
18:E7:F4, Apple
40:D8:55:1C:80:00/36, SensataT
40:D8:55:1C:90:00/36, Andy-L
40:D8:55:1C:A0:00/36, RigelEng
40:D8:55:1C:B0:00/36, MgSRL
40:D8:55:1C:D0:00/36, YxlonInt
40:D8:55:1C:E0:00/36, PeterHub
40:D8:55:1C:F0:00/36, OmnikNew
40:D8:55:1D:00:00/36, WebeasyB
FC:F8:B7, TronteqE
FC:FA:F7, Shanghai
FC:FB:FB, Cisco
FC:FE:77, HitachiR
FF:FF:FF:FF:FF:FF/48, BroadCast
```

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 467.

12.7.5 Ethernet Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Examples

The example in Figure 12-39 shows decoded and binary signals in Ethernet 10BASE-T.

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

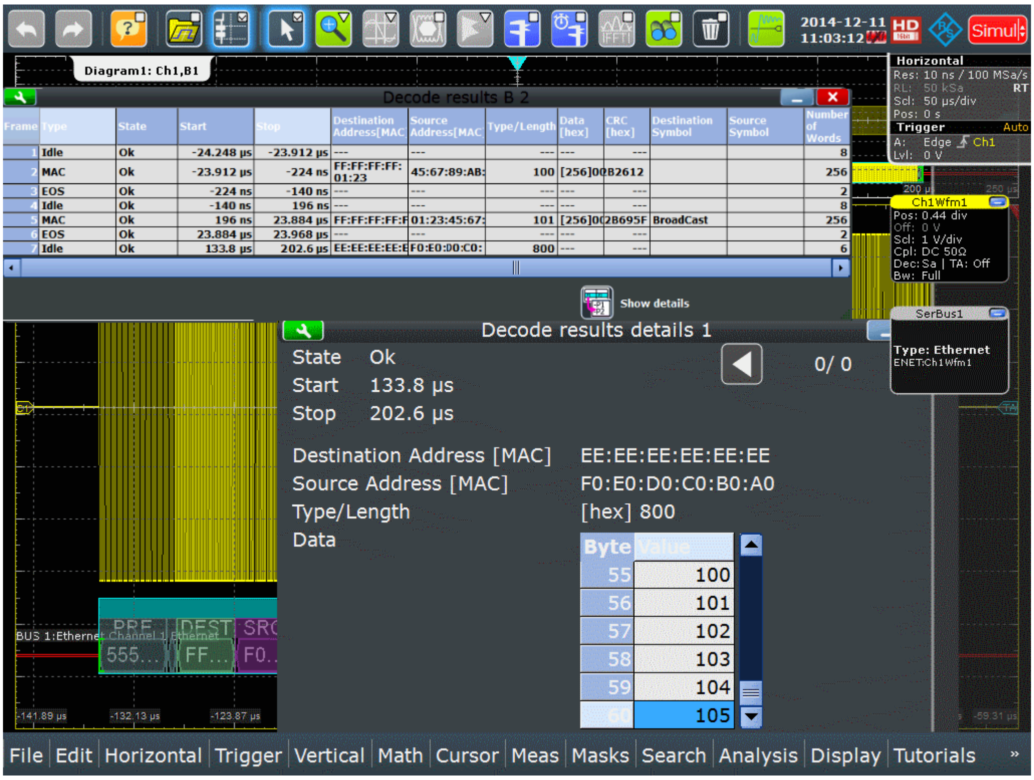


Figure 12-39: Ethernet 10BASE-T: decoded and binary signal, with decode results table and details

green brackets [...] = start / end of frame
blue frame = frame ok
red frame = error frame
grey = preamble / SFD / FrameCheck
green = destination address
purple = source address
brown = address
yellow = data

The screenshot in Figure 12-40 is a view of Figure 12-39 without the decode results table and details.

The screenshot in Figure 12-41 is a zoomed view of Figure 12-40.

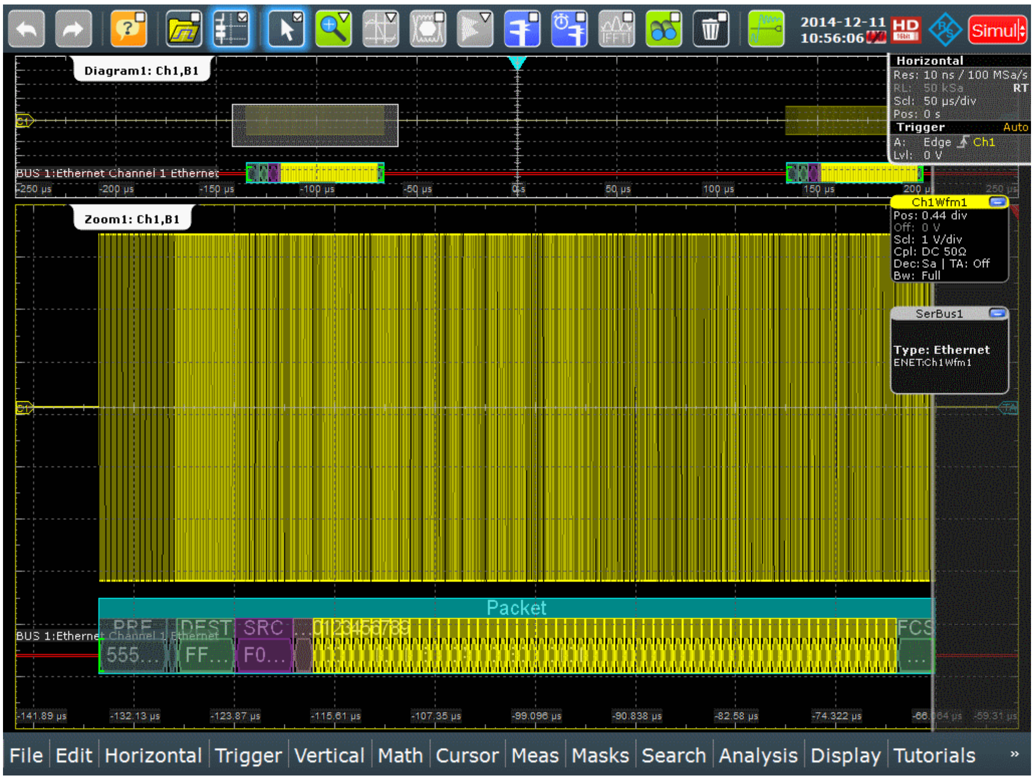


Figure 12-40: Ethernet 10BASE-T: decoded and binary signal

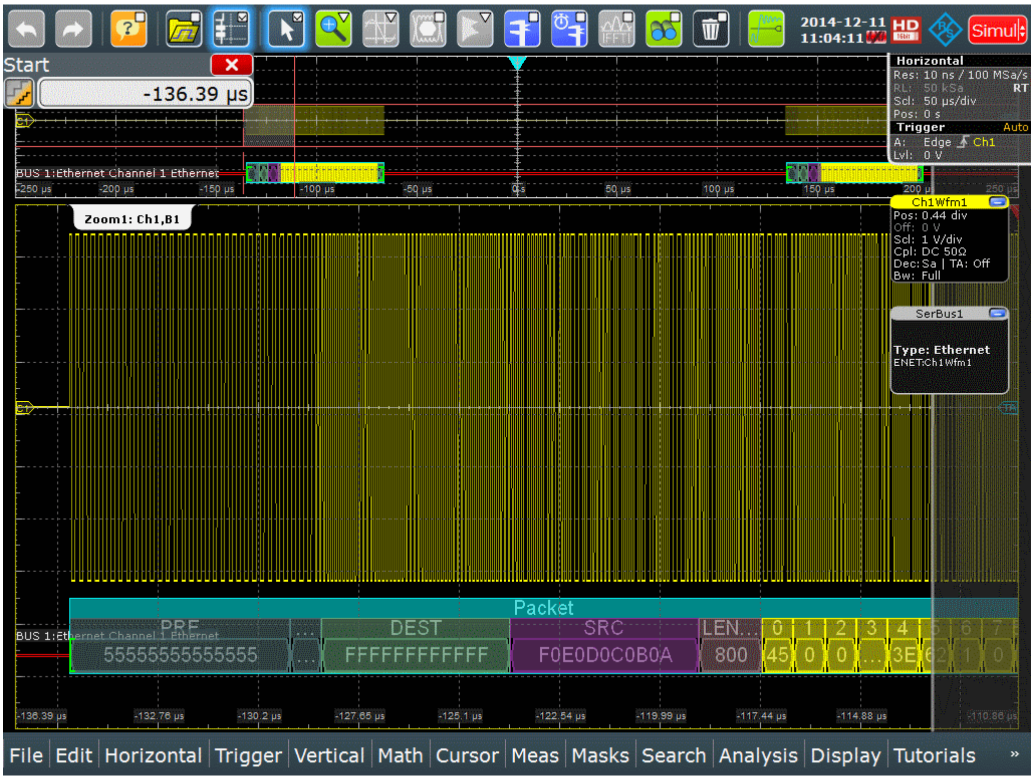


Figure 12-41: Ethernet 10BASE-T: decoded and binary signal (zoomed view)

The example in Figure 12-42 shows a zoomed view of binary signals and decode results in Ethernet 100BASE-TX.

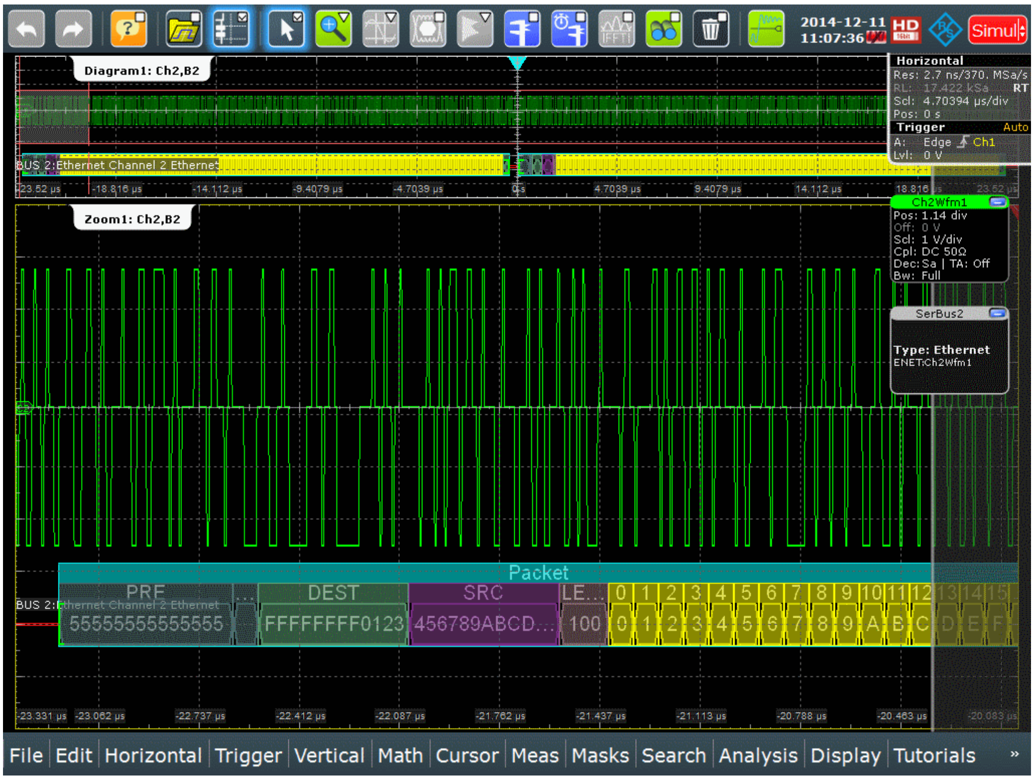


Figure 12-42: Ethernet 100BASE-TX: decoded and binary signal (zoomed view)

green brackets [...]	= start / end of frame
blue frame	= frame ok
red frame	= error frame
grey	= preamble / SFD / FrameCheck
green	= destination address
purple	= source address
brown	= address
yellow	= data

The content of the "Decode results" table in Figure 12-39 is described in Table 12-8:

Table 12-8: Content of the "Decode results" table

Column	Description
Type	Frame type
State	Overall state of the frame: either OK or the relevant error condition (preamble, length)
Start	Start time of the frame
Stop	Stop time of the frame
Destination Address	Destination address of the frame
Source Address	Source address of the frame
Type/Length	The subprotocol (e.g. HTML, video, etc.) determines what meaning this field has. Since the content of this data area is not decoded, the interpretation of this field is ambivalent. It could either be the word type (specific for the subprotocol) or the word length.

Column	Description
Data	Values of the data bytes in a frame. The table shows a truncated version; to see all the bytes in a separate data table, activate "Show details". The data format is always hexadecimal.
CRC	FrameCheck (Cyclic Redundancy Code, CRC)
Destination Symbol	Translation (or symbolic label) of the destination address, if the label list is enabled.
Source Symbol	Translation (or symbolic label) of the source address, if the label list is enabled.
Number of Words	Number of words in the frame

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.8.3, "Decode Results", on page 1436.

12.7.6 Search on Decoded Ethernet Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

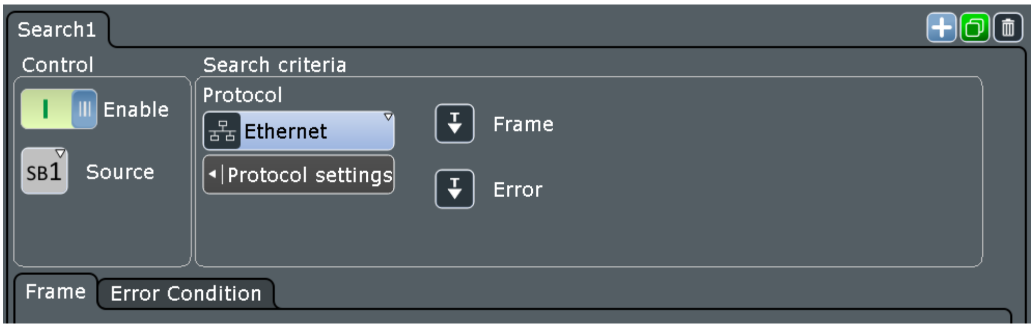
For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 396.

If you need information on how to get started with searching Ethernet data, see Chapter 12.7.6.3, "Searching Ethernet Data", on page 581. Otherwise proceed with the Ethernet search setup.

12.7.6.1 Ethernet Search Setup

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for Ethernet

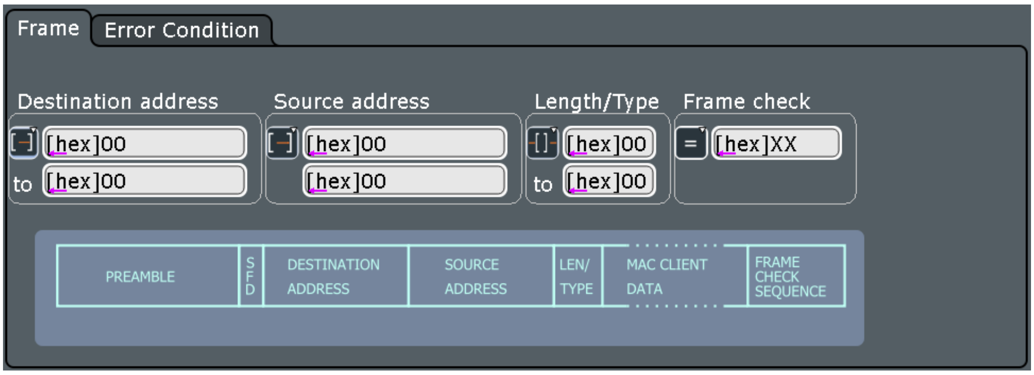
Search criteria
Define the event types to be searched. Available event types are "Frame" and "Error".



Search parameters for each event type are specified in the tabs below the "Search criteria".

Remote command:
`SEARch:TRIGger:ETHernet:FRAMe:SELect` on page 1442
`SEARch:TRIGger:ETHernet:ERRor:SELect` on page 1446

Frame
Searches for the following frame conditions: "Destination address", "Source address", "Length/Type", or "Frame check".



Destination address ← Frame
To search for a destination address, an address pattern or optionally an address range have to be specified.

Remote command:
`SEARch:TRIGger:ETHernet:FRAMe:DCONdition` on page 1442
`SEARch:TRIGger:ETHernet:FRAMe:DMIN` on page 1442
`SEARch:TRIGger:ETHernet:FRAMe:DMAX` on page 1443

Source address ← Frame
To search for a source address, an address pattern or optionally an address range have to be specified.

Remote command:
SEARch:TRIGger:ETHernet:FRAMe:SCONdition on page 1443
SEARch:TRIGger:ETHernet:FRAMe:SMIN on page 1443
SEARch:TRIGger:ETHernet:FRAMe:SMAX on page 1444

Length/Type ← Frame
To search for a frame length or frame type, a type/length pattern or optionally a range of type/length patterns have to be specified.

Remote command:
SEARch:TRIGger:ETHernet:FRAMe:TCONdition on page 1444
SEARch:TRIGger:ETHernet:FRAMe:TMIN on page 1444
SEARch:TRIGger:ETHernet:FRAMe:TMAX on page 1445

Frame check ← Frame
To search for a specific pattern, this pattern or optionally a range of patterns have to be specified.

Remote command:
SEARch:TRIGger:ETHernet:FRAMe:CCONdition on page 1445
SEARch:TRIGger:ETHernet:FRAMe:CMIN on page 1445
SEARch:TRIGger:ETHernet:FRAMe:CMAX on page 1446

Error Condition
Searches for the following error conditions: "Preamble Error" or "Length Error".

Preamble Error ← Error Condition
Searches for any preamble errors.

Remote command:
SEARch:TRIGger:ETHernet:ERRor:PREamble on page 1446

Length Error ← Error Condition
Searches for any preamble errors.

Remote command:
SEARch:TRIGger:ETHernet:ERRor:LENGth on page 1446

12.7.6.2 Ethernet Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

Remote commands:

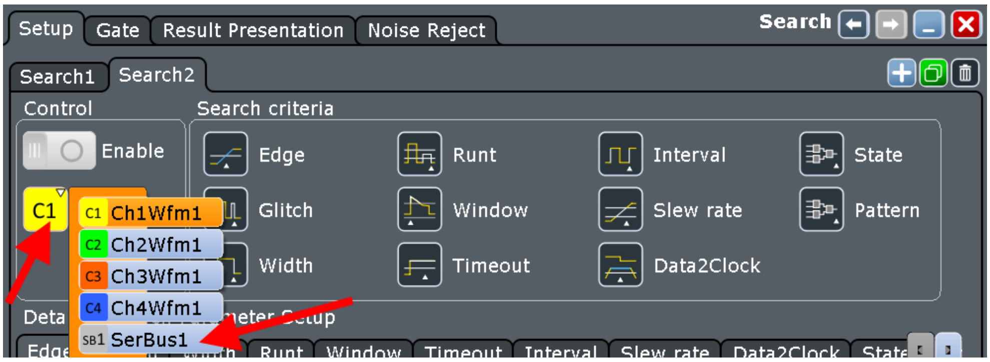
- `SEARch:RESult:ETHernet:WCOunt?` on page 1447
- `SEARch:RESult:ETHernet:WORD<m>:TYPE?` on page 1449
- `SEARch:RESult:ETHernet:WORD<m>:FTYPe?` on page 1449
- `SEARch:RESult:ETHernet:WORD<m>:STATe?` on page 1447
- `SEARch:RESult:ETHernet:WORD<m>:STARt?` on page 1448
- `SEARch:RESult:ETHernet:WORD<m>:STOP?` on page 1448
- `SEARch:RESult:ETHernet:WORD<m>:DESTaddress?` on page 1448
- `SEARch:RESult:ETHernet:WORD<m>:SRCaddress?` on page 1449
- `SEARch:RESult:ETHernet:WORD<m>:DATA?` on page 1450
- `SEARch:RESult:ETHernet:WORD<m>:CRC?` on page 1450
- `SEARch:RESult:ETHernet:WORD<m>:DSYMbol?` on page 1450
- `SEARch:RESult:ETHernet:WORD<m>:SSYMbol?` on page 1451
- `SEARch:RESult:ETHernet:WORD<m>:BYTE<n>:VALue?` on page 1451

12.7.6.3 Searching Ethernet Data

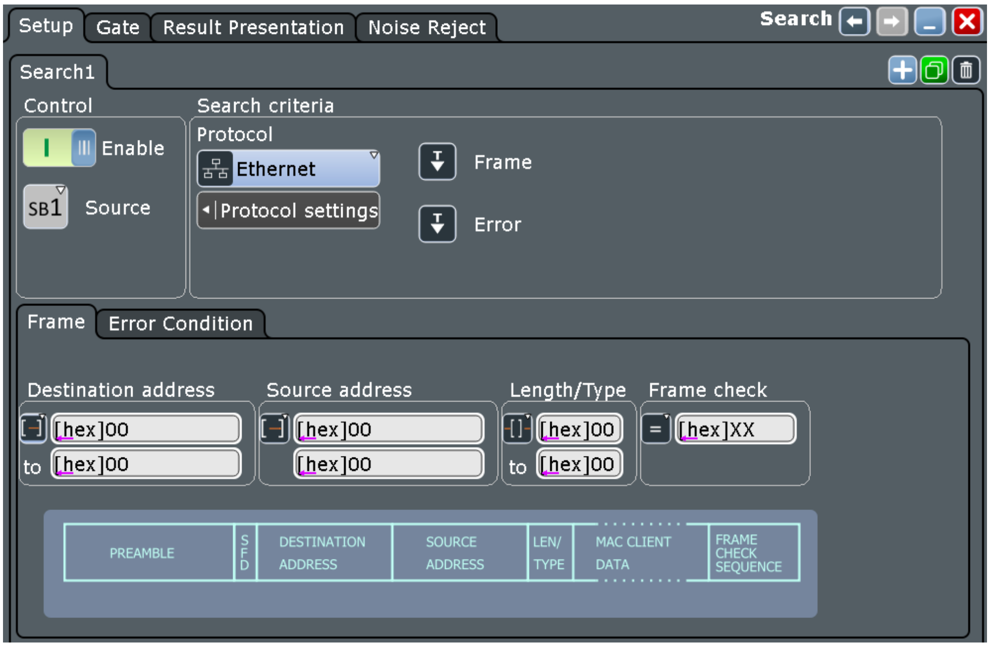
Prerequisite: A serial bus is configured for the Ethernet signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press [Search] or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the ⊞ icon to create one, as described in "To create a user-defined search" on page 411.
3. Tap "Source" and select the serial bus that is set to Ethernet (e.g. "SerBus1", unless already selected).



The search dialog for Ethernet protocol analysis is opened.



4. Specify search criteria according to Chapter 12.7.6.1, "Ethernet Search Setup", on page 578.
5. To acquire a waveform, press [Single].

   The R&S RTP performs an Ethernet decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTP displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 417 and "Navigating search results" on page 398.

12.8 Ethernet 100BASE-T1 (Option R&S RTP-K57)

100BASE-T1 is an Ethernet based protocol specialized for the needs of the automotive industry, such as in the automotive networking applications, enabling advanced safety, comfort and infotainment features within the automobile.

Its specifications, with reference to IEEE Standard 802.3-2012, were developed by the OPEN (One-Pair Ether-Net) alliance under BroadR-Reach®.

BroadR-Reach is a Broadcom® point-to-point Ethernet physical layer (PHY) technology. Therefore, 100BASE-T1 is also known as BroadR-Reach Physical Layer (BR-PHY) or Open Alliance BroadR-Reach PHY (OABR PHY). For more details on the specifications, refer to http://www.opensig.org/about/specifications/.

The R&S RTP-K57 firmware option enables the R&S RTP to analyze the 100BASE-T1 protocol by decoding the signal and searching within the decoded events. To trigger the signal, use the edge trigger on the source channel.

This option is compatible with the MII (IEEE 802.3 Clause 22) and IEEE 802.3 MAC operating at 100Mbps.

12.8.1 100BASE-T1 Basics

The BR-PHY has the following objectives:

- Provides a PHY that supports full duplex operating at 100 Mbps over a pair of unshielded twisted pair (UTP) cable or better cable
- Provides compatibility with the Media Independent Interface (MII) IEEE 802.3 Clause 22 and IEEE 802.3 Media Access Controller (MAC) operating at 100 Mbps
- Achieves bit error rate (BER) of less than $1e^{-10}$

To achieve the above objectives, 100BASE-T1 uses 1000BASE-T PHYs with parts of IEEE 802.3 100BASE-TX in operation at 100 MBps and develops a new solution for the PHY sublayers, i.e. Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer as follows:

- Adopts full duplex communication of 1000BASE-T and therefore echo cancellation on a single twisted-pair channel. This feature reduces cabling while preserving the Ethernet MAC compatibility
- Adopts Pulse Amplitude Modulation (PAM-3) encoding scheme with the following encoding techniques:
  – Data encoding is carried out via a 4b3b encoder that converts the MII data (4B - four bits) with 25 MHz clock to three bits (3B) wide of data that is transmitted during one 33.3 MHz clock period

- Symbol encoding is carried out via a one-dimensional (1D) PAM-3 encoder that converts the 3-bit groups into pairs of ternary symbols. These symbols are transmitted using three voltage levels (-1 V, 0 V and +1 V). One symbol is transmitted in each symbol period
- Data scrambling is carried out via a sidestream scramble to randomize the sequence of transmitted symbols and avoid the presence of spectral lines in the signal spectrum

PAM-3 has a higher spectral efficiency that limits the signaling bandwidth to 33.3 MHz instead of 65 MHz to 80 MHz in 1000BASE-T and 100BASE-TX such that communication occurs in the best part of a twisted-pair channel. This in turn improves return loss, reduces crosstalk and EMI, allows for a more aggressive Electromagnetic Compatibility (EMC) filtering and lower cost (often lower quality) cabling

In terms of the trigger and decoder development, multiple aspects of this protocol are new, specifically:

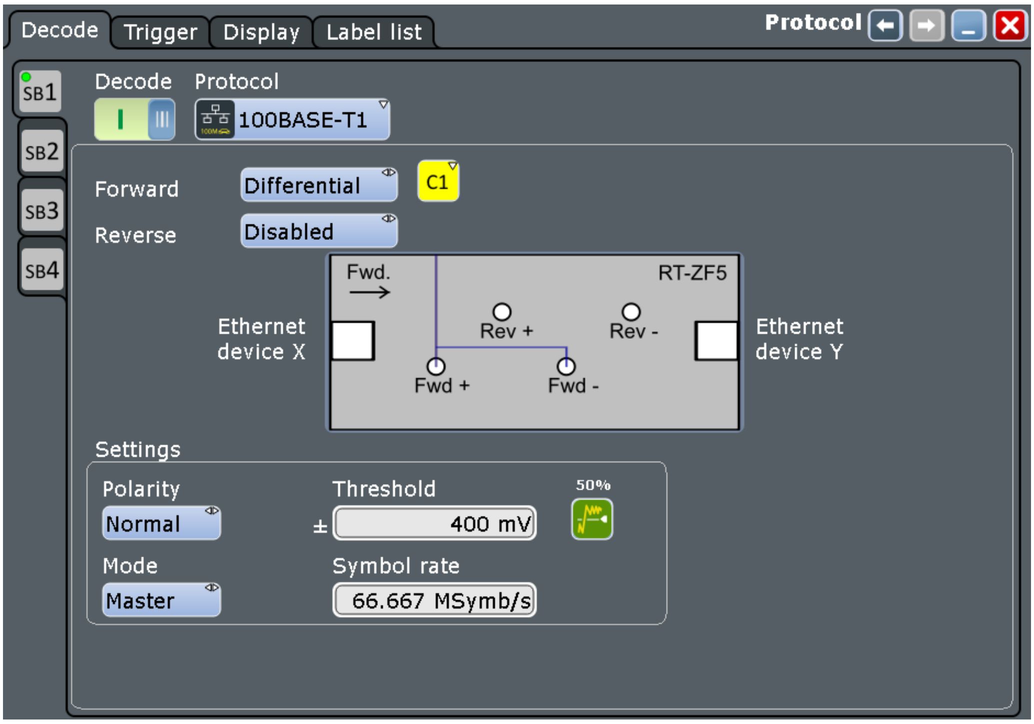
- Sidestream descrambler: Descrambles the randomized sequence of received ternary symbols
- 1D PAM-3 decoder: Decodes the received ternary symbols into groups of three bits according to a conversion chart
- 4b/3b line decoder: Decodes the groups of three bits (result of ternary pair) back to groups of four bits of the data stream

12.8.2 100BASE-T1 Configuration

12.8.2.1 100BASE-T1 Configuration Settings

Access: [Protocol] > "Decode" tab > "Protocol" = *100BASE-T1*

Make sure that the tab of the correct serial bus is selected on the left side.



For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Reverse

Defines the reversed signal settings. The reverse direction is optional and can be disabled.

You can choose between a differential and single-ended signal and set the source channel for the waveform. Only analog channels are available for selection.

Remote command:
`BUS<m>:HBTO:RTYP` on page 1454
`BUS<m>:HBTO:RDIF` on page 1454
`BUS<m>:HBTO:RDAP` on page 1453
`BUS<m>:HBTO:RDAM` on page 1453

Forward

Defines the forward signal settings.

You can choose between a differential and single-ended signal and set the source channel for the waveform. Only analog channels are available for selection.

Remote command:
`BUS<m>:HBTO:FTYP` on page 1453
`BUS<m>:HBTO:FDIF` on page 1453
`BUS<m>:HBTO:FDAP` on page 1452
`BUS<m>:HBTO:FDAM` on page 1452

Attenuation
Sets the attenuation factor. It is used to de-amplify the reverse signal before subtracting it from the forward signal.

The effective signal amplitude passed to the decoder is:

$$Amp = (Fwd_+ - Fwd_-) - 10^{\frac{Attn}{20}}(Rev_+ - Rev_-)$$

Remote command:
`BUS<m>:HBTO:ATTN` on page 1452

Polarity
Selects the polarity of the data signal. You can select between "Normal" and "Inverted".

In "Normal" polarity, active high is defined as +1 V and active low is defined as -1 V. The opposite is true in "Inverted" polarity.

Remote command:
`BUS<m>:HBTO:POLarity` on page 1454

Thresholds
Sets the hysteresis and threshold value for the digitization of the signal line. If the signal value on the line is higher than the upper threshold, the signal state is high. Else if the signal value is below the lower threshold, the signal state is considered low.

There are several ways to set these values:
- "Thresholds"
  Enter the values directly: upper threshold in the first field, upper hysteresis in the second field, lower hysteresis in the third field, and lower threshold in the fourth field.
- "50%"
  Executes a measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Remote command:
`BUS<m>:HBTO:THReshold` on page 1454

Mode
Selects the desired direction of the full-duplex signal for analysis. The direction can be either "Master" or "Slave".

Remote command:
`BUS<m>:HBTO:MODE` on page 1454

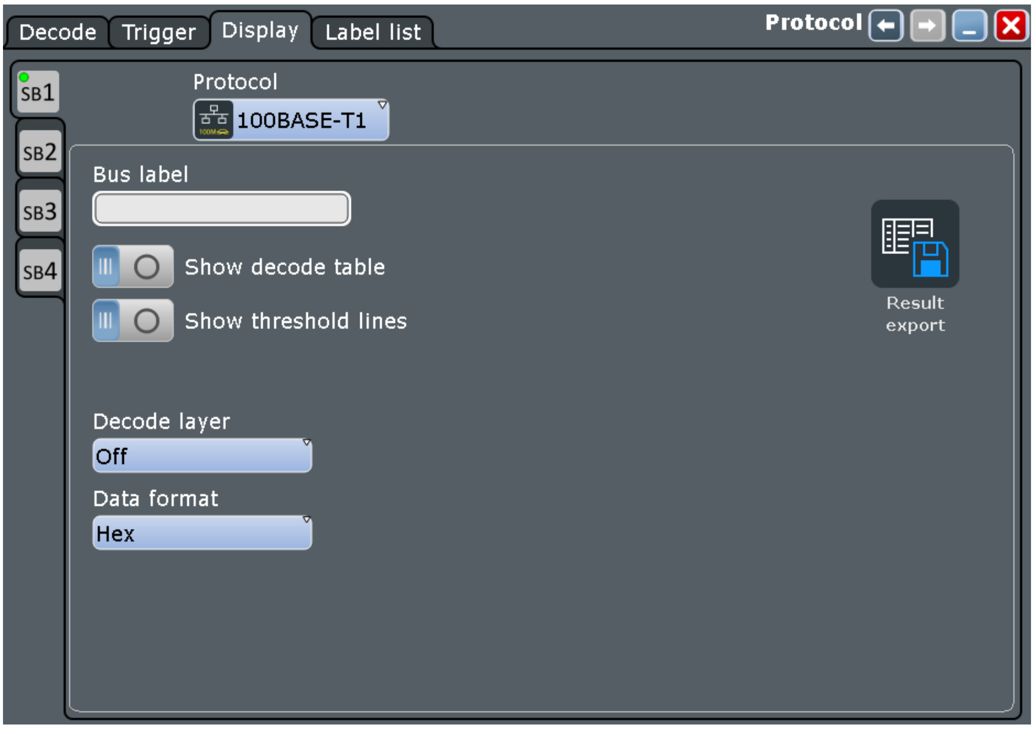
Symbol rate
Defines the transmission rate of ternary symbols which is by default 66.67 MSymb/s. This parameter should be rarely changed.

Remote command:
`BUS<m>:HBTO:SYMRate` on page 1455

12.8.2.2 100BASE-T1 Display Settings

Access: [Protocol] > "Decode" tab > "Protocol = 100BASE-T1" > "Display" tab

To enhance the decode possibilities of the 100BASE-T1 protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 465.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Off"	No decode layer is displayed.
"Ternary symbols"	Decoded ternary symbols.
"Scrambled bits"	Scrambled ternary bits.
"Descrambled bits"	Descrambled ternary bits.
"Reversed Bits"	Reserved bits

12.8.2.3 Configuring 100BASE-T1 Signals

For configuration, assign the lines to the input channels and define the active states and the logical thresholds.

Serial Bus Setup

1. Press the [Protocol] key on the front panel.
2. At the left hand-side, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Select the "Decode" tab.
4. Tap "Protocol" and select the protocol: "100BASE-T1".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Select the type and source for the reversed and forward signal.
7. Select the polarity ("Normal" or "Inverted") of the signal.
8. Set the logical thresholds. See "Thresholds" on page 586.
9. Select the "Mode" and the "Symbol rate".
10. Enable "Decode", if available.

12.8.3 100BASE-T1 Trigger

12.8.3.1 100BASE-T1 Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = 100BASE-T1"

In this section, all trigger settings are described. Their availability on the instrument depends on the selected trigger type. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to data sheet.

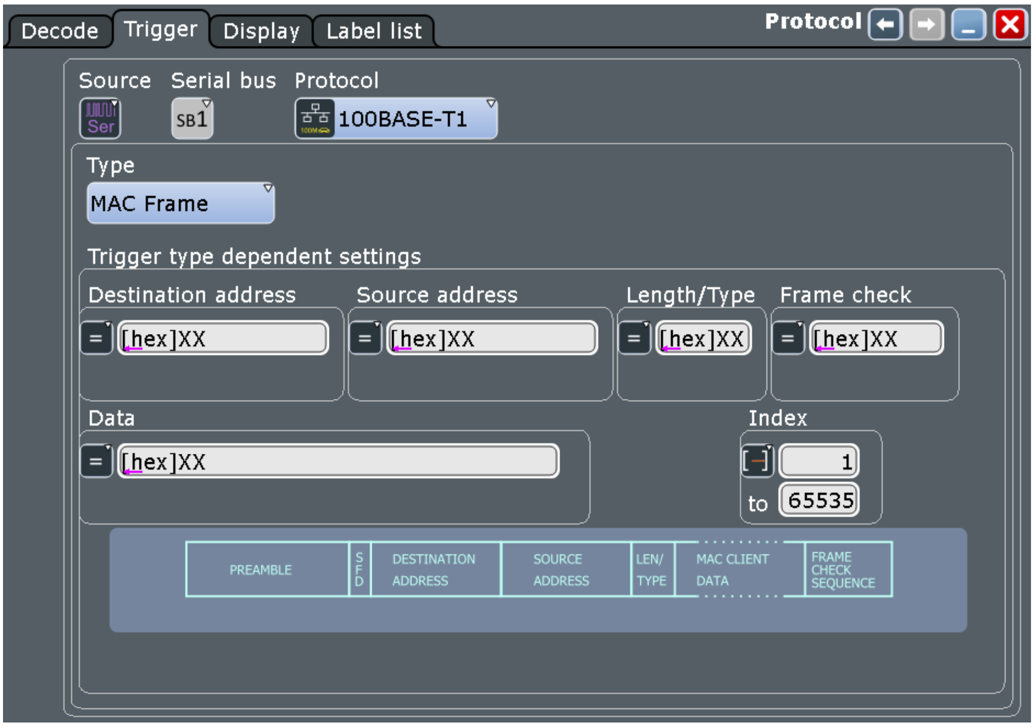


Figure 12-43: 100BASE-T1 trigger event settings dialog

Make sure that:

- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Type

Selects the trigger type for 100BASE-T1 analysis.

Remote command:

`TRIGger<m>:HBTO:TYPE` on page 1456

Frame Start ← Type

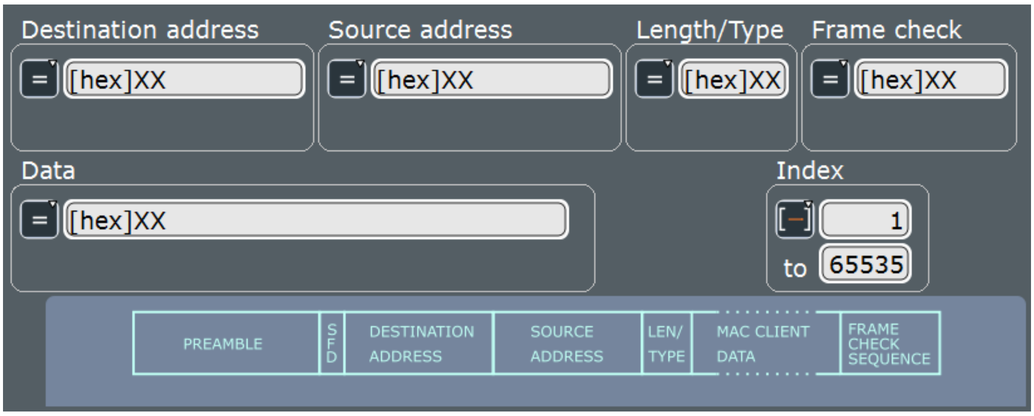
Triggers on the start of frame.

MAC Frame ← Type

Triggers on a Media Access Control (MAC) frame. You can specify:

- Destination address
- Source address
- Length/Type
- Frame check
- Data
- Index

The frame contains addresses of the devices and MAC control information that define how to go about transmitting and receiving frames.

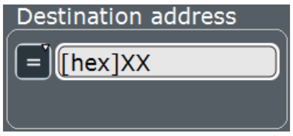


IDLE ← Type
Triggers on an idle frame. The frame is used for clock synchronization.

Error ← Type
Triggers on the specified error frame.

Destination address
Sets the specified destination address to be triggered on. The destination address setup consists of the condition and one or two data patterns.

The destination address corresponds to the address of the interface in the device that receives the frame. If the destination address does not match the interface's own Ethernet address, then the interface is free to ignore the rest of the frame.



"Condition" Defines the operator to set a specific destination address, e.g. "Equal" or "Not Equal") or a range.

"Data Min/Data"
Defines the bit pattern of the destination address pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

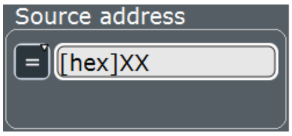
"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:HBTO:DADDress:CONDition` on page 1456
`TRIGger<m>:HBTO:DADDress:MIN` on page 1456
`TRIGger<m>:HBTO:DADDress:MAX` on page 1457

Source address

Sets the specified source address to be triggered on. The source address setup consists of the condition and one or two data patterns.

The source address is the physical address of the device that sends the frame.



"Condition" Defines the operator to set a specific source address, e.g. "Equal" or "Not Equal") or a range.

"Data Min/Data"
Defines the bit pattern of the source address pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

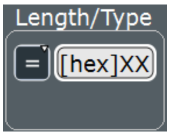
"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:HBTO:SADDress:CONDition` on page 1457
`TRIGger<m>:HBTO:SADDress:MIN` on page 1457
`TRIGger<m>:HBTO:SADDress:MAX` on page 1458

Length/Type

Sets the specified Length/Type to be triggered on. The Length/Type setup consists of the condition and one or two data patterns.

The value in this field indicates the manner in which the field is being used, either as a length or type field. As a length field, the value in the field indicates the number of logical link control (LLC) data octets that follow in the data field of the frame. As a type field, the value in the field is used to indicate the type of protocol data being carried in the data field of the frame.



"Condition" Defines the operator to set a specific Length/Type, e.g. "Equal" or "Not Equal") or a range.

"Data Min/Data"
Defines the bit pattern of the Length/Type pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

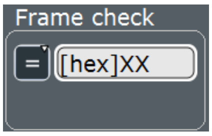
"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:HBTO:LENGth:CONDition` on page 1458
`TRIGger<m>:HBTO:LENGth:MIN` on page 1458
`TRIGger<m>:HBTO:LENGth:MAX` on page 1459

Frame check

Sets the specified frame check to be triggered on. The frame check setup consists of the condition and one or two data patterns.

This field contains a value that is used to check the integrity of the various bits in the frame fields (excluding the preamble / SFD).



"Condition" Defines the operator to set a specific frame check, e.g. "Equal" or "Not Equal") or a range.

"Data Min/Data"
Defines the bit pattern of the frame check pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:HBTO:CRC:CONDition` on page 1459
`TRIGger<m>:HBTO:CRC:MIN` on page 1459
`TRIGger<m>:HBTO:CRC:MAX` on page 1459

Data

Sets the specified data to be triggered on. The data setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific data, e.g. "Equal" or "Not Equal") or a range.

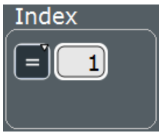
"Data Min/Data"
Defines the bit pattern of the data pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:HBTO:DATA:DCONdition` on page 1460
`TRIGger<m>:HBTO:DATA:DMIN` on page 1460
`TRIGger<m>:HBTO:DATA:DMAX` on page 1460

Index

Sets the specified value or range within this series of data that is considered for the analysis. The index setup consists of the condition and one or two index values.



"Condition" Defines the operator to set a specific index, e.g. "Equal" or a range.

"Index Min/Index"
Defines the bit pattern of the index pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Index Max" The second index pattern is required to specify a range with conditions "In range".

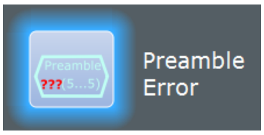
Remote command:
`TRIGger<m>:HBTO:DATA:ICONdition` on page 1461
`TRIGger<m>:HBTO:DATA:IMIN` on page 1461
`TRIGger<m>:HBTO:DATA:IMAX` on page 1461

Errors

Sets the type of error events to be triggered on.

Preamble Error ← Errors

Triggers on a frame with invalid preamble.



Remote command:
`TRIGger<m>:HBTO:ERRor:PREamble` on page 1462

CRC Error ← Errors

Triggers on a frame that has a mismatch of the Cyclic Redundancy Check (CRC) value between the transmitting and receiving device.

Remote command:
`TRIGger<m>:HBTO:ERRor:CRC` on page 1462

SFD Error ← Errors
Triggers on a frame with invalid Start Frame Delimiter (SFD).

Remote command:
`TRIGger<m>:HBTO:ERRor:SFD` on page 1462

12.8.3.2 Triggering on 100BASE-T1

Prerequisite: A bus is configured for the 100BASE-T1 signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Select the serial bus that is set to 100BASE-T1.
5. Tap "Type" and select the trigger type to be used for 100BASE-T1 protocol analysis.
6. To refine the trigger settings, configure additional settings, which are available for some trigger types.

For details, see Chapter 12.8.3, "100BASE-T1 Trigger", on page 588.

12.8.4 100BASE-T1 Label List

Label lists are protocol-specific. Label lists for 100BASE-T1 are available in CSV and PTT format.

A 100BASE-T1 label file contains two values for each ethernet header:

- Ethernet Header Display
- Symbolic label: name of the address, specifiing its function in the bus network.

12.8.5 100BASE-T1 Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Examples

The example in Figure 12-45 shows decoded signals in 100BASE-T1.

Figure 12-44: 100BASE-T1 decoded signal

green brackets [...]	= start / end of frame
dark cyan frame	= frame ok
red frame	= error frame
light purple	= destination address
purple	= source address
orange or yellow	= data
light gray	= idle
gray	= filler
dark gray	= reserved
light blue	= check
blue	= marker
dark blue	= sync / SFD
lime	= count

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Figure 12-45: 100BASE-T1 decode results table and details

The content of the "Decode results" table in Figure 12-45 is described in Table 12-9:

Table 12-9: Content of the "Decode results" table

Column	Description
Frame	Frame count
Type	Type of frame (e.g. Idle, MAC or data)
State	Overall state of the frame: either OK or the relevant error condition (preamble, CRC or SFD)
Start	Start time of the frame
Stop	Stop time of the frame
Destination Address	Destination address of the frame
Source Address	Source address of the frame
Type/Length	The sub-protocol (e.g. HTML, video, etc.) determines what meaning this field has. Since the content of this data area is not decoded, the interpretation of this field is ambivalent. It could either be the word type (specific for the sub-protocol) or the word length.

Column	Description
Data	Values of the data bytes in a frame. The table shows a truncated version; to see all the bytes in a separate data table, activate "Show details". The data format is always hexadecimal.
CRC	Frame Check (Cyclic Redundancy Code, CRC)

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:

- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.9.3, "Decode Results", on page 1462.

12.8.6 Search on Decoded 100BASE-T1 Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

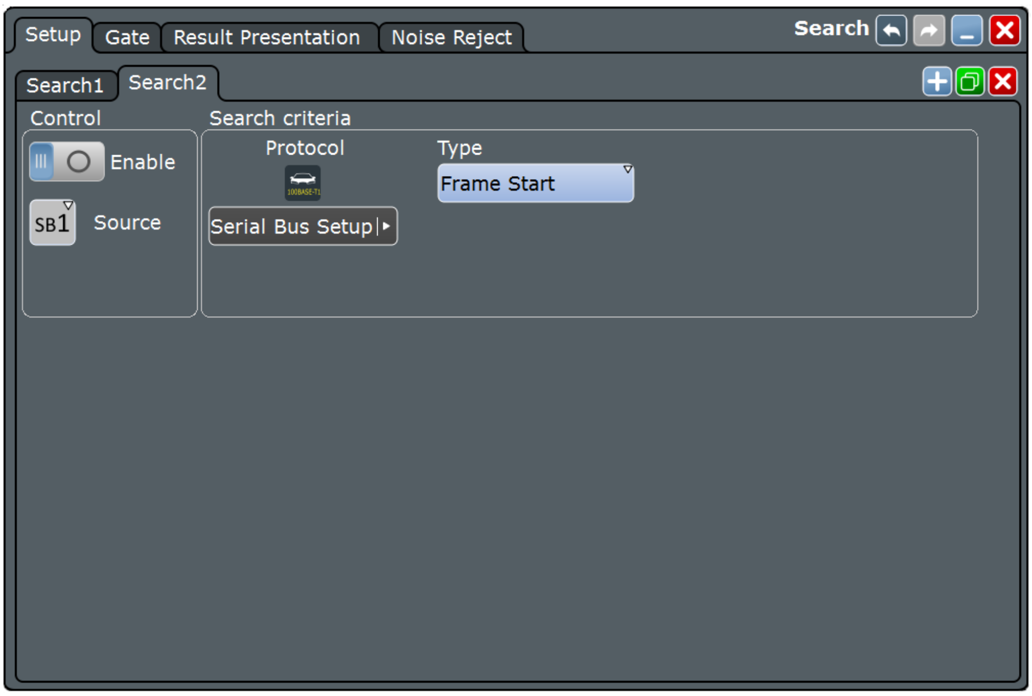
For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 396.

12.8.6.1 100BASE-T1 Search Setup

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for 100BASE-T1

Search criteria

Use the "Search criteria" dialog to define the event types to be searched.



Type

Selects the search type for 100BASE-T1 analysis.

Remote command:

SEARch:TRIGger:HBTO:TYPE on page 1468

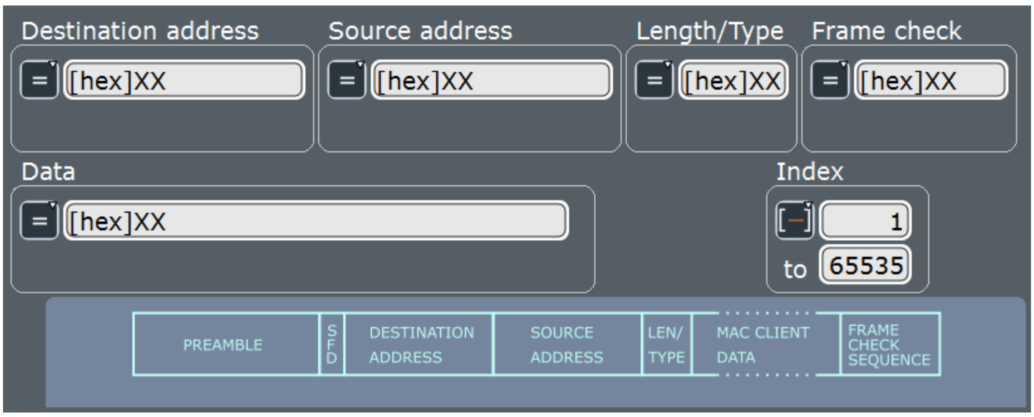
Frame Start ← Type

Searches for the start of frame.

MAC Frame ← Type

Searches for a Media Access Control (MAC) frame that matches the specified Destination address, Source address, Length/Type, Frame check, Data or Index condition.

The frame contains addresses of the devices and MAC control information that define how to go about transmitting and receiving frames.



FILLER ← Type

Searches for a Filler frame. The frame is used to maintain transmission activity.

IDLE ← Type

Searches for an idle frame. The frame is used for clock synchronization.

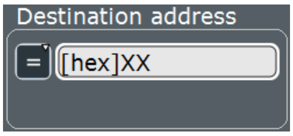
Error ← Type

Searches for the specified error frame.

Destination address

Sets the specified destination address to be searched for. The destination address setup consists of the condition and one or two data patterns.

The destination address corresponds to the address of the interface in the device that receives the frame. If the destination address does not match the interface's own Ethernet address, then the interface is free to ignore the rest of the frame.



"Condition" Defines the operator to set a specific destination address, e.g. "Equal" or "Not Equal") or a range.

"Data Min/Data"

Defines the bit pattern of the destination address pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:

`SEARch:TRIGger:HBTO:DADDress:CONDition` on page 1469

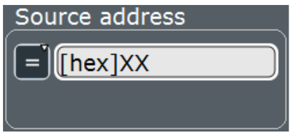
`SEARch:TRIGger:HBTO:DADDress:MIN` on page 1469

`SEARch:TRIGger:HBTO:DADDress:MAX` on page 1470

Source address

Sets the specified source address to be searched for. The source address setup consists of the condition and one or two data patterns.

The source address is the physical address of the device that sends the frame.



"Condition" Defines the operator to set a specific source address, e.g. "Equal" or "Not Equal") or a range.

"Data Min/Data"
Defines the bit pattern of the source address pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

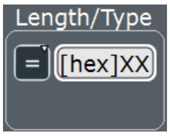
"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:HBTO:SADDress:CONDition` on page 1470
`SEARch:TRIGger:HBTO:SADDress:MIN` on page 1470
`SEARch:TRIGger:HBTO:SADDress:MAX` on page 1471

Length/Type

Sets the specified Length/Type to be searched for. The Length/Type setup consists of the condition and one or two data patterns.

The value in this field indicates the manner in which the field is being used, either as a length or type field. As a length field, the value in the field indicates the number of logical link control (LLC) data octets that follow in the data field of the frame. As a type field, the value in the field is used to indicate the type of protocol data being carried in the data field of the frame.



"Condition" Defines the operator to set a specific Length/Type, e.g. "Equal" or "Not Equal") or a range.

"Data Min/Data"
Defines the bit pattern of the Length/Type pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

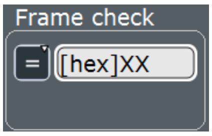
"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:HBTO:LENGth:CONDition` on page 1471
`SEARch:TRIGger:HBTO:LENGth:MIN` on page 1471
`SEARch:TRIGger:HBTO:LENGth:MAX` on page 1472

Frame check

Sets the specified frame check to be searched for. The frame check setup consists of the condition and one or two data patterns.

This field contains a value that is used to check the integrity of the various bits in the frame fields (excluding the preamble / SFD).



"Condition" Defines the operator to set a specific frame check, e.g. "Equal" or "Not Equal") or a range.

"Data Min/Data"
Defines the bit pattern of the frame check pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
SEARch:TRIGger:HBTO:CRC:CONDition on page 1472
SEARch:TRIGger:HBTO:CRC:MIN on page 1472
SEARch:TRIGger:HBTO:CRC:MAX on page 1473

Data

Sets the specified data to be searched for. The data setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific data, e.g. "Equal" or "Not Equal") or a range.

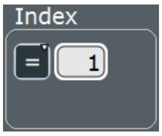
"Data Min/Data"
Defines the bit pattern of the data pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
SEARch:TRIGger:HBTO:DATA:DCONdition on page 1473
SEARch:TRIGger:HBTO:DATA:DMIN on page 1473
SEARch:TRIGger:HBTO:DATA:DMAX on page 1474

Index

Sets the specified value or range within this series of data that is considered for the search. The index setup consists of the condition and one or two index values.



"Condition" Defines the operator to set a specific index, e.g. "Equal" or a range.

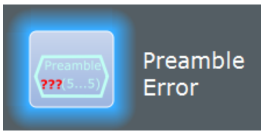
"Index Min/Index"
Defines the bit pattern of the index pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Index Max" The second index pattern is required to specify a range with conditions "In range".

Remote command:
`SEARch:TRIGger:HBTO:DATA:ICONdition` on page 1474
`SEARch:TRIGger:HBTO:DATA:IMIN` on page 1474
`SEARch:TRIGger:HBTO:DATA:IMAX` on page 1475

Errors
Sets the type of error events to be searched for.

Preamble Error ← Errors
Searches for a frame with invalid preamble.



Remote command:
`SEARch:TRIGger:HBTO:ERRor:PREamble` on page 1475

CRC Error ← Errors
Searches for a frame that has a mismatch of the Cyclic Redundancy Check (CRC) value between the transmitting and receiving device.

Remote command:
`SEARch:TRIGger:HBTO:ERRor:CRC` on page 1475

SFD Error ← Errors
Searches for a frame with invalid Start Frame Delimiter (SFD).

Remote command:
SEARch:TRIGger:HBTO:ERRor:SFD on page 1475

12.8.6.2 100BASE-T1 Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

Remote commands:

- SEARch:RESult:HBTO:FCOunt? on page 1476
- SEARch:RESult:HBTO:FRAMe<m>:TYPE? on page 1476
- SEARch:RESult:HBTO:FRAMe<m>:STATe? on page 1477
- SEARch:RESult:HBTO:FRAMe<m>:STARt? on page 1477
- SEARch:RESult:HBTO:FRAMe<m>:STOP? on page 1477
- SEARch:RESult:HBTO:FRAMe<m>:DESTaddress? on page 1478
- SEARch:RESult:HBTO:FRAMe<m>:SRCaddress? on page 1478
- SEARch:RESult:HBTO:FRAMe<m>:DATA? on page 1478
- SEARch:RESult:HBTO:FRAMe<m>:CRC? on page 1479
- SEARch:RESult:HBTO:FRAMe<m>:NUMWords? on page 1479
- SEARch:RESult:HBTO:FRAMe<m>:FTYPe? on page 1479
- SEARch:RESult:HBTO:FRAMe<m>:DSYMbol? on page 1480
- SEARch:RESult:HBTO:FRAMe<m>:SSYMbol? on page 1480
- SEARch:RESult:HBTO:FRAMe<m>:WORD<n>:TYPE? on page 1480
- SEARch:RESult:HBTO:FRAMe<m>:WORD<n>:VALue? on page 1481

12.8.6.3 Searching 100BASE-T1 Data

Prerequisite: A serial bus is configured for the 100BASE-T1 signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press [Search] or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 411.

3. Tap "Source" and select the serial bus that is set to 100BASE-T1 (e.g. "SB1", unless already selected).
   The search dialog for 100BASE-T1 protocol analysis opens.
4. Specify search criteria according to Chapter 12.8.6, "Search on Decoded 100BASE-T1 Data", on page 597.
5. To acquire a waveform, press [Single].
   The R&S RTP performs an 100BASE-T1 decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog.
   The R&S RTP displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 417 and "Navigating search results" on page 398.

12.9 RFFE (Option R&S RTP-K40)

Radio Frequency Front-End (RFFE) control interface is a serial interface specified by the Mobile Industry Processor Interface (MIPI) alliance. The RFFE interface is designed to control RF front-end components in mobile terminals.

12.9.1 The RFFE Protocol

The RFFE interface is specified in the "MIPI® Alliance Specification for RF Front-End Control Interface". The RFFE interface is used by the radio frequency front-end interface chips in most LTE-Advanced platforms and in smart phones in general. RFFE is a replacement for existing standards like SPI and I²C that do no meet performance requirements.

Bus structure

RFFE is a two-wire, serial interface that connects up to 4 master devices (Radio Frequency IC, RFIC) to up to 15 slaves (front-end modules, FEM) on a single RFFE bus. A slave device has read-write capability, or it is write only. Only one of the masters is the active master (bus owner master, BOM), which can initiate command sequences on the bus.

The interface has two lines: one clock signal (SCLK) controlled by the master, and a serial bidirectional data signal (SDATA). Furthermore, a VIO supply/reference voltage from a common source is applied to all components on the bus.

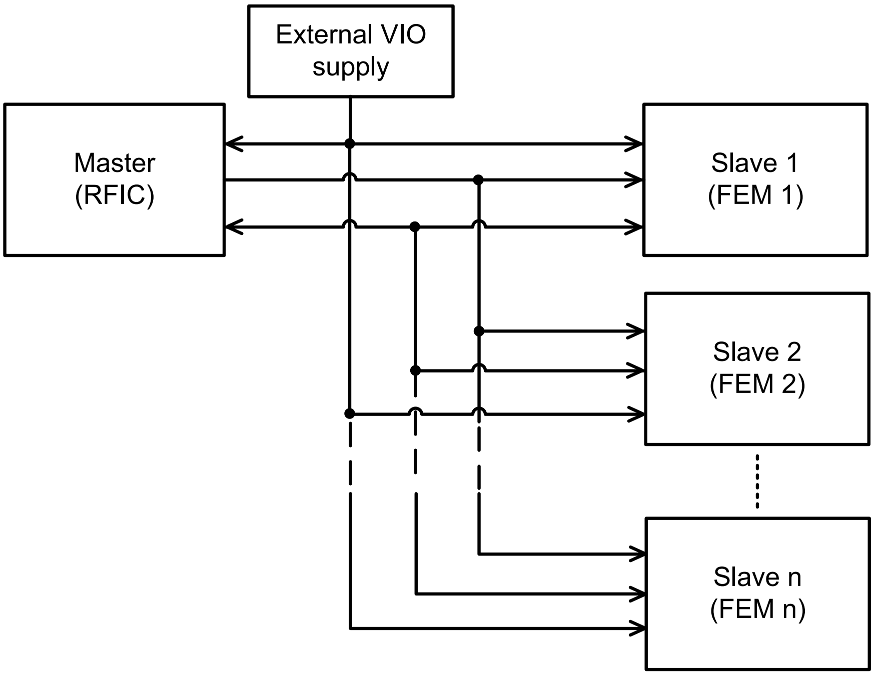


Figure 12-46: RFFE bus structure with external VIO supply

Command sequences

Protocol messages are called command sequences in RFFE. The standard defines various command sequences to accomplish read and write access to slaves and to non-active masters. Command sequences are initiated by the BOM master on the SDATA line.

In general, a command sequence consists of:

- Sequence start condition (SSC)
  Two bits: 1 followed by 0 on SDATA while SCLK is at logic level zero.
- Command frame
  Consist of a 4-bit slave address field (SA), followed by 8 command payload bits and a single parity bit.
- Address and/or data frames, depending on the command sequence
  A frame consists of 8 data bits or 8 register address bits, followed by a single parity bit. The number of address and data frames varies depending on the command sequence type.
- Bus park cycle (BP)
  A BP cycle is sent at the end of a command sequence, and when the device transfers control of SDATA to another device.

Between the end of a command sequence and the beginning of a new command sequence, the bus is in idle condition at least for 10 ns.

The bits are sent MSB first.

<table>
<tr><td rowspan="3">SSC</td><td colspan="2">Command frame</td><td colspan="2">Address and data frames</td><td rowspan="3">BP</td></tr>
<tr><td>SA</td><td>Command payload</td><td>[Address frames]</td><td>[Data frames]</td></tr>
<tr><td>4 bits</td><td>8 bits + P</td><td>8 bits + P</td><td>8 bits + P</td></tr>
</table>

Figure 12-47: General structure of a RFFE Write command sequence

<table>
<tr><td rowspan="3">SSC</td><td colspan="2">Command frame</td><td colspan="3">Address and data frames</td><td rowspan="3">BP</td></tr>
<tr><td>SA</td><td>Command payload</td><td>[Address frames]</td><td rowspan="2">BP</td><td>[Data frames]</td></tr>
<tr><td>4 bits</td><td>8 bits + P</td><td>8 bits + P</td><td>8 bits + P</td></tr>
</table>

Figure 12-48: General structure of a RFFE Read command sequence

Trigger

The R&S RTP uses a hardware-based trigger to trigger on various parts of slave device messages, to trigger at maximum bus speed and on frame gaps. The data and clock lines must be connected to the input channels. Triggering on math and reference waveforms is not possible.

You can trigger on:

- Start of command sequence (SSC). In addition, you can specify a slave address.
- End of command sequence). In addition, you can specify a slave address.
- Various errors, for example, parity and bus park error
- Read and write command sequences between the BOM and the slaves.
  Within a command sequence, you can trigger on specific parts of the message:
  – Slave address
  – Byte count
  – Register address
  – Data word

Search

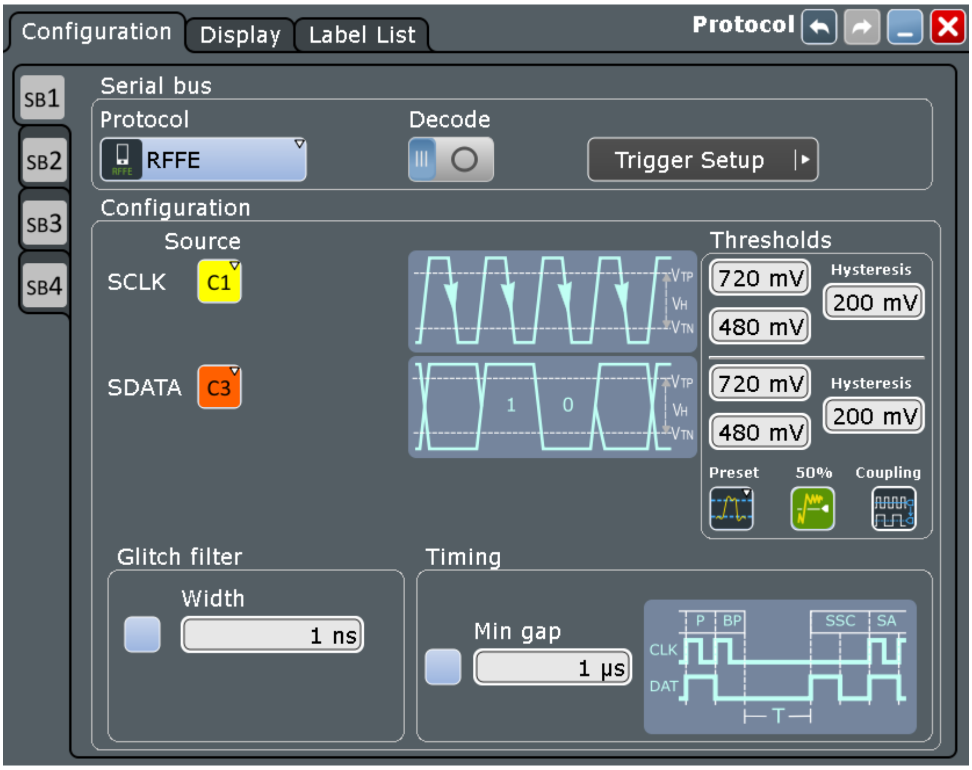
Using the search functionality, you can find various events in the acquired and decoded data. You can find the same events which you also can trigger on. In addition, you can find command sequences of master-to master communication and "interrupt summary and identification" command sequences.

12.9.2 RFFE Configuration

12.9.2.1 RFFE Configuration Settings

Access: [Protocol] > "Decode" tab > "Protocol" = *RFFE*

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

SCLK Source

Sets the source of the clock line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTP-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:

`BUS<m>:RFFE:CLOCk:SOURce` on page 1481

SDATA Source

Sets the source of the data line.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Alternatively, digital channels can be used if MSO option R&S RTP-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on a serial bus, analog or digital channel sources are required.

Remote command:
BUS<m>:RFFE:DATA:SOURce on page 1482

Thresholds
Set the threshold values for digitization of signals for each line: the positive going threshold (V_{TP}, upper value), the negative going threshold (V_{TN}, lower value), and the hysteresis. The hysteresis is the difference of V_{TP} and V_{TN}.

If the signal value on the line is higher than the positive going threshold, the signal state is high. Otherwise, the signal state is considered low if the signal value is below the negative going threshold.

There are several ways to set the thresholds:
- "Preset"
  Sets default threshold voltages for 1.2 V or 1.8 V bus. The value is set to "Manual" if at least one threshold was entered manually.
- Manual setup
  Enter the values directly in the fields. Note that the three values are dependent, so it is sufficient to enter two values for each line.
- "50%"
  Automatic setup: The instrument measures the signal voltages and calculates the thresholds.
- "Coupling"
  If enabled, the SDATA thresholds are set to the SCLK threshold values.

Remote command:
BUS<m>:RFFE:PRESet on page 1482
BUS<m>:RFFE:CLOCk:THReshold:HIGH on page 1483
BUS<m>:RFFE:CLOCk:THReshold:LOW on page 1484
BUS<m>:RFFE:CLOCk:THReshold:HYSTeresis on page 1484
BUS<m>:RFFE:DATA:THReshold:HIGH on page 1482
BUS<m>:RFFE:DATA:THReshold:LOW on page 1483
BUS<m>:RFFE:DATA:THReshold:HYSTeresis on page 1483
BUS<m>:RFFE:COUPling on page 1482
BUS<m>:SETReflevels on page 1299

Glitch filter
Enables the glitch filter on the SCLK and SDATA lines to improve decode accuracy.

The "Width" field sets the maximum glitch width to be ignored.

Remote command:
BUS<m>:RFFE:GFILter on page 1484
BUS<m>:RFFE:GFWidth on page 1485

Timing
Defines the idle time between the Bus Park Cycle (BP) and Sequence Start Condition (SSC).

You can define a minimum time "Min gap". The standard defines a minimum of 10 ns to separate two subsequent command sequences.

Remote command:
`BUS<m>:RFFE:MINGap:SELect` on page 1485
`BUS<m>:RFFE:MINGap:TIME` on page 1485

12.9.2.2 Configuring RFFE Signals

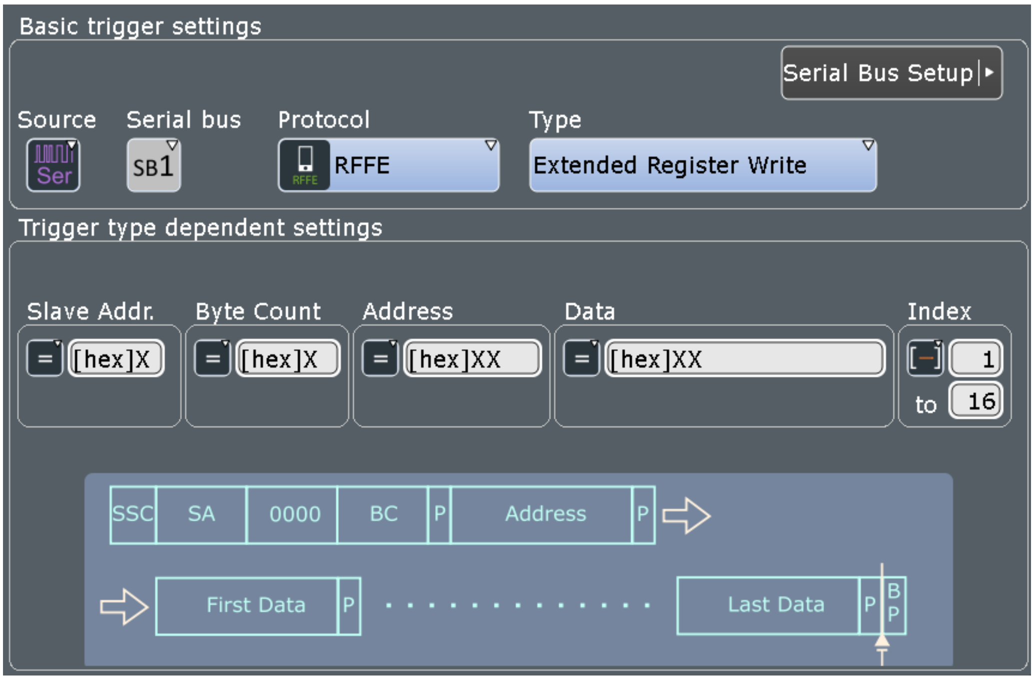
For details on configuration settings, see Chapter 12.9.2.1, "RFFE Configuration Settings", on page 606.

1. Press the [Protocol] key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "RFFE".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "SCLK" button, and select the waveform of the clock line.
7. Tap the "SDATA" button, and select the waveform of the data line.
8. Set the logical thresholds using one of these ways:
   - Tap "Preset" and select the reference voltage of the bus.
   - Tap "50%" to set up thresholds by automatic measurements.
   - To couple the SDATA thresholds to the clock settings, tap "Coupling".
   - If the default settings and the automatic setup do not fit, enter the threshold and values into the corresponding fields. Hysteresis is adjusted by the instrument.
9. If the signal has glitches which can distort the decoding, enable the glitch filter. Set the glitch width.
10. Enable "Decode".

12.9.3 RFFE Trigger

12.9.3.1 RFFE Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = REFE"



Make sure that:
- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Type
Selects the trigger type for RFFE analysis.

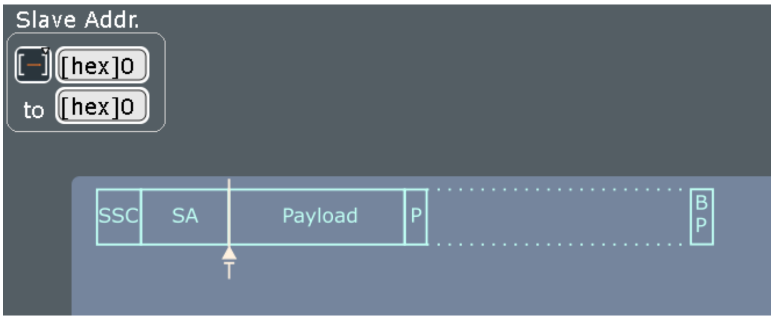
The instrument triggers always at the end of the met trigger criteria.

Remote command:
TRIGger<m>:RFFE:TYPE on page 1486

Sequence Start ← Type
Triggers on the beginning of a command sequence, after the slave address. The SSC is a 1 followed by 0 on SDATA line while SCLK is at logic level zero.

Optionally, you can specify a slave address pattern or a slave address range to trigger only on command sequences that are sent to these slaves.

See: "Slave Addr." on page 615.



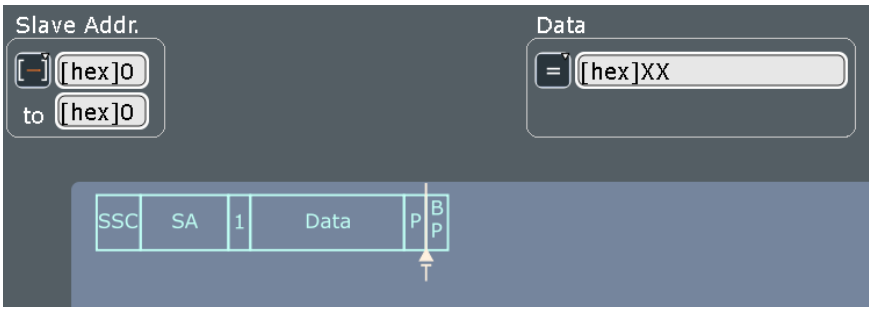
Sequence Stop ← Type
Triggers on the end of a command sequence, on the bus park cycle.

Optionally, you can specify a slave address pattern or a slave address range to trigger only on command sequences that are sent to these slaves.

See: "Slave Addr." on page 615.

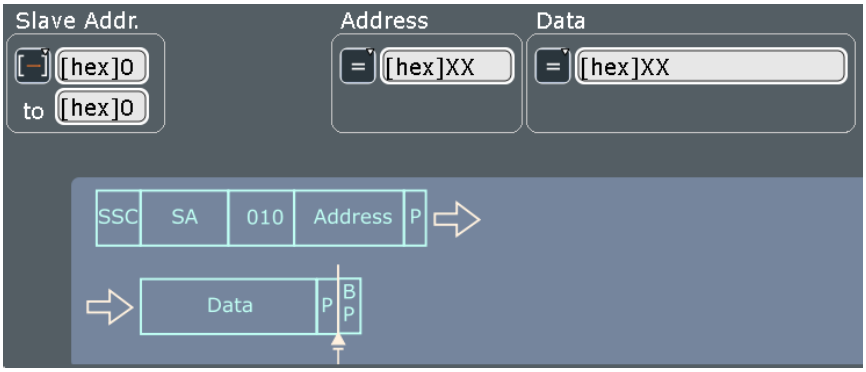
Register 0 Write ← Type
Triggers on "Register 0 Write" command sequences. This sequence sends 7 data bits in the command payload.

You can refine the trigger condition:
- Set a slave address condition to trigger only on command sequences that are sent to the specified slaves.
  See: "Slave Addr." on page 615.
- Set a data pattern condition to trigger on data patterns expected in the message.
  See: "Data" on page 616.



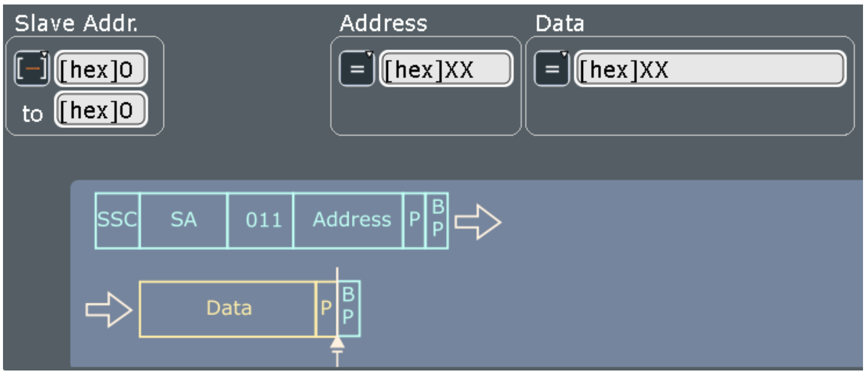
Register Write ← Type
Triggers on "Register Write" command sequences. This sequence sends the register address in the command payload, and sends one data frame.

You can refine the trigger condition:
- Set a slave address condition to trigger only on command sequences that are sent to the specified slaves.
  See: "Slave Addr." on page 615.
- Set a register address condition to trigger only on command sequences that write data to the specified register.
  See: "Address" on page 615.
- Set a data pattern condition to trigger on data patterns expected in the message.
  See: "Data" on page 616.



Register Read ← Type
Triggers on "Register Read" command sequences. This sequence sends the register address in the command payload, and reads back one data frame.

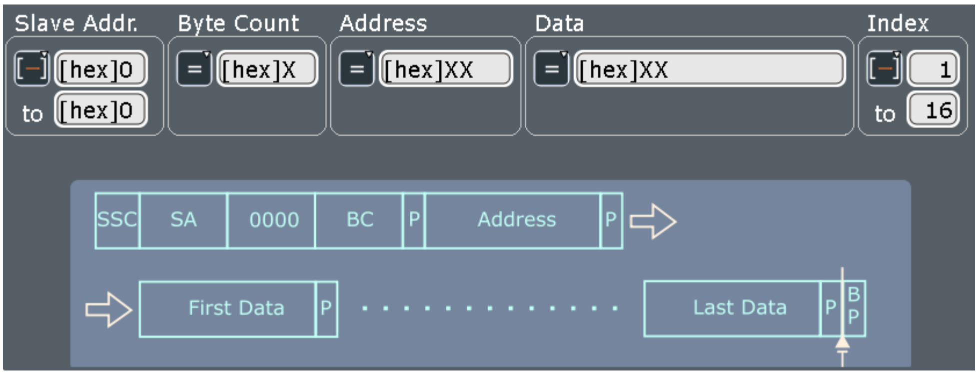
You can refine the trigger condition using the same settings as for the "Register Write" command sequence, see "Register Write" on page 611.



Extended Register Write ← Type
Triggers on "Extended Register Write" command sequences. This sequence sends the byte count of data frames in the command payload, followed by one address frame with the address of the first extended register, and up to 16 data frames.

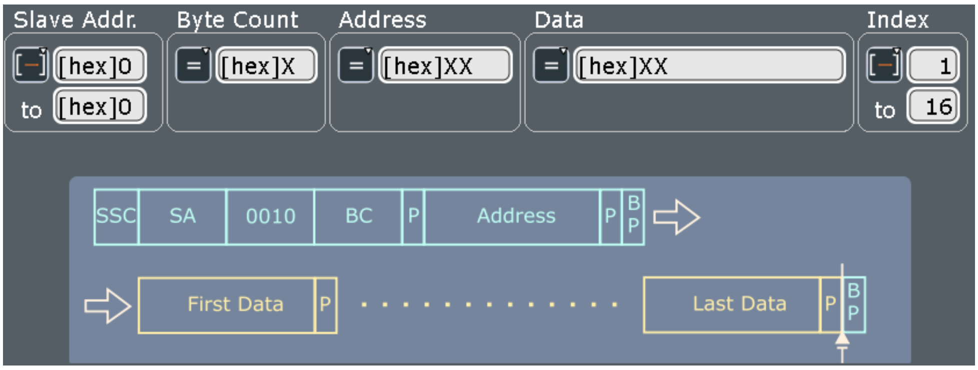
You can refine the trigger condition:
- Set a slave address condition to trigger only on command sequences that are sent to the specified slaves.
  See: "Slave Addr." on page 615
- Set a byte count condition to trigger only on command sequences that send the specified number of data frames.
  See: "Byte count" on page 616

- Set a register address condition to trigger only on command sequences that write data to the specified register.
  See: "Address" on page 615
- Set a data pattern condition to trigger on data patterns expected in the message.
  See: "Data" on page 616 and "Index" on page 617



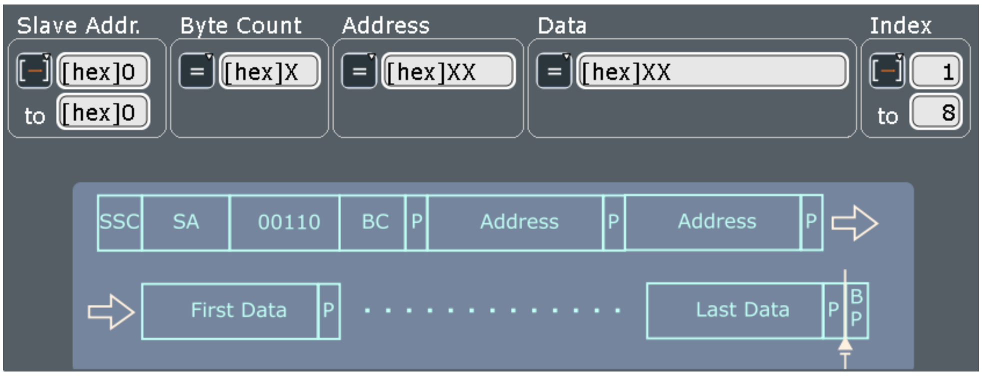
Extended Register Read ← Type
Triggers on "Extended Register Read" command sequences. This sequence sends the byte count of data frames in the command payload, followed by one address frame with the address of the first extended register, and reads back up to 16 data frames.

You can refine the trigger condition using the same settings as for the "Extended Register Write" command sequence, see "Extended Register Write" on page 612.



Extended Register Write Long ← Type
Triggers on "Extended Register Write" command sequences. This sequence sends the byte count of data frames in the command payload, followed by 2 address frames with the address of the first extended register, and up to 8 data frames.

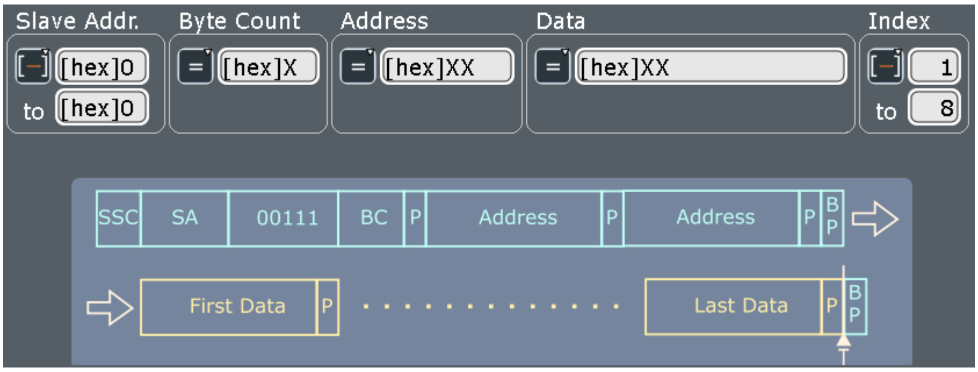
You can refine the trigger condition using the same settings as for the "Extended Register Write" command sequence, see "Extended Register Write" on page 612.



Extended Register Read Long ← Type

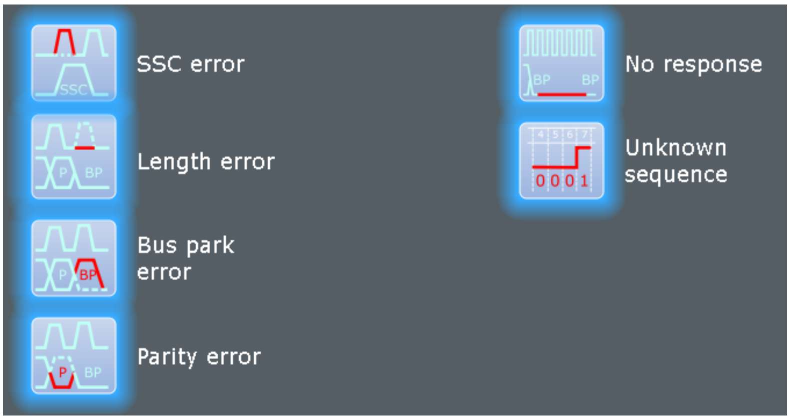
Triggers on "Extended Register Write" command sequences. This sequence sends the byte count of data frames in the command payload, followed by 2 address frames with the address of the first extended register, and reads back up to 8 data frames.

You can refine the trigger condition using the same settings as for the "Extended Register Write" command sequence, see "Extended Register Write" on page 612.



Error conditions ← Type

Triggers if at least one of the selected errors occurs in a frame. The instrument triggers on the first detected error.



"SSC error" Triggers when no valid SSC sequence has been found after the idle time. The instrument triggers at the invalid sequence.

"Length error" Triggers on an incorrect length of the command sequence - when additional or missing bits are detected and the sequence of bits is not as expected.

"Bus park error" Triggers on an incorrect bus park cycle - when the instrument expects a low bit in bus park but detects high bit.

"Parity error" Triggers on incorrect parity bits.

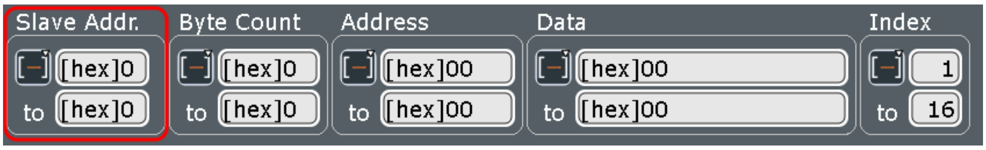
"No response" Triggers on any No Response Frame. All 9 bits of a No Response Frame, including the parity bit, are zero.

"Unknown sequence" Triggers when the instrument cannot detect any supported command sequence.

Remote command:
`TRIGger<m>:RFFE:ERRor:SSC` on page 1490
`TRIGger<m>:RFFE:ERRor:LENGth` on page 1489
`TRIGger<m>:RFFE:ERRor:BP` on page 1489
`TRIGger<m>:RFFE:ERRor:PARity` on page 1490
`TRIGger<m>:RFFE:ERRor:NOResponse` on page 1489
`TRIGger<m>:RFFE:ERRor:USEQuence` on page 1490

Slave Addr.

Defines the address of the slave. The slave address setup consists of the condition and one or two address patterns.



"Condition" Sets the operator to trigger on a specific address pattern ("Equal" or "Not equal") or an address range.

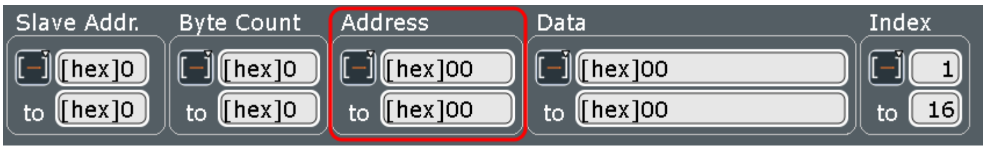
"Slave Address (Min)" Defines the slave address pattern for all operators that require one pattern.

"Slave Adress (Max)" Defines the second address pattern that is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:RFFE:SADD:CONDition` on page 1488
`TRIGger<m>:RFFE:SADD:MIN` on page 1488
`TRIGger<m>:RFFE:SADD:MAX` on page 1489

Address

Defines the register address. The register address setup consists of the condition and one or two address patterns.



"Condition" Sets the operator to trigger on a specific address pattern ("Equal" or "Not equal") or an address range.

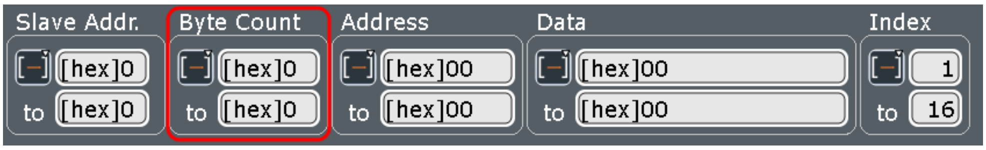
"Address (Min)" Defines the register address pattern for all operators that require one pattern.

"Adress (Max)" Defines the second address pattern that is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:RFFE:ADDRess:CONDition on page 1488
TRIGger<m>:RFFE:ADDRess:MIN on page 1488
TRIGger<m>:RFFE:ADDRess:MAX on page 1489

Byte count

Sets the number of data frames to be read or written in the command sequence. The setting is available for all "Extended Register" command sequences, which can transfer more than one data frame.



"Condition" Sets the operator to trigger on a specific byte count ("Equal" or "Not equal") or an byte count range.

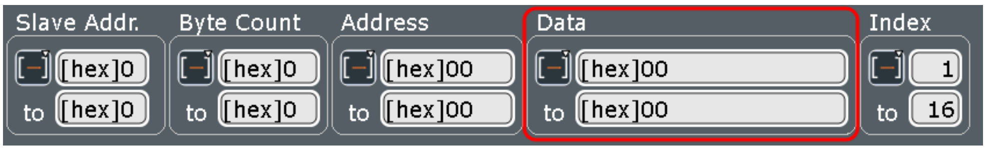
"Byte count (Min)" Defines the byte count for all operators that require one count setting.

"Byte count (Max)" Defines the second byte count value that is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:RFFE:BCOunt:CONDition on page 1488
TRIGger<m>:RFFE:BCOunt:MIN on page 1488
TRIGger<m>:RFFE:BCOunt:MAX on page 1489

Data

Defines the data trigger condition. The data setup consists of the condition and one or two data patterns.



To define on which data frames of the sequence you want to trigger, use the Index settings.

"Condition" Sets the operator to trigger on a specific data pattern ("Equal" or "Not equal") or an data range.

"Data (Min)" Defines the data pattern for all operators that require one pattern.

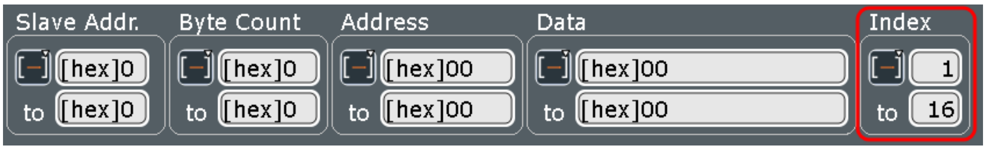
"Data (Max)" Defines the second data pattern that is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:RFFE:DATA:DCON on page 1488
TRIGger<m>:RFFE:DATA:DMIN on page 1488
TRIGger<m>:RFFE:DATA:DMAX on page 1489

Index

Defines which data frames are relevant for the trigger. The setting is available for all "Extended Register" command sequences, which can transfer more than one data frame.

The index allows you to check for a certain bit pattern at a certain position in the byte sequence. Furthermore, you can trigger on the occurrence of a certain bit pattern within a data range.



To trigger on any data byte that fulfills the data pattern settings, set the index to XX.

"Condition"	Sets the operator to trigger on a specific data frame ("Equal") or an data frame range.
"Data (Min)"	Defines the frame index of the data pattern for all operators that require one index.
"Data (Max)"	Defines the frame index of the last data pattern that is required to specify a range with condition "In range". The instrument adjusts this value, if you enter a data pattern that is longer than the index range.

Remote command:
TRIGger<m>:RFFE:DATA:ICONdition on page 1488
TRIGger<m>:RFFE:DATA:IMIN on page 1488
TRIGger<m>:RFFE:DATA:IMAX on page 1489

12.9.3.2 Triggering on RFFE Signals

Prerequisites: An RFFE bus is configured, see Chapter 12.9.2, "RFFE Configuration", on page 606, and "Decode" is enabled.

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Tap "Serial bus" and select the serial bus that is set to RFFE, e.g.:

   The "Protocol" selection is then automatically set to "RFFE".
5. Select the "Trigger type".

6. To refine the trigger settings, configure additional settings, which are available for many trigger types.
   For details, see Chapter 12.9.3.1, "RFFE Trigger Settings", on page 609.

12.9.4 RFFE Label List

Label lists are protocol-specific. A label list file for RFFE contains slave addresses and/or register addresses and their symbolic names:

- "SA": slave address (SID in the labal list file)
- Address: register address.
- "Symbolic label": symbolic name as combination of the slave name (SID text) and the address name (Address text), specifying the device function

Example: RFFE label list file

```
# Labels for RFFE protocol
#   Column order: SID, SID text, Address, Address text
# ---------------------------------------------------------------------------
@PROTOCOL_NAME = rffe
0x01,LM8335
0x01,LM8335,0x00,CMTL_REG
0x01,LM8335,0x01,GPO_PULL_DIR
0x01,LM8335,0x02,GPO_PULL_ENABLE
0x01,LM8335,0x03,GPO_OUT_HIGH_CFG
0x01,LM8335,0x04,GPO_OUT_MASK
0x01,LM8335,0x05,GPO_OUT_DATA
0x01,LM8335,0x1C,PM_TRIG
0x01,LM8335,0x1D,PROD_ID
0x01,LM8335,0x1E,MAN_ID
0x01,LM8335,0x1F,USID_REG
0x05,LM3279
0x05,LM3279,0x00,VSET_CTRL
0x05,LM3279,0x01,STATE_CTRL
0x05,LM3279,0x02,GPO_CTRL
0x05,LM3279,0x1C,PM_TRIG
0x05,LM3279,0x1D,PROD_ID
0x05,LM3279,0x1E,MAN_ID
0x05,LM3279,0x1F,USID_REG
0x0A,Test
```

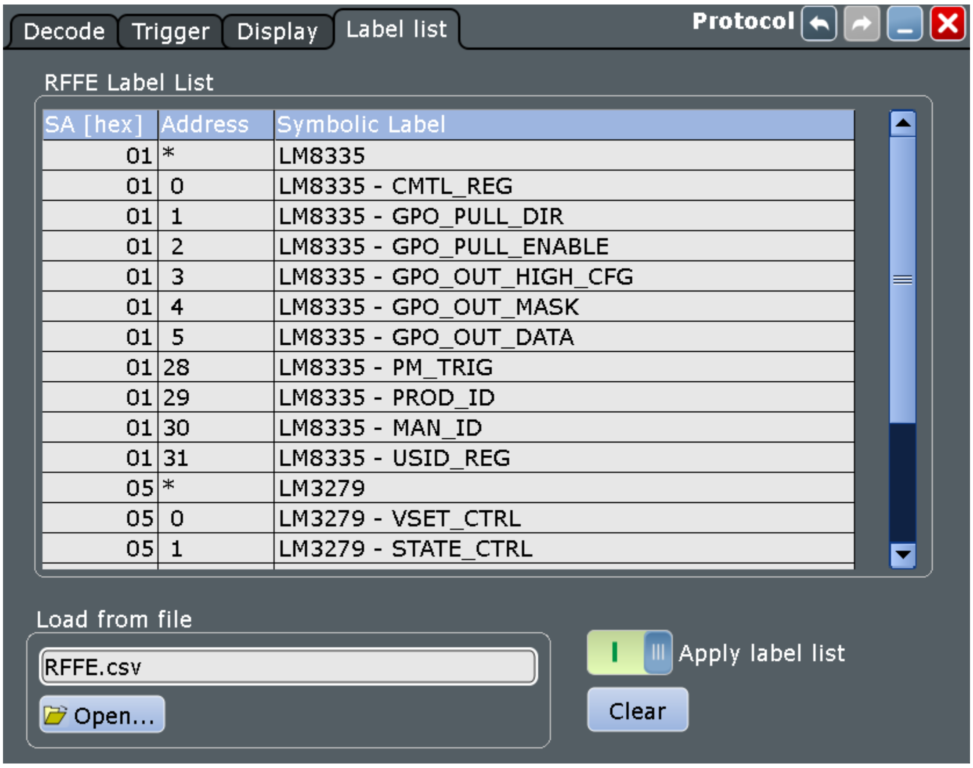


Figure 12-49: RFFE label list in R&S RTP

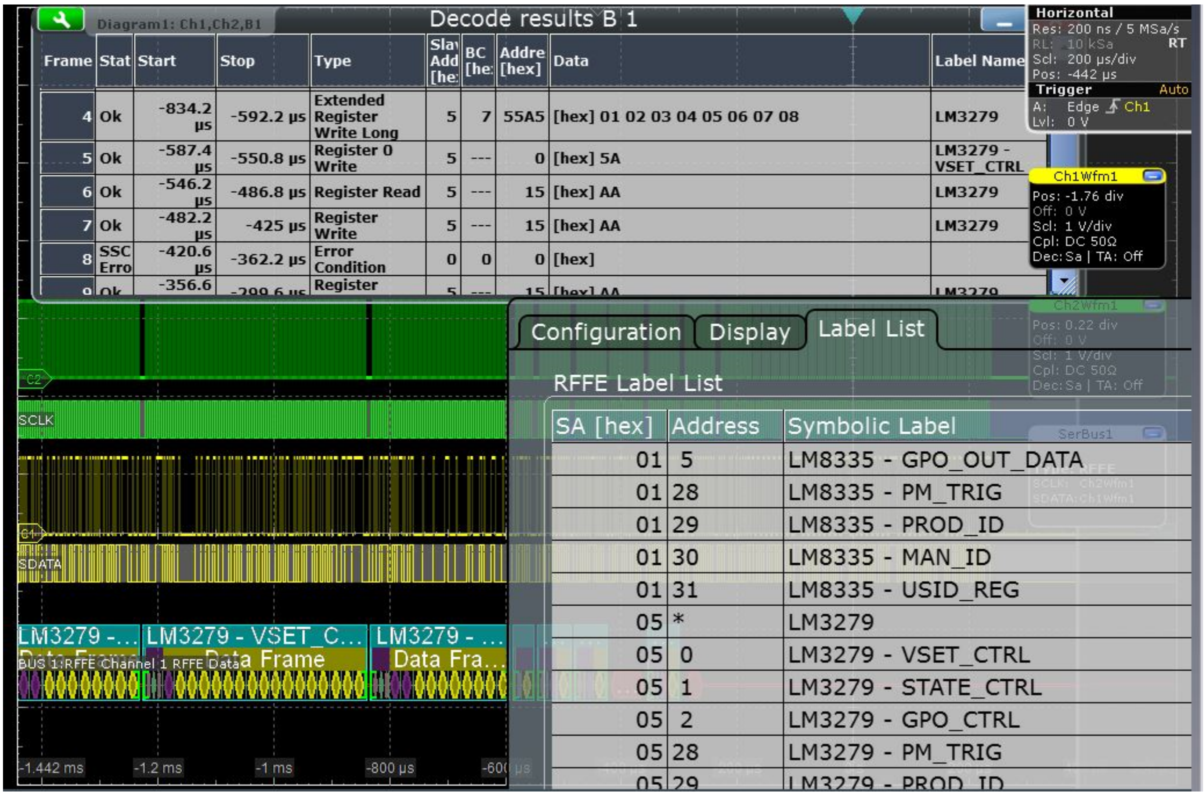


Figure 12-50: Decoded RFFE signal with applied label list and results table

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 467.

Remote command:

- `BUS<m>:RFFE:SEQuence<n>:SYMBol?` on page 1494

12.9.5 RFFE Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

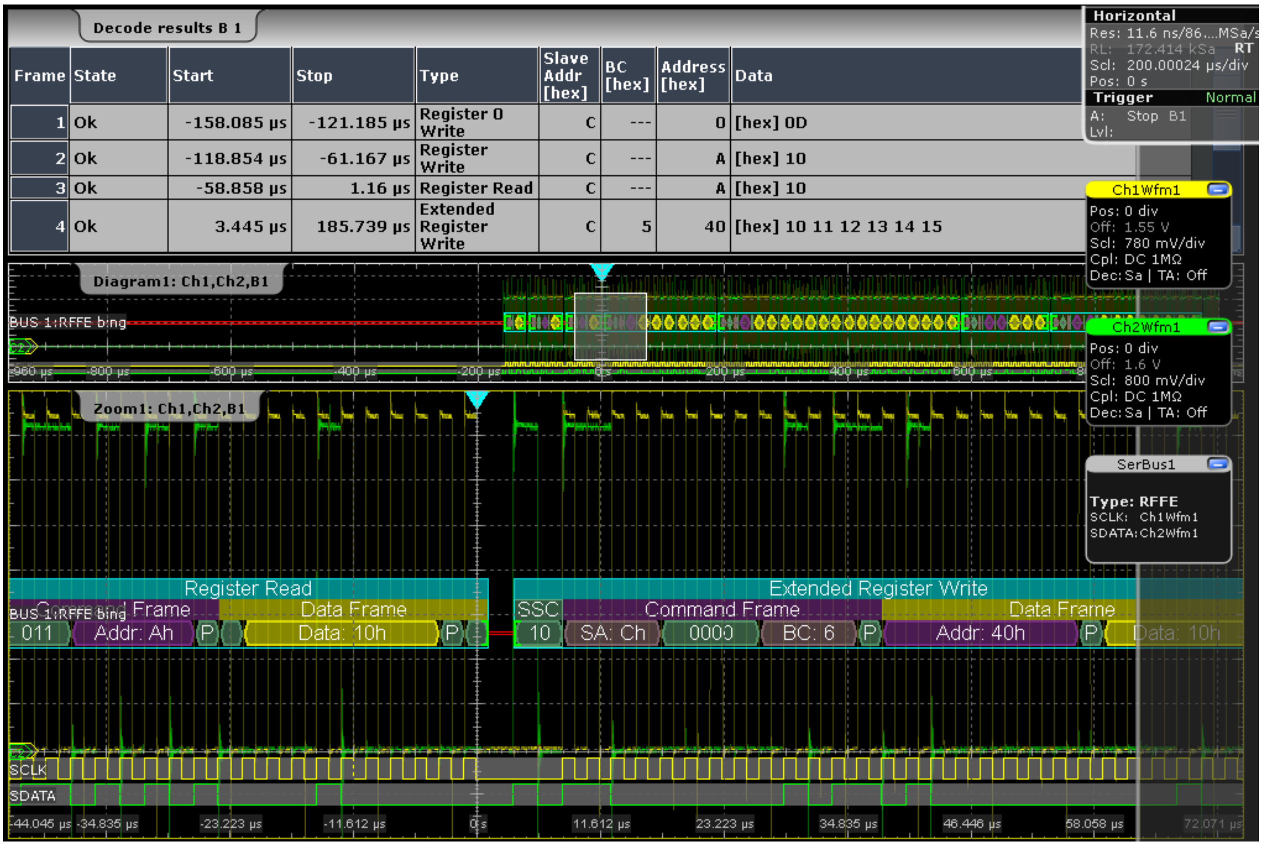


Figure 12-51: Decoded RFFE signal and results table. The signal is triggered on sequence stop. A part of the decoded data is shown in a zoom diagram.

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Table 12-10: Content of the "Decode results" table

Column	Description
State	Overall state of the frame. "Insuffcient waveform length" indicates that the frame is not completely contained in the acquisition. Change the horizontal scale, or move the reference point to the left to get a longer acquisition.
Start	Time of command sequence start (SSC)
Stop	Time of command sequence end
Type	Type of the command sequence
Slave address	Address of the slave (hex value)
BC	Byte count (decimal value)
Address	Register address (hex value)
Data	Values of the data bytes. The data format is selected below the table.
Label name	Symbolic name of the address if a label list is applied.

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:

- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.10.3, "Decode Results", on page 1490.

12.9.6 Search on Decoded RFFE Data

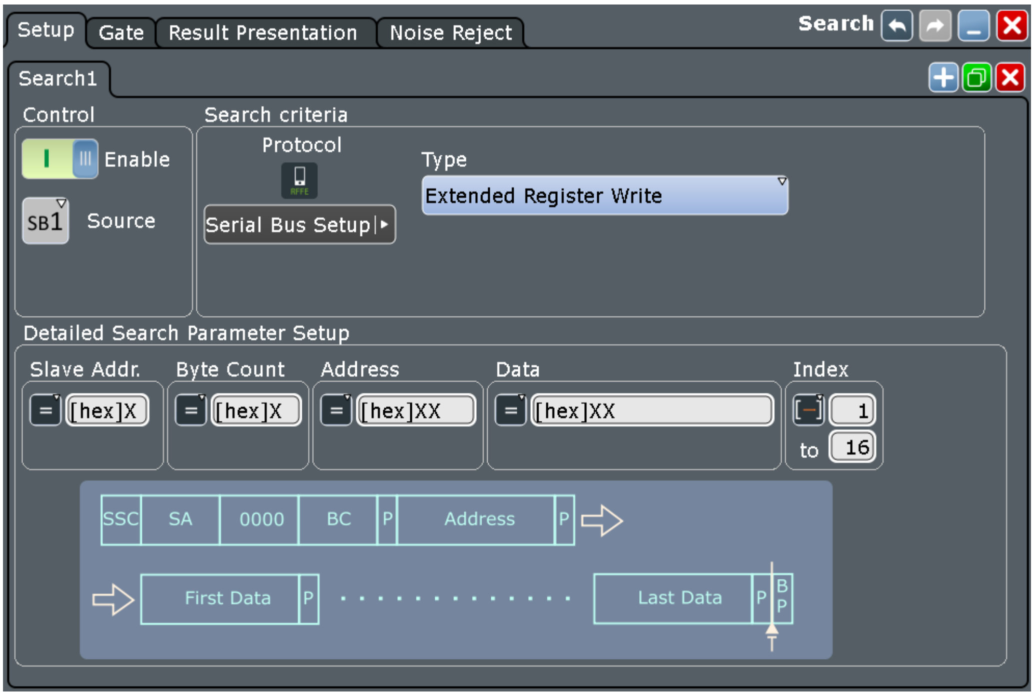
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 396.

12.9.6.1 RFFE Search Setup

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for RFFE



Type

The search criterion is defined by "Type". All trigger types are also available for search.

Additional search parameters are provided under "Detailed Search Parameter Setup".

For details, see also "Type" on page 610.

"Sequence Start"

Searches for SSC.
Additional search parameter: "Slave Addr." on page 625

"Sequence Stop"

Searches for bus park at the end of a command sequence.
Additional search parameter: "Slave Addr." on page 625

"Register 0 Write"

Searches for "Register 0 Write" command sequences. Additional search parameters:

- Slave address, see "Slave Addr." on page 625.
- Data pattern, see "Data" on page 626

"Register Write"

Searches for "Register Write" command sequences. Additional search parameters:

- Slave address, see "Slave Addr." on page 625
- Register address, see "Address" on page 625
- Data pattern, see "Data" on page 626

"Register Read"

Searches for "Register Read" command sequences.
This search uses the same additional parameters as the "Register Write" search.

"Extended Register Write"
Searches for "Extended Register Write" command sequences. Additional search parameters:
- Slave address, see "Slave Addr." on page 625
- Byte count, see "Byte count" on page 625
- Register address, see "Address" on page 625
- Data pattern, see "Data" on page 626 and "Index" on page 626

"Extended Register Read"
Searches for "Extended Register Read" command sequences.
This search uses the same additional parameters as the "Extended Register Write" search.

"Extended Register Write Long"
Searches for "Extended Register Write Long" command sequences.
This search uses the same additional parameters as the "Extended Register Write" search.

"Extended Register Read Long"
Searches for "Extended Register Read Long" command sequences.
This search uses the same additional parameters as the "Extended Register Write" search.

"Master Read"
Searches for "Master Read" command sequences. Additional search parameters:
- Address of the non-BOM master, see "Slave Addr." on page 625.
- Register address, see "Address" on page 625.
- Data patterns that is returned by the non-BOM master, see "Data" on page 626.

"Master Write"
Searches for "Master Write" command sequences. Additional search parameters:
- Address of the non-BOM master, see "Slave Addr." on page 625
- Register address, see "Address" on page 625
- Data pattern to be written into the non-BOM, see "Data" on page 626.

"Master Ownership Handover"
Searches for "Master Ownership Handover" command sequences.
Additional search parameters:
- Address of the BOM-to-be, see "Slave Addr." on page 625
- Data pattern of the confirmation sequence of the new BOM, see "Data" on page 626.

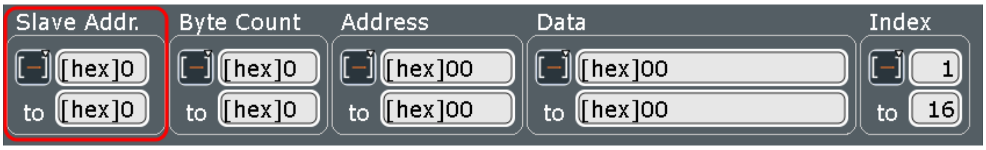
"Interrupt Summary and Notification"
Searches for interrupts. Additional search parameters:
- Slave address, see "Slave Addr." on page 625
- Byte count, see "Byte count" on page 625
- Data of the interrupt identification sequence, see

"Error Condition"
Searches for the selected errors, see "Error conditions" on page 626.

Remote command:
SEARch:TRIGger:RFFE:TYPE on page 1496

Slave Addr.
Searches for a slave address or a slave address range.

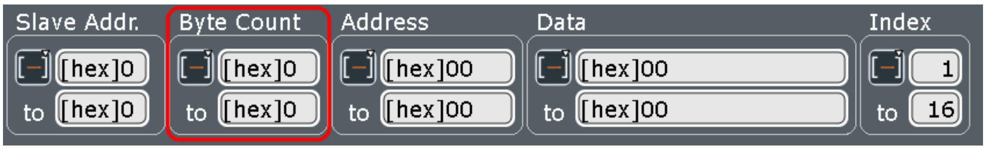
In command sequences transferred between masters, this is the non-BOM address.



The slave address settings are the same as in the RFFE trigger setup, see "Slave Addr." on page 615.

Remote command:
SEARch:TRIGger:RFFE:SADD:CONDition on page 1498
SEARch:TRIGger:RFFE:SADD:MIN on page 1499
SEARch:TRIGger:RFFE:SADD:MAX on page 1499

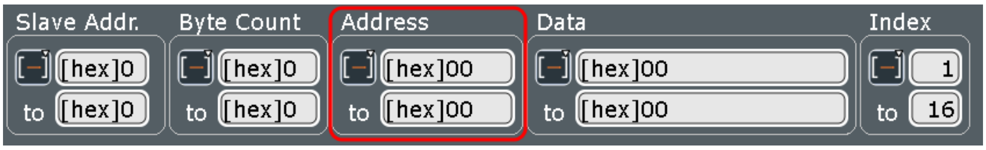
Byte count
Searches for a byte count or a byte count range.



The byte count settings are the same as in the RFFE trigger setup, see "Byte count" on page 616

Remote command:
SEARch:TRIGger:RFFE:BCOunt:CONDition on page 1498
SEARch:TRIGger:RFFE:BCOunt:MIN on page 1499
SEARch:TRIGger:RFFE:BCOunt:MAX on page 1499

Address
Searches for a register address or an address range.

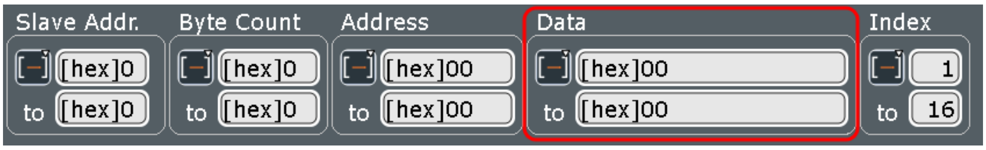


The register address settings are the same as in the RFFE trigger setup, see "Address" on page 615.

Remote command:
SEARch:TRIGger:RFFE:ADDRess:CONDition on page 1498
SEARch:TRIGger:RFFE:ADDRess:MIN on page 1499
SEARch:TRIGger:RFFE:ADDRess:MAX on page 1499

Data

Searches for a data pattern or an data word range. The setting is available for all "Extended Register" command sequences, which can transfer more than one data frame.

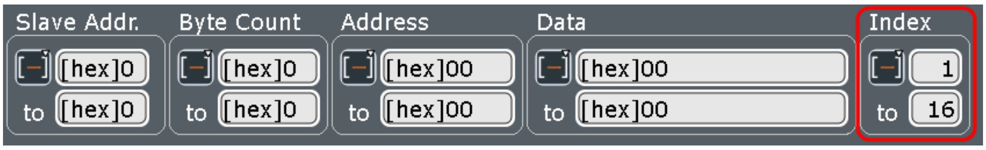


The data settings are the same as in the RFFE trigger setup, see "Data" on page 616.

Remote command:
`SEARch:TRIGger:RFFE:DATA:DCON` on page 1498
`SEARch:TRIGger:RFFE:DATA:DMIN` on page 1499
`SEARch:TRIGger:RFFE:DATA:DMAX` on page 1500

Index

Defines which data frames are relevant for the search. The setting is available for all "Extended Register" command sequences, which can transfer more than one data frame. To search for any data byte that fulfills the data pattern settings, set the index to XX.



Remote command:
`SEARch:TRIGger:RFFE:DATA:ICONdition` on page 1499
`SEARch:TRIGger:RFFE:DATA:IMIN` on page 1499
`SEARch:TRIGger:RFFE:DATA:IMAX` on page 1500

Data

Defines the pattern of the interrupt identification sequence, which consists of interrupt slots 15 to 0. The setting is only available for "Interrupt Summary and Notification" command sequence.

Remote command:
`SEARch:TRIGger:RFFE:INTerrupt` on page 1500

Error conditions

Unlike trigger, search for timing conditions (idle time) is not available.

Remote command:
SEARch:TRIGger:RFFE:ERRor:BP on page 1500
SEARch:TRIGger:RFFE:ERRor:LENGth on page 1500
SEARch:TRIGger:RFFE:ERRor:NOResponse on page 1501
SEARch:TRIGger:RFFE:ERRor:PARity on page 1501
SEARch:TRIGger:RFFE:ERRor:SSC on page 1501
SEARch:TRIGger:RFFE:ERRor:USEQuence on page 1501

12.9.6.2 RFFE Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

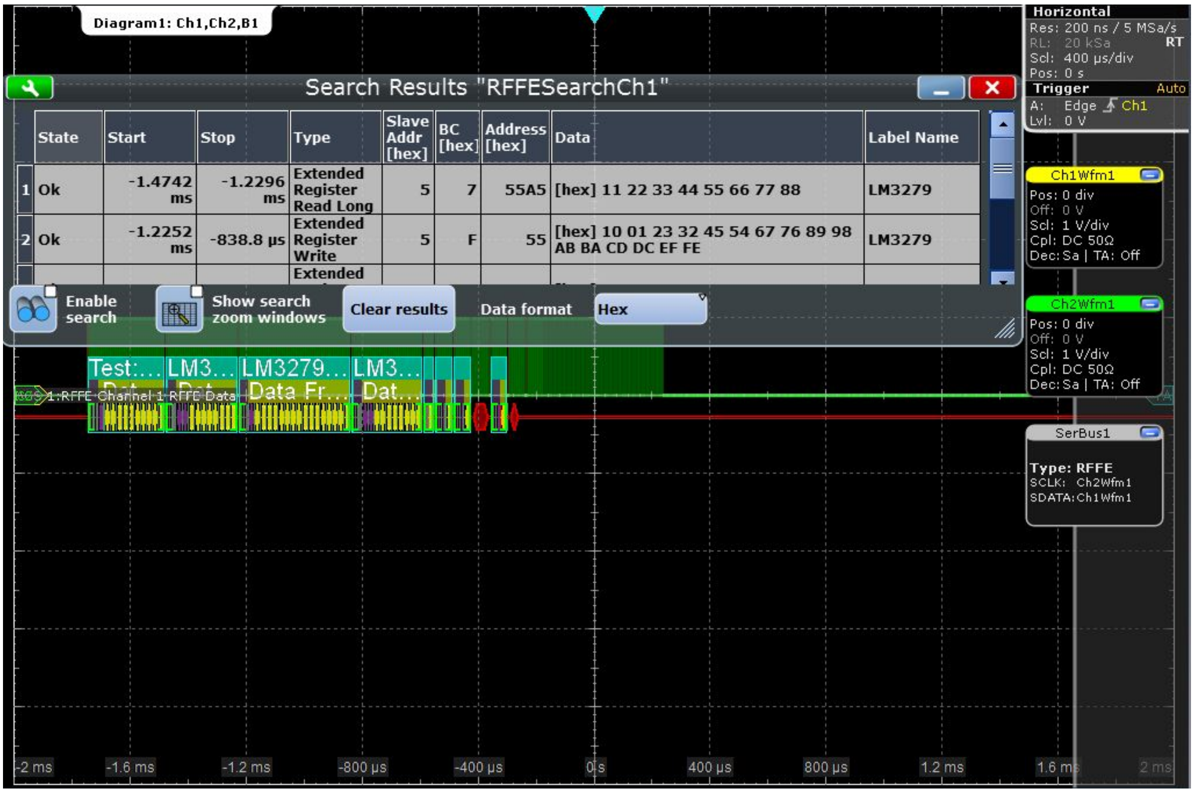


Figure 12-52: Results of a search for sequence start. All command sequences of the acquisition are found.

Remote commands:

- SEARch:RESult:RFFE:FCOunt? on page 1502
- SEARch:RESult:RFFE:SEQuence<m>:TYPE? on page 1502
- SEARch:RESult:RFFE:SEQuence<m>:STATe? on page 1503
- SEARch:RESult:RFFE:SEQuence<m>:STARt? on page 1503
- SEARch:RESult:RFFE:SEQuence<m>:STOP? on page 1504
- SEARch:RESult:RFFE:SEQuence<m>:SADD? on page 1503
- SEARch:RESult:RFFE:SEQuence<m>:ADDRess? on page 1504
- SEARch:RESult:RFFE:SEQuence<m>:BCOunt? on page 1504
- SEARch:RESult:RFFE:SEQuence<m>:DATA? on page 1505
- SEARch:RESult:RFFE:SEQuence<m>:SYMBol? on page 1505
- SEARch:RESult:RFFE:SEQuence<m>:BYTE<n>:STATe? on page 1505
- SEARch:RESult:RFFE:SEQuence<m>:BYTE<n>:VALue? on page 1505

12.9.6.3 Searching RFFE Data

Prerequisites: An RFFE bus is configured, see Chapter 12.9.2, "RFFE Configuration", on page 606, and "Decode" is enabled.

1. Press the [Search] key on the front panel.

2. Tap the "Source" button and select the serial bus that is set to RFFE.
   "Protocol" shows the RFFE icon.
3. Tap "Type" and select the search type.
   All trigger types are also available for search.
4. To refine the search settings, configure additional settings, which are available for many search types.
   For details, see Chapter 12.9.6.1, "RFFE Search Setup", on page 622.
5. Under "Control", "Enable" the search.
   The "Search Results" box opens.
6. Close the "Search" dialog box.
7. Press [Run Stop] to start acquisition.
8. Stop acquisition, or tap "Show search zoom window".
   Now you can navigate the search results and analyze the signal.

12.10 D-PHY (Option R&S RTP-K42)

The D-PHY is a specification developed by the Mobile Industry Processor Interface (MIPI) alliance as a standard for the communication of high-speed components, like cameras and displays, within mobile devices.

12.10.1 D-PHY Basic

A D-PHY interface consists of one clock lane and up to four data lanes. The D-PHY data lanes have two operational modes:

- A high speed mode (HS): differential signal with a data rate of 80 Mbps to 1.5GHz.This mode is used for the transmission of large volumes of information.
- A low power mode (LP): single-ended signal with a data rate < 10 Mbps. This mode is used for conserving power .

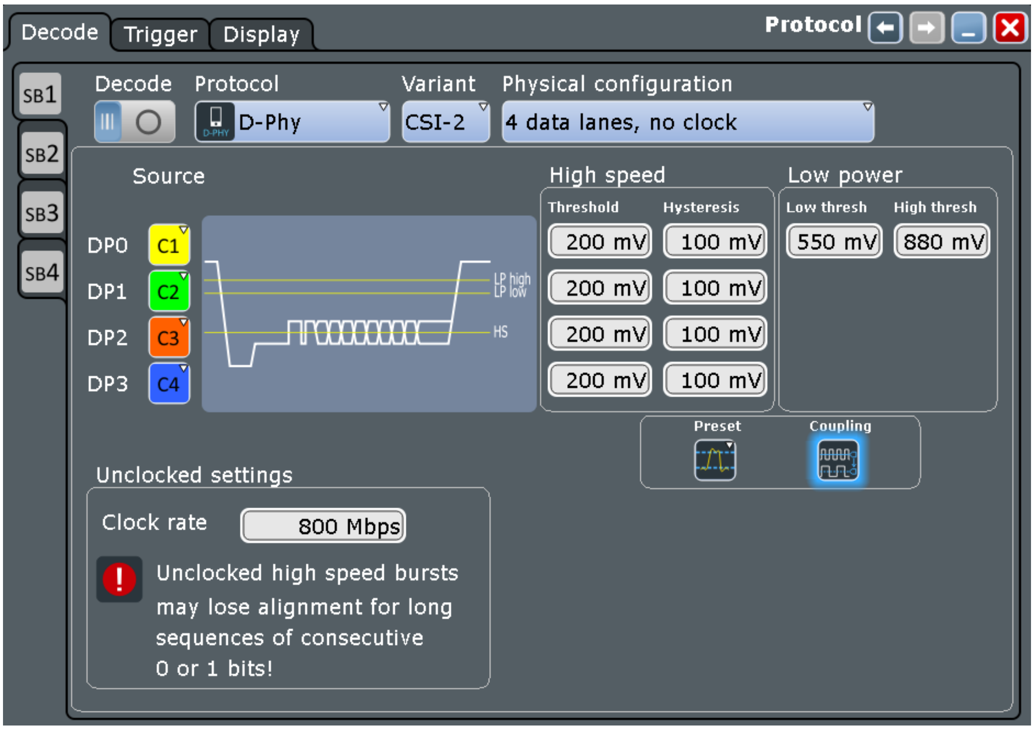
D-PHY provides a framework for other protocols such as the Display Serial Interface (DSI) and Camera Serial Interface (CSI-2).

12.10.2 D-PHY Configuration

12.10.2.1 D-PHY Configuration Settings

Access: [Protocol] > "Decode" tab > "Protocol = D-PHY"

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Variant

Selects the protocol running on the interface. You can select between the Display Serial Interface (DSI) and Camera Serial Interface (CSI-2).

Remote command:

`BUS<m>:DPHY:VARiant` on page 1508

Physical configuration

Selects the number of data lanes and if the clock lane and low power are available.

Remote command:

`BUS<m>:DPHY:CONFig` on page 1507

Source Connection

Defines the source and the type of probe used for the respective lane.

Permitted source selections are none, the analog, mathematical, and reference channels.

CP ← Source Connection
Sets the source of the clock lane.

Remote command:
`BUS<m>:DPHY:CP:SOURce` on page 1507

DP0/DN0 ← Source Connection
Selects the source of the low-power data lanes.

The "DP0" lane has to be present all the time, hence "Source DP0">"None" is not allowed.

Remote command:
`BUS<m>:DPHY:DPZero:SOURce` on page 1509
`BUS<m>:DPHY:DNZero:SOURce` on page 1510

DP1/DP2/DP3 ← Source Connection
Selects the source of the high-speed data lanes.

Remote command:
`BUS<m>:DPHY:DPONe:SOURce` on page 1510
`BUS<m>:DPHY:DPTWo:SOURce` on page 1510
`BUS<m>:DPHY:DPTHree:SOURce` on page 1510

Probe ← Source Connection
Selects the type of probe used for the respective lane. The D-PHY low-power mode uses a single-ended signal, while the high-speed mode signaling is differential.

Remote command:
`BUS<m>:DPHY:CP:PROBe` on page 1507
`BUS<m>:DPHY:DNZero:PROBe` on page 1510
`BUS<m>:DPHY:DPZero:PROBe` on page 1510
`BUS<m>:DPHY:DPONe:PROBe` on page 1510
`BUS<m>:DPHY:DPTWo:PROBe` on page 1510
`BUS<m>:DPHY:DPTHree:PROBe` on page 1510

Data Rate
Sets a data rate.

Remote command:
`BUS<m>:DPHY:DRATe` on page 1507
`BUS<m>:DPHY:DSPData` on page 1508

HS Threshold
Sets the threshold value for the digitization of high-speed data line.

Remote command:
`BUS<m>:DPHY:DPZero:HSPeed:THReshold` on page 1511
`BUS<m>:DPHY:DPONe:HSPeed:THReshold` on page 1511
`BUS<m>:DPHY:DPTWo:HSPeed:THReshold` on page 1511
`BUS<m>:DPHY:DPTHree:HSPeed:THReshold` on page 1511

Hysteresis
Sets a value for the hysteresis of the respective lane.

Remote command:
`BUS<m>:DPHY:CP:HSPeed:HYSTeresis` on page 1510
`BUS<m>:DPHY:DPZero:HSPeed:HYSTeresis` on page 1510
`BUS<m>:DPHY:DPONe:HSPeed:HYSTeresis` on page 1510
`BUS<m>:DPHY:DPTWo:HSPeed:HYSTeresis` on page 1510
`BUS<m>:DPHY:DPTHree:HSPeed:HYSTeresis` on page 1510

Preset
Presets the threshold and hysteresis values of the high-speed data lanes. A preset sets the low-power threshold to 1.20V and high-speed threshold to 200 mV.

Remote command:
`BUS<m>:DPHY:THPReset` on page 1508

Coupling
Enables coupling, i.e. the same threshold and hysteresis value is used for all lanes.

Remote command:
`BUS<m>:DPHY:THCoupling` on page 1508

Low power thresholds
Sets the thresholds for the low-power mode.

DP0 High / DN0 High ← Low power thresholds
Sets the high-power threshold value for the respective lane.

Remote command:
`BUS<m>:DPHY:DNZero:LPOWer:THUPper` on page 1509
`BUS<m>:DPHY:DPZero:LPOWer:THUPper` on page 1509

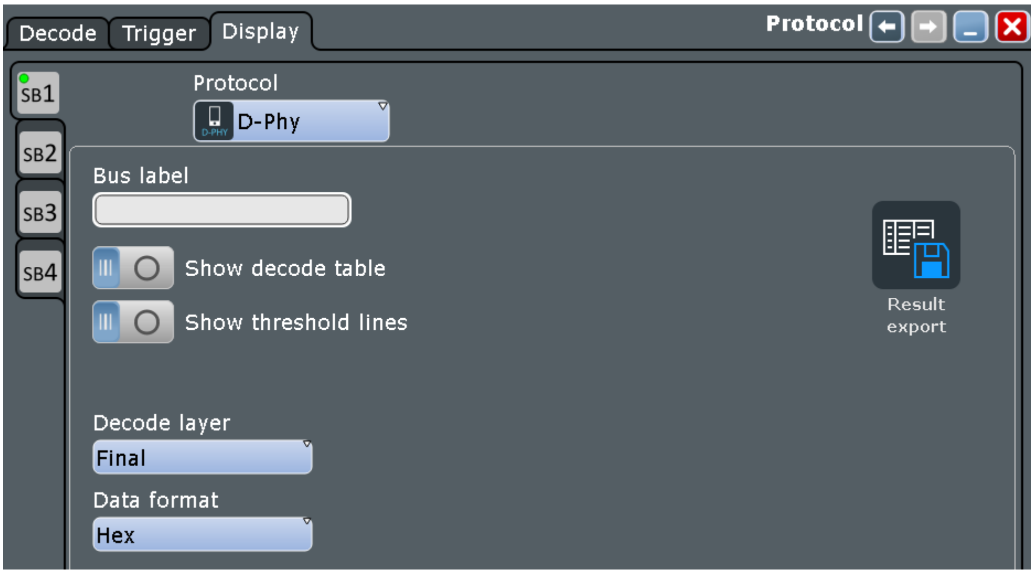
DP0 Low / DN0 Low ← Low power thresholds
Sets the low-power threshold value for the respective lane.

Remote command:
`BUS<m>:DPHY:DNZero:LPOWer:THLower` on page 1509
`BUS<m>:DPHY:DPZero:LPOWer:THLower` on page 1509

12.10.2.2 Display Settings

Access: [Protocol] > "Configuration" tab > "Protocol = D-PHY" > "Display" tab

To enhance the decode possibilities of the D-PHY protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 465.

Decode layer

Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"HS Edges" The high-speed edges of each lane, showing the transitions in high-speed mode.

"HS Binary" All high-speed bits of each lane, whether they are part of a burst or not.

"HS Burst Bits" The filtered high-speed bits of each lane , including only bits that are part of a burst.

"HS Burst Words" 8 bits per word in a high-speed burst of each lane.

"HS Merged Bytes" The words from the previous layer after they have been merged into one honeycomb.

"HS Merged Words" The bytes that are combined/split into words.

"LP Edges" The combined edge display of DP0 and DN0.

"LP States" The low-power states LP00, LP01, LP10, LP11 of DP0 and DN0.

12.10.2.3 Configuring the D-PHY Signals

For configuration, assign the lines to the input channels and define the logical thresholds and the hysteresis.

1. Press the [Protocol] key on the front panel.

2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Decode" tab.
4. Tap the "Protocol" button and select the protocol: "D-PHY".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "Variant" button, and select the protocol.
7. Enter the number of "Data Lanes".
8. Select the source and type of "Probe", for each lane.
9. Enter the "HS threshold" and the "Hysteresis" for each data lane.
10. Enter the low-power thresholds.
11. Enable "Decode", if available.

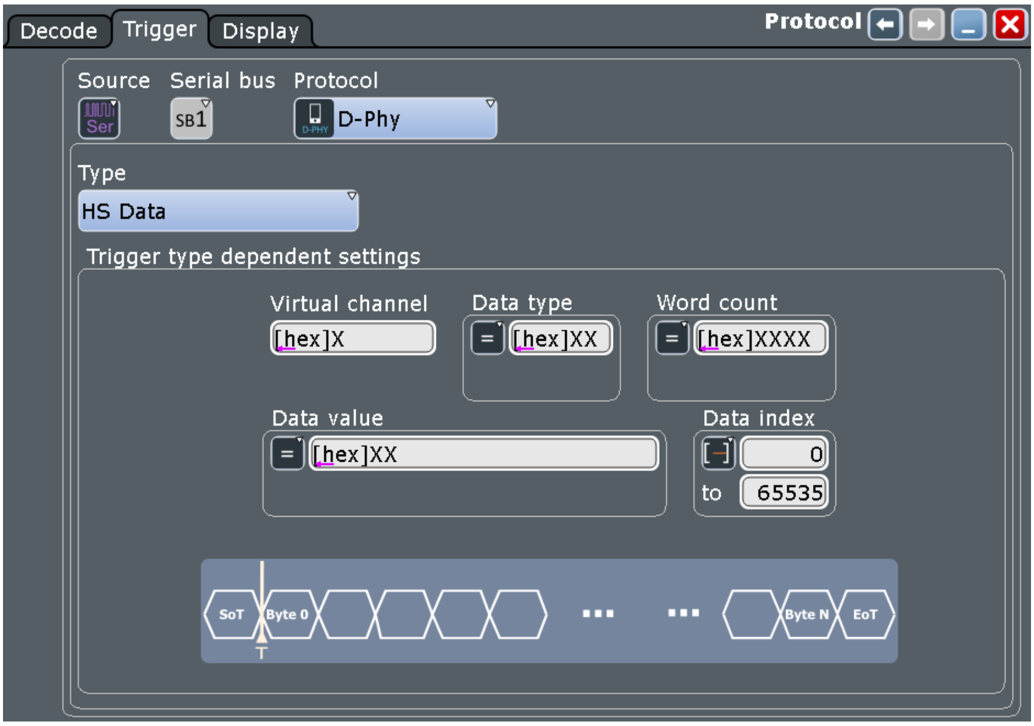
12.10.3 D-PHY Trigger

12.10.3.1 D-PHY Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = DPHY"

In this section, all trigger settings are described. Their availability on the instrument depends on the selected USB protocol type and trigger type. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to data sheet.



Make sure that:

- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Serial bus

Selects the serial bus to be triggered on. Make sure to select the correct bus before you enter the settings.

To trigger on a serial bus, the signals sources must be channel signals. If the data or clock source is a math or reference waveform, you cannot trigger on that bus.

Remote command:

TRIGger<m>:SOURce:SBSelect on page 1303

Protocol

Defines the protocol type of the selected serial bus.

Remote command:

BUS<m>:TYPE on page 1299

Type

Selects the trigger type for the D-PHY analysis.

Remote command:

TRIGger<m>:DPHY:TYPE on page 1512

HS Start of Packet ← **Type**

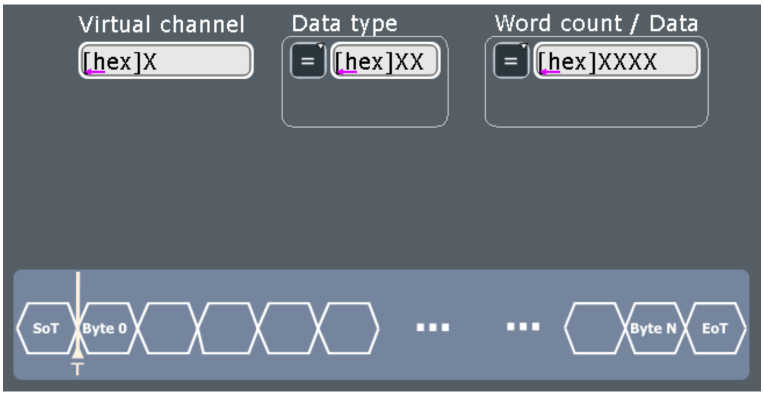
Sets the trigger to the transmission start of a high-speed packet.

HS End of Packet ← **Type**

Sets the trigger to the transmission end of a high-speed packet.

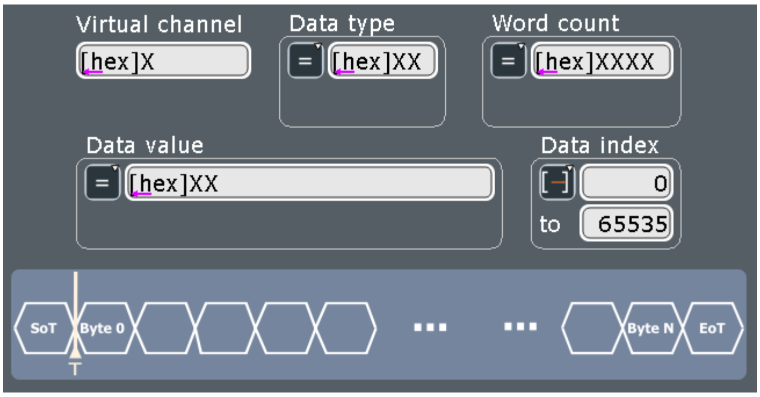
HS Packet Header ← **Type**

Sets the trigger to a packet header of a high-speed package. The header consists of a data identifier (containing the Virtual Channel and the Data Type) and a Word Count. You can specify the values each part of the packet header.



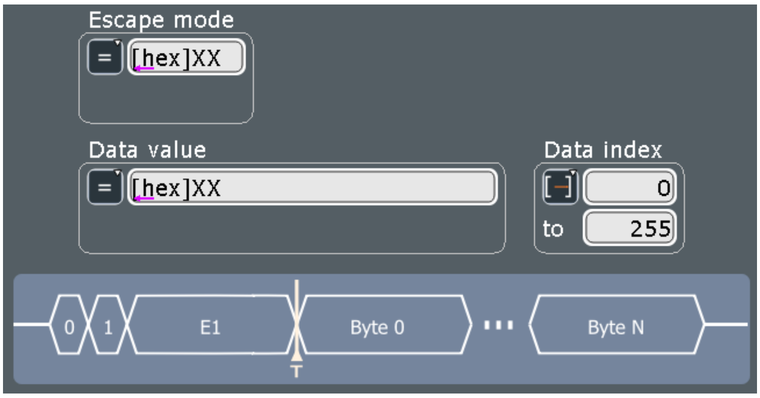
HS Data ← **Type**

Sets the trigger to a specified high-speed data.



LP Escape Mode ← **Type**

Sets the trigger to an escape mode event.



LP Lane Turnaround ← Type

Sets the trigger to a low-power turnaround, a reversion of the transmission direction.

LP HS Request ← Type

Sets the trigger to a high-speed request.

Virtual Channel

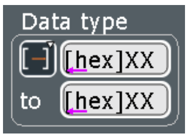
Triggers on a specific virtual channel, an independent data stream for up to four peripherals.

Remote command:

`TRIGger<m>:DPHY:HSVC` on page 1517

Data Type

Sets the specified data type to be triggered on. The data type setup consists of the condition and one or two data patterns.

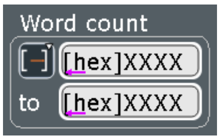


"Condition"	Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.
"Data Min/ Data"	Defines the bit pattern of the data pattern. In binary format, use the following characters: 1; 0; or X (do not care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.
"Data Max"	The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:DPHY:DTYPe:CONDition on page 1514
TRIGger<m>:DPHY:DTYPe:MAX on page 1514
TRIGger<m>:DPHY:DTYPe:MIN on page 1514

Word Count

Sets the specified specific word count to be triggered on. The word count setup consists of the condition and one or two data patterns.



"Condition" Defines the operator to set a specific word count ("Equal" or "Not equal") or a word count range.

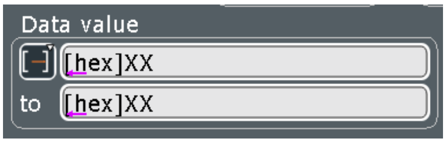
"Data Min/ Data" Defines the bit pattern of the word pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second word pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:DPHY:WCOunt:CONDition on page 1517
TRIGger<m>:DPHY:WCOunt:MAX on page 1517
TRIGger<m>:DPHY:WCOunt:MIN on page 1518

Data Value

Set the specified data value to be triggered on. The data value setup consists of the condition and one or two data value patterns.



"Condition" Defines the operator to set a specific data value ("Equal" or "Not equal") or a data value range.

"Data Min/ Data" Defines the bit pattern of the data value pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

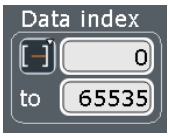
"Data Max" The second data value pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
For "Type">"HS Data":
TRIGger<m>:DPHY:DATA:CONDition on page 1512
TRIGger<m>:DPHY:DATA:MAX on page 1513
TRIGger<m>:DPHY:DATA:MIN on page 1513

For "Type">"LP Escape Mode":
TRIGger<m>:DPHY:ESDTa:CONDition on page 1515
TRIGger<m>:DPHY:ESDTa:MAX on page 1516
TRIGger<m>:DPHY:ESDTa:MIN on page 1516

Data Index

Data index sets the range within this series of the data value that is considered for the analysis. The data index setup consists of the condition and one or two data index values.



"Condition" Defines the operator to set a specific data ("Equal") or a data range.

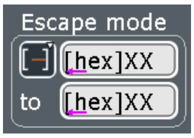
"Index Min/Index" Defines the minimum index.

"Index Max" The second index pattern is required to specify a range with conditions "In range".

Remote command:
For "Type">"HS Data":
TRIGger<m>:DPHY:DIDX:CONDition on page 1513
TRIGger<m>:DPHY:DIDX:MAX on page 1513
TRIGger<m>:DPHY:DIDX:MIN on page 1514
For "Type">"LP Escape Mode":
TRIGger<m>:DPHY:ESINdex:CONDition on page 1516
TRIGger<m>:DPHY:ESINdex:MAX on page 1517
TRIGger<m>:DPHY:ESINdex:MIN on page 1517

Escape mode

The escape mode setup consists of the condition and one or two data patterns.



"Condition" Defines the operator to set a specific word count ("Equal" or "Not equal") or a word count range.

"Data Min/Data" Defines the bit pattern of the data pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:DPHY:ESCMode:CONDition on page 1515
TRIGger<m>:DPHY:ESCMode:MAX on page 1515
TRIGger<m>:DPHY:ESCMode:MIN on page 1515

12.10.3.2 Triggering on D-PHY

Prerequisite: A bus is configured for the D-PHY signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Tap "Serial bus" and select the serial bus that is set to D-PHY, e.g.:

   The "Protocol" selection is then automatically set to "D-PHY".
5. Select the "Trigger Type" to be used for D-PHY protocol analysis.
6. To refine the trigger settings, configure additional settings, which are available for some trigger types.
   For details, see Chapter 12.10.3.1, "D-PHY Trigger Settings", on page 634.

12.10.4 D-PHY Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Example

The example in Decoded D-PHY short packet, single-ended probes shows a decoded short packet with a two lane measurement. Single-ended probes are used on the "CP" , "DP0", "DN0" and "DP1" lanes. You can see the low-power HS Request which is only possible when "DP0" and "DN0" are running with single ended probes.

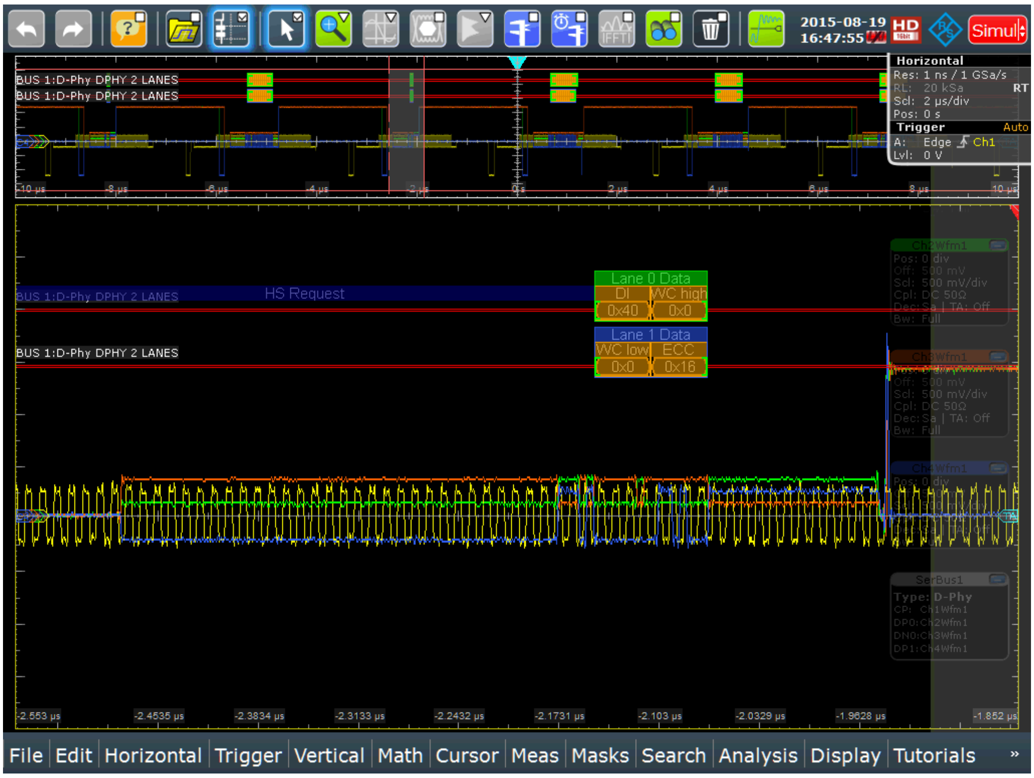


Figure 12-53: Decoded D-PHY short packet, single-ended probes

The example in Figure 12-54 shows a decoded D-PHY signal and the result tables. Differential probes are used for the four data lanes "DP0", "DP1", "DP2" and "DP3".

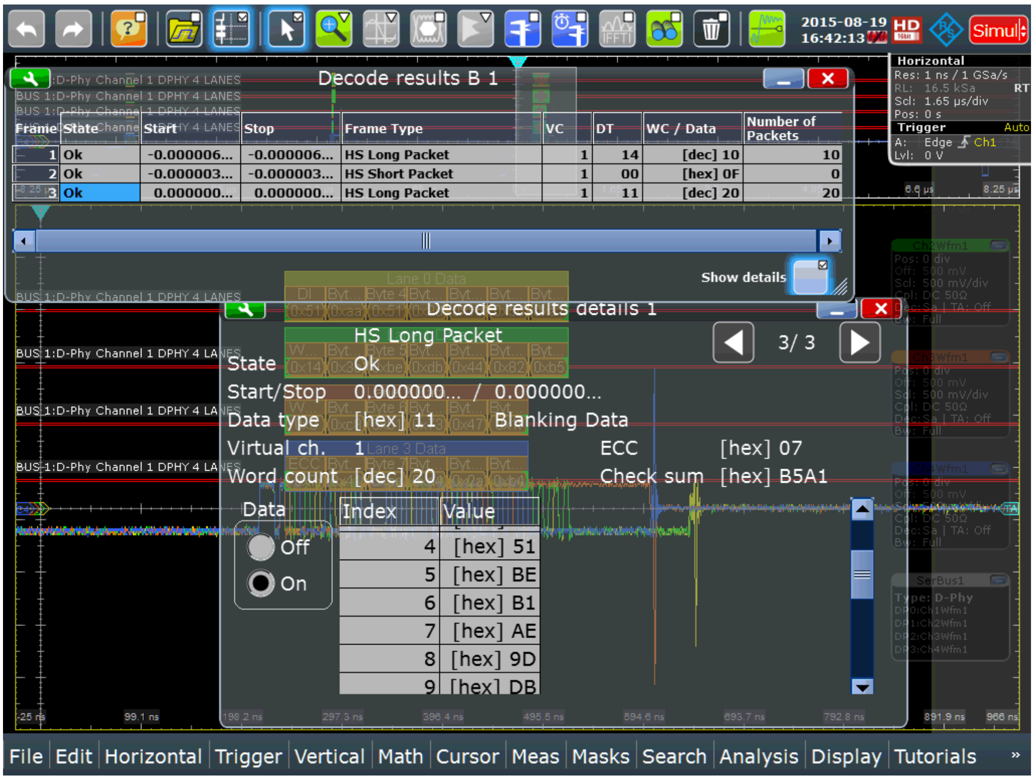


Figure 12-54: Decoded D-PHY signal with result tables, differential probes

Table 12-11: Content of the decode result table

Column	Description
State	Overall state of the frame
Start	Time of frame start in relation to the trigger point
Stop	Time of frame stop in relation to the trigger point
Frame Type	Frame type
VC	Number of virtual channels
DT	Data type
WC/ Data	Word count or data value
Number of Packets	Number of packets in the frame

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.

3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.11.3, "D-PHY Decode Results", on page 1518.

12.10.5 Search on Decoded D-PHY Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 396.

12.10.5.1 D-PHY Search Setup

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for D-PHY

Type
Searches for the selected D-PHY type.

Remote command:
`SEARch:TRIGger:DPHY:TYPE` on page 1524

HS Start of Packet ← Type
Searches for a transmission start of a high-speed packet.

HS End of Packet ← Type
Searches for a transmission end of a high-speed packet.

HS Packet Header ← Type
Searches for a packet header of a high-speed package. The header consists of a data identifier (containing the Virtual Channel and the Data Type) and a Word Count/ Data. You can specify the values each part of the packet header.

HS Data ← Type
Searches for a specified high-speed data.

LP Escape Mode ← Type
Searches for an escape mode event.

LP Lane Turnaround ← Type
Searches for a low-power turnaround, a reversion of the transmission direction.

LP HS Request ← Type
Searches for a high-speed request.

Virtual Channel
Searches for a specific virtual channel, an independent data stream for up to four peripherals.

Remote command:
`SEARch:TRIGger:DPHY:HSVC` on page 1531

Data Type
Searches for a specific data type. The data type setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific data type ("Equal" or "Not equal") or a data type range.

"Data Min/Data"
Defines the bit pattern of the data pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:DPHY:DTYPe:CONDition` on page 1527
`SEARch:TRIGger:DPHY:DTYPe:MAX` on page 1527
`SEARch:TRIGger:DPHY:DTYPe:MIN` on page 1527

Word Count/ Data
Searches for a specific word count /data. The word count setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific word count ("Equal" or "Not equal") or a word count range.

"Data Min/Data"
Defines the bit pattern of the word pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second word pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:DPHY:WCOunt:CONDition` on page 1531
`SEARch:TRIGger:DPHY:WCOunt:MAX` on page 1531
`SEARch:TRIGger:DPHY:WCOunt:MIN` on page 1532

Data Value

Searches for a specific data value. The data value setup consists of the condition and one or two data value patterns.

"Condition" Defines the operator to set a specific data value ("Equal" or "Not equal") or a data value range.

"Data Min/Data"
Defines the bit pattern of the data value pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second data value pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
For "Type">"HS Data":
`SEARch:TRIGger:DPHY:DATA:CONDition` on page 1525
`SEARch:TRIGger:DPHY:DATA:MAX` on page 1525
`SEARch:TRIGger:DPHY:DATA:MIN` on page 1525
For "Type">"LP Escape Mode":
`SEARch:TRIGger:DPHY:ESDTa:CONDition` on page 1529
`SEARch:TRIGger:DPHY:ESDTa:MAX` on page 1529
`SEARch:TRIGger:DPHY:ESDTa:MIN` on page 1529

Data Index

Data index sets the range within this series of the data value to be searched for. The data index setup consists of the condition and one or two data index values.

"Condition" Defines the operator to set a specific data ("Equal") or a data range.

"Index Min/Index"
Defines the minimum index.

"Index Max" The second index pattern is required to specify a range with conditions "In range".

Remote command:
For "Type">"HS Data":
`SEARch:TRIGger:DPHY:DIDX:CONDition` on page 1526
`SEARch:TRIGger:DPHY:DIDX:MAX` on page 1526
`SEARch:TRIGger:DPHY:DIDX:MIN` on page 1526
For "Type">"LP Escape Mode":
`SEARch:TRIGger:DPHY:ESINdex:CONDition` on page 1530
`SEARch:TRIGger:DPHY:ESINdex:MAX` on page 1530
`SEARch:TRIGger:DPHY:ESINdex:MIN` on page 1530

Escape mode

Searches for an escape mode event. The escape mode setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific word count ("Equal" or "Not equal") or a word count range.

"Data Min/Data"

Defines the bit pattern of the data pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:DPHY:ESCMode:CONDition` on page 1528
`SEARch:TRIGger:DPHY:ESCMode:MAX` on page 1528
`SEARch:TRIGger:DPHY:ESCMode:MIN` on page 1528

12.10.5.2 D-PHY Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

Remote commands:

- `SEARch:RESult:DPHY:FCOunt?` on page 1532
- `SEARch:RESult:DPHY:FRAMe<m>:CS?` on page 1532
- `SEARch:RESult:DPHY:FRAMe<m>:DATA?` on page 1533
- `SEARch:RESult:DPHY:FRAMe<m>:DTName?` on page 1533
- `SEARch:RESult:DPHY:FRAMe<m>:DTYPe?` on page 1533
- `SEARch:RESult:DPHY:FRAMe<m>:ECC?` on page 1534
- `SEARch:RESult:DPHY:FRAMe<m>:PACKet<n>:IDX?` on page 1534
- `SEARch:RESult:DPHY:FRAMe<m>:PACKet<n>:VALue?` on page 1534
- `SEARch:RESult:DPHY:FRAMe<m>:STARt?` on page 1535
- `SEARch:RESult:DPHY:FRAMe<m>:STATe?` on page 1535
- `SEARch:RESult:DPHY:FRAMe<m>:STOP?` on page 1535
- `SEARch:RESult:DPHY:FRAMe<m>:TYPE?` on page 1536
- `SEARch:RESult:DPHY:FRAMe<m>:VCHannel?` on page 1536

12.10.5.3 Searching D-PHY

Prerequisite: A serial bus is configured for the D-PHY signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press [Search] or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the ➕ icon to create one, as described in "To create a user-defined search" on page 411.
3. Tap "Source" and select the serial bus that is set to D-PHY (e.g. "SB1", unless already selected).
4. Specify search criteria according to Chapter 12.10.5.1, "D-PHY Search Setup", on page 643.
5. To acquire a waveform, press [Single].

   The R&S RTP performs a D-PHY decode according to the thresholds and protocol settings of the associated serial bus source.
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTP displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 417 and "Navigating search results" on page 398.

12.11 M-PHY and USB SSIC (Option R&S RTP-K44 and -K64)

The M-PHY® is a serial communication protocol. Its specifications were developed by the Mobile Industry Processor Interface (MIPI) alliance as standards for the communication of high-speed components, like smartphones and tablets, within mobile devices. For more details on the specifications, refer to http://mipi.org/specifications/physical-layer#M-PHY Specification.

This protocol is the foundation for several upper layer protocols, such as UniPro℠ (Unified Protocol), which manage complex data transfer functions. Each of these protocols is optimized for its particular purpose, such as data storage, data transfer, display, camera, memory sharing and radio interface.

When implemented together with the MIPI UniPro, defined as UniPort-M, they deliver high speed, low power, scalable and flexible data transport solutions.

The super speed inter-chip (SSIC) was developed by the USB standards committee based on USB3.1 G1 (SuperSpeed). It is developed to support the chip to chip communication of USB3 components. The lower communication layers are using M-PHY as the encoder platform and use a multilane distribution similar to UniPro. The higher communication layers (above 8b/10b) are almost identical to USB3.1 G1.

12.11.1 M-PHY Basic

This chapter provides an overview of the characteristics of the M-PHY and UniPro protocols.

12.11.1.1 Data Transfer

M-PHY words are always 10 bits long (both data and control words). For UniPro, they have variable lengths that depend on the frame type. For example, control words have 8 bits, data words have 16 bits and reserved words have 3 bits.

To achieve power efficiency and high-performance transmissions, multiple power-saving states and recovery times are utilized. Scalability and flexibility are achieved through the various transmission speed ranges and rates.

Different modes of operations:

- Disable mode: lowest power mode entered into once the power supply is turned on
- Hibernate (Hibern8): ultra low-power state, which can be used without configuration loss
- High-speed mode (HS): supports three gears with predefined data rates. This mode is used during high-speed transmission for transporting large volume of data. This mode utilizes the power-saving Stall state to reduce power consumption while offering a fast state transition in the range of nanoseconds
- Low-power mode (PWM): supports seven gears with predefined frequency ranges. This mode is used during low-speed transmission for power conservation. This mode utilizes the power-saving Sleep state with a state transition time typically in the range of microseconds

The R&S RTP supports all operating speed modes: high-speed and low-power mode. The gear settings of these modes are auto detected by the instrument.

12.11.1.2 Data Analysis

The M-PHY and UniPro decoding process involves several stages, similar to D-PHY.

The stages are as the following:

- Stage 1: involves two substages:
  - Stage 1a: converts the three stage cross points into bit and attempts a HS-Sync. This stage involves the Hibern8-Detection/Filter, NRZ Unclocked Decoder and Burst Detection.

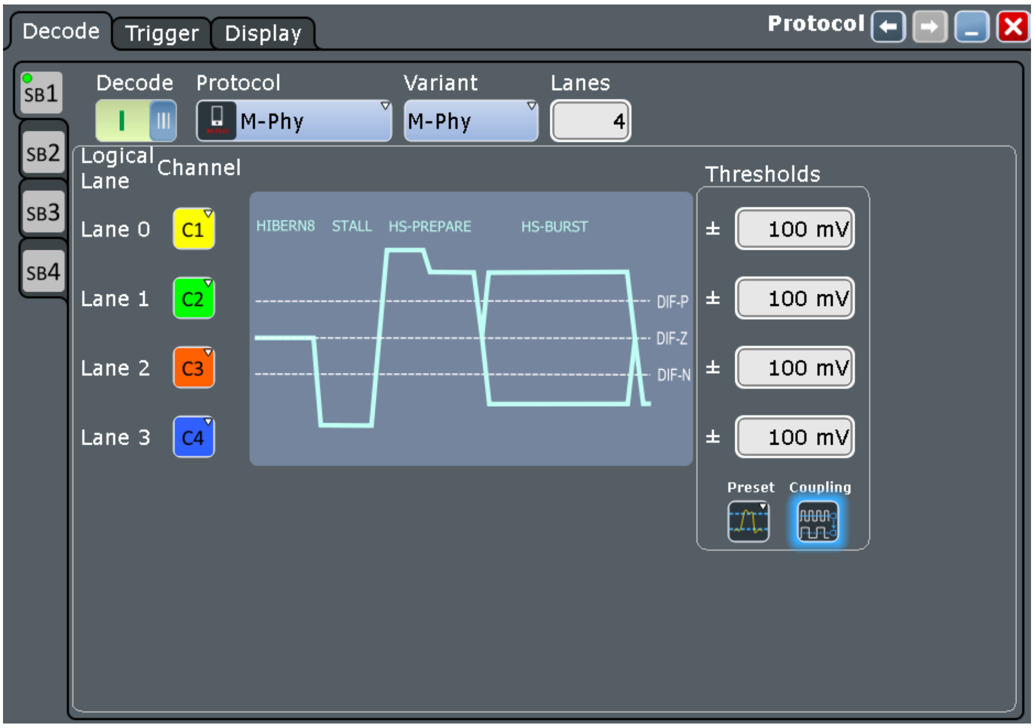
  – Stage 1b is only involved if Stage 1a burst detection fails, assuming using PWM. Input is from the bits from stage 1a. This stage involves the PWM Decoder, Line CFG Decoder and Burst Detection.
- Stage 2: performs the 8b/10b decoding of bits from stage 1 into Bytes and identifies the 8b/10b control words. This stage involves the 8b/10b Decoder and Shift-decoder to Bytes.
- Stage 3: starts decoding the Bytes from stage 2. This stage involves the Descrambler and 17-bit Shift Decoder.
- Stage 4: merges the data lanes and finalizes the decoding to the UniPro data frames. This stage involves the Lane Merger, PDU Sync Detector, Shift Decode and Dynamic Data unit Decoder.

12.11.2 M-PHY Configuration

12.11.2.1 M-PHY Configuration Settings

Access: [Protocol] > "Configuration" tab > "Protocol" = "M-Phy"

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Variant

Selects the protocol running on the interface. You can select between the M-PHY, Uni-Pro and SSIC.

Remote command:
`BUS<m>:MPHY:VARiant` on page 1537

Lanes

Sets the number of logical lanes that are mapped to the physical lines. You can select up to four lanes.

Remote command:
`BUS<m>:MPHY:DLANes` on page 1537

Lane 0 / Lane 1 / Lane 2 / Lane 3: Channel

Select the signal sources for the logical lanes.

Remote command:
`BUS<m>:MPHY:DZERo:SOURce` on page 1538
`BUS<m>:MPHY:DONE:SOURce` on page 1538
`BUS<m>:MPHY:DTWO:SOURce` on page 1538
`BUS<m>:MPHY:DTHRee:SOURce` on page 1538

Thresholds

Sets the threshold value to properly condition the signal for decode.

Remote command:
`BUS<m>:MPHY:DZERo:THReshold` on page 1538
`BUS<m>:MPHY:DONE:THReshold` on page 1538
`BUS<m>:MPHY:DTWO:THReshold` on page 1538
`BUS<m>:MPHY:DTHRee:THReshold` on page 1538

Preset

Selects the predefined value to preset the threshold value of the data lanes.

Remote command:
`BUS<m>:MPHY:THPReset` on page 1539

Coupling

Enables the same threshold value for all lanes.

Remote command:
`BUS<m>:MPHY:THCoupling` on page 1539

Scrambled Mode

Selects, if the SSIC data is scrambled or descrambled. Set this parameter according to your signal parameters, to ensure a proper decoding.

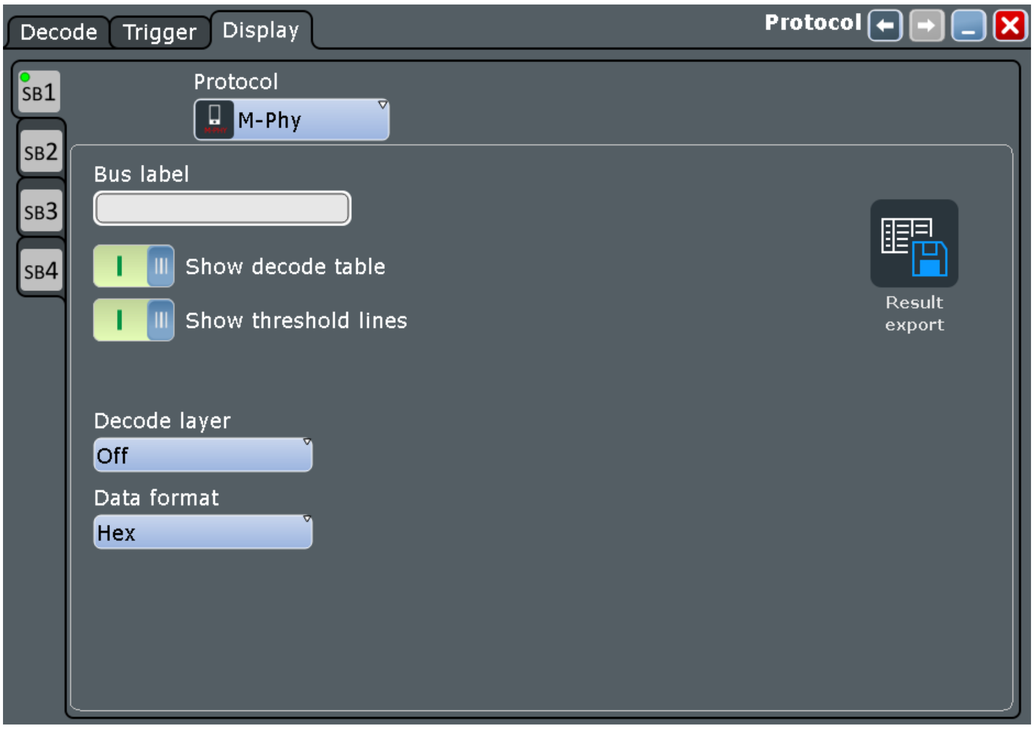
The setting is available in SSIC option R&S RTP-K64.

Remote command:
`BUS<m>:MPHY:SCRMode` on page 1539

12.11.2.2 Display Settings

Access: [Protocol] > "Configuration" tab > "Protocol = M-Phy" > "Display" tab

To enhance the decode possibilities of the M-PHY or UniPro protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 465.

Decode layer

Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final" Final decoded frames of each lane.

"Edges" All edges of each lane in stage 1 decoding.

"Bits" All bits of each lane in stage 1 decoding.

"8b/10b Symbols"
8b/10b symbols in stage 2 decoding.

"LCC bits" LCC bits in stage 3 decoding.

"UniPro filter/descrambler"
UniPro filter/descrambler in stage 3 decoding.

"UniPro lane merge"
UniPro lane merge in stage 4 decoding.

"UniPro bytes" UniPro bytes in stage 2 decoding.

12.11.2.3 Configuring the M-PHY Signals

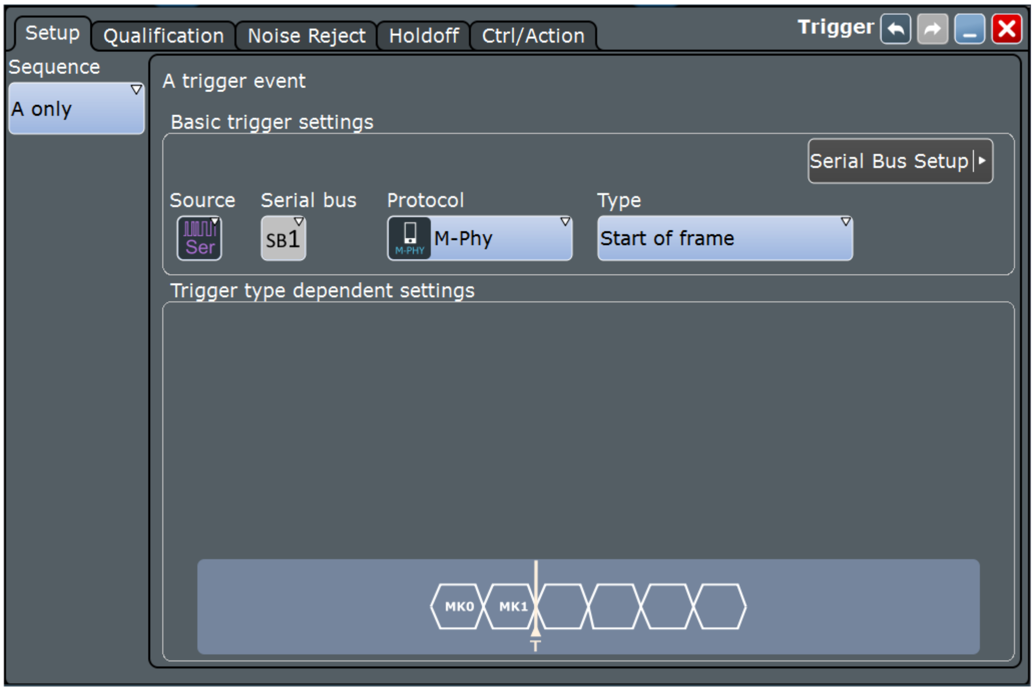
Assign the lanes to the channels and define the thresholds:

1. Press [Protocol] on the front panel.
2. On the left, select the bus you want to configure.
3. Select the "Configuration" tab.
4. Tap "Protocol" and select "M-Phy".
5. Tap "Variant" and select the protocol.
6. Enter the number of "Lanes".
7. Select the source "Channel" for each lane.
8. Enter the "Thresholds" for each lane.
9. Enable "Decode".
10. Optionally, you can:
    a) Enter a "Bus label" on the "Display" tab.
    b) Select a "Decode layer" on the "Display" tab.

12.11.3 M-PHY Trigger

12.11.3.1 M-PHY Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = M-PHY"



Make sure that:
- The data sources of the serial bus are channel signals: [Protocol] > "Configuration" tab.
- The trigger sequence is set to "A only": [Trigger] > "Setup" tab.
- The trigger source is "Serial bus": [Trigger] > "Setup" tab.
- The correct serial bus is selected: [Trigger] > "Setup" tab.
- The correct protocol is selected: [Trigger] > "Setup" tab.

Type
Selects the trigger type for the analysis of the selected protocol.

Remote command:
`TRIGger<m>:MPHY:TYPE` on page 1541

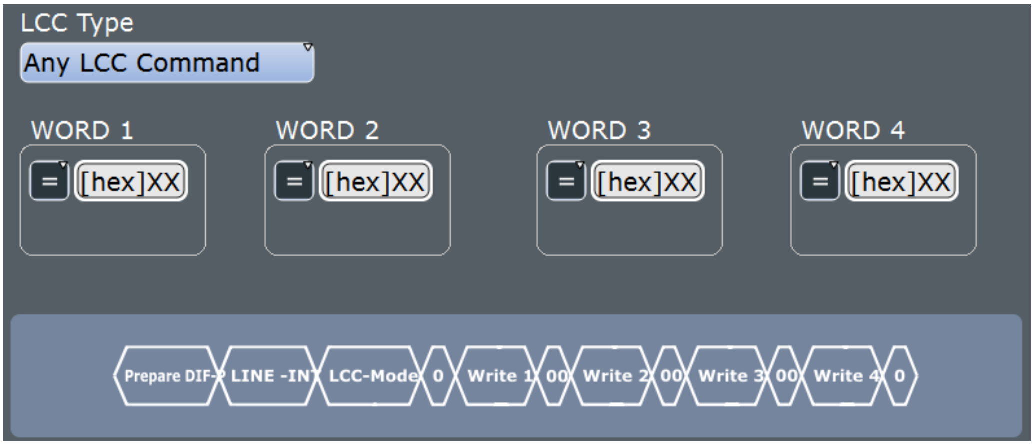
Start of frame ← Type
Triggers on the start of an M-PHY or a UniPro frame.

Burst ← Type
Triggers on an M-PHY burst frame.

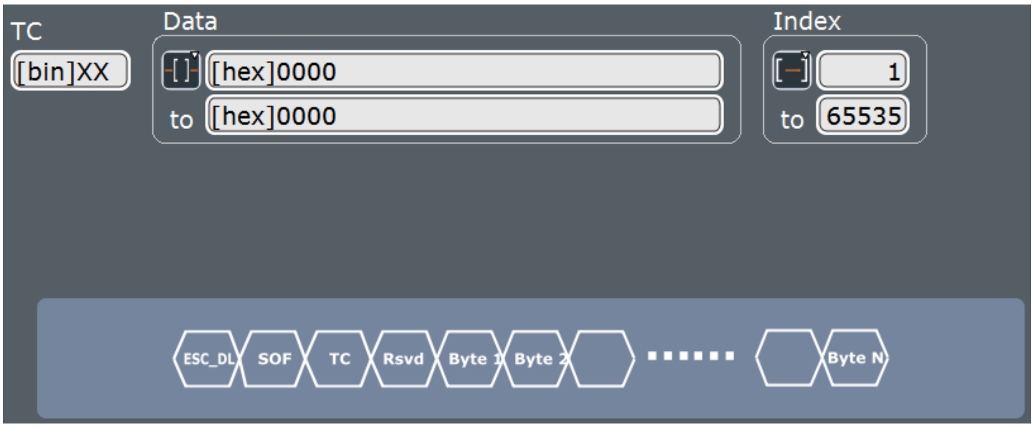
Adapt ← Type
Triggers on an M-PHY Adapt frame. This control frame is used for clock/bit synchronization.

LCC ← Type
Triggers on an M-PHY Line Control Command (LCC) frame that matches the specified LCC Type or any WORD condition.

This control frame is used for configuring the line to a different state or mode depending on the LCC type.

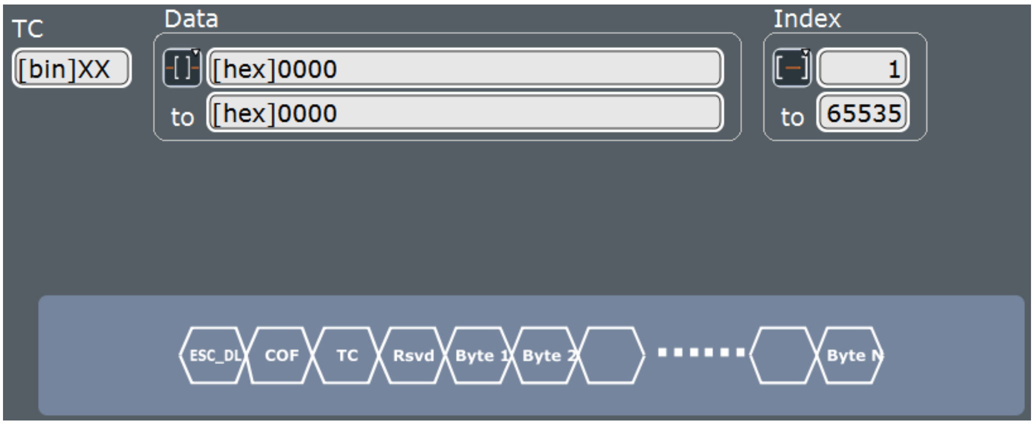


DL PDU SOF ← Type
Triggers on a UniPro Downlink Protocol Data Unit (DL PDU) Start Of Frame (SOF) that matches the specified TC, Data or Index condition.



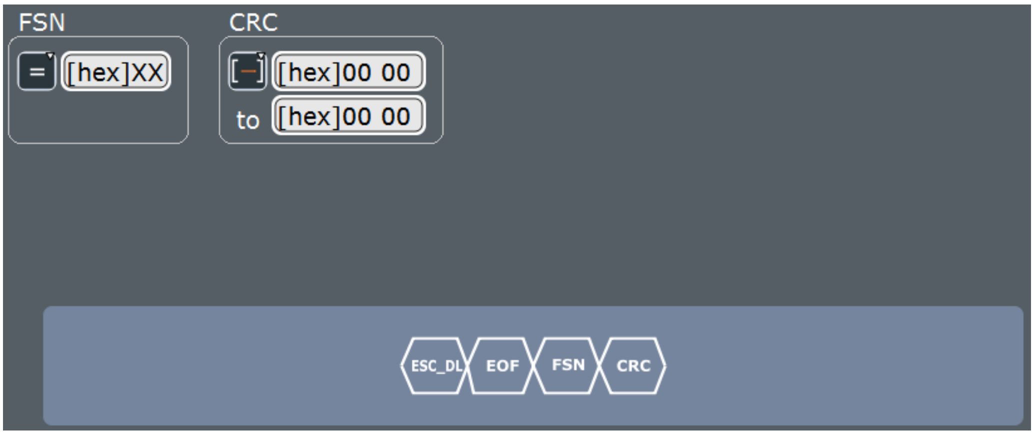
DL PDU COF ← Type

Triggers on a UniPro DL PDU Continuation Of Pre-empted Frame (COF) that matches the specified TC, Data or Index condition.



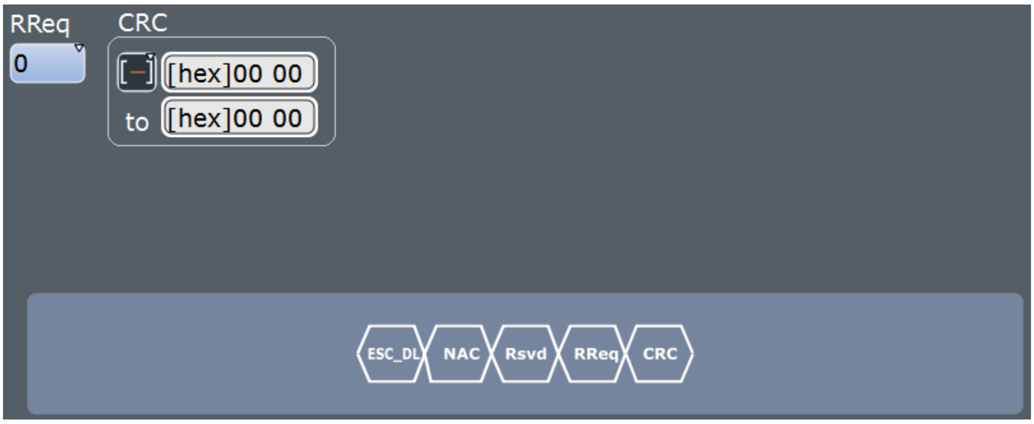
DL PDU EOF ← Type

Triggers on a UniPro DL PDU End Of Frame (EOF) frame that matches the specified FSN or CRC condition.

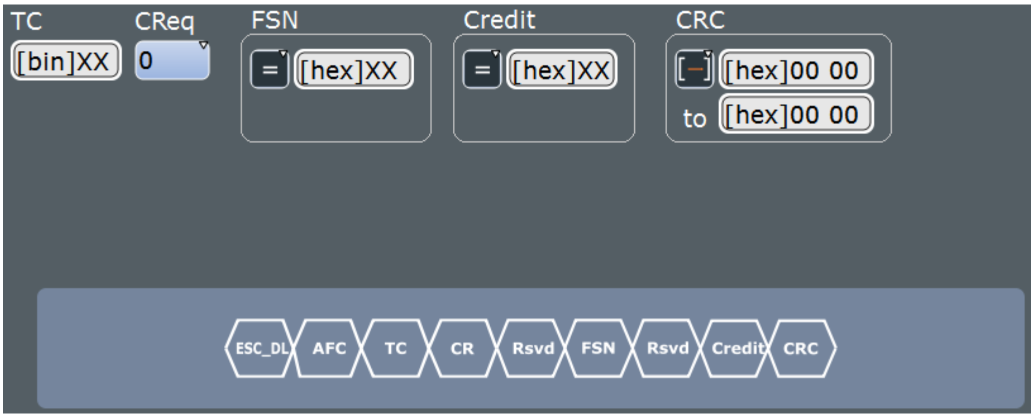


DL PDU NAC ← Type

Triggers on a UniPro DL PDU Negative Acknowledgment Control (NAC) frame that matches the specified RReq or CRC condition.

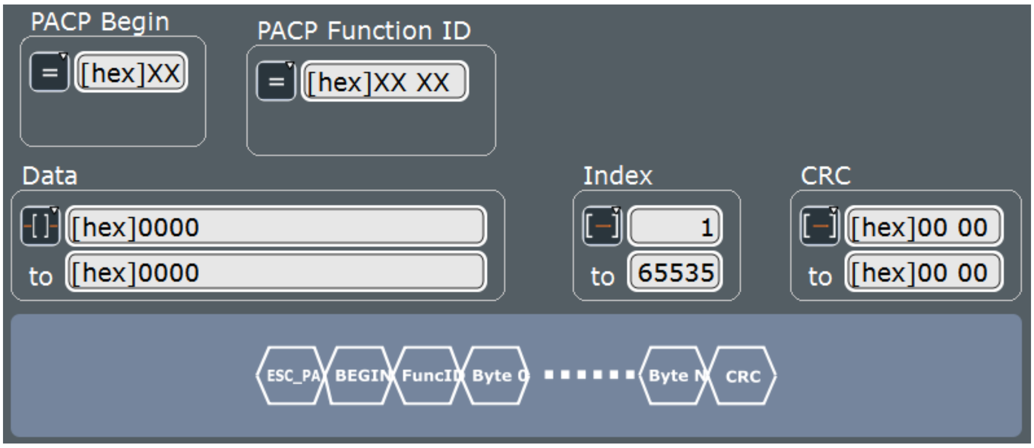


DL PDU AFC ← Type
Triggers on a UniPro DL PDU Acknowledgement and L2 Flow Control (AFC) frame that matches the specified TC, CReq, FSN, Credit or CRC condition.



PACP ← Type
Triggers on a UniPro PHY Adapter Control Protocol (PACP) frame that matches the specified PACP Begin, PACP Function ID, Data, Index or CRC condition.

This control frame is used mainly for power mode change and L1.5 link management. It is also used in scrambling request.

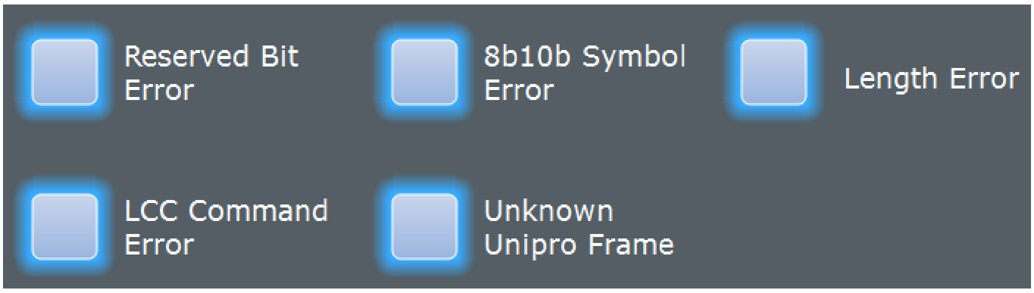


Trigger Upr0 ← Type
Triggers on a UniPro Trigger Upper0 frame. This control frame is used for link startup sequence.

Trigger Upr1 ← Type
Triggers on a UniPro Trigger Upper1 frame. This control frame is used for link startup sequence.

Trigger Upr2 ← Type
Triggers on a UniPro Trigger Upper2 frame. This control frame is used for link startup sequence.

Errors ← Type
Triggers on the specified M-PHY or UniPro error frame.



LCC Type
Selects the type of LCC command to be triggered on.

"Any LCC Command"
: All the available LCC commands

"HIBERN8-SLEEP"
: Switches the power-saving state to ultra-low power without configuration loss. This state saves up to 90% power and is used with PWM burst.

"HIBERN8-STALL"
: Switches the power-saving state to ultra-low power without configuration loss. This state saves up to 75% power and is used with HS burst.

"READ-CAPABILITY"
: Recovers data about the Optical Media Converter (OMC) capabilities

"READ-MFG-INFO"
: Retrieves manufacturing ID and vendor-specific information

"READ-VEND-INFO"
: Retrieves the additional four delimited bytes containing vendor-specific information

"WRITE-ATTRIBUTE"
Sets the configuration parameters required for lane operation

"PWM-G0/PWM-G1/PWM-G2/PWM-G3/PWM-G4/PWM-G5/PWM-G6/PWM-G7"
Switches the transmission mode to the selected low-power gear

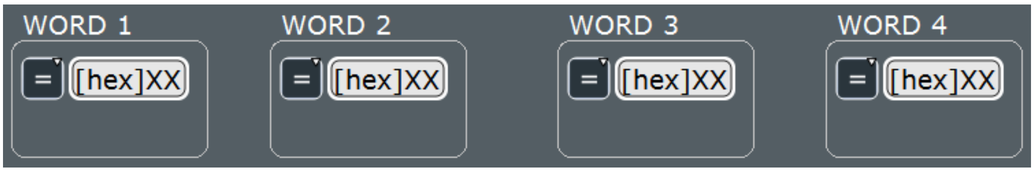
"HS-G1A/HS-G2A/HS-G3A/HS-G4A/HS-G1B/HS-G2B/HS-G3B/HS-G4B"
Switches the transmission mode to the selected high-speed gear

"Reserved"
Reserved bit command. These bits are reserved for future use.

Remote command:
TRIGger<m>:MPHY:LCCType on page 1541

WORD 1/WORD 2/WORD 3/WORD 4

Sets the specified words to be triggered on. The setup for a word consists of the condition and one or two word patterns.



"Condition" Defines the operator to set a specific word, e.g. "Equal" or "Not Equal" or a range.

"Data Min/Data"
Defines the bit pattern of the word pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

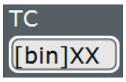
"Data Max" The second word pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
For "WORD 1":
TRIGger<m>:MPHY:LWONe:CONDition on page 1542
TRIGger<m>:MPHY:LWONe:MIN on page 1543
TRIGger<m>:MPHY:LWONe:MAX on page 1543
For "WORD 2":
TRIGger<m>:MPHY:LWTWo:CONDition on page 1543
TRIGger<m>:MPHY:LWTWo:MIN on page 1543
TRIGger<m>:MPHY:LWTWo:MAX on page 1544
For "WORD 3":
TRIGger<m>:MPHY:LWTHree:CONDition on page 1544
TRIGger<m>:MPHY:LWTHree:MIN on page 1544
TRIGger<m>:MPHY:LWTHree:MAX on page 1545
For "WORD 4":
TRIGger<m>:MPHY:LWFour:CONDition on page 1545
TRIGger<m>:MPHY:LWFour:MIN on page 1545
TRIGger<m>:MPHY:LWFour:MAX on page 1546

TC

Sets the specified Traffic Class (TC) to be triggered on.

TC is used for classifying the traffic flow based on protocol and port number, e.g. TC0 and TC1 are two priority classes with guaranteed link reliability defined and used in L2.



"Data" Defines the bit pattern of the TC pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

Remote command:
TRIGger<m>:MPHY:TC on page 1546

Data

Sets the specified data to be triggered on. The data setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific data, e.g. "Equal" or "Not Equal") or a range.

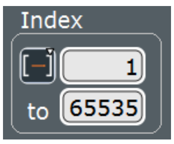
"Data Min/Data"
Defines the bit pattern of the data pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:MPHY:DATA:DCON on page 1546
TRIGger<m>:MPHY:DATA:DMIN on page 1546
TRIGger<m>:MPHY:DATA:DMAX on page 1547

Index

Sets the specified value or range within this series of data that is considered for the analysis. The index setup consists of the condition and one or two index values.



"Condition" Defines the operator to set a specific index, e.g. "Equal" or a range.

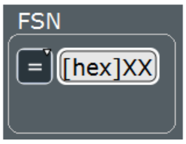
"Index Min/Index"
Defines the bit pattern of the index pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Index Max" The second index pattern is required to specify a range with conditions "In range".

Remote command:
TRIGger<m>:MPHY:DATA:ICONdition on page 1547
TRIGger<m>:MPHY:DATA:IMIN on page 1547
TRIGger<m>:MPHY:DATA:IMAX on page 1548

FSN

Sets the specified Frame Sequence Number (FSN) to be triggered on. The FSN setup consists of the condition and one or two FSN patterns.



"Condition" Defines the operator to set a specific FSN, e.g. "Equal" or "Not Equal" or a range.

"Data Min/Data"
Defines the bit pattern of the FSN pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

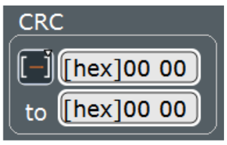
"Data Max" The second FSN pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:MPHY:FSNumber:CONDition on page 1548
TRIGger<m>:MPHY:FSNumber:MIN on page 1548
TRIGger<m>:MPHY:FSNumber:MAX on page 1549

CRC

Sets the specified Cyclic Redundancy Check (CRC) to be triggered on. The CRC setup consists of the condition and one or two CRC patterns.

CRC is an error detecting code to detect accidental changes to raw data.



"Condition" Defines the operator to set a specific CRC, e.g. "Equal" or "Not Equal" or a range.

"Data Min/Data"
Defines the bit pattern of the CRC pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max"
The second CRC pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
TRIGger<m>:MPHY:CRC:CONDition on page 1549
TRIGger<m>:MPHY:CRC:MIN on page 1549
TRIGger<m>:MPHY:CRC:MAX on page 1549

Req
Sets the specified Reset Link Request (RReq) or Credit Transmit Request (CReq) to be triggered on.

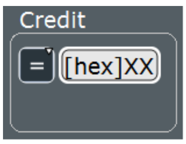
RReq is used for requesting the remote end to reinitialize its Transmit (TX) Physical Layer (PHY) while CReq is used for requesting flow control information for the corresponding TC from the remote end.

"Data"
Defines the bit pattern of the RReq pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

Remote command:
For "RReq":
TRIGger<m>:MPHY:RREQ on page 1550
For "CReq"
TRIGger<m>:MPHY:CREQ on page 1550

Credit
Sets the specified credit to be triggered on. The credit setup consists of the condition and one or two credit patterns.

Credit represents the total number of credits available since boot time.



"Condition"
Defines the operator to set a specific credit, e.g. "Equal" or "Not Equal" or a range.

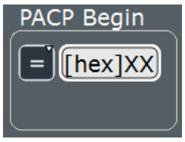
"Data Min/Data"
: Defines the bit pattern of the credit pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max"
: The second credit pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:MPHY:CREDit:CONDition` on page 1550
`TRIGger<m>:MPHY:CREDit:MIN` on page 1551
`TRIGger<m>:MPHY:CREDit:MAX` on page 1551

PACP Begin

Sets the specified PACP Begin to be triggered on. The PACP Begin setup consists of the condition and one or two PACP Begin patterns.



"Condition"
: Defines the operator to set a specific PACP Begin, e.g. "Equal" or "Not Equal" or a range.

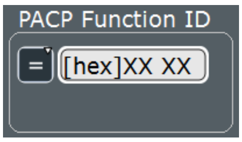
"Data Min/Data"
: Defines the bit pattern of the data value pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max"
: The second PACP Begin pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:MPHY:PBEGin:CONDition` on page 1551
`TRIGger<m>:MPHY:PBEGin:MIN` on page 1552
`TRIGger<m>:MPHY:PBEGin:MAX` on page 1552

PACP Function ID

Sets the specified PACP Function ID to be triggered on. The PACP Function ID setup consists of the condition and one or two PACP Function ID patterns.



"Condition"
: Defines the operator to set a specific PACP Function ID, e.g. "Equal" or "Not Equal" or a range.

"Data Min/Data"
Defines the bit pattern of the PACP Function ID pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second PACP Function ID pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`TRIGger<m>:MPHY:PFID:CONDition` on page 1552
`TRIGger<m>:MPHY:PFID:MIN` on page 1553
`TRIGger<m>:MPHY:PFID:MAX` on page 1553

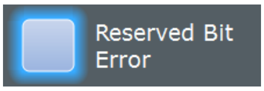
Errors

Sets the type of error events to be triggered on.

Reserved Bit Error ← Errors

Triggers on reserved bit error.

This error means that the waveform violates the reserved field according to the specification. For example, a DL_PDU_AFC frame requires that the two bits before and three bits after the FSN field to be reserved and set as 0. If the waveform carries 1 in these positions instead, it is marked as this error.

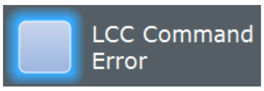


Remote command:
`TRIGger<m>:MPHY:ERRor:REServed` on page 1554

LCC Command Error ← Errors

Triggers on LCC command error.

This error is marked when the Command field in the LCC packet is not a known command defined in the specification.

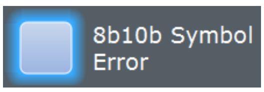


Remote command:
`TRIGger<m>:MPHY:ERRor:LCMD` on page 1554

8b10b Symbol Error ← Errors

Triggers on 8b10b symbol error.

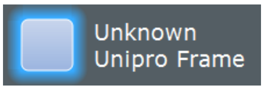
For example, some of the 10-bit combinations that do not map to 8-bit according to the specification are invalid 10-bit and therefore marked as this error.



Remote command:
`TRIGger<m>:MPHY:ERRor:SYMBol` on page 1554

Unknown Unipro Frame ← Errors

Triggers on unidentified UniPro frame error. This error is marked when the end mark on UniPro packets is undetected.

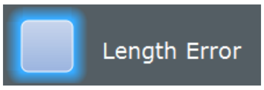


Remote command:

TRIGger<m>:MPHY:ERRor:UNKNown on page 1555

Length Error ← Errors

Triggers on frames that violate the length according to the specification.



Remote command:

TRIGger<m>:MPHY:ERRor:LENGth on page 1554

12.11.3.2 Triggering on M-PHY

Prerequisite: A bus is configured for the M-PHY signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Tap "Serial bus" and select the serial bus that is set to M-PHY, e.g.:

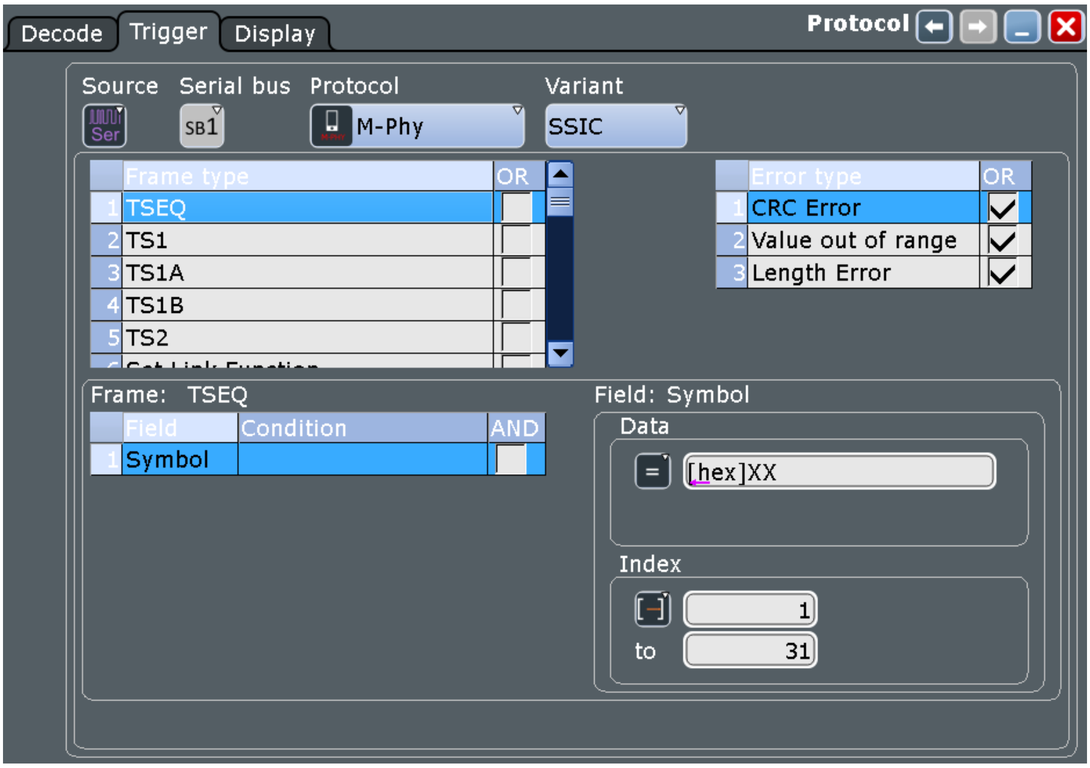
   

   The "Protocol" selection is then automatically set to "M-PHY".
5. Select the "Type" to use in the M-PHY protocol analysis.
6. To refine the trigger settings, configure additional settings, which are available for some trigger types.
   For details, see Chapter 12.11.3.1, "M-PHY Trigger Settings", on page 652.

12.11.3.3 SSIC Trigger Settings

Access: [Trigger] > "Source" = "Serial Bus" , "Protocol" = "M-Phy" and "M-PHY" > "Variant" = "SSIC"

The setting is available for SSIC option R&S RTP-K64.



Error types: Item name, Enable

The table lists the error types you can trigger on. Select the required errors in the "Enable" column.

Remote command:

`TRIGger<m>:MPHY:SSIC:ERENable` on page 1583

`TRIGger<m>:MPHY:SSIC:ERRor<n>:ENABle` on page 1583

Field name / Condition Summary / Enable

This table lists the field numbers and names in the selected frame together with a summary of the user settings of checking conditions for each field and a checkbox to enable the checking.

Select a field in the table to specify the checking conditions for this field in the "Data", "BitState" and/or "Index" dialog (whichever applies). The condition is only applied, and the "Condition Summary" is only shown in the table, if "Enable" is checked.

The SSIC trigger frames and fields are the same as for USB3.1, see "Frame types" on page 753.

Remote command:

`TRIGger<m>:MPHY:SSIC:FRENable` on page 1584

`TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:ENABle` on page 1584

Data

Defines for the selected field, how a data check is executed.

"Condition" Defining specific data or a data range requires to set the operator to one of the following conditions: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies data or sets the start value of a data range.

"Max" Sets the end value of a data range, if "Condition" is set to "In range" or "Out of range".

Remote command:
`TRIGger<m>:MPHY:SSIC:DOPerator` on page 1586
`TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:DOPerator` on page 1586
`TRIGger<m>:MPHY:SSIC:DMIN` on page 1585
`TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:DMIN` on page 1585
`TRIGger<m>:MPHY:SSIC:DMAX` on page 1585
`TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:DMAX` on page 1585

BitState
Defines the bit state to be checked for the selected field. Permitted bit states are "1", "0" or "X" (do not care).

Remote command:
`TRIGger<m>:MPHY:SSIC:BIT` on page 1585
`TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:BIT` on page 1585

Index
Defines for the selected field, how an index check is executed.

"Condition" Defining a specific index or an index range requires to set the operator to one of the following conditions: equal, in range.

"Min" Specifies the index or sets the start value of an index range.

"Max" Sets the end value of an index range, if "Condition" is set to "In range".

Remote command:
`TRIGger<m>:MPHY:SSIC:IOPerator` on page 1587
`TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:IOPerator` on page 1587
`TRIGger<m>:MPHY:SSIC:IMIN` on page 1587
`TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:IMIN` on page 1587
`TRIGger<m>:MPHY:SSIC:IMAX` on page 1586
`TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:IMAX` on page 1586

12.11.3.4 Triggering on SSIC

Prerequisite: A bus is configured for the "M-PHY" > "Variant" = "SSIC" signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.

3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Tap "Serial bus" and select the serial bus that is set to SSIC, e.g.:
   The "Protocol" selection is then automatically set to "M-PHY".
5. If you trigger on errors, select the error types you want to find.
6. Select the frame type to be used for SSIC protocol analysis.
7. For some frame types, you can define the frame fields.
   For details, see Chapter 12.11.3.3, "SSIC Trigger Settings", on page 664.

12.11.4 M-PHY Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Example

The example in Figure 12-55 shows a decoded M-PHY signal and the result tables.

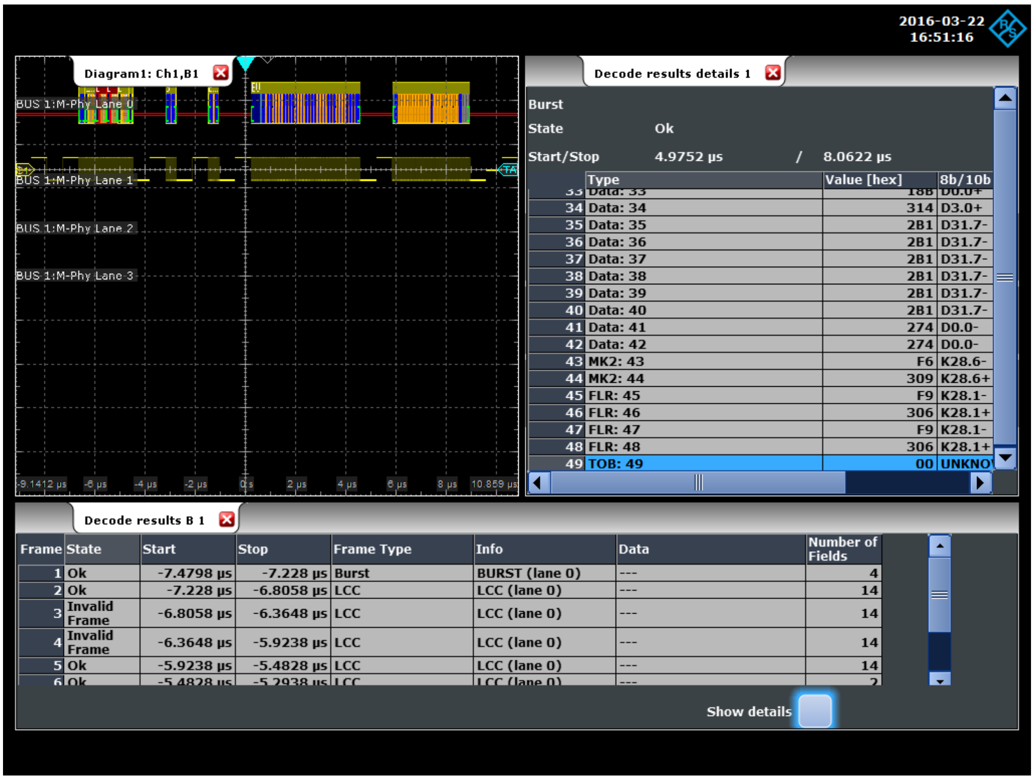


Figure 12-55: Decoded M-PHY signal with result tables

green brackets [...] = start and end of frame
yellow frame header = burst
red frame header = frame containing error (also reported in the results table)
dark blue = data before synchronization (M-PHY frame) / line init (LCC frame)
orange = data after synchronization (M-PHY frame) / data (LCC frame)
light blue = marker 0
marine blue = marker 1 to 6
yellow = command type (LCC frame)
grey = fillers (M-PHY frame) / reserved word (LCC frame)

The example in Figure 12-56 shows a decoded UniPro signal and the result tables.

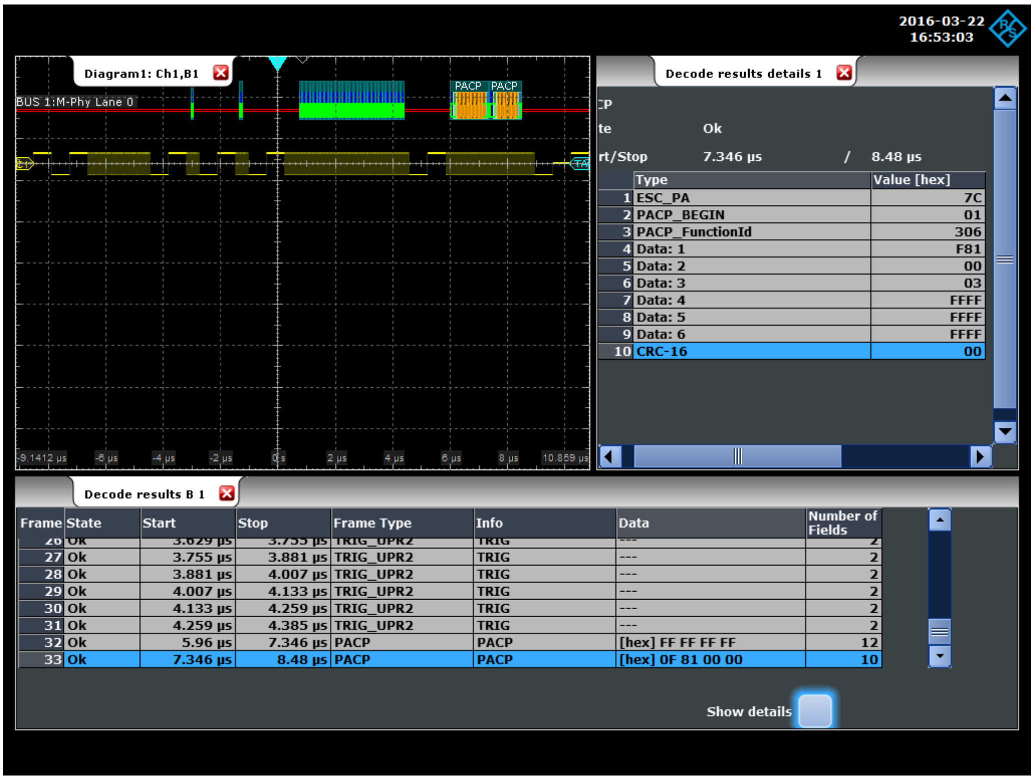


Figure 12-56: Decoded UniPro signal with result tables

green brackets [...]	= start and end of frame
turquoise frame header	= PDU
red frame header	= frame containing error (also reported in the results table)
marine blue	= ESC_DL word
dark blue	= identifier (ID) word such as SOF, COF, EOF, NAC or AFC
yellow	= TC word
orange	= data
light blue	= CRC
grey	= filler, spacer or reserved word

The example in Figure 12-57 shows a decoded SSIC signal and the result tables.

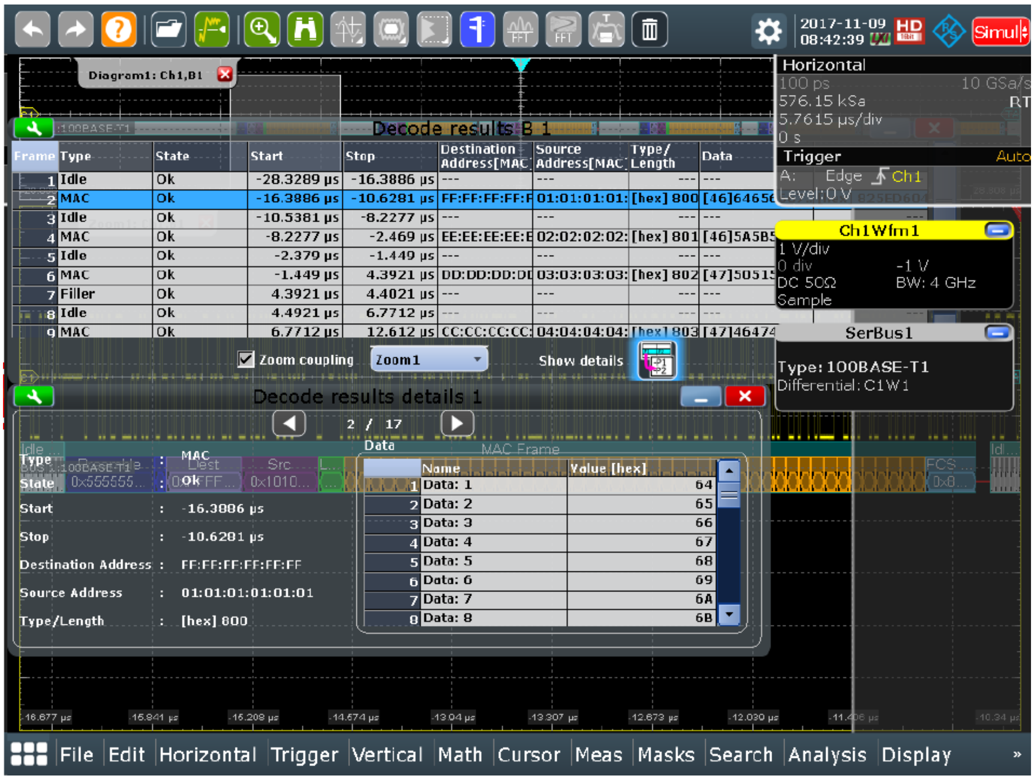


Figure 12-57: Decoded SSIC signal with result tables

Table 12-12: Content of the decode result table

Column	Description
Frame	Frame count
State	Overall state of the frame indicating, for example, if the frame is valid or invalid
Start	Time of frame start in relation to the trigger point
Stop	Time of frame stop in relation to the trigger point
Frame Type	Frame identifier specifying the data or control frame name
Info	Label on top of the frame
Data	Payload information
Number of Fields	Total number of fields in the frame

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:

- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.12.3, "Decode Results M-PHY", on page 1555.

12.11.5 Search on Decoded M-PHY Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 396.

12.11.5.1 M-PHY Search Setup

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for M-PHY

Type
Selects the search type for the selected protocol.

Remote command:
`SEARch:TRIGger:MPHY:TYPE` on page 1562

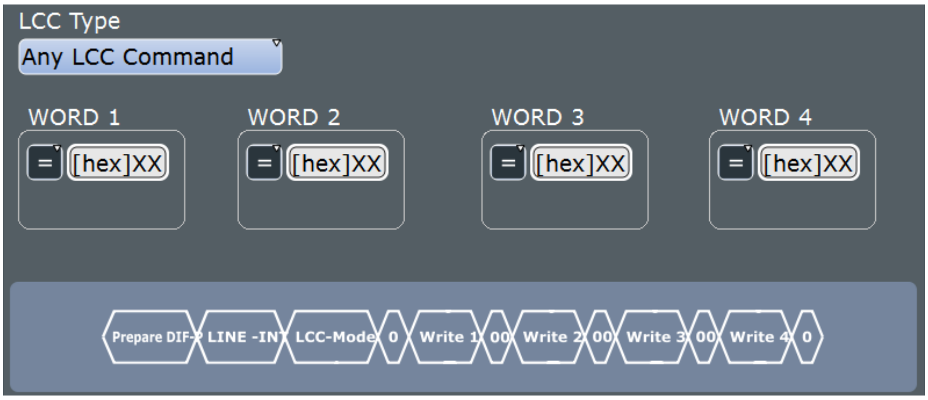
Start of frame ← Type
Searches for the start of an M-PHY or a UniPro frame.

Burst ← Type
Searches for an M-PHY burst.

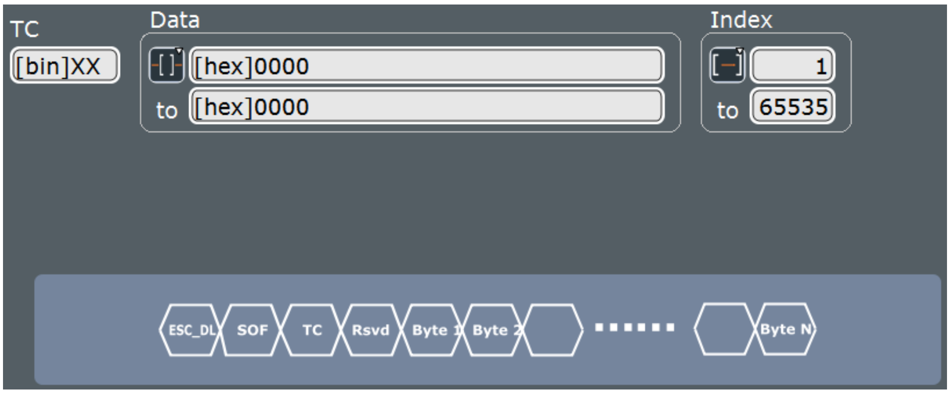
Adapt ← Type
Searches for an M-PHY Adapt frame. This control frame is used for clock/bit synchronization.

LCC ← Type
Searches for an M-PHY Line Control Command (LCC) frame that matches the specified LCC Type or any WORD condition.

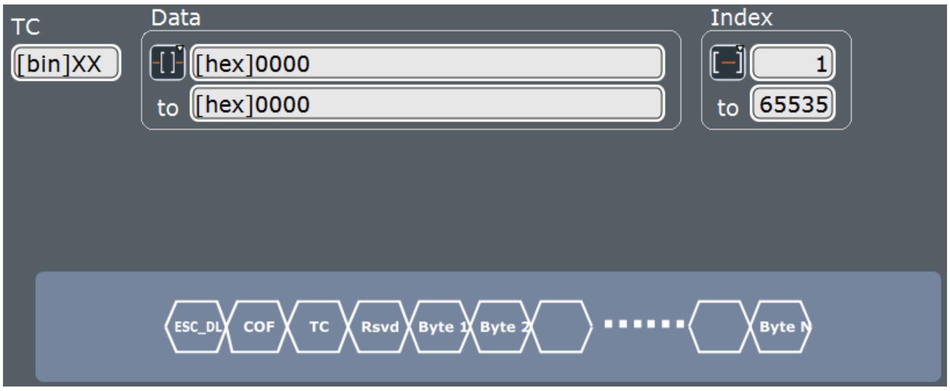
This control frame is used for configuring the line to a different state or mode depending on the LCC type.



DL PDU SOF ← Type
Searches for a UniPro Downlink Protocol Data Unit (DL PDU) Start Of Frame (SOF) that matches the specified TC, Data or Index condition.

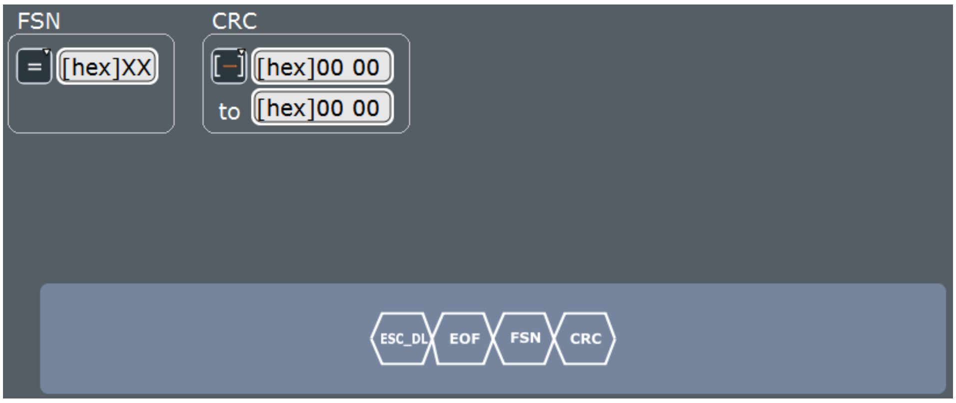


DL PDU COF ← Type
Searches for a UniPro DL PDU Continuation Of Pre-empted Frame (COF) that matches the specified TC, Data or Index condition.



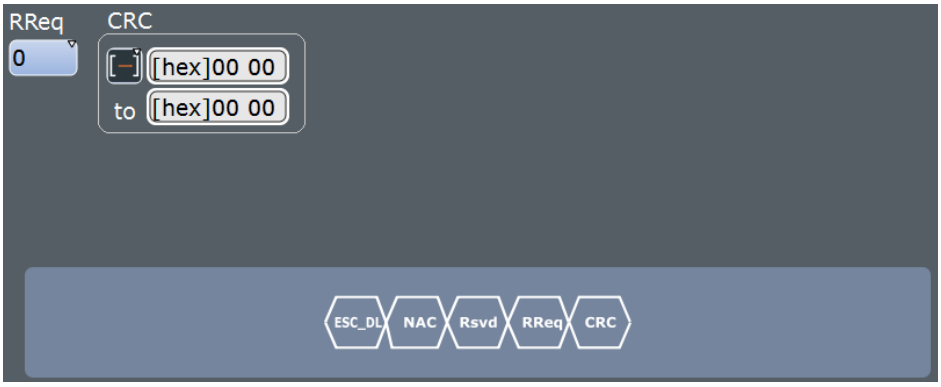
DL PDU EOF ← Type

Searches for a UniPro DL PDU End Of Frame (EOF) that matches the specified FSN or CRC condition.



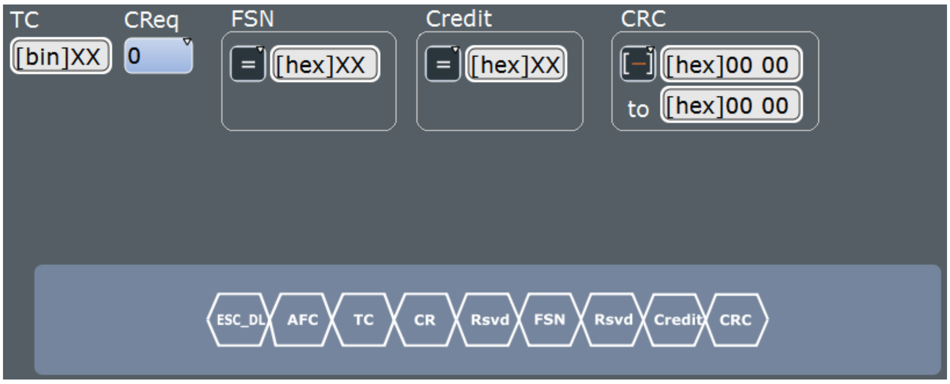
DL PDU NAC ← Type

Searches for a UniPro DL PDU Negative Acknowledgment Control (NAC) frame that matches the specified RReq or CRC condition.



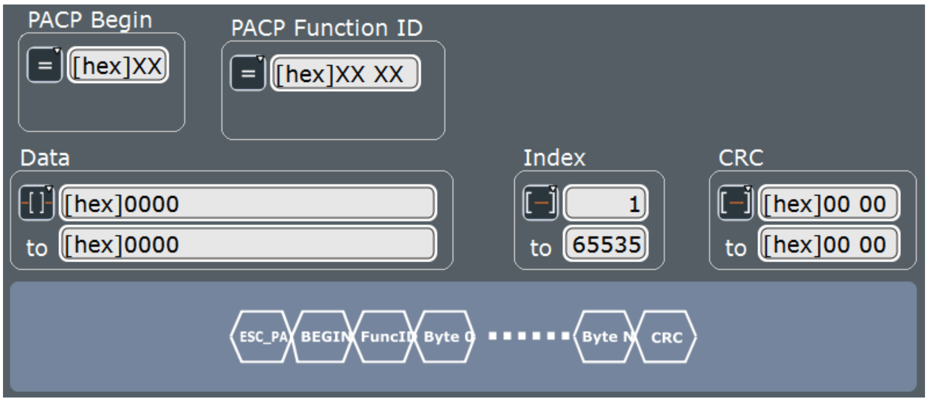
DL PDU AFC ← Type

Searches for a UniPro DL PDU Acknowledgement and L2 Flow Control (AFC) frame that matches the specified TC, CReq, FSN, Credit or CRC condition.



PACP ← Type
Searches for a UniPro PHY Adapter Control Protocol (PACP) frame that matches the specified PACP Begin, PACP Function ID, Data, Index or CRC condition.

This control frame is used mainly for power mode change and L1.5 link management. It is also used in scrambling request.

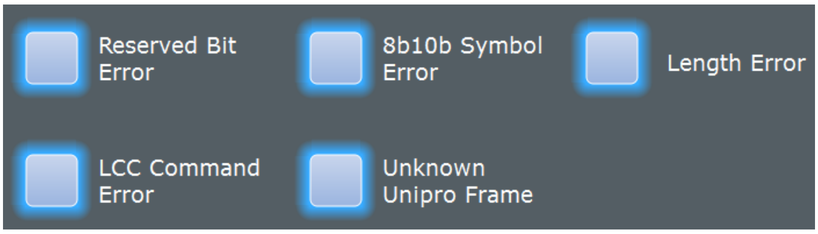


Trigger Upper0 ← Type
Searches for a Trigger Upper0 frame. This control frame is used for link startup sequence.

Trigger Upper1 ← Type
Searches for a Trigger Upper1 frame. This control frame is used for link startup sequence.

Trigger Upper2 ← Type
Searches for a Trigger Upper2 frame. This control frame is used for link startup sequence.

Errors ← Type
Searches for the specified error frame.



LCC Type
Selects the type of LCC command to be searched for.

"Any LCC Command"
: All the available LCC commands

"HIBERN8-SLEEP"
: Switches the power-saving state to ultra-low power without configuration loss. This state saves up to 90% power and is used with PWM burst.

"HIBERN8-STALL"
: Switches the power-saving state to ultra-low power without configuration loss. This state saves up to 75% power and is used with HS burst.

"READ-CAPABILITY"
: Recovers data about the Optical Media Converter (OMC) capabilities

"READ-MFG-INFO"
: Retrieves manufacturing ID and vendor-specific information

"READ-VEND-INFO"
: Retrieves the additional four delimited bytes containing vendor-specific information

"WRITE-ATTRIBUTE"
: Sets the configuration parameters required for lane operation

"PWM-G0/PWM-G1/PWM-G2/PWM-G3/PWM-G4/PWM-G5/PWM-G6/PWM-G7"
: Switches the transmission mode to the selected low-power gear

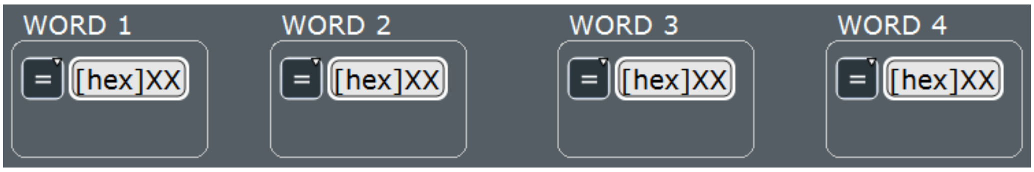
"HS-G1A/HS-G2A/HS-G3A/HS-G4A/HS-G1B/HS-G2B/HS-G3B/HS-G4B"
: Switches the transmission mode to the selected high-speed gear

"Reserved"
Reserved bit command. These bits are reserved for future use.

Remote command:
SEARch:TRIGger:MPHY:LCCType on page 1563

WORD 1/WORD 2/WORD 3/WORD 4

Sets the specified words to be searched for. The setup for a word consists of the condition and one or two word patterns.



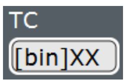
"Condition"	Defines the operator to set a specific word, e.g. "Equal" or "Not Equal" or a range.
"Data Min/Data"	Defines the bit pattern of the word pattern. In binary format, use the following characters: 1; 0; or X (do not care). The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.
"Data Max"	The second word pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
For "WORD 1":
SEARch:TRIGger:MPHY:LWONe:CONDition on page 1564
SEARch:TRIGger:MPHY:LWONe:MIN on page 1564
SEARch:TRIGger:MPHY:LWONe:MAX on page 1565
For "WORD 2":
SEARch:TRIGger:MPHY:LWTWo:CONDition on page 1565
SEARch:TRIGger:MPHY:LWTWo:MIN on page 1565
SEARch:TRIGger:MPHY:LWTWo:MAX on page 1566
For "WORD 3":
SEARch:TRIGger:MPHY:LWTHree:CONDition on page 1566
SEARch:TRIGger:MPHY:LWTHree:MIN on page 1566
SEARch:TRIGger:MPHY:LWTHree:MAX on page 1567
For "WORD 4":
SEARch:TRIGger:MPHY:LWFour:CONDition on page 1567
SEARch:TRIGger:MPHY:LWFour:MIN on page 1567
SEARch:TRIGger:MPHY:LWFour:MAX on page 1568

TC

Sets the specified Traffic Class (TC) to be searched for.

TC is used for classifying the traffic flow based on protocol and port number, e.g. TC0 and TC1 are two priority classes with guaranteed link reliability defined and used in L2.



"Data" Defines the bit pattern of the TC pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

Remote command:
`SEARch:TRIGger:MPHY:TC` on page 1568

Data

Sets the specified data to be searched for. The data setup consists of the condition and one or two data patterns.

"Condition" Defines the operator to set a specific data, e.g. "Equal" or "Not Equal") or a range.

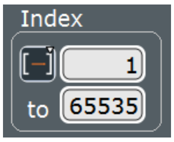
"Data Min/Data"
Defines the bit pattern of the data pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second data pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:MPHY:DATA:DCONdition` on page 1568
`SEARch:TRIGger:MPHY:DATA:DMIN` on page 1569
`SEARch:TRIGger:MPHY:DATA:DMAX` on page 1569

Index

Index sets the range within this series of data that is considered for the search. The index setup consists of the condition and one or two data index values.



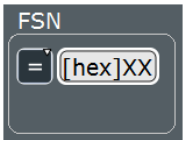
"Condition" Defines the operator to set a specific index, e.g. "Equal" or a range.

"Index Min/Index"
Defines the bit pattern of the index pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Index Max" The second index pattern is required to specify a range with conditions "In range".

Remote command:
SEARch:TRIGger:MPHY:DATA:ICONdition on page 1569
SEARch:TRIGger:MPHY:DATA:IMIN on page 1570
SEARch:TRIGger:MPHY:DATA:IMAX on page 1570

FSN
Sets the specified Frame Sequence Number (FSN) to be searched for. The FSN setup consists of the condition and one or two FSN patterns.



"Condition" Defines the operator to set a specific FSN, e.g. "Equal" or "Not Equal" or a range.

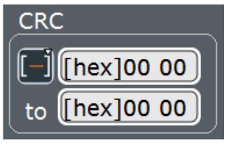
"Data Min/Data"
Defines the bit pattern of the FSN pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second FSN pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
SEARch:TRIGger:MPHY:FSNumber:CONDition on page 1570
SEARch:TRIGger:MPHY:FSNumber:MIN on page 1571
SEARch:TRIGger:MPHY:FSNumber:MAX on page 1571

CRC
Sets the specified Cyclic Redundancy Check (CRC) to be searched for. The CRC setup consists of the condition and one or two CRC patterns.

CRC is an error detecting code to detect accidental changes to raw data.



"Condition" Defines the operator to set a specific CRC, e.g. "Equal" or "Not Equal" or a range.

"Data Min/Data"
Defines the bit pattern of the CRC pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second CRC pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:MPHY:CRC:CONDition` on page 1571
`SEARch:TRIGger:MPHY:CRC:MIN` on page 1572
`SEARch:TRIGger:MPHY:CRC:MAX` on page 1572

Req

Sets the specified Reset Link Request (RReq) or Credit Transmit Request (CReq) to be searched for.

RReq is used for requesting the remote end to reinitialize its Transmit (TX) Physical Layer (PHY) while CReq is used for requesting flow control information for the corresponding `TC` from the remote end.

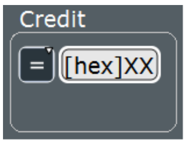
"Data" Defines the bit pattern of the RReq pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

Remote command:
For "RReq":
`SEARch:TRIGger:MPHY:RREQ` on page 1573
For "CReq"
`SEARch:TRIGger:MPHY:CREQ` on page 1572

Credit

Sets the specified credit to be searched for. The credit setup consists of the condition and one or two credit patterns.

Credit represents the total number of credits available since boot time.



"Condition" Defines the operator to set a specific credit, e.g. "Equal" or "Not Equal" or a range.

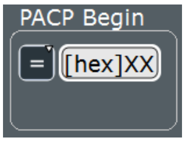
"Data Min/Data"
Defines the bit pattern of the credit pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second credit pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
SEARch:TRIGger:MPHY:CREDit:CONDition on page 1573
SEARch:TRIGger:MPHY:CREDit:MIN on page 1573
SEARch:TRIGger:MPHY:CREDit:MAX on page 1574

PACP Begin

Sets the specified PACP Begin to be searched for. The PACP Begin setup consists of the condition and one or two PACP Begin patterns.



"Condition" Defines the operator to set a specific PACP Begin, e.g. "Equal" or "Not Equal" or a range.

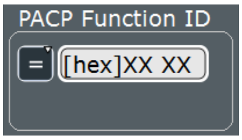
"Data Min/Data"
Defines the bit pattern of the data value pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

"Data Max" The second PACP Begin pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
SEARch:TRIGger:MPHY:PBEGin:CONDition on page 1574
SEARch:TRIGger:MPHY:PBEGin:MIN on page 1574
SEARch:TRIGger:MPHY:PBEGin:MAX on page 1575

PACP Function ID

Sets the specified PACP Function ID to be searched for. The PACP Function ID setup consists of the condition and one or two PACP Function ID patterns.



"Condition" Defines the operator to set a specific PACP Function ID, e.g. "Equal" or "Not Equal" or a range.

"Data Min/Data"
Defines the bit pattern of the PACP Function ID pattern.
In binary format, use the following characters: 1; 0; or X (do not care).
The bit pattern editor helps you to enter the pattern in any format, see Chapter 12.1.4, "Bit Pattern Editor", on page 470.

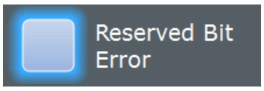
"Data Max" The second PACP Function ID pattern is required to specify a range with conditions "In range" and "Out of range".

Remote command:
`SEARch:TRIGger:MPHY:PFID:CONDition` on page 1575
`SEARch:TRIGger:MPHY:PFID:MIN` on page 1575
`SEARch:TRIGger:MPHY:PFID:MAX` on page 1576

Errors
Sets the type of error events to be searched for.

Reserved Bit Error ← Errors
Searches for reserved bit error.

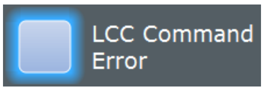
This error means that the waveform violates the reserved field according to the specification. For example, a DL_PDU_AFC frame requires that the two bits before and three bits after the FSN field to be reserved and set as 0. If the waveform carries 1 in these positions instead, it is marked as this error.



Remote command:
`SEARch:TRIGger:MPHY:ERRor:REServed` on page 1576

LCC Command Error ← Errors
Searches for LCC command error.

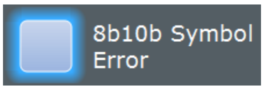
This error is marked when the Command field in the LCC packet is not a known command defined in the specification.



Remote command:
`SEARch:TRIGger:MPHY:ERRor:LCMD` on page 1576

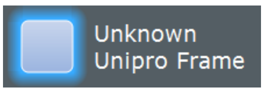
8b10b Symbol Error ← Errors
Searches for 8b10b symbol error.

For example, some of the 10-bit combinations that do not map to 8-bit according to the specification are invalid 10-bit and therefore marked as this error.



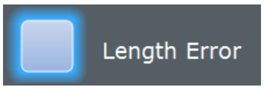
Remote command:
`SEARch:TRIGger:MPHY:ERRor:SYMBol` on page 1576

Unknown Unipro Frame ← Errors
Searches for unidentified UniPro frame error. This error is marked when the end mark on Unipro packets is undetected.



Remote command:
SEARch:TRIGger:MPHY:ERRor:UNKNown on page 1577

Length Error ← Errors
Searches for frames that violate the length according to the specification.



Remote command:
SEARch:TRIGger:MPHY:ERRor:LENGth on page 1577

12.11.5.2 M-PHY Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

The columns in the search result table are the same as in the decoding table, see M-PHY Decode Results.

Remote commands:

- SEARch:RESult:MPHY:FCOunt? on page 1577
- SEARch:RESult:MPHY:FRAMe<m>:CCOunt? on page 1578
- SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:DATA? on page 1578
- SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:TYPE? on page 1578
- SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:STARt? on page 1579
- SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:STOP? on page 1579
- SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:STATe? on page 1579
- SEARch:RESult:MPHY:FRAMe<m>:DATA? on page 1580
- SEARch:RESult:MPHY:FRAMe<m>:FTYPe? on page 1580
- SEARch:RESult:MPHY:FRAMe<m>:STARt? on page 1582
- SEARch:RESult:MPHY:FRAMe<m>:STATe? on page 1581
- SEARch:RESult:MPHY:FRAMe<m>:STOP? on page 1582

12.11.5.3 Searching M-PHY

Prerequisite: A serial bus is configured for the M-PHY signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press [Search] or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 411.
3. Tap "Source" and select the serial bus that is set to M-PHY (e.g. "SerBus1").
4. Specify the search criteria according to Chapter 12.11.5.1, "M-PHY Search Setup", on page 671.
5. To acquire a waveform, press [Single].

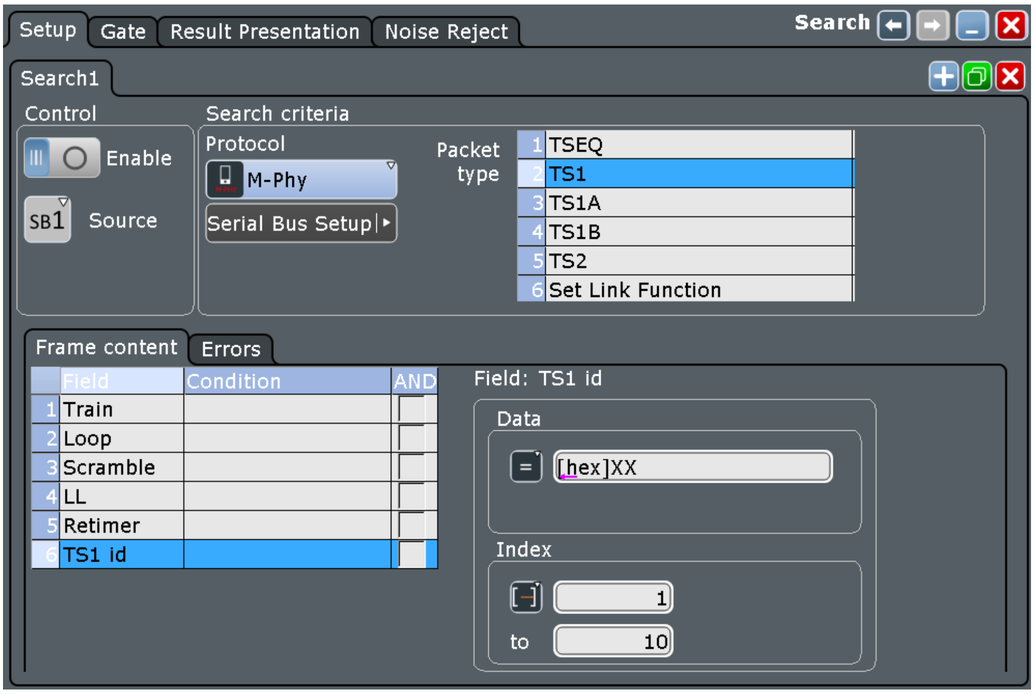
   The R&S RTP performs an M-PHY decode according to the thresholds and protocol settings of the associated serial bus source.
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTP displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and navigate the search results, see also "To display search zoom windows" on page 417 and "Navigating search results" on page 398.

12.11.5.4 SSIC Search Setup

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for M-PHY and "M-PHY" > "Variant" = "SSIC"



Search criteria

Use the "Search criteria" dialog to define the search type. If you search for frame content, define the frame type in which data is to be searched.

You can define individual search parameters for the fields of the selected frame in the table below the "Search criteria". To specify these parameters, select a field in the table and define the data and/or index operators and values, or the bit state.

For a description of how to set the search conditions, see Chapter 12.11.3.3, "SSIC Trigger Settings", on page 664.

Remote command:
`SEARch:TRIGger:MPHY:SSIC:ERRor<m>:ENABle` on page 1588
`SEARch:TRIGger:MPHY:SSIC:FIENable` on page 1589
`SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:ENABle` on page 1588
`SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:BIT` on page 1590
`SEARch:TRIGger:MPHY:SSIC:BIT` on page 1590
`SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DMAX` on page 1590
`SEARch:TRIGger:MPHY:SSIC:DMAX` on page 1590
`SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DMIN` on page 1591
`SEARch:TRIGger:MPHY:SSIC:DMIN` on page 1591
`SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DOPerator` on page 1591
`SEARch:TRIGger:MPHY:SSIC:DOPerator` on page 1591
`SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:ENABle` on page 1589
`SEARch:TRIGger:MPHY:SSIC:FRENable` on page 1588
`SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IMAX` on page 1592
`SEARch:TRIGger:MPHY:SSIC:IMAX` on page 1592
`SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IMIN` on page 1592
`SEARch:TRIGger:MPHY:SSIC:IMIN` on page 1592
`SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IOPerator` on page 1593
`SEARch:TRIGger:MPHY:SSIC:IOPerator` on page 1593

12.12 Custom: Manchester / NRZ (Option R&S RTP-K50)

R&S RTP-K50 is a firmware option that enables the R&S RTP to analyze customizable serial bus signals encoded by the following coding standards:

- Manchester
- Manchester II
- NRZ Clocked
- NRZ Unclocked

For analysis, signals encoded in any of these protocols can be triggered and decoded.

Due to the free format description, no search within the decoded events is available.

This chapter describes:

12.12.1 Custom: Manchester / NRZ Protocols

"Manchester" coding is a self-clocked coding scheme also known as phase-shift keying (or phase encoding, PE). It is used in protocols such as ProfiBus (IEC 61158), DALI (Digital Addressable Lighting Interface, IEC 60929 and IEC 62386), MVB (Multifunction Vehicle Bus, part of IEC 61375 for Train Communication Networks, TCN), and Ethernet 10BASE-T (10 Mbit/s, IEEE 802.3i). In terms of a logical Boolean operation, the Manchester value of each bit (as per G. E. Thomas) is the exclusive disjunction (XOR) of the original data value and the clock value. A "0" is expressed by a high-to-low transition, a "1" by a low-to-high transition. These transitions, which occur at the middle of each bit period, make the signal self-clocked.

"Manchester II" coding (as per IEEE 802.3) is represented by inverted Manchester values: a "0" is expressed by a low-to-high transition, a "1" by a high-to-low transition.

NRZ stands for "non-return-to-zero" coding: Typically a "1" is represented by a positive voltage and a "0" is represented by a negative voltage, with no "zero" voltage state. NRZ code requires only half the bandwidth of Manchester code, and it can either be clocked or unclocked. NRZ unclocked signals require a user-defined bit rate and gap time setting for triggering and decoding.

12.12.1.1 Special Features of Manchester Coding

In practical protocols, Manchester coding appears in many variations, often employing deliberate coding violations to encode special waveform features, such as unambiguous synchronization and termination patterns. To adapt to these specific Manchester implementations and handle ambiguous signals, the option R&S RTP-K50 for Custom Serial Bus uses a combination of automatic algorithms and user configurable parameters.

Quaternary Symbols

The software supports not just traditional binary symbols "0" and "1", but also arbitrary violation waveforms that use two additional symbols, yielding a total of four valid "quaternary bit" values. The two additional violation symbols are "H" (high) and "L" (low). Values of "H" correspond to a waveform lacking a transition in the center of the bit, with a physical high voltage state. Similarly, "L" violations also lack a center transition, but have a physical low voltage state. Most Manchester synchronization and termination conventions, even those containing violations, may be expressed as sequences of these four symbols. R&S RTP-K50 uses the quaternary notation to support Manchester patterns in the honeycomb display and to describe synchronization and termination patterns in the frame description table.

Idle Conditions

The state of the signal line in between messages is the idle condition. Manchester appears in practical standards with varying idle conditions: it can idle at the high, low, or middle voltage state. High and low idle states correspond to "biphase" Manchester, while the middle voltage (often ground) adds a third state to become "ternary" Manchester. Using ternary Manchester, option R&S RTP-K50 can usually establish the gaps between messages automatically. Using binary Manchester, the software has no way to automatically discriminate an idling bus from monotonic sequences of "H" or "L" violations. For these biphase situations, R&S RTP-K50 offers a "Gap Time" detection feature, which allows to distinguish long intervals of non-transitions between bus idling and sequences of violations. Other differences between biphase and ternary Manchester are managed automatically by the software, with no user input required.

Edge Conventions

Most Manchester encodings establish the beginning of the first bit by a first transition, hence an "overhead" edge. The center of the bit is then marked by a second transition, which is a "sampling" edge. Some Manchester implementations, however, sample the first bit on the first edge. The option R&S RTP-K50 attempts to automatically detect this situation. Unfortunately, it is possible to trick the algorithm with waveforms that contain many (legitimate) violations. In these situations, the user can force a "First Edge" or "Second Edge" convention for handling edges. Edge sampling according to the "First Edge" convention is more likely to appear in biphase Manchester, but the software also supports this setting for ternary Manchester situations.

Bit Rate

Typically, a single bit rate is clearly specified in Manchester protocols; however, some implementations use a variable bit rate. By default, R&S RTP-K50 automatically determines the bit rate with no user input required. However, there are fundamental ambiguities possible in Manchester, if the bitrate is unknown. In particular, sequences like "0000", "1111", "0101", "1010", and many situations involving "H" and "L" violations, cannot be decoded without a known bit rate. The situation becomes even less defined with eventual Manchester coding violations. In these situations, a fixed "Bit Rate" setting has to be provided by the user to bypass the software's estimation algorithm.

12.12.2 Custom: Manchester / NRZ Configuration

If you need information on how to get started with configuring the custom serial bus setup, see Chapter 12.12.2.5, "Configuring Custom Manchester / NRZ Signals", on page 707. Otherwise proceed with the configuration settings.

12.12.2.1 Custom: Manchester / NRZ Configuration Settings

Access: [Protocol] > "Decode" tab > "Protocol" = *Custom*

Make sure that the tab of the correct serial bus is selected on the left side.

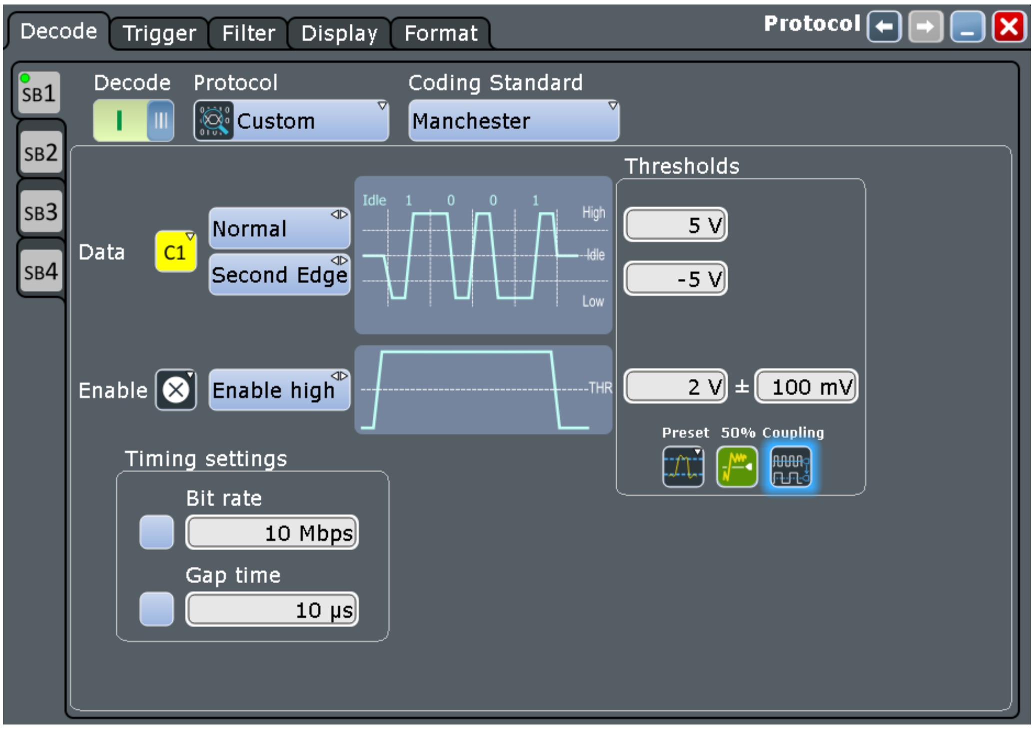


Figure 12-58: Coding standard selection in the serial bus protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Coding Standard
To define the coding of the custom serial bus to be analyzed, select one of the following standards:

"Manchester" Selects the coding standard Manchester.
Optional "Timing settings" are "Bit Rate" (default: disabled, 10 Mbit/s) and "Gap time" (default: disabled, 10 µs), as shown in Figure 12-58.

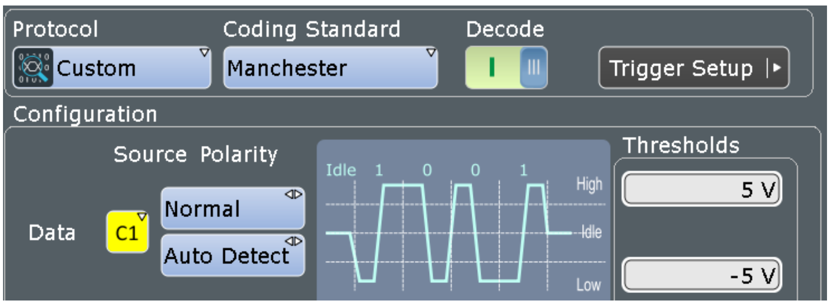


Figure 12-59: Custom serial bus coding configuration Manchester

"Manchester II" Selects the coding standard Manchester II, which is the inverted signal of the coding standard Manchester.
Optional "Timing settings" are "Bit Rate" (default: disabled, 10 Mbit/s) and "Gap time" (default: disabled, 10 µs), as shown in Figure 12-58.

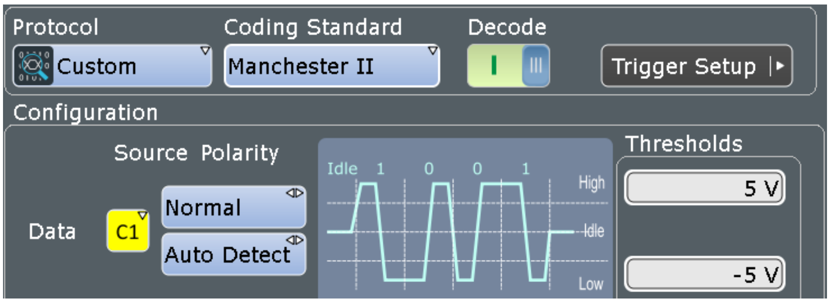


Figure 12-60: Custom serial bus coding configuration Manchester II

w

"NRZ Clocked" Selects the coding standard NRZ Clocked.
Optional "Timing settings" is "Gap time" (default: disabled, 10 µs), as shown in Figure 12-61.

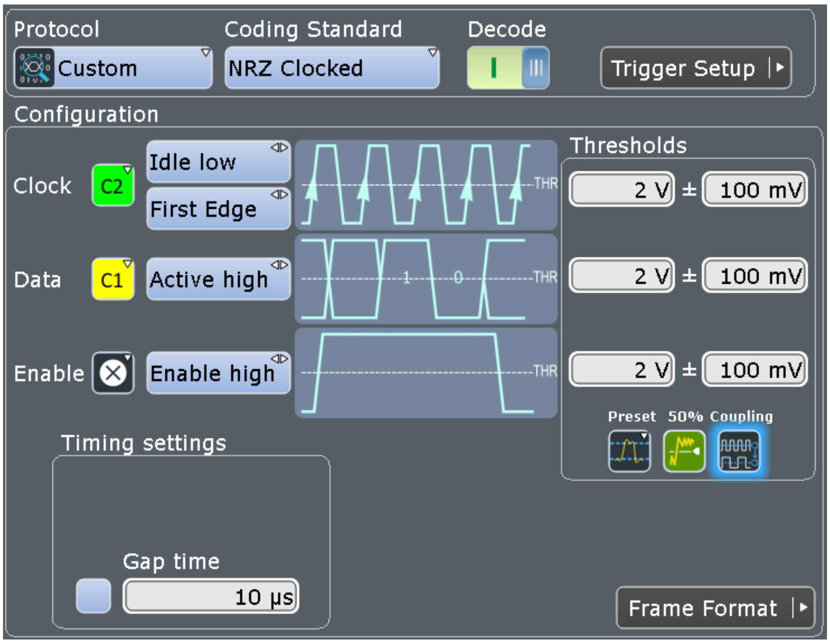


Figure 12-61: Custom serial bus coding configuration NRZ clocked

"NRZ Unclocked"
Selects the coding standard NRZ unclocked.
Obligatory "Timing settings" are "Bit Rate" (default 10 Mbit/s) and "Gap time" (default 10 µs), as shown in Figure 12-62.

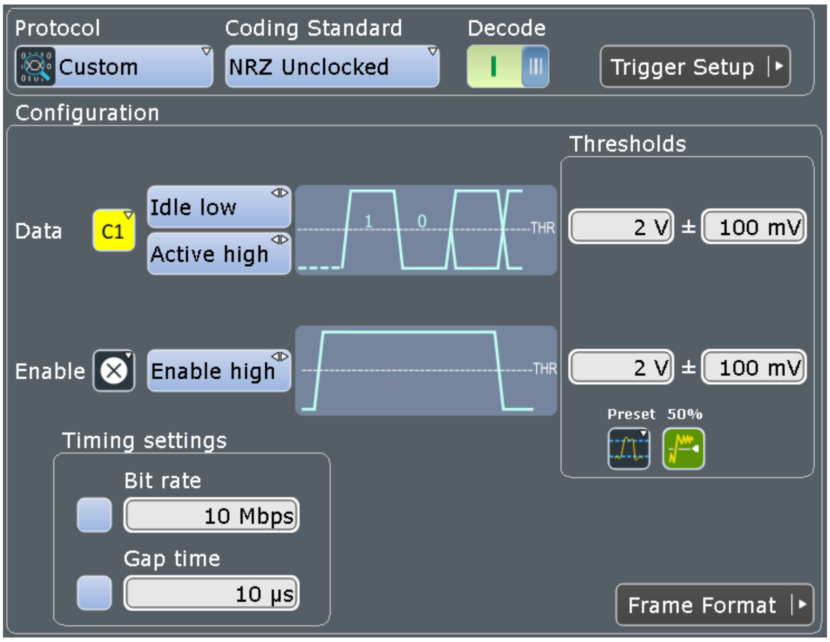


Figure 12-62: Custom serial bus coding configuration NRZ Unclocked

Remote command:
BUS<m>:CMSB:CODing on page 1595

Data Source
Defines the input source for the custom serial bus data signal.

The data source for Manchester and NRZ coding standards is selected separately, independent of each other. The data source is set to default upon switching the coding standard.

Permitted source selections are:
- For "Manchester"/ "Manchester II":
  – Decoding: the analog, mathematical, and reference channels
  – Triggering: the analog channels
- For "NRZ Clocked":
  – Decoding: the analog, mathematical, reference and digital channels
    Digital channels can be only used if MSO option R&S RTP-B1 is installed. Digital and analog channels cannot be used at the same time.
  – Triggering: the analog and digital channels
- For "NRZ Unclocked":
  – Decoding: the analog, mathematical, reference and digital channels
    Digital channels can be only used if MSO option R&S RTP-B1 is installed. Digital and analog channels cannot be used at the same time.
  – Triggering: the analog channels

Remote command:
BUS<m>:CMSB:MANChester:DATA on page 1595
BUS<m>:CMSB:NRZ:DATA on page 1598

Clock Source
Defines the source for the custom serial bus clock signal (only available for the coding standard "NRZ Clocked").

Permitted source selections are the analog, mathematical, reference and digital channels.

Digital channels can be only used if MSO option R&S RTP-B1 is installed. Digital and analog channels cannot be used at the same time.

For triggering on the serial bus, when the NRZ clocked coding standard is selected, analog or digital channel sources are required.

Remote command:
BUS<m>:CMSB:NRZ:CLCK on page 1598

Data Polarity (Manchester)
Defines the polarity of the custom serial bus data signal in Manchester coding standards. The available settings are "Normal" or "Inverted".

Remote command:
BUS<m>:CMSB:MANChester:POLarity on page 1595

Data Polarity (NRZ)
Defines the polarity of the custom serial bus data signal in NRZ coding standards. The available settings are:

"Active high"	The value "1" is represented by a voltage above the threshold.
"Active low"	The value "1" is represented by a voltage below the threshold.

Remote command:
BUS<m>:CMSB:NRZ:POLarity on page 1600

Data Idle Polarity (NRZ Unclocked)
Defines the idle polarity of the custom serial bus data signal (only available for the coding standard "NRZ Unclocked"). The available settings are:

"Idle low"	The base value of the clock is "0"; after an idle period, the data signal starts with a low-to-high transition.
"Idle high"	The base value of the clock is "1"; after an idle period, the data signal starts with a high-to-low transition.

Remote command:
BUS<m>:CMSB:NRZ:IDLPolarity on page 1598

Clock Polarity (NRZ Clocked)
Defines the polarity of the custom serial bus clock signal (only available for the coding standard "NRZ Clocked"). The available settings are:

"Idle low"	The base value of the clock is "0".
"Idle high"	The base value of the clock is "1".

Remote command:
BUS<m>:CMSB:NRZ:CPOLarity on page 1599

Clock Phase (Manchester)
Defines the phase of the custom serial bus clock signal for the Manchester coding standards. The available settings are:

"Auto Detect" Lets the decoder automatically select the method ("First Edge" or "Second Edge") for detecting the clock phase.

"First Edge"
- At "Idle" = "low": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge.
- At "Idle" = "high": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge.

"Second Edge"
- At "Idle" = "low": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge.
- At "Idle" = "high": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge.

Note: The requirement to specify "First Edge" or "Second Edge" (or let the decoder decide) has the following background: In Manchester coding, an edge is always a transition from high to low (0) or from low to high (1). However, if the signal comes from the idle state, this implies that right before the first valid edge, there is always an overhead transition from idle to high or from idle to low. Some standards may regard this as a valid transition. To avoid a potentially ambiguous situation, a decision has to be made if the first edge is indeed only some overhead transition - or a transition that needs to be sampled. For more details on edge conditions, see Chapter 12.12.1.1, "Special Features of Manchester Coding", on page 686.

Remote command:
BUS<m>:CMSB:MANChester:CPHase on page 1597

Clock Phase (NRZ Clocked)
Defines the phase of the custom serial bus clock signal for the coding standard "NRZ Clocked", depending on "Clock Polarity". The available settings are:

"First Edge"
- At "Idle" = "low": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge
- At "Idle" = "high": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge

"Second Edge"
- At "Idle" = "low": data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge
- At "Idle" = "high": data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge

Remote command:
BUS<m>:CMSB:NRZ:CPHase on page 1599

Enable Source (NRZ)
Defines the input source for the custom serial bus enable signal.

If an input is chosen, signals are only decoded when this channel is in the enabled state. This allows you to mark a time when the signal on the selected source is active and when not.

Permitted source selections are the analog, mathematical, and reference channels.

When the serial bus trigger has been selected, the only permitted source selections are the analog channels "C1" – "C4", which are required for triggering.

Math and Reference channels can only be selected, if no serial bus trigger is selected.

Remote command:
`BUS<m>:CMSB:NRZ:ENBLe` on page 1600

Enable Polarity (NRZ)
Selects whether the transmitted enable signal is active when the voltage is below the Thresholds ("Enable low") or higher than it ("Enable high").

Remote command:
`BUS<m>:CMSB:NRZ:ENAPolarity` on page 1600

Thresholds
Sets the threshold value for the digitization of each signal line and the hysteresis. If the signal voltage on the line is higher than the upper threshold, the signal state is high. Otherwise, if the signal voltage is below the lower threshold, the signal state is considered low.

- Manchester coding standards use 3-state signals with an upper and a lower voltage threshold in the range of -25 V to +25 V. A low-to-high transition requires the signal to exceed the upper threshold; a high-to-low transition requires the signal to fall below the lower threshold.
  You can set a hysteresis only for the enable signal.
- NRZ coding standards use a single voltage threshold for the data line. The value is in the range of -25 V to +25 V. It is entered into the middle of three available threshold input fields, or into the upper available threshold input field for NRZ Unclocked.
  You can set the hysteresis for all signal lines.
- In the NRZ Clocked coding standard, there is an additional clock voltage threshold available. This value in the range of -25 V to +25 V is entered into the upper threshold input field.
  You can set the hysteresis for the clock line.

There are four ways to set the threshold:

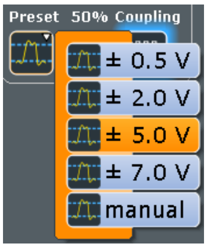
"Threshold" Directly sets the threshold values.

- For Manchester: upper threshold in the upper field, lower threshold in the lower field.
- For NRZ Clocked: clock threshold in the upper field, data threshold in the middle field and enable threshold in the lower field. Hysteresis values are in the right column.
- For NRZ Unclocked: data threshold in the upper field and enable threshold in the lower field. Hysteresis values are in the right column.

Remote command:
BUS<m>:CMSB:MANChester:THReshold:HIGH on page 1596
BUS<m>:CMSB:MANChester:THReshold:LOW on page 1596
BUS<m>:CMSB:NRZ:THReshold:CLCK on page 1601
BUS<m>:CMSB:NRZ:THReshold:DATA on page 1601
BUS<m>:CMSB:NRZ:THReshold:ENBLe on page 1602
BUS<m>:CMSB:NRZ:HYSTeresis:CLCK on page 1601
BUS<m>:CMSB:NRZ:HYSTeresis:DATA on page 1601
BUS<m>:CMSB:NRZ:HYSTeresis:ENBLe on page 1602

"Preset"

- Either sets individual voltages by selecting "manual",
- or sets the voltages to one out of various pre-defined levels.



When any non-predefined threshold is set, the "Preset" status automatically changes to "manual" (without affecting anything else).

Remote command:
BUS<m>:CMSB:MANChester:THReshold:PRESet on page 1596
BUS<m>:CMSB:NRZ:THReshold:PRESet on page 1602

"50%" Executes a measurement of reference levels and sets the thresholds to the middle reference voltage level of the measured amplitude.

Remote command:
BUS<m>:SETReflevels on page 1299

"Coupling"
- For Manchester and Manchester II coding, the upper and lower thresholds are coupled to voltage values with the same magnitude but opposite sign (positive for the upper threshold and negative for the lower threshold). However, if the upper threshold is set to a negative voltage or the lower threshold is set to a positive voltage, coupling is disabled, and the other voltage (the one that was not actively set) is automatically adjusted, to avoid an upper threshold below the lower one, or a lower threshold above the upper one.
- For NRZ Clocked coding, the clock and data threshold values are coupled to the same voltage.

Remote command:
`BUS<m>:CMSB:MANChester:THReshold:COUPling` on page 1597
`BUS<m>:CMSB:NRZ:THReshold:COUPling` on page 1603

Enable Bit Rate
Enables the bit rate settings for the coding standards "Manchester" and "Manchester II". This setting is not available for "NRZ Clocked", but always enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard.

Remote command:
`BUS<m>:CMSB:BITRate:ENABle` on page 1603

Bit Rate
Defines the transmission speed setting for the data signal. A bit rate definition is optional for the coding standards "Manchester" and "Manchester II", not available for "NRZ Clocked", but obligatory for "NRZ Unclocked" (and also for triggering on signals in any coding standard). Default bit rate is 10 Mbps, permitted bit rates range from 300 bps to 2 Gbps.

For more details on the bit rate, see Chapter 12.12.1.1, "Special Features of Manchester Coding", on page 686.

Remote command:
`BUS<m>:CMSB:BITRate:VALue` on page 1603

Enable Gap Time
Enables the gap time settings (always enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard).

Remote command:
`BUS<m>:CMSB:GAPTime:ENABle` on page 1604

Gap time
Specifies a minimum gap time (idle time or timeout) between two frames. A gap time definition is optional for the coding standards "Manchester", "Manchester II" and "NRZ Clocked", but obligatory for "NRZ Unclocked" (and also for triggering on signals in any coding standard). Default gap time is 10 µs, permitted gap times range from 1 ns to 1 s.

For more details on gap time and idle conditions, see Chapter 12.12.1.1, "Special Features of Manchester Coding", on page 686.

Remote command:
`BUS<m>:CMSB:GAPTime:VALue` on page 1604

12.12.2.2 Frame Format Configuration

This dialog enables you to describe the generic format and logical structure of typical protocols by creating customized frame descriptions of various structures and lengths.

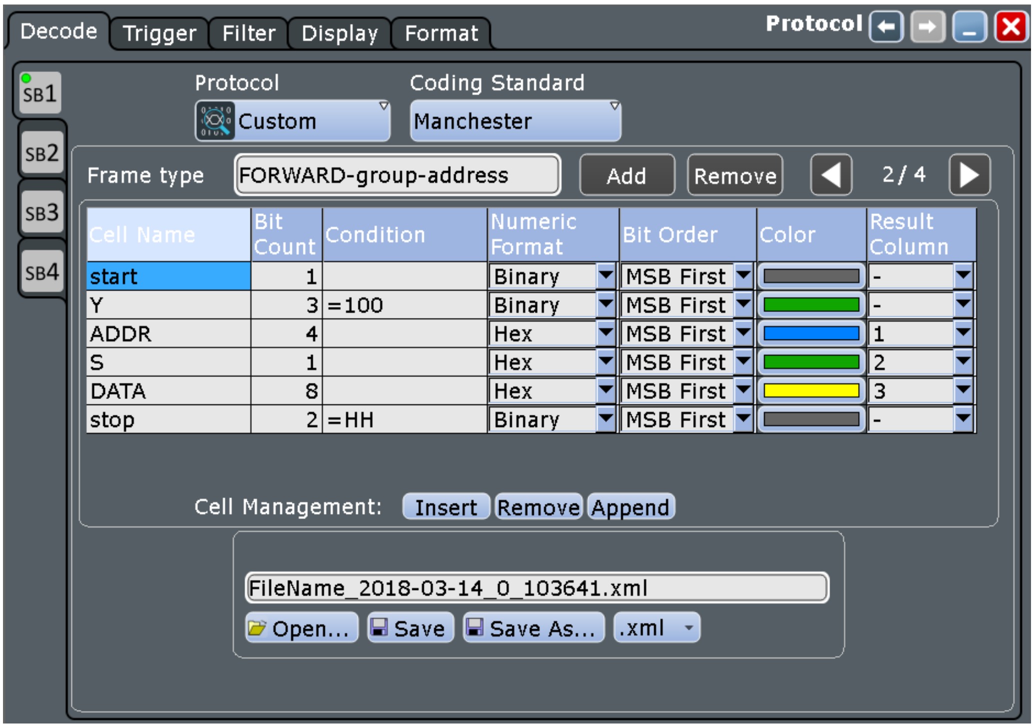


Figure 12-63: Example of a custom "DALI" frame format description (frame 2 of 4)

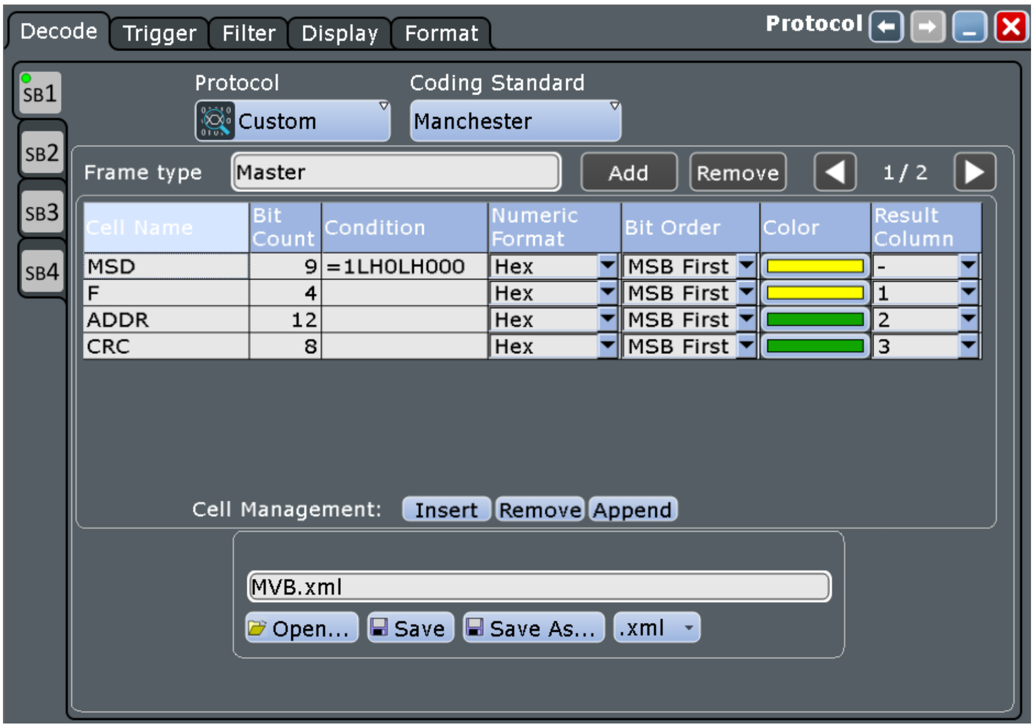


Figure 12-64: Example of a custom "MVB" frame format description (frame 1 of 2)

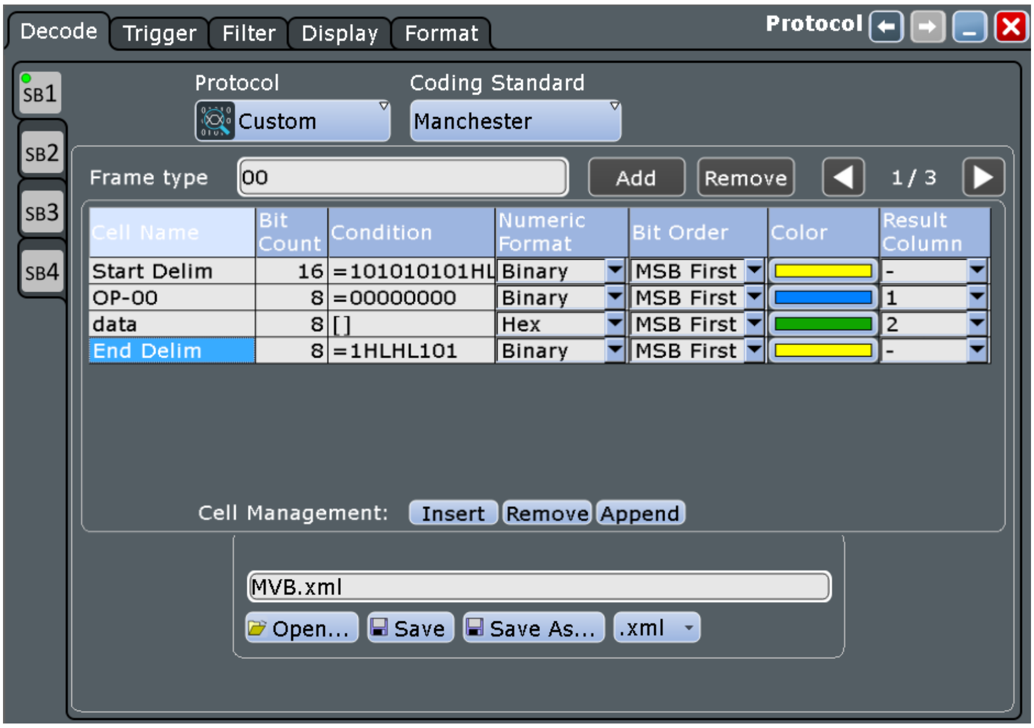


Figure 12-65: Example of a custom "ProfiBus Voltage" frame format description (frame 1 of 3)

Figure 12-66: Example of a crc, parity and block frame conditions

Frames

A frame format description (or *frame description*, for short) is represented by one "page" in this dialog. It can be created by clicking on "Add". If one or several frame descriptions already exist, the new frame description is then created at the end of the frame format description list (or *frame list*, for short). Describing a frame format requires assigning it a name as well as creating Cells and specifying cell descriptions. The number of frame descriptions is limited to 100. The frame description that is on display can be deleted from the frame list by clicking "Remove".

The "Frame type" string is intended for the user to label the frame description (typically according to the specifications of the applicable protocol standard). For example, MDIO (Management Data Input/Output) specifies the frames "READ", "WRITE", "ADDRESS". The example for the DALI protocol in Figure 12-63 has been created with the frame type "*FORWARD-group-address*".

The frame format dialog also provides the features "Open", "Save", "Save As...", and "Explore...", to store created sets of frame descriptions into files (in ".xml" format), or load existing files of this kind.

The frame identification is executed top down, in the order in which the frame formats are described in the frame list. This provides a hierarchy of criteria for identifying frames.

In case it is required to change the order of previously created frame descriptions, it is recommended to save the set of frame descriptions, and then edit the XML file with any suitable editor. This also allows - with due care - additional editing features, if required.

If no user-defined frame description should be suitable to identify an incoming frame, per default such a "missed" frame is reproduced as "Undescribed Bits" in the honeycomb display, as in the example in Figure 12-73. These bits are not shown in the results table.

Note: There may be frame descriptions that positively identifies each kind of frame, e.g. if no **equal** operator (see Condition) is defined for any of the cells. This "catches" every frame, even if there are other frame descriptions to follow in the frame list. Therefore, if a "catch all" frame description is used, it should be placed at the end of the frame list, or it overwrites any subsequent frame description. However, instead of using a "catch all" frame description, the built-in "undescribed bits" display as mentioned above may be the better approach to create frame descriptions.

It is in the responsibility of the user to define unambiguous settings for each frame type. For a description of these conditions in `XML` file format and the required `XML` grammar and syntax, see Chapter 12.12.2.3, "XML Syntax", on page 705.

Remote command:

`BUS<m>:CMSB:FRAMe<n>:TYPE` on page 1605

`BUS<m>:CMSB:ADDFrame` on page 1604

`BUS<m>:CMSB:CLR` on page 1605

`BUS<m>:CMSB:FCOunt?` on page 1604

Cells

A cell description (which is represented by one row in one frame description) can be created at any position of a frame description (see Frames) by clicking on "Insert". This brings up a new cell description in the active frame description, on top of the selected position. The "Append" button adds a cell description at the end of a frame description, below the lowest existing cell description. The number of cell descriptions is not limited. The "Remove" button deletes a selected cell description from the active frame description.

The cell result can be selected to be displayed in a specified result column of the decode table (see "Result Column" on page 704).

Note: The cell descriptions must be sequential and complete. No gaps are allowed, since the Bit Count is used to calculate the start position of the next cell.

A frame type is identified when all user-defined cell conditions are met, which can be regarded as related by the Boolean AND operator.

This can also locate a synchronization pattern, specified by the equal operator in the Condition cell. For example, if you define a "Preamble" cell with the condition *=FFFFFFFF*, the decoder scans the data for this pattern, and then synchronize to it.

The cells in a frame are described by:

- Cell Name
- Bit Count
- Condition
- Numeric Format
- Bit Order
- Color
- Result Column

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CCOunt?` on page 1605
`BUS<m>:CMSB:FRAMe<n>:APPend` on page 1605

Cell Name

The strings in the column title describe cell names. They do not have to be unique; cell names are just for user support.

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:NAME` on page 1606

Bit Count

This crucial information defines the length of the cell and - based on the previous cells - also the cell end position and the next cell start position within a frame.

If, for a given bit count, the Condition value is longer, it is truncated. If the condition value is shorter, it is padded with 0. Both truncation and padding occur at the left side of the condition value.

Examples:

- if "Condition" is "=111000" and the Bit Order is "MSB", then
  - if "Bit Count" is 4, the truncated condition is "=1000"
  - if "Bit Count" is 8, the padded condition is "=00111000"
- if "Condition" is "=111000" and the bit order is "LSB" (accordingly, the condition in "MSB" format would be "=000111"), then
  - if "Bit Count" is 4, the truncated condition is "=1000" for LSB and "=0001" for MSB
  - if "Bit Count" is 8, the padded condition is "=00111000" for LSB and "=00011100" for MSB

These examples are true for the Numeric Format specified as "binary".

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITCount` on page 1606

Condition

This text field is used to apply various conditions and functionalities for a cell. Among others, it can be used to identify mandatory values (such as CRC checksum or ID) that help to identify a frame. The numeric format and bit order of the condition value has to match up with what is defined in the fields Numeric Format and Bit Order.

The following conditions are implemented:

"= (equal)"

The **equal** operator (represented by the "=" sign) defines a pattern for the cell to match. Valid condition entries are characters that match the cell's defined Numeric Format, Bit Order, and Bit Count. In binary format, for example, valid characters are "1", "0", "H" (high), and "L" (low).

Three cases have to be distinguished (cases A, B1, and B2), depending on the presence of a Variable Length Array: [] in the same frame description:

- **Case A**: If there is **no** "Variable Length Array" cell, then each cell marked with the equal operator acts as a key to identify a frame type. Only if all these cells match up with the expected value, the frame type is identified.
- **Cases B1 and B2**: If there **is** a "Variable Length Array" cell, then the equal operator has two different functionalities, depending on the position of the equal-operator cell within the frame description:
  - **B1**: If the cell is located *anywhere before* the "Variable Length Array" cell, the condition acts as a key to identify a frame type (as in case A).
  - **B2**: If the cell is located *immediately after* the "Variable Length Array" cell, the condition acts as an array delimiter.
    (Note: If the cell, which is marked with the equal operator, is located after the "Variable Length Array" cell, but *not* immediately after it, the decode result is unpredictable.)

Typically, Manchester protocols use code violations for synchronization. The states "H" and "L", supported by the equal operator in binary Numeric Format, mark that a transition is expected at this bit, but only a high or low signal is found.
Examples for the MVB protocol:
Master - Delimiter: "*=1LH0LH000*" (also shown in Figure 12-64)
Slave - Delimiter: "*=0000LH0LH*"
For more details on the violation symbols "H" and "L", see Chapter 12.12.1.1, "Special Features of Manchester Coding", on page 686.
Also, the length of the pattern must correspond to the bit field length (or the results are unpredictable).

"[ ] (array)"

The **array** operator (represented by the "[" and "]" bracket signs) defines the number of permissible repetitions of the cell.

Example: Fixed-Length Array: [n]

The length parameter "n" is a decimal number > 0, which determines that the cell is repeated n times within the frame. If, for example, the Bit Count is 8, then the array operator identifies n cells of 8-bit length, and present them in the results table and honeycomb display with the specified name and color.

A fixed-length array is treated the same as other cells, except the real length of such an array is n · bit count.

Example: Variable Length Array: []

This array operator with empty "[" and "]" bracket signs does not determine a fixed size array. The cell could be repeated any number of times, including 0 times. As a result, the cell and the frame are of unspecified length (a situation that covers typical use cases). For an example, see Figure 12-65.

The length of the frame is then determined by the end of frame condition, which can be an operator or a gap.

For processing reasons, only one (1) variable length array is supported in a frame, and a delimiter must follow immediately in the next cell after it. This is required to enable the software to correctly terminate the array. Otherwise the bits could not be assigned correctly, and it would not be possible to determine where a repletion starts and where it ends. With an end of frame condition, the software can calculate the length of one single array within a frame. But if there were more arrays, it would be impossible to know which array was how long.

The variable length array can also be the last cell of a frame. In this case, no delimiter is required. If decoded successfully, the detailed view in the results table shows the elements of the array. If the cell name of the array is "Data", then the detail view of result table displays the elements with an array index as "Data: 1", "Data: 2" ... etc.

If the variable length array cell is selected in the Result Column, it is shown as array [n], where n is the actual size detected in the waveform.

As an exception to the rule, it is permissible to assign the variable length array to consecutive fields. In this case, the fields are treated as a structure which is repeated. For example, if two consecutive fields are defined as A[] and B[], the decoder creates a sequence of ABABAB until the end condition has been detected.

Note: It is possible to combine check functions in a dynamic array. In the example above, if B[] is extended by odd(1), with "1" being the index of A[], then B checks the parity for each index of A.

"crc5usb(n-m)" The **crc 5-bit** operator performs a check for a 5\-bit CRC function using the polynomial as defined by the USB standard. n and m define the index range for the CRC check.
For example, if the CRC shall check fields 1 to 4, the function shall be written "crc5usb(1-5)".
If the range of the CRC check includes an array, all elements in the array is included in the CRC check.
If the check fails, the CRC field is marked as "CRC error" in the result details and displayed in the color red in the honeycomb display. The frame that contains the field is marked in the same way, except if another higher priority error is found within this frame.

"odd(n-m), even(n-m)" The "**parity**" operators perform checks on odd or even parity in the given index range n to m.
Odd parity is fulfilled if the count of "1" bits in the range including the parity bit is odd. Even parity is fulfilled if the count of "1" bits in the range including the parity bit is even.
If the parity check fails, the parity field is marked as "CRC error" in the result details and displayed in red color in the honeycomb display. The frame that contains the field is marked in the same way, except if another higher priority error is found within this frame.

"{Block}" The **block** operator is represented by the "{" and "}" bracket signs. Consecutive fields marked with "{Block}" and using the same name are displayed in the honeycomb display as a consecutive packet of name "Block" with the first field's color. This feature is a visual effect in the honeycomb only.

Remote command:
`BUS<m>:CMSB:FRAMe<n>:CELL<o>:CONDition` on page 1606

Numeric Format
Selects from the following numeric data formats for the Condition value:
- Decimal
- Hexadecimal
- Octal
- Binary

The following rules apply:
- If the condition value contains at least one "H", "h", "L", "l", "X", "x", and the remaining characters only contain "1" and/or "0", the numeric format is automatically interpreted as binary, regardless of its definition.
- The wild-card characters "x" and "X" are only supported in binary format.
  Examples: If the numeric format is set to be "HEX", then:
  – "=1HL111000" is valid (read as binary)
  – "=0x10101" is valid (read as binary, the "x" is interpreted here as a wild card)
  – "=1010" is valid (read as HEX, with a total of 16 bits)
  – "=0x5A" is valid (read as HEX "5A", since "0x" is a valid HEX prefix; nevertheless, it is recommended to enter "5A" instead)
  – "=5X12" is invalid
  – "=1H33" is invalid

Remote command:
BUS<m>:CMSB:FRAMe<n>:CELL<o>:FORMat on page 1607

Bit Order

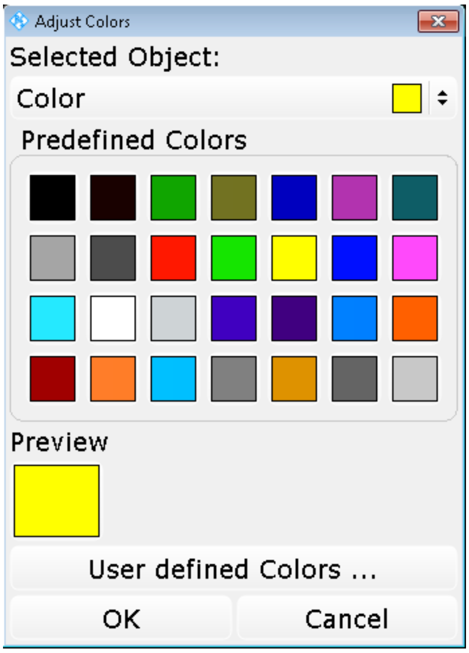
This defines, in which order the bits of a cell's Condition value are evaluated: either the most significant bit (MSB) or the least significant bit (LSB) first. Since the bit order is considered for the interpretation of the condition, you should specify MSB or LSB correctly.

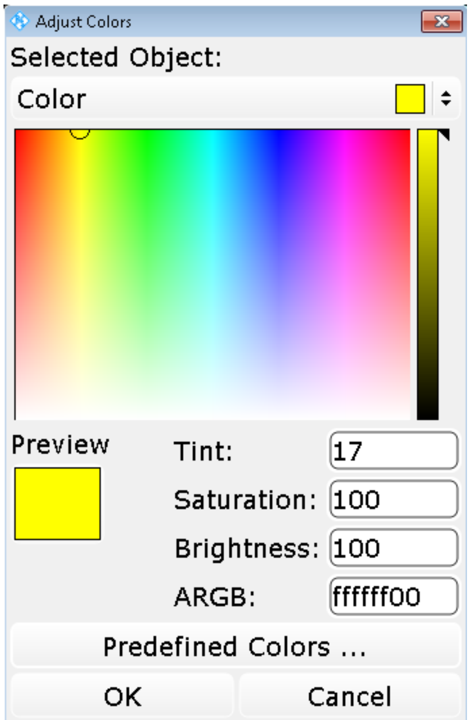
Remote command:
BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITorder on page 1607

Color

Opens a dialog to select the color representation of different cells in the honeycomb display. Assigning user-selected colors helps to interpret the decode results more easily.

In the "Adjust Colors" dialog, you can either select one of the predefined colors or define a new one.





Remote command:
BUS<m>:CMSB:FRAMe<n>:CELL<o>:CRGB on page 1607

Result Column

This determines which cells shall be displayed in which result columns of the decode table. No index means that the result is not displayed. The decode table supports three result columns, which have to be unique for each frame type. For different frame types, though, the user can define different result columns, to display unrelated information.

Note: To see more than the three selected results, bring up a full list of the states and values of all cells by activating "Show details" in the decode table dialog. For an example, see Figure 12-72.

Remote command:

`BUS<m>:CMSB:FRAMe<n>:CELL<o>:CLMN` on page 1608

Open or Save XML File

For efficient working and for convenient exchange of frame descriptions, they can both be loaded ("Open") or saved ("Save" / "Save As...") in `XML` file format. "Explore..." opens the `SaveXML` folder, which is the "Default Path" for saving frame descriptions.

Remote command:

`BUS<m>:CMSB:LOAD` on page 1608

`BUS<m>:CMSB:SAVE` on page 1609

12.12.2.3 XML Syntax

This chapter explains the required grammar and syntax of `XML` files, which contain frame descriptions and can be loaded or saved. Below is a typical example of such an `XML` file:

```xml
<?xml version="1.0" encoding="utf-8"?>
<FrameDescription xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" Version="1" xsi:noNamespaceSchemaLocation=".\Schema\FrameDescription.xsd">
  <Frame Type="00">
    <Format Name="Start Delim" BitCount="16" Condition="=101010101HL" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
    <Format Name="OP-00" BitCount="8" Condition="=00000000" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="0080ff" Column="1"/>
    <Format Name="data" BitCount="8" Condition="[]" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="10a500" Column="2"/>
    <Format Name="End Delim" BitCount="8" Condition="=1HLHL101" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
  </Frame>
  <Frame Type="01">
    <Format Name="Start Delim" BitCount="16" Condition="=101010101HL" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
    <Format Name="OP-01" BitCount="8" Condition="=00000001" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="0080ff" Column="1"/>
    <Format Name="data" BitCount="8" Condition="[]" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="10a500" Column="2"/>
    <Format Name="CRC" BitCount="16" Condition="" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="ff808080" Column="2"/>
    <Format Name="End Delim" BitCount="8" Condition="=1HLHL101" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00"" Column="-"/>
  </Frame>    <Frame Type="ff">
    <Format Name="Start Delim" BitCount="16" Condition="=101010101HL" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
    <Format Name="OP-ff" BitCount="8" Condition="=11111111" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="0080ff" Column="1"/>
    <Format Name="data" BitCount="8" Condition="[]" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="ffb233af" Column="2"/>
    <Format Name="CRC" BitCount="16" Condition="" NumericFormat="Hex" BitOrder="MSB First" ColorRGB="ff808080" Column="2"/>
    <Format Name="End Delim" BitCount="8" Condition="=1HLHL101" NumericFormat="Binary" BitOrder="MSB First" ColorRGB="ffff00" Column="-"/>
  </Frame>
</FrameDescription>
```

Figure 12-67: Example of XML file syntax with three custom frame format descriptions

The first out of three `XML` frames in Figure 12-67 is interpreted by the software in the following way:

Cell Name	Bit Count	Condition	Numeric Format	Bit Order	Color	Result Column
Start Delim	16	=101010101HL	Binary	MSB First		-
OP-00	8	=00000000	Binary	MSB First		1
data	8	[]	Hex	MSB First		2
End Delim	8	=1HLHL101	Binary	MSB First		-

Figure 12-68: Example of one custom frame format description for the MVB protocol

For the context of this figure, see Chapter 12.12.2.2, "Frame Format Configuration", on page 696.

A suitable `XML` file as shown in Figure 12-67 is composed as follows:

Header:

```
<?xml version="1.0" encoding="utf-8"?>
```

Root Element:

```
<FrameDescription xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
 Version="1" xsi:noNamespaceSchemaLocation=".\Schema\FrameDescription.xsd">
```

The root element contains the "Frame Description" attributes, including a link for the file`FrameDescription.xsd`. This schema file, which is installed in the system, enables the software to validate an `XML` file before opening it.

Frame:

A frame description must include between *0* and *n* tags of the following kind:

```
<Frame> </Frame>
```

Frame Type:

Each "<Frame>" tag requires a "Type" attribute in string format:

```
<Frame Type = "string">
```

Tells the software the name of each frame, as described in section Frame Type.

Format:

Each frame must include between *1* and *n* tags of the following kind:

```
<Format> </Format>
```

Together with the attributes, this is written in short form, as in Figure 12-67:

```
<Format attribute... attribute... attribute... />
```

The format describes the fields (or Cells) in each frame. It can have the following attributes:

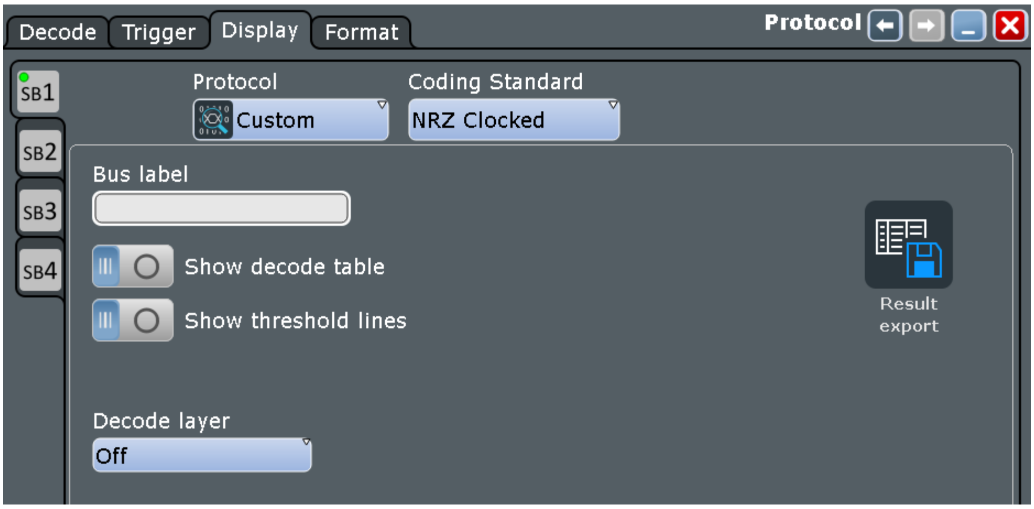
- Name (optional) is the "Cell Name", in string format.
- BitCount specifies the length of bits, in numerical format.
- Condition (optional) identifies the bit pattern to match, in string format.
- NumericFormat allows the following choices:
  – "Decimal"
  – "Hex"
  – "Octal"
  – "Binary"
- BitOrder allows two alternatives:
  – "MSB First" (most significant bit first)
  – "LSB First" (least significant bit first)
- Color allows you to set a user defined ARGB hexadecimal color value.
- Column is the "Result Column" with four options:
  – "-" (none, which is the default)

– "1"
– "2"
– "3"

12.12.2.4 Custom: Manchester / NRZ Display Settings

Access: [Protocol] > "Decode" tab > "Protocol = Custom" > "Display" tab

To enhance the decode possibilities of the custom serial protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 465.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final"	...
"Edges"	...
"Binary"	...
"Synchronization"	...

12.12.2.5 Configuring Custom Manchester / NRZ Signals

For configuration, assign the lines to the input channels, define the active states and the logical thresholds, and specify frame format descriptions.

Serial bus setup

1. Press the [Protocol] key on the front panel.

2. At the left-hand side, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Select the "Decode" tab.
4. Tap "Protocol" and select the protocol: "Custom".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Switch to the "Trigger" tab, tap "Source" and select "Serial bus".

   This prevents using digital waveforms (Math and Reference) as channel signals.

   Note: For triggering on a custom serial bus, analog input channels are required.
7. Switch back to the "Decode" tab.
8. Tap "Coding Standard" and select the coding ("Manchester", "Manchester II", "NRZ Clocked", or "NRZ Unclocked") you want to set up.
9. Select the polarity and phase of the data signal (and potentially of the clock signal).
10. Set the logical thresholds. See "Thresholds" on page 693.
11. Still in the protocol "Decode" tab, select "Decode" to activate the decode functionality.
12. Switch to the "Format" tab and open or create frame format descriptions.

For details on configuration settings, see Chapter 12.12.2.1, "Custom: Manchester / NRZ Configuration Settings", on page 687.

12.12.3 Custom: Manchester / NRZ Trigger

If you need information on how to get started with triggering on Custom serial bus signals, see Chapter 12.12.3.2, "Triggering on Custom Manchester / NRZ Serial Bus", on page 713. Otherwise proceed with the Custom serial bus trigger settings.

12.12.3.1 Custom: Manchester / NRZ Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = Custom"

In this section, all trigger settings are described. Their availability on the instrument depends on the selected coding standard and trigger type. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

You can adjust the "Gap time" and "Bit rate" also in the "Trigger" tab if necessary.

For a list of supported trigger conditions, refer to the data sheet.

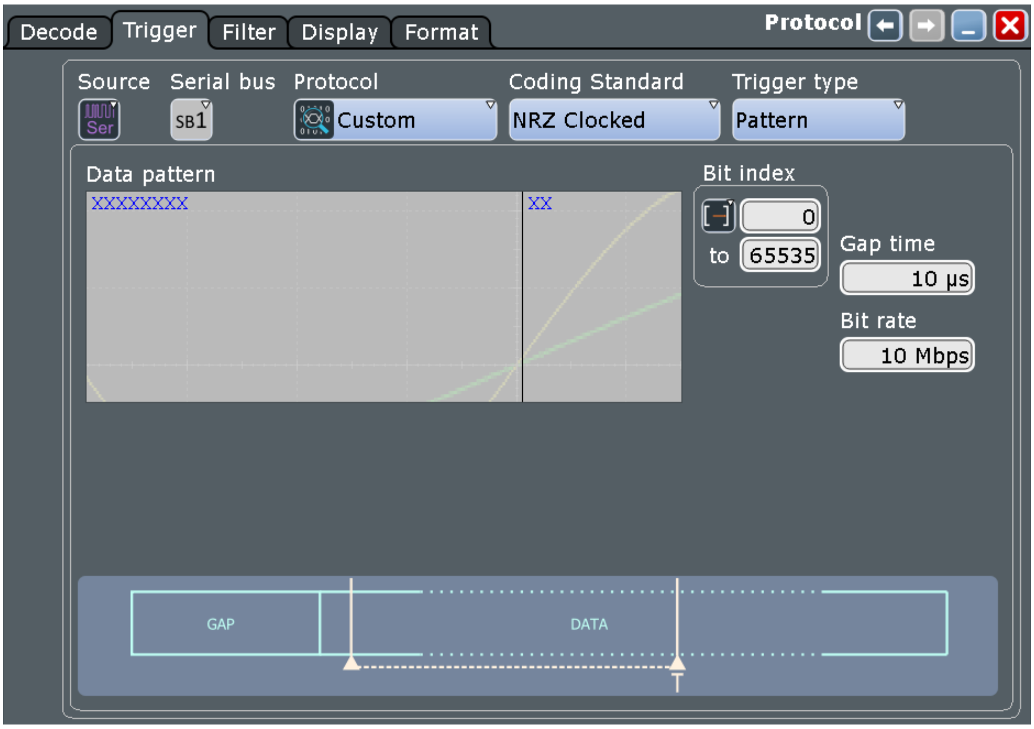


Figure 12-69: Custom serial bus trigger settings, here with NRZ Clocked and Pattern selected

Make sure that:

- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Type

Defines the trigger type for custom serial bus analysis. The available trigger types are "Frame Start", "Pattern" and "Advanced".

Remote command:
`TRIGger<m>:CMSB:TYPE` on page 1610

Frame Start ← Type

For Manchester and NRZ Clocked coding standards, the frame start trigger is set to the end of the gap time. The start of frame (SOF) condition is the first bit after the gap (timeout).

For the NRZ Unclocked coding standard, the trigger requires that the signal contains a start bit. The frame start trigger follows the gap time and is set to the end of the start bit.

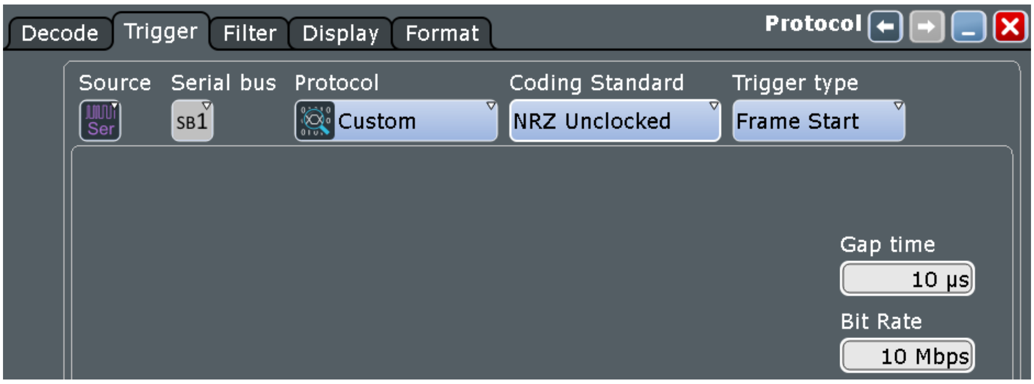


Figure 12-70: Custom serial bus: setting the trigger to frame start

Pattern ← Type

Specifies the pattern match conditions for a payload data check. The trigger is set to the first occurrence of a matching data bit pattern (which can be freely specified), starting after the minimum gap time, and after the detected start of the data frame. The trigger instant is after the last bit of the specified data pattern.

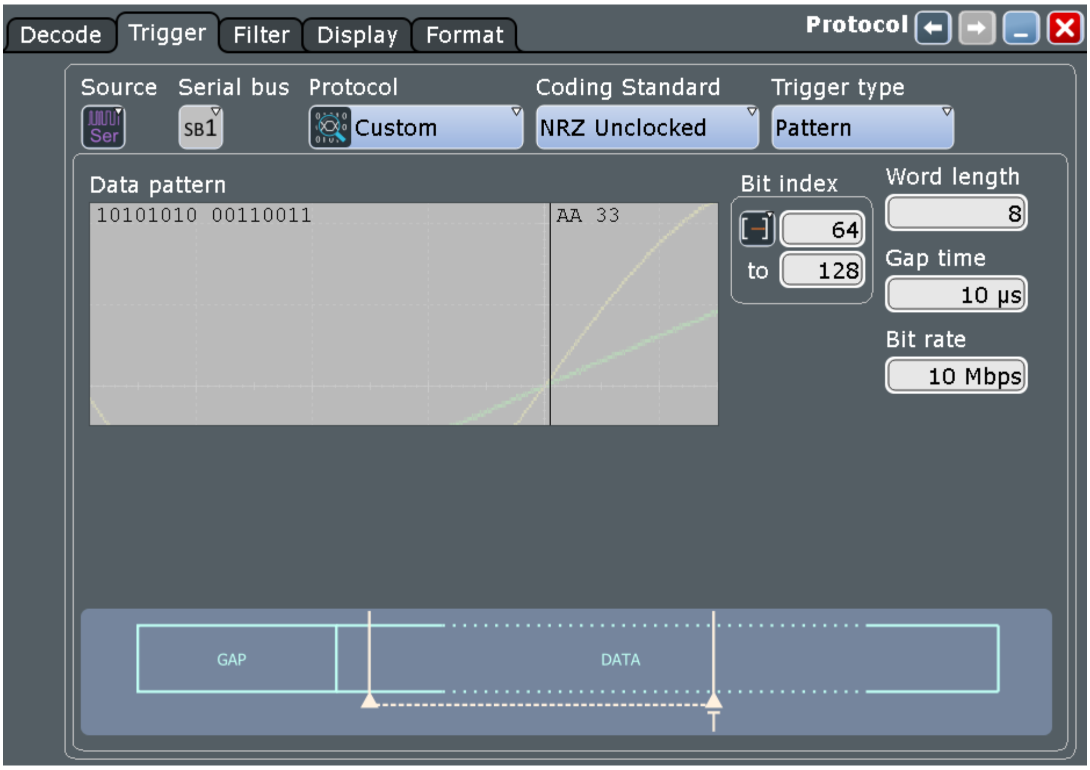


Figure 12-71: Custom serial bus: setting the pattern trigger, here for coding standard NRZ Unclocked

"Data Pattern" Specifies the data pattern that is to be found and triggered. The pattern can be entered in binary or hexadecimal format, maximum pattern length is 256 binary characters or 64 hexadecimal characters.

"Bit index operator" Sets the operator ("Equal", "Greater or equal", or "In range") to set a specific bit index (data position).

"Bit index" Sets the bit index (data position), or the start value of a bit index range. Default bit index value is 0, permitted values range from 0 to 65535.

"Bit index to" Sets the end value of a bit index range (data position range). Available only, if the "Bit index operator" is set to "In range". Default bit index end value is 65535, permitted values range from 0 to 65535.

"Word Length" Sets the number of bits in an NRZ Unclocked word (hence, the size of the data frame). Default word length is 8 bits, permitted lengths range from 0 bits to 31 bits .

Note: The NRZ Unclocked coding standard requires a signal that contains both a start bit and a stop bit:

- The start bit should be opposite in polarity to the idle state of the signal, and it is the first transition detected following the gap time.
- The stop bit should be the same polarity of the idle state, and it is the last bit in a data frame.

The end of the stop bit and the detection of the next frame's start bit constitutes the maximum gap time.

In order for the trigger to operate correctly, **you have to specify** the correct word length in the trigger menu. The trigger then counts the number of bits it decodes, and when the count matches the word length, the next bit is treated as the stop bit.

"Gap Time" Sets the minimum gap time for synchronization. The trigger is set to a position after the gap time, when the other trigger conditions are met. Default gap time is 10 µs, permitted gap times range from 1 ns to 1 s.

"Bit Rate" Sets the transmission speed for the data signal. Default bit rate is 10 Mbps, permitted bit rates range from 300 bps to 50 Mbps.

Remote command:
`TRIGger<m>:CMSB:PATTern` on page 1610
`TRIGger<m>:CMSB:ICONdition` on page 1610
`TRIGger<m>:CMSB:IMIN` on page 1611
`TRIGger<m>:CMSB:IMAX` on page 1611
`BUS<m>:CMSB:GAPTime:VALue` on page 1604
`TRIGger<m>:CMSB:NRZ:WRDLength` on page 1611

Advanced
Trigger on various frame types, fields in the frames, and data patterns.

Which settings are available, depends on what you have defined in the "Format" tab. For more information, see Chapter 12.12.2.2, "Frame Format Configuration", on page 696.

You can further refine the trigger criteria, selecting which frames you want to select for the triggering and what conditions their field values must fulfill.

Error types: Item name, Enable ← Advanced
The table lists the error types you can trigger on. Select the required errors in the "Enable" column. Available are "CRC" error and "Parity" error.

Remote command:
`TRIGger<m>:CMSB:ADVanced:ERENable` on page 1614
`TRIGger<m>:CMSB:ADVanced:ERRor<n>:ENABle` on page 1614

Frame type ← Advanced
Selects the frame type for the custom bus trigger analysis.

You can define individual checking parameters for the fields listed in the "Trigger type dependent settings".

To specify these parameters, select a field from this list and define the data and/or index operators and values, or the bit state.

The trigger instant is the last criterion that is fulfilled.

Remote command:
`TRIGger<m>:CMSB:ADVanced:FRAMe<n>:ENABle` on page 1611

Field name / Condition / Enable ← Advanced
This table lists the field numbers and names in the selected frame together with a summary of the user settings of checking conditions for each field and a checkbox to enable the checking.

Select a field in the table to specify the checking conditions for this field in the "Data", "BitState" and/or "Index" dialog (whichever applies). The condition is only applied, and the "Condition" is only shown in the table, if "Enable" is checked.

Remote command:
`TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:ENABle` on page 1612
`TRIGger<m>:CMSB:ADVanced:FIENable` on page 1612

BitState ← Advanced
Defines the bit state to be checked for the selected field. Permitted bit states are "1", "0" or "X" (do not care).

Remote command:
`TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:BIT` on page 1612
`TRIGger<m>:CMSB:ADVanced:BIT` on page 1612

Data ← Advanced
Defines for the selected field, how a data check is executed.

"Condition"	Defining specific data or a data range requires to set the operator to one of the following conditions: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.
"Min"	Specifies data or sets the start value of a data range.
"Max"	Sets the end value of a data range, if "Condition" is set to "In range" or "Out of range".

Remote command:
`TRIGger<m>:CMSB:ADVanced:DMAX` on page 1613
`TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:DMAX` on page 1613
`TRIGger<m>:CMSB:ADVanced:DMIN` on page 1613
`TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:DMIN` on page 1613

`TRIGger<m>:CMSB:ADVanced:DOPerator` on page 1613
`TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:DOPerator` on page 1613

Index ← Advanced

Defines for the selected field, how an index check is executed.

"Condition" Defining a specific index or an index range requires to set the operator to one of the following conditions: equal, in range.

"Min" Specifies the index or sets the start value of an index range.

"Max" Sets the end value of an index range, if "Condition" is set to "In range".

Remote command:
`TRIGger<m>:CMSB:ADVanced:IMAX` on page 1614
`TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:IMAX` on page 1614
`TRIGger<m>:CMSB:ADVanced:IMIN` on page 1615
`TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:IMIN` on page 1615
`TRIGger<m>:CMSB:ADVanced:IOPerator` on page 1615
`TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:IOPerator` on page 1615

12.12.3.2 Triggering on Custom Manchester / NRZ Serial Bus

Prerequisite: A bus is configured for the custom serial bus signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Select the serial bus that is set to Custom.
5. Tap "Type" and select the trigger type to be used for custom serial bus protocol analysis.
6. Depending on the selected custom serial bus coding standard, more setup conditions have to be specified.

For information on how to proceed with the configuration settings, see Chapter 12.12.3.1, "Custom: Manchester / NRZ Trigger Settings", on page 708.

12.12.4 Custom Filter

With the filter function you can display only selected events in the acquired data. Only one single filter can be enabled on the protocol at a time.

12.12.4.1 Custom Filter Settings

Access: [Protocol] > "Protocol = Custom" > "Filter" tab

Filter
Enables filtering on a custom serial bus.

Remote command:
BUS<m>:CMSB:FILTer:ENABle on page 1617

Frame type
Selects the frame type for the custom bus filtering.

You can define individual checking parameters for the fields listed in the "Trigger type dependent settings".

To specify these parameters, select a field from this list and define the data and/or index operators and values, or the bit state.

Remote command:
BUS<m>:CMSB:FILTer:FRAMe<n>:ENABle on page 1618

Error types: Item name, Enable
The table lists the error types you can filter on. Select the required errors in the "Enable" column. Available are "CRC" error and "Parity" error.

Remote command:
BUS<m>:CMSB:FILTer:ERRor<n>:ENABle on page 1618

Field name / Condition / Enable
This table lists the field numbers and names in the selected frame together with a summary of the user settings of checking conditions for each field and a checkbox to enable the checking.

Select a field in the table to specify the checking conditions for this field in the "Data", "BitState" and/or "Index" dialog (whichever applies). The condition is only applied, and the "Condition" is only shown in the table, if "Enable" is checked.

Remote command:
BUS<m>:CMSB:FILTer:FIENable on page 1618

Bit State
Defines the bit state to be checked for the selected field. Permitted bit states are "1", "0" or "X" (do not care).

Remote command:
BUS<m>:CMSB:FILTer:BIT on page 1616

Data
Defines for the selected field, how a data check is executed.

"Condition" Defining specific data or a data range requires to set the operator to one of the following conditions: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies data or sets the start value of a data range.

"Max" Sets the end value of a data range, if "Condition" is set to "In range" or "Out of range".

Remote command:
BUS<m>:CMSB:FILTer:DMAX on page 1616
BUS<m>:CMSB:FILTer:DMIN on page 1616
BUS<m>:CMSB:FILTer:DOPerator on page 1617

Index
Defines for the selected field, how an index check is executed.

This function is avalible only for array fields, see "Condition" on page 700.

"Condition"	Defining a specific index or an index range requires to set the operator to one of the following conditions: equal, in range.
"Min"	Specifies the index or sets the start value of an index range.
"Max"	Sets the end value of an index range, if "Condition" is set to "In range".

Remote command:
BUS<m>:CMSB:FILTer:IMAX on page 1619
BUS<m>:CMSB:FILTer:IMIN on page 1619
BUS<m>:CMSB:FILTer:IOPerator on page 1619

12.12.5 Custom: Manchester / NRZ Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Configuration" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" (and optionally "Show threshold lines"). For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the Frame Format Configuration settings.

The color-coding of the various Cells simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

The Frame Format Configuration defines the cells and their Color scheme. The honeycomb display applies these settings according to the following rules:

- Each frame is displayed as a honeycomb frame with the frame type being displayed (in the 1st line of the honeycomb).
- Each cell (row) is displayed as a honeycomb cell with the name in the header line (2nd line in the honeycomb) and the formatted content in the value line (3rd line in the honeycomb).

Since the frame description is customizable, the result table has to be mostly generic. Due to the limited width of the result table, you have to select a limited number of results to be displayed by specifying it in the frame description. For example, the three results defined in the Result Column). This leads to a detailed view that shows all information on a per-frame base.

Examples

The example in Figure 12-72 shows decoded and binary signals of a custom serial bus. The format information of DALI is being used to display as a result.

Note that activating "Show details" in the decode table provides a more detailed analysis of decode results for one selected frame. This brings up a list of the states and values of all cells of the selected frame (in binary format). With this details dialog open, you can still click on the basic decode table, to change the selection of the frame to be displayed in detail.

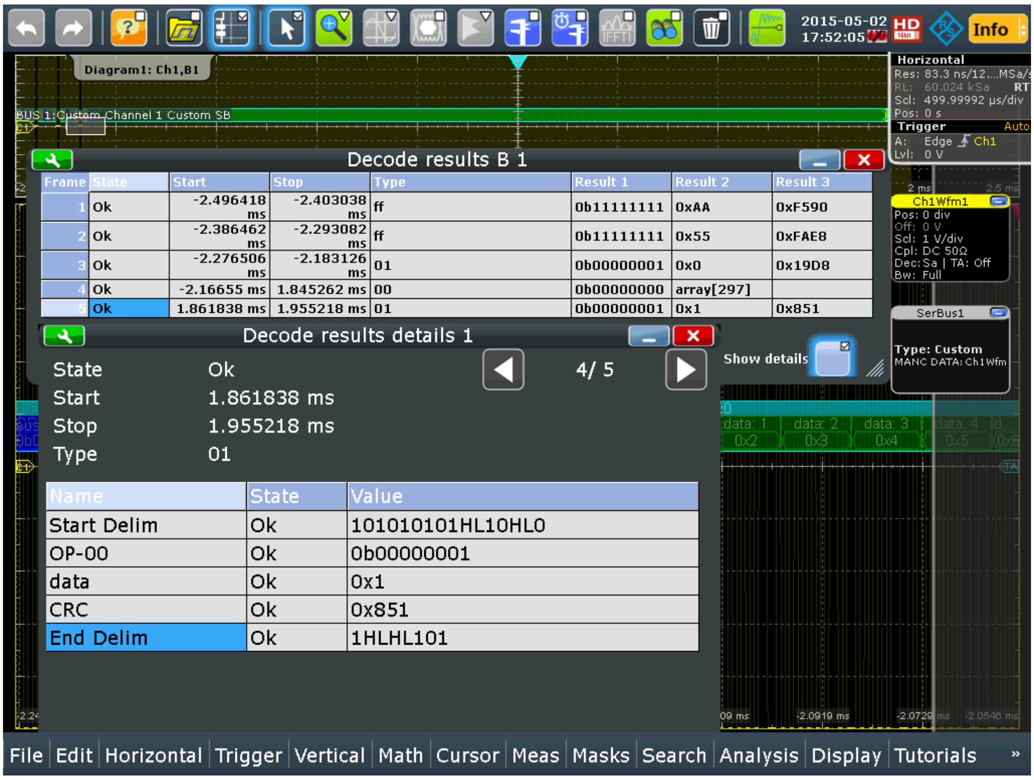


Figure 12-72: Decode results table and details of a "ProfiBus Voltage" protocol sample waveform

In the honeycomb display, Cells are shown in the Color that have been set in the Frame Format Configuration.

For example, the result "array[297]" in "Frame 4", "Result 2" of the decoding table in Figure 12-72, is the short name for an array field display, and the number in the brackets indicates the length of the array, as described in Variable Length Array: [].

The tables "Decode results" and "Decode results details" in Figure 12-72 are described in Table 12-13 and Table 12-14:

Table 12-13: Content of the "Decode results" table

Column	Description
State	Overall state of the frame: either OK or the relevant error condition (e.g. preamble, length)
Start	Start time of the frame

Column	Description
Stop	Stop time of the frame
Type	Frame type as specified in the "Frame type" field of the "Frame Format" description dialog (see "Frames" on page 698)
Result 1	1st cell content as specified in the Result Column of the "Frame Format" description dialog (see "Frames" on page 698)
Result 2	2nd cell content (as above)
Result 3	3rd cell content (as above)

Table 12-14: Content of the "Decode results details" table

Column	Description
Name	Name of the cell (e.g. Start, Data) as specified in the Cell Name column of the "Frame Format" description dialog (see "Frames" on page 698)
State	Overall state of the cell: either OK or the relevant error condition (e.g. length error)
Value	Data content of the cell (e.g. 0x1, 1000LL00L)

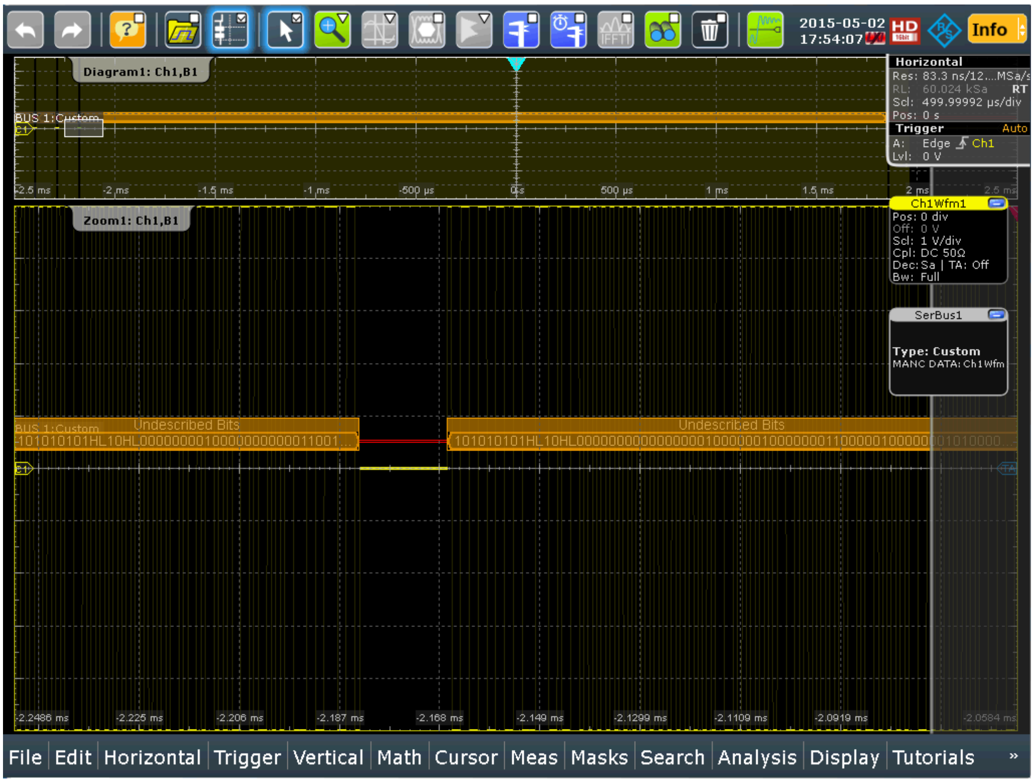


Figure 12-73: The function "Undescribed Bits" catches frames missed by the frame format descriptions

In the result presentation, frames labeled "Undescribed Bits" (as in Figure 12-73) show the bit patterns that are not matched by any user defined frame format description. Showing these raw bits is a functionality to help you develop suitable frame format descriptions.

The following commands are used to retrieve decode results in remote control. For an example on how to query the status of a frame, see Chapter 20.17.13.4, "Decode Results", on page 1620.

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:

- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.13.4, "Decode Results", on page 1620.

12.12.6 Search on Decoded Custom Manchester / NRZ Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 396.

If you need information on how to get started with searching custom serial bus data, see Chapter 12.12.6.3, "Searching Custom Serial Bus Data", on page 720. Otherwise proceed with the custom serial bus search setup.

12.12.6.1 Custom Manchester / NRZ Search Setup

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for "Custom"

Search criteria

Use the "Search criteria" dialog to define the event types to be searched. Available event types are "Frame" and "Error".

Individual search parameters, which do not depend on the coding standard and trigger settings of the custom serial bus, can be specified in the tabs below the "Search criteria" dialog.

Example:

Search dialog Custom decode shows an example of a custom decode search dialog setup. In this example, you search for "Frame Type 1" and "Frame Type 2". "Frame Type 1" has an additional condition for the range of "Data" and, since the "Data" field is an array, also to the range in the index. So this will only search, if the "Data" field in "Frame Type 1" has a value between 0x10 and 0x50 in the first 100 indexes.

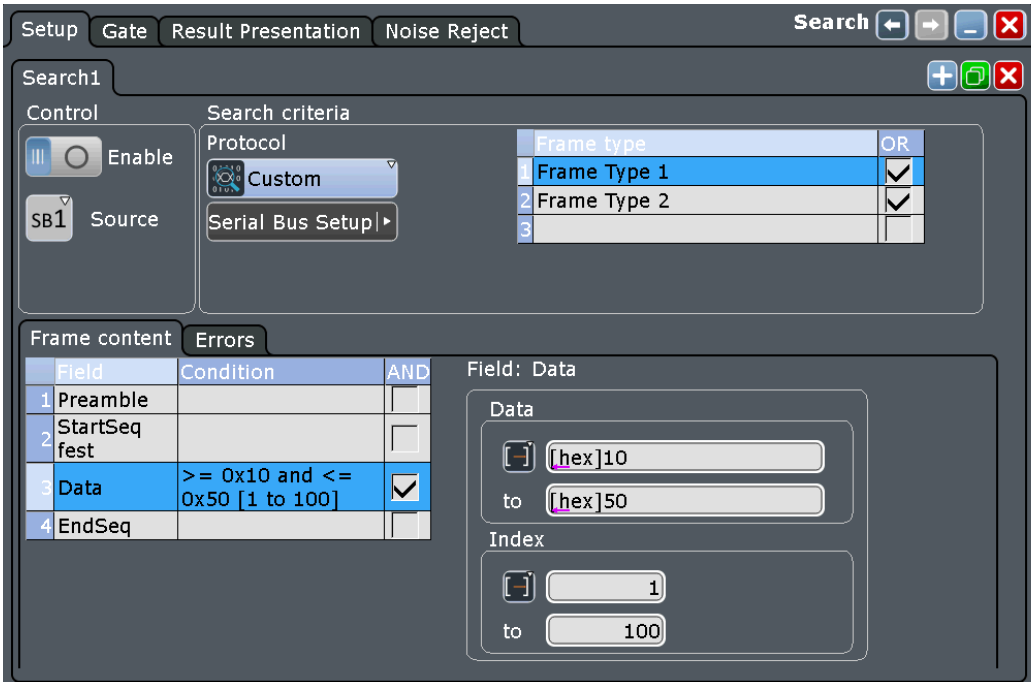


Figure 12-74: Search dialog Custom decode

Frame

Searches for four different frame conditions.

Remote command:

SEARch:TRIGger:CMSB:ERRor<m>:ENABle on page 1627

SEARch:TRIGger:CMSB:FIENable on page 1627

SEARch:TRIGger:CMSB:FRAMe<m>:ENABle on page 1629

SEARch:TRIGger:CMSB:FRENable on page 1627

SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:BIT on page 1627

SEARch:TRIGger:CMSB:BIT on page 1627

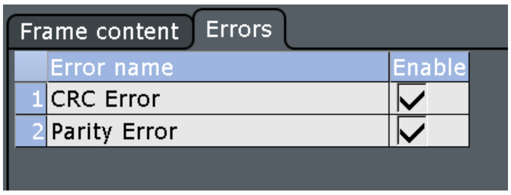
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DMAX on page 1628

SEARch:TRIGger:CMSB:DMAX on page 1628

SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DMIN on page 1628

SEARch:TRIGger:CMSB:DMIN on page 1628
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DOPerator on page 1629
SEARch:TRIGger:CMSB:DOPerator on page 1629
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IMAX on page 1630
SEARch:TRIGger:CMSB:IMAX on page 1630
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IMIN on page 1630
SEARch:TRIGger:CMSB:IMIN on page 1630
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IOPerator on page 1630
SEARch:TRIGger:CMSB:IOPerator on page 1630

Error Condition
Searches for two error conditions: "CRC Error" or "Parity Error".



Remote command:
SEARch:TRIGger:CMSB:ERRor<m>:ENABle on page 1627

12.12.6.2 Custom Serial Bus Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:
- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

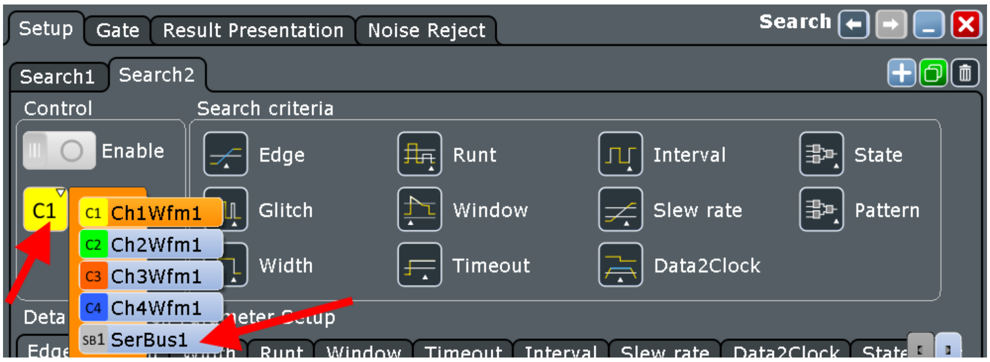
Remote commands are listed in Chapter 20.17.13.6, "Search Results", on page 1631

12.12.6.3 Searching Custom Serial Bus Data

Prerequisite: A serial bus is configured for the custom serial bus signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press [Search] or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 411.
3. Tap "Source" and select the serial bus that is set to "Custom" (e.g. "SB1", unless already selected).



The search dialog for custom serial bus protocol analysis is opened.

4. Specify search criteria according to Chapter 12.12.6.1, "Custom Manchester / NRZ Search Setup", on page 718.
5. To acquire a waveform, press [Single].

   The R&S RTP performs a custom serial bus decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTP displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 417 and "Navigating search results" on page 398.

12.13 8b/10b (Option R&S RTP-K52)

The 8b/10b coding scheme is used for high-speed serial data transmission, used by different standards, like fibre channel, PCIe, DVI and USB 3.0. Also the MIPI UniPro M-PHY interface in smartphones and display interfaces such as HDMI use 8b/10b encoding, as do base stations based on the Common Public Radio Interface (CPRI).

The R&S RTP can decode differential and single-ended 8b/10b signals. Furthermore, you can search the decoded data to isolate data contents and error states such as disparity violations.

You can also trigger on defined data contents and on error states.

12.13.1 The 8b/10b Code

The 8b10b is a code where an 8-bit parallel data input is mapped into a 10-bit output. This code achieves a DC-balance and bounded disparity and simultaneously allows a reasonable clock recovery.

In the coding scheme, the original 8 bits are split into two blocks, three most significant bits and five least significant bits, see Figure 12-75. After that the 3-bit block is encoded into 4 bits and the 5-bit block into 6 bits. The 4-bit and the 6-bit blocks are then combined into a 10-bit.

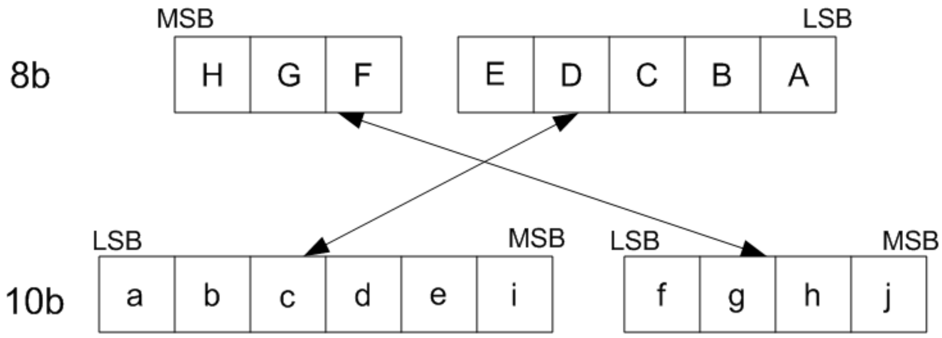


Figure 12-75: Coding scheme of the 8b/10b

The additional two bits I and j that join the stream are variable and ensure the running disparity.

There are two types of characters used in the 8b/10b coding, special characters Kx.y and data characters Dx.y. x denotes the decimal value of EDCBA and is within the range from 0 to 31. y denotes the decimal value of HGF and is within the range 0 to 7.

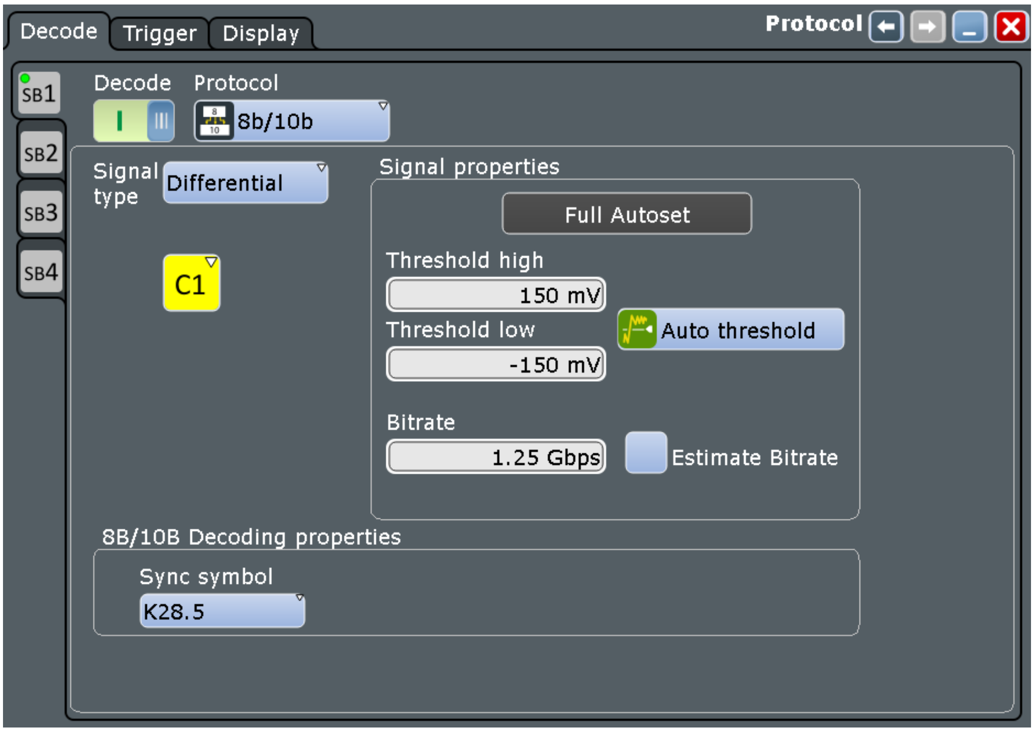
12.13.2 8b/10b Configuration

12.13.2.1 8b/10b Configuration Settings

Access: [Protocol] > "Decode" tab > "Protocol" = "8b/10b"

The full autoset function configures all settings at the tap of a button. You can readjust all settings manually.

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Signal type

Selects the signal type that is used for the decoding. You can choose between a differential and single-ended signal.

Remote command:

`BUS<m>:EBTB:TYPE` on page 1641

Source

Selects the source of the provided differential signal , if "Signal type" > "Differential".

Remote command:

`BUS<m>:EBTB:DIFFerential:SOURce` on page 1638

Source D+

Selects the source of the provided single ended signal, if "Signal type" > "Single ended".

Remote command:

`BUS<m>:EBTB:DPLus:SOURce` on page 1640

Source D-

Selects the source of the provided single ended signal , if "Signal type" > "Single ended".

Remote command:

`BUS<m>:EBTB:DMINus:SOURce` on page 1639

Full Autoset
Starts software algorithms for determining the signal threshold levels and bitrate.

Remote command:
BUS<m>:EBTBFAUToscale on page 1642

Threshold High
Sets the threshold high of the signal, if "Signal type" > "Differential".

Remote command:
BUS<m>:EBTB:DIFFerential:THRHigh on page 1638

Threshold Low
Sets the threshold low of the signal, if "Signal type" > "Differential".

Remote command:
BUS<m>:EBTB:DIFFerential:THRLow on page 1638

Threshold D+
Sets the high threshold (D+) of the signal, if "Signal type" > "Single ended".

Remote command:
BUS<m>:EBTB:DPLus:THReshold on page 1640

Threshold D-
Sets the high threshold (D-) of the signal, if "Signal type" > "Single ended".

Remote command:
BUS<m>:EBTB:DMINus:THReshold on page 1639

Auto Threshold
Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Bitrate
Sets the number of transmitted bits per second.

Remote command:
BUS<m>:EBTB:BITRate on page 1637

Estimated Bitrate
Displays the value of the If enabled, estimates a bitrate value.

Remote command:
BUS<m>:EBTB:EBTRate? on page 1638

Estimate Bitrate
Starts a software algorithm for the automatic determination of the bitrate.

Remote command:
BUS<m>:EBTBBITDetermi on page 1641

Sync Symbol
Selects the sync symbol, a control symbol used for low-level control functions. You can select one of the comma control symbols (K28.1, K28.5, K28.7) used for synchronization or you can enter a pattern.

Remote command:
`BUS<m>:EBTB:SYNC` on page 1641

Pattern
Selects a pattern that serves as a sync symbol.

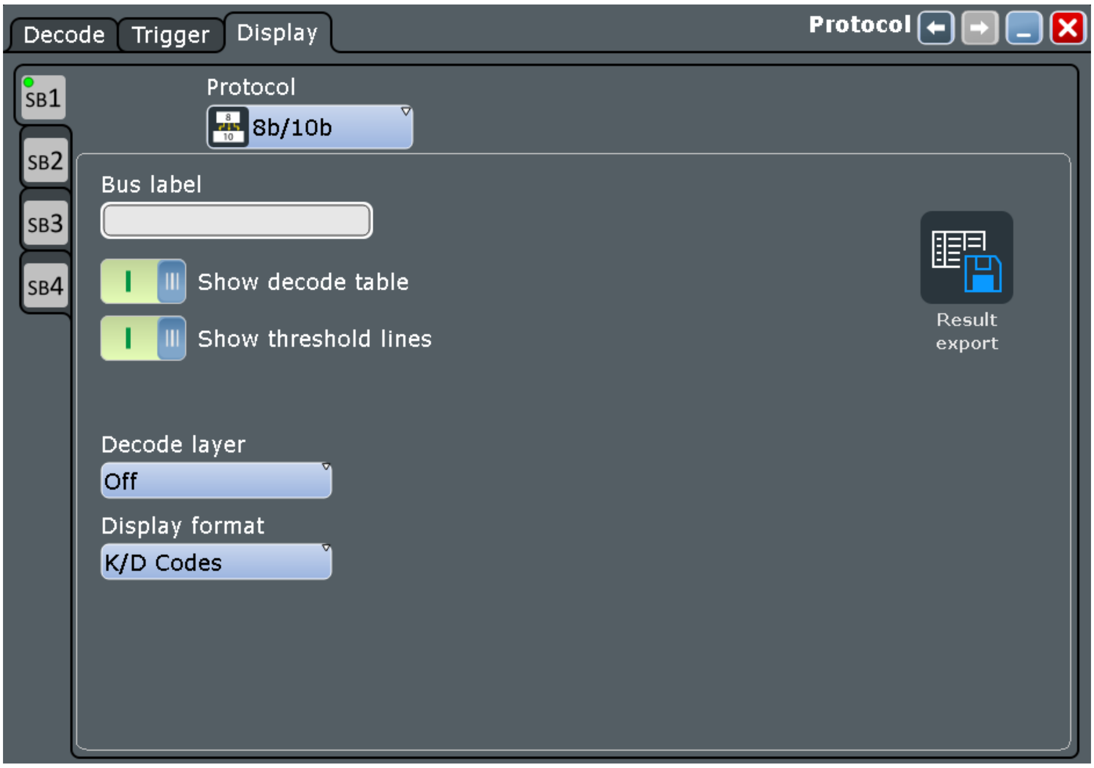
Remote command:
`BUS<m>:EBTB:FCSY` on page 1640

Second pattern
Enables a second pattern that serves as a sync symbol and sets its value.

Remote command:
`BUS<m>:EBTB:SCSY` on page 1641
`BUS<m>:EBTB:USCS` on page 1641

12.13.2.2 Display Settings

Access: [Protocol] > "Configuration" tab > "Protocol" = "8b/10b" > "Display" tab



Display Format
Selects the display format for the results of the display table.

Remote command:
BUS<m>:EBTB:DISF on page 1639

12.13.2.3 Configuring 8b/10b

For configuration, you assign the line to the input channel, set the threshold, the bitrate, and the sync symbol.

For details on configuration settings, see Chapter 12.13.2.1, "8b/10b Configuration Settings", on page 722.

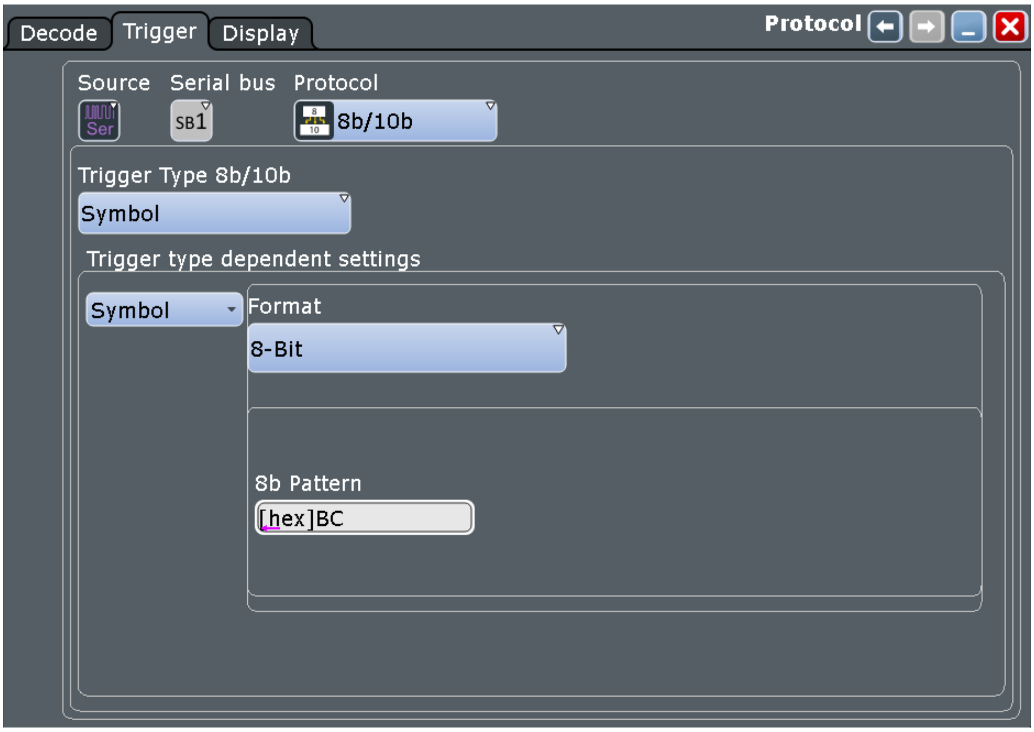
1. Press the [Protocol] key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Decode" tab.
4. Tap the "Protocol" button and select the protocol: "8b/10b".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Tap the "Signal type" button, and select the used signal type for the measurement.
7. Select the source for the signal type.
8. Tap "Full Autoset".
   Alternatively, you can determine the signal threshold using "Auto threshold" and the bitrate using "Bitrate Determination".
9. Check the threshold and bitrate settings. Adjust the values if necessary.
10. Select the "Sync symbol" to be used for decoding.
11. Enable "Decode".

12.13.3 8b/10b Trigger

If you need information on how to get started with triggering on 8b/10b signals, see Chapter 12.13.3.2, "Triggering on 8b/10b Data", on page 728. Otherwise proceed with the 8b/10b trigger settings.

12.13.3.1 8b/10b Trigger Setup

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = 8b/10b"



Trigger Type 8b/10b

Selects the type of condition to be triggered on.

"Symbol"	Triggers on a specified symbol or expression.
"Error Condition"	Triggers on the selected error conditions.

Remote command:
`TRIGger<m>:EBTB:TYPE` on page 1644

Disparity error

Triggers on disparity errors.

Remote command:
`TRIGger<m>:EBTB:DISParityerr` on page 1642

Glitching error

Triggers on glitch errors.

Remote command:
`TRIGger<m>:EBTB:GLITcherror` on page 1643

Unknown symbol error

Triggers on a symbol that is not defined by the 8b/10b.

Remote command:
`TRIGger<m>:EBTB:UNK` on page 1644

Symbol Type

Selects the symbol type to be triggered on.

"Symbol"	Sets a specific symbol.
"Expression"	Sets a series of symbols.

Remote command:
`TRIGger<m>:EBTB:SSTYpe` on page 1643

Format
Selects the format of the symbol to be triggered on, if "Symbol Type" > "Symbol".

Remote command:
`TRIGger<m>:EBTB:SYMFormat` on page 1644

K/D Codes Symbol
Selects the data character (Dx.y) or control character to be triggered on. You can specify the value of the data character to be searched for with "Dx Value" and "Dy Value".

Remote command:
`TRIGger<m>:EBTB:SYMType` on page 1644

Dx Value ← K/D Codes Symbol
Sets the x value of the data character Dx.y to be triggered on, if "K/D Codes Symbol" > "Dx.y".

Remote command:
`TRIGger<m>:EBTB:DX` on page 1642

Dy Value ← K/D Codes Symbol
Sets the y value of the data character Dx.y to be triggered on, if "K/D Codes Symbol" > "Dx.y".

Remote command:
`TRIGger<m>:EBTB:DY` on page 1643

8b Pattern
Sets the 8-bit pattern to be triggered on, if "Format" > "8-bit".

Remote command:
`TRIGger<m>:EBTB:EBPA` on page 1643

10b Pattern
Sets the 10-bit pattern to be searched for, if "Format" > "10-bit".

Remote command:
`TRIGger<m>:EBTB:TBPA` on page 1644

Expression
Defines the expression to be triggered on, if "Symbol Type" > "Expression".

Remote command:
`TRIGger<m>:EBTB:SYME` on page 1643

12.13.3.2 Triggering on 8b/10b Data

Prerequisite: A bus is configured for the 8b/10b signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Tap "Serial bus" and select the serial bus that is set to 8b/10b, e.g.:

   The "Protocol" selection is then automatically set to "8b/10b".
5. Tap "Trigger Type 8b/10b" and select the trigger type to be used for 8b/10b protocol analysis.
6. Depending on the selected trigger type, more setup conditions have to be specified.

For information on how to proceed with the configuration settings, see Chapter 12.13.3.1, "8b/10b Trigger Setup", on page 726.

12.13.4 8b/10b Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

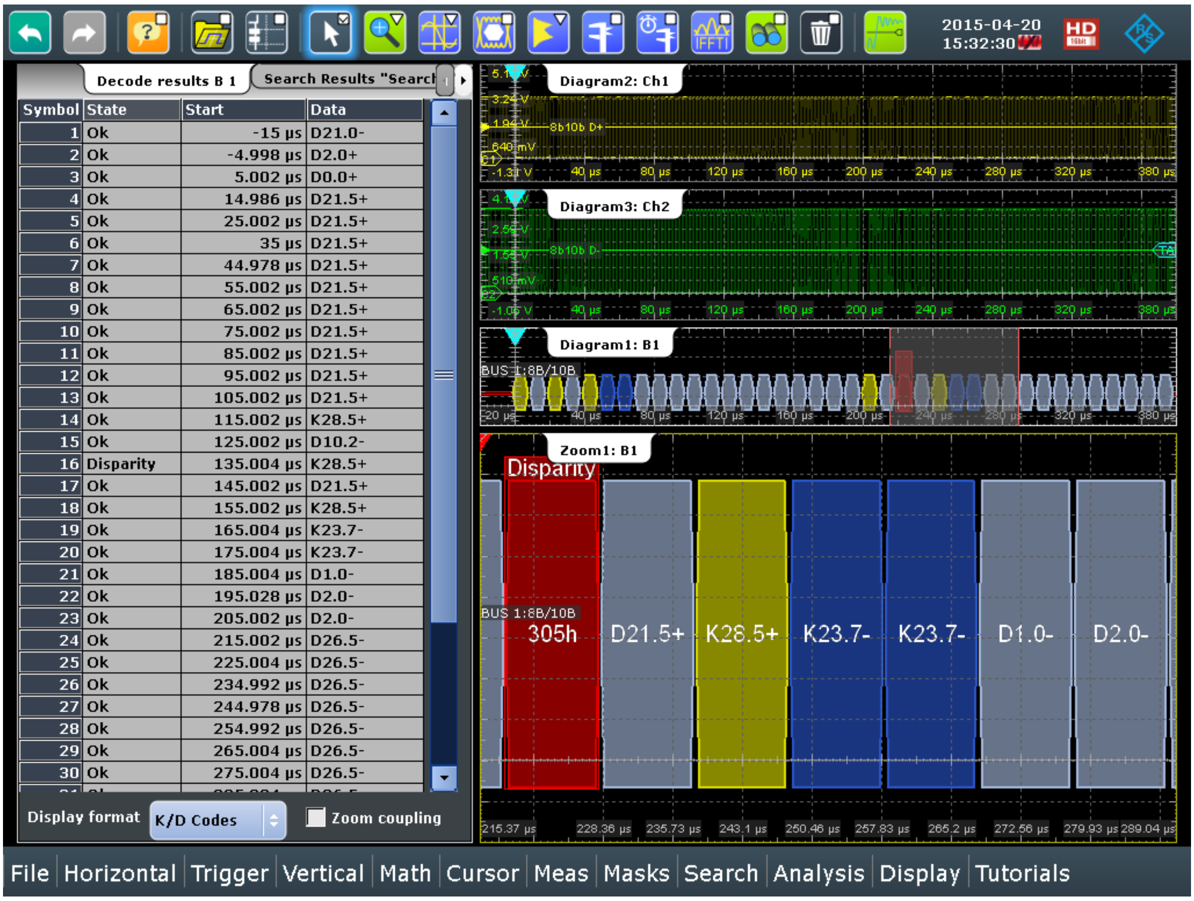


Table 12-15: Content of the decode result table

Column	Description
Symbol	Shows the index number of the symbol
State	Overall state of the symbol
Start	Time of the symbol start in relation to the trigger point
K/D Code	The K/D code
8-bit	The 8-bit value
10-bit	10-bit output value

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:

- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.14.3, "Decode Results", on page 1645.

12.13.5 Search on Decoded 8b/10b Data

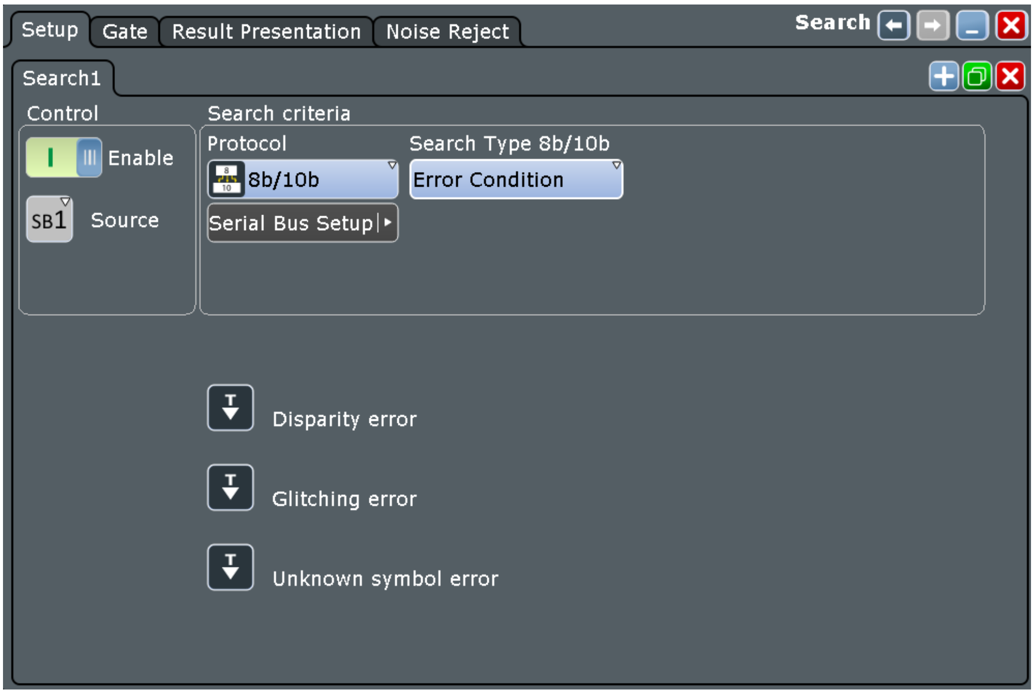
Using the search functionality, you can find various events in the decoded data, the same events which you also can trigger on. Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search "Source" to the serial bus that is configured for the protocol to be analyzed.

See also Chapter 10, "Search Functions", on page 396.

12.13.5.1 8b/10b Search Setup

Access: [Search] > "Setup" tab.



Search Type 8b/10b

Selects the type of condition to be searched for.

"Symbol"	Searches for a specified symbol or expression.
"Error Condition"	Searches for the selected error conditions.

Remote command:
`SEARch:TRIGger:EBTB:TYPE` on page 1650

Disparity error

Searches for disparity errors.

Remote command:
`SEARch:TRIGger:EBTB:DISParityerr` on page 1648

Glitching error

Searches for glitching errors.

Remote command:
`SEARch:TRIGger:EBTB:GLITcherror` on page 1649

Unknown symbol error

Searches for a symbol that is not defined by the the 8b/10b.

Remote command:
`SEARch:TRIGger:EBTB:UNK` on page 1650

Symbol Type

Selects the symbol type to be searched for.

"Symbol"	Sets a sepcific symbol.
"Expression"	Sets a series of symbols.

Remote command:
`SEARch:TRIGger:EBTB:SSTYpe` on page 1649

Format

Selects the format of the symbol to be searched for, if "Symbol Type" > "Symbol".

Remote command:
`SEARch:TRIGger:EBTB:SYMFormat` on page 1649

K/D Codes Symbol

Selects the data character (Dx.y) or control character to bea searched for. You can specify the value of the data character to be searched for with "Dx Value" and "Dy Value".

Remote command:
`SEARch:TRIGger:EBTB:SYMType` on page 1650

Dx Value ← K/D Codes Symbol

Sets the x value of the data character Dx.y to be searched for, if "K/D Codes Symbol" > "Dx.y".

Remote command:
`SEARch:TRIGger:EBTB:DX` on page 1648

Dy Value ← K/D Codes Symbol
Sets the y value of the data character Dx.y to be searched for, if "K/D Codes Symbol" > "Dx.y".

Remote command:
`SEARch:TRIGger:EBTB:DY` on page 1648

8b Pattern
Sets the 8-bit pattern to be searched for, if "Format" > "8-bit".

Remote command:
`SEARch:TRIGger:EBTB:EBPA` on page 1648

10b Pattern
Sets the 10-bit pattern to be searched for, if "Format" > "10-bit".

Remote command:
`SEARch:TRIGger:EBTB:TBPA` on page 1650

Expression
Defines the expression to be searched for, if "Symbol Type" > "Expression".

Remote command:
`SEARch:TRIGger:EBTB:SYME` on page 1649

12.13.5.2 8b/10b Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:
- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

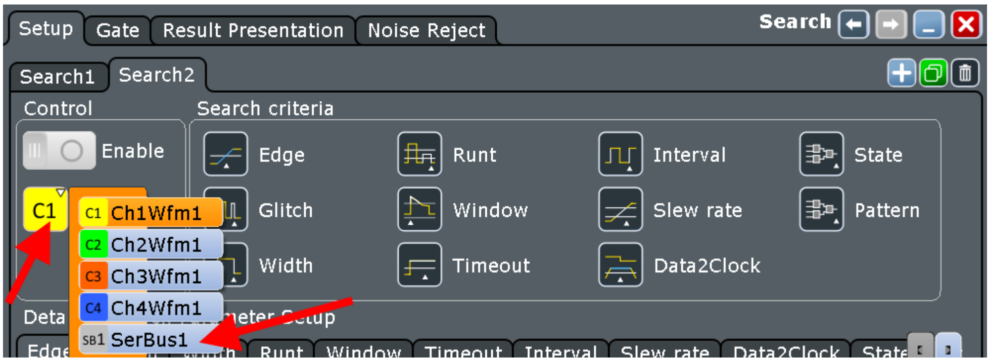
Remote Commands:
- `SEARch:RESult:EBTB:SCOunt?` on page 1651
- `SEARch:RESult:EBTB:SYMBol<m>:DATA?` on page 1651
- `SEARch:RESult:EBTB:SYMBol<m>:STARt?` on page 1651
- `SEARch:RESult:EBTB:SYMBol<m>:STATus?` on page 1652
- `SEARch:RESult:EBTB:SYMBol<m>:STOP?` on page 1652

12.13.5.3 Searching 8b/10b Data

Prerequisite: A serial bus is configured for the 8b/10b signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press [Search] or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 411.
3. Tap "Source" and select the serial bus that is set to 8b/10b (e.g. "SB1", unless already selected).



The search dialog for 8b/10b protocol analysis is opened.
There are no additional search criteria to be specified.

4. Tap "Source" and select the serial bus that is set to 8b/10b (e.g. "SB1", unless already selected).
5. Specify search criteria according to Chapter 12.13.5.1, "8b/10b Search Setup", on page 731.
6. To acquire a waveform, press [Single].

   The R&S RTP performs a 8b/10b decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
7. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTP displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 417 and "Navigating search results" on page 398.

12.14 MDIO (Option R&S RTP-K55)

The R&S RTP-K55 option enables the R&S RTP to analyse Management Data Input/ Output (MDIO) protocols. The option is compatible with the Ethernet standard IEEE 802.3 (http://standards.ieee.org/findstds/standard/802.3-2012.html) and supports simplified triggering and decoding for both variants of MDIO: Clause 22 with basic addressing, and Clause 45 with advanced addressing that meets the requirements of 10 Gigabit Ethernet devices.

12.14.1 The MDIO Protocol

MDIO is used for bidirectional transfer of control and status information between the physical layer entity (PHY) and the station management entities (STA).

A major application of MDIO is fault detection by interrogating registers of physical devices. Hence, MDIO serial bus visualization helps debugging new products by giving developers a quick insight into the native data on the bus without using a special decoder.

On physical level, MDIO is a clocked non-return-to-zero (NRZ) code similar to SPI. According to the Ethernet standard, the protocol defines two threshold levels, 2 V and 0.8 V, which establish a hysteresis.

On logical level, MDIO is a fairly simple protocol with a fixed word length of 64 bits. The structure of MDIO frames is shown in the following tables:

Table 12-16: MDIO frame structure according to Clause 22

	Management Frame Fields							
Frame	PRE	ST	OP	PHYAD	REGAD	TA	DATA	IDLE
WRITE	1...1	01	01	AAAAA	RRRRR	10	DDDDDDDDDDDDDDDD	Z
READ	1...1	01	10	AAAAA	RRRRR	Z0	DDDDDDDDDDDDDDDD	Z

Table 12-17: MDIO frame structure according to Clause 45

	Management Frame Fields							
Frame	PRE	ST	OP	PRTAD	DEVAD	TA	ADDRESS / DATA	IDLE
ADDRESS	1...1	00	00	PPPPP	EEEEE	10	AAAAAAAAAAAAAAAA	Z
WRITE	1...1	00	01	PPPPP	EEEEE	10	DDDDDDDDDDDDDDDD	Z

READ	1...1	00	11	PPPPP	EEEEE	Z0	DDDDDDDDDDDDDDDD	Z
POST-READ increment address	1...1	00	10	PPPPP	EEEEE	Z0	DDDDDDDDDDDDDDDD	Z

The following abbreviations are used in the tables:

- PRE = preamble, consisting of 32 logic "one" bits ("1...1")
- PRE = preamble, consisting of 32 logic "one" bits ("1...1")
- ST = start of frame code (2 bits), "01" for Clause 22, "00" for Clause 45, "0X" for any, no other options permitted
- OP = operation code or "OpCode" (2 bits). This is a frame type code specifying the type of transaction. For more details on the OpCode, see "OP" in Table 12-18, or `TRIGger<m>:MDIO:FRAMetype`.
- PHYAD = address of a physical layer entity (in Clause 22)
- PRTAD = address of a port (in Clause 45)
- REGAD = register address within a PHY (in Clause 22)
- DEVAD = device address within a port (in Clause 45)
- TA = turnaround time, a 2-bit time spacing between REGAD/DEVAD and DATA. The turnaround provides the slave some time to answer upon a read command. TA is hard-wired even in write commands, although it is not required there.
- ADDRESS / DATA = address or payload data, 16 bits
- IDLE = A single value (high-impedance state) indicating to the Physical Medium Attachment (PMA) that there is no data to convey

Instead of a specific hardware trigger, the option R&S RTP-K55 uses a predefined generic serial bus pattern trigger. It simply triggers on a bit pattern in the data stream. This is fast, but limited in the complexity of the conditions.

The MDIO trigger settings allow you to define the MDIO fields individually. The firmware concatenates the settings to a single search pattern that is then used by the serial bus pattern.

While this design is simple, it does not allow triggering on a data range or even inequality. This explains the much simpler structure compared to other protocols.

12.14.2 MDIO Configuration

12.14.2.1 MDIO Configuration Settings

Access: [Protocol] > "Decode" tab > "Protocol" = *MDIO*

Make sure that the tab of the correct serial bus is selected on the left side.

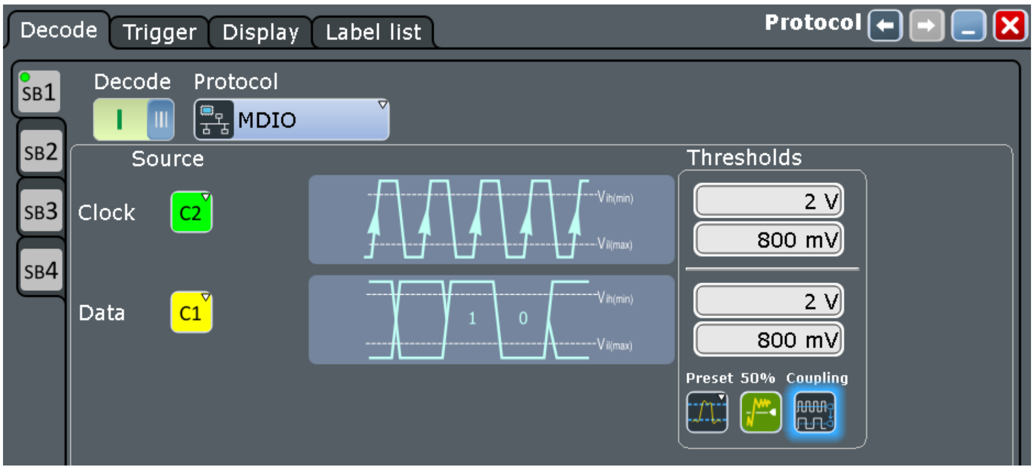


Figure 12-76: Serial bus MDIO protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Source

MDIO requires two source channels, one for clock and one for data.

"Clock" Defines the source settings for the clock line (management data clock, MDC). Typically, select any of the analog channels "C1" – "C4" or digital channels "D0" – "D15", depending on the test application. "Math" or "Ref" waveforms are also permitted.

"Data" Defines the source settings for the data signal. Typically, select any of the analog channels "C1" – "C4" or digital channels "D0" – "D15", depending on your application, but not the same as for "Clock". "Math" or "Ref" waveforms are also permitted.

Remote command:

`BUS<m>:MDIO:CLOCk:SOURce` on page 1653

`BUS<m>:MDIO:DATA:SOURce` on page 1653

Thresholds

MDIO defines two thresholds for each source line:

- Vih(min) is being used for the rising edge evaluation. This "h" (high) threshold is the minimum value for the signal to be identified as "1". If the signal value comes from a low state (hence, rising edge), the state remains to be considered as low ("0"), until it has risen above Vih(min).
- Vil(max) is being used for the falling edge evaluation. This "l" (low) threshold is the maximum level for the signal to be identified as "0". If the signal value comes from a high state (hence, falling edge), the state remains to be considered as high ("1"), until it has fallen below Vil(max).

There are four ways to set the thresholds for the digitization of the signal lines:

- "Threshold"
  Enter the values directly in the fields.
- "Preset"

Allows to select the default threshold settings according to the Ethernet standard: 2.0 V and 0.8 V.
- "50%"
Executes a measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.
- "Coupling"
Overwrites the data thresholds with the clock thresholds.

Remote command:
BUS<m>:MDIO:CLOCk:THReshold:HIGH on page 1654
BUS<m>:MDIO:CLOCk:THReshold:LOW on page 1654
BUS<m>:MDIO:DATA:THReshold:HIGH on page 1654
BUS<m>:MDIO:DATA:THReshold:LOW on page 1655
BUS<m>:MDIO:PRESet on page 1655
BUS<m>:SETReflevels on page 1299
BUS<m>:MDIO:COUPling on page 1655

12.14.2.2 MDIO Display Settings

Access: [Protocol] > "Configuration" tab > "Protocol = MDIO" > "Display" tab

To enhance the decode possibilities of the MDIO protocol, you can use an additional setting in the "Display" tab: "Decode layer".

Common display settings are explained in Chapter 12.1.2, "Display", on page 465.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final" ...

"Edges" ...

"Binary" ...

12.14.2.3 Configuring MDIO Signals

For configuration, assign the lines to the input channels and define the active states and the logical thresholds.

1. Press the [Protocol] key on the front panel.
2. At the left hand-side of the "Configuration" tab, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Tap "Protocol" and select the protocol: "MDIO".
4. Optionally, you can enter a "Bus label" in the "Display" tab.
5. Select the waveform for the "Clock" and "Data" lines.
6. Set the logical thresholds: Either according to technology definition with "Preset", or to the middle reference levels by setting it to "50%", or enter a user-defined value directly in the "Threshold" fields. Optionally, use "Coupling" to couple the data thresholds to the clock thresholds.
7. In the protocol "Configuration" tab, select "Decode" to activate the decode functionality.

For details on configuration settings, see Chapter 12.14.2.1, "MDIO Configuration Settings", on page 736.

12.14.3 MDIO Trigger

12.14.3.1 MDIO Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = MDIO"

In this section, all trigger settings are described. The user interface of the instrument displays only appropriate settings and guides you through the trigger setup.

For a list of supported trigger conditions, refer to the data sheet.

Make sure that:
- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Serial bus

Selects the serial bus to be triggered on. Make sure to select the correct bus before you enter the settings.

To trigger on a serial bus, the signals sources must be channel signals. If the data or clock source is a math or reference waveform, you cannot trigger on that bus.

Remote command:

`TRIGger<m>:SOURce:SBSelect` on page 1303

Protocol

Defines the protocol type of the selected serial bus.

Remote command:

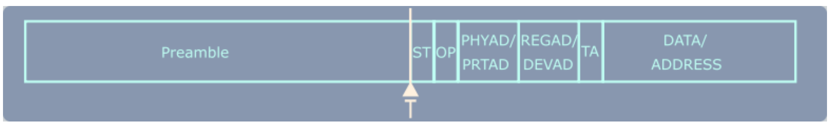
`BUS<m>:TYPE` on page 1299

MDIO Trigger Type

Selects the trigger type for MDIO analysis.

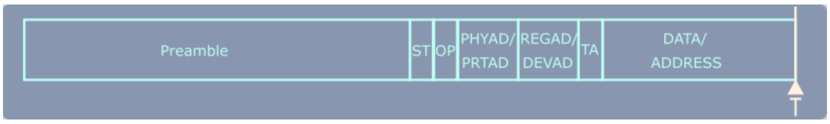
Figure 12-77: MDIO trigger event settings dialog

"Frame Start" Sets the trigger to the start of frame (SOF) field. The start of frame condition and the trigger instant is the end of the preamble.
Trigger pattern: preamble (32 bits "1")



There are no additional parameters to be specified.

"Frame Stop" Sets the trigger to the end of frame (EOF) field. The trigger instant is after the last data bit.
Trigger pattern: preamble (32 bits "1") + 32 bits "X"

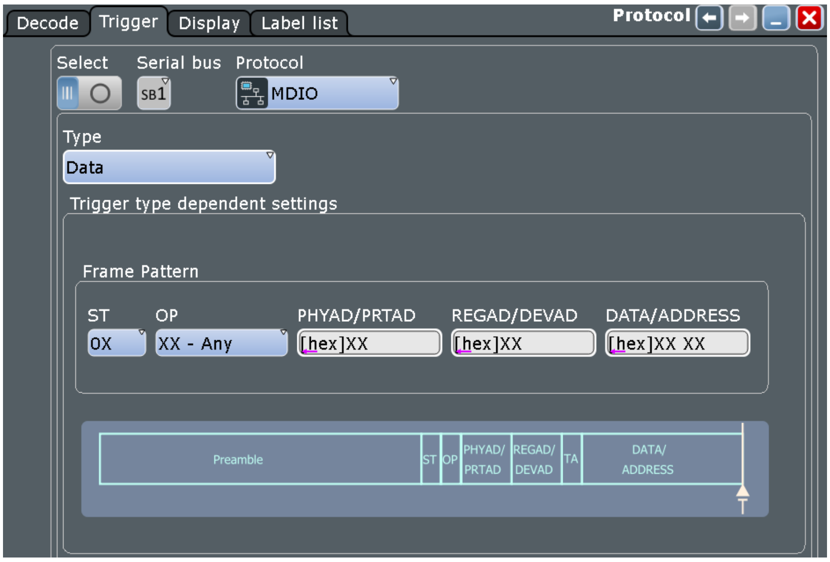


There are no additional parameters to be specified.

"Data" Sets the trigger to the data field. For more information on the data condition, see MDIO in the Ethernet standard. The trigger instant is at the end of the frame after the last data bit, as indicated in the GUI.

Note: All data triggers are always at the end of the frame, even if the specified pattern to trigger for is at a different position within the data word.

Trigger pattern: preamble (32 bits "1") + "ST" (2 bits, Start of Frame Code) + "OP" (2 bits, operation code or frame type code) + "PHYAD/PRTAD" (5 bits, Physical Layer Entity Address / Port Address) + "REGAD/DEVAD" (5 bits, Register Address / Device Address) + "TA" (2 "X" bits, turnaround time) + "DATA/ADDRESS" (16 bits)
For the parameters to be specified, see "ST" on page 741, "OP" on page 742, "PHYAD/PRTAD" on page 742, "REGAD/DEVAD" on page 742, and "DATA/ADDRESS" on page 742.



Remote command:
`TRIGger<m>:MDIO:TYPE` on page 1656

ST ← MDIO Trigger Type
Selects the start of frame code of the frame pattern; available only in trigger type "Data". Permissible frame patterns are: Clause 22, Clause 45, or Any

Remote command:
`TRIGger<m>:MDIO:ST` on page 1656

OP ← MDIO Trigger Type
Selects the type of frame code (or OP code, OpCode, operation code); available only in trigger type "Data". Available frame types are: Address, Write, Read, Post Read, or Any

Remote command:
`TRIGger<m>:MDIO:FRAMetype` on page 1657

PHYAD/PRTAD ← MDIO Trigger Type
Sets the physical address or port address (5 bits) of the frame pattern; available only in trigger type "Data".

Remote command:
`TRIGger<m>:MDIO:PHYS` on page 1657

REGAD/DEVAD ← MDIO Trigger Type
Sets the register address or device address (5 bits) of the frame pattern; available only in trigger type "Data".

Remote command:
`TRIGger<m>:MDIO:REGI` on page 1657

DATA/ADDRESS ← MDIO Trigger Type
Defines the payload data pattern or address pattern (16 bits); available only in trigger type "Data".

Remote command:
`TRIGger<m>:MDIO:DATA` on page 1657

12.14.3.2 Triggering on MDIO

Prerequisite: A serial bus is configured for the MDIO signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Tap "Serial bus" and select the serial bus that is set to MDIO, e.g.:

   The "Protocol" selection is then automatically set to "MDIO".
5. Tap "Trigger Type MDIO" and select the trigger type to be used for MDIO protocol analysis.
6. If the trigger type "Data" is selected, the frame pattern has to be specified.

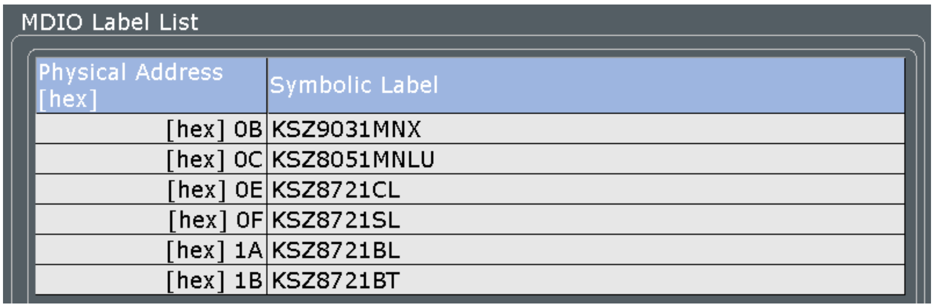
For information on how to proceed with the configuration settings, see Chapter 12.14.3.1, "MDIO Trigger Settings", on page 739.

12.14.4 MDIO Label List

Label lists are protocol-specific. A label list file for MDIO contains physical addresses and their symbolic names.

Example: MDIO label list CSV file

```
@PROTOCOL_NAME = mdio
0x0B, KSZ9031MNX
0x0C, KSZ8051MNLU
0x0E, KSZ8721CL
0x0F, KSZ8721SL
0x1A, KSZ8721BL
0x1B, KSZ8721BT
```


MDIO Label List

Physical Address [hex]	Symbolic Label
[hex] 0B	KSZ9031MNX
[hex] 0C	KSZ8051MNLU
[hex] 0E	KSZ8721CL
[hex] 0F	KSZ8721SL
[hex] 1A	KSZ8721BL
[hex] 1B	KSZ8721BT

For general information on the "Label List" tab, see Chapter 12.1.3, "Label Lists", on page 467.

Remote command:

- BUS<m>:MDIO:WORD<n>:SYMBol? on page 1661

12.14.5 MDIO Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Example

An example test waveform consisting of six frames is shown in Figure 12-78. The corresponding "Decode results" table for these frames can be seen in the foreground. The upper part of the screen, behind the table, represents the waveform in a honeycomb display, along with the binary decode results. In the lower part of the screen there is a zoom into frame #2, which is a "Write" frame, containing PRE, ST, OP, PRTAD, DEVAD, TA and DATA fields. The zoom shows both the honeycomb display and the binary decode results of that second frame.

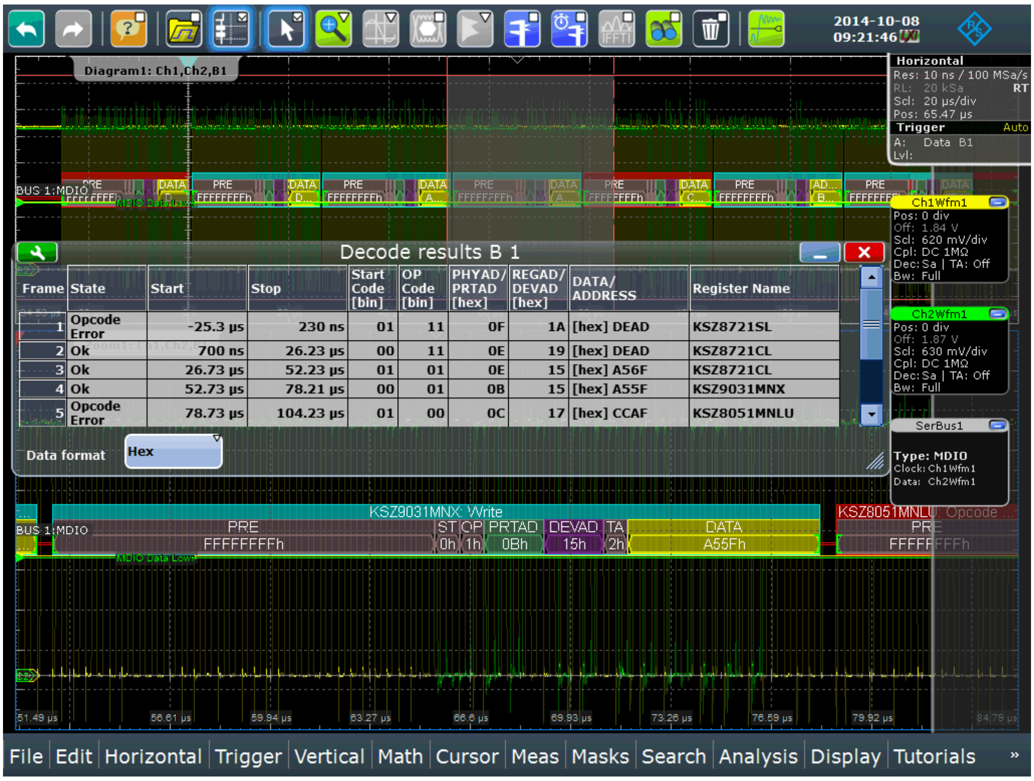


Figure 12-78: Decoded and binary MDIO signal trace, and decode results table

green brackets [...]	= start and end of frame
blue frame	= frame ok
red frame	= frame containing an error
grey	= preamble (PRE), start pattern (ST), operation code (OP = frame type), or turnaround (TA) fields
dark green	= PHY address or port address (depending on clause)
dark purple	= register address or device address field (depending on clause)
yellow	= data field or address field (depending on clause)

Table 12-18: Content of the "Decode results" table in the previous figure

Column	Description
Frame	Number of the acquired frame
State	State of frame, available messages are: ● OK ● OPcode error ● Length error ● Incomplete frame ● Unsynchronized bits
Start	Start time of the frame
Stop	Stop time of the frame
ST	Start of frame code, 2 bits ● "01" (Clause 22) ● "00" (Clause 45)
OP	Operation code (= Frame type), 2 bits ● "00" = Address frame (in Clause 45, only) ● "01" = Write frame (in Clause 22 or Clause 45) ● "10" = Read frame (in Clause 22) or Post Read frame (in Clause 45) ● "11" = Read frame (in Clause 45)
PHYAD/PRTAD	Address field, shown as 2 hex characters (corresponding to 5 binary bits) ● PHY address (in Clause 22) ● Port address (in Clause 45)
REGAD/DEVAD	Address field, shown as 2 hex characters (corresponding to 5 binary bits) ● Register address (in Clause 22) ● Device address (in Clause 45)
DATA/ADDRESS	Payload data field (in Clause 22 or Clause 45), or Address field (in Clause 45, only), shown as 4 hex characters or 16 binary bits (see Figure 12-79).
Register Name	Displays a translation of the PHYAD/PRTAD address label in textual form

In the decode results table, the contents of column "DATA/ADDRESS" can also be displayed in alternative numerical formats, e.g. in binary format, as shown in Figure 12-79.

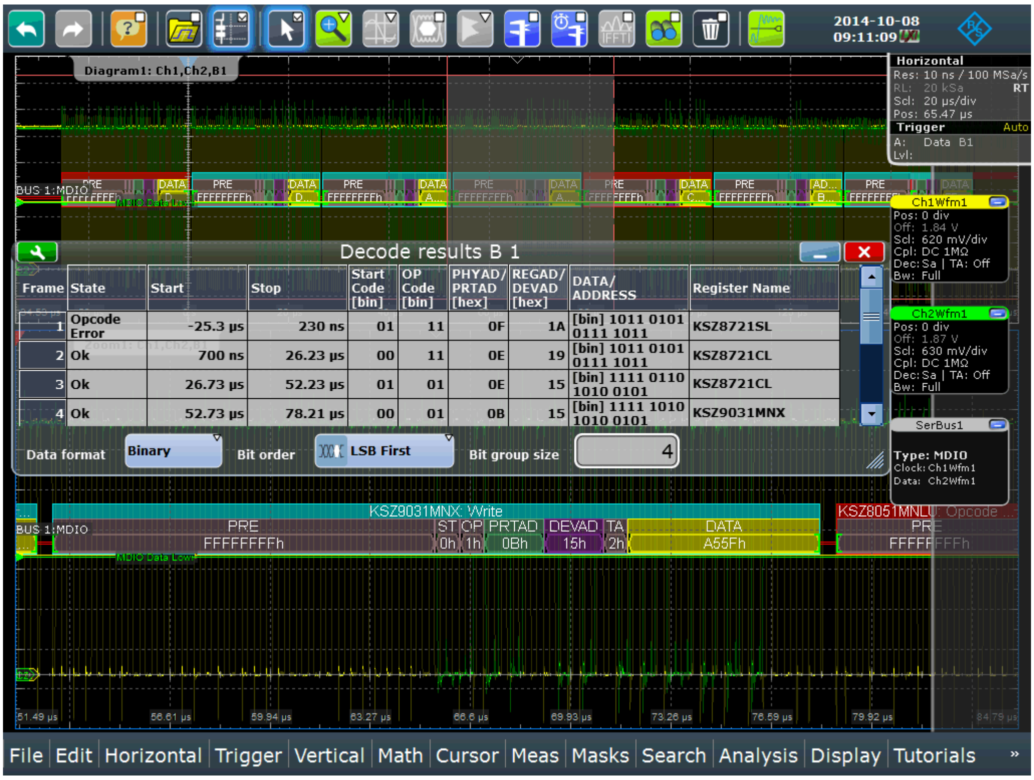


Figure 12-79: The same signal trace and decode results table as in the previous figure, but only with "DATA" in binary format

To configure the numerical format of the content in column "DATA/ADDRESS", either use the button "Data format" in the "Decode results" table, as shown in Figure 12-79, or the same button in the "Display" tab of the "Protocol" dialog, as shown in Figure 12-80. Available data formats are "Hex", "Octal", "Binary", "Ascii", "Signed", and "Unsigned". If the binary format is selected, additional data format options are "Binary bit order", and "Binary bit group size". This defines if the data word is displayed most significant bit (MSB) or least significant bit (LSB) first, and in which size of groups the bits are displayed. This feature is also described in Chapter 12.1.2, "Display", on page 465.

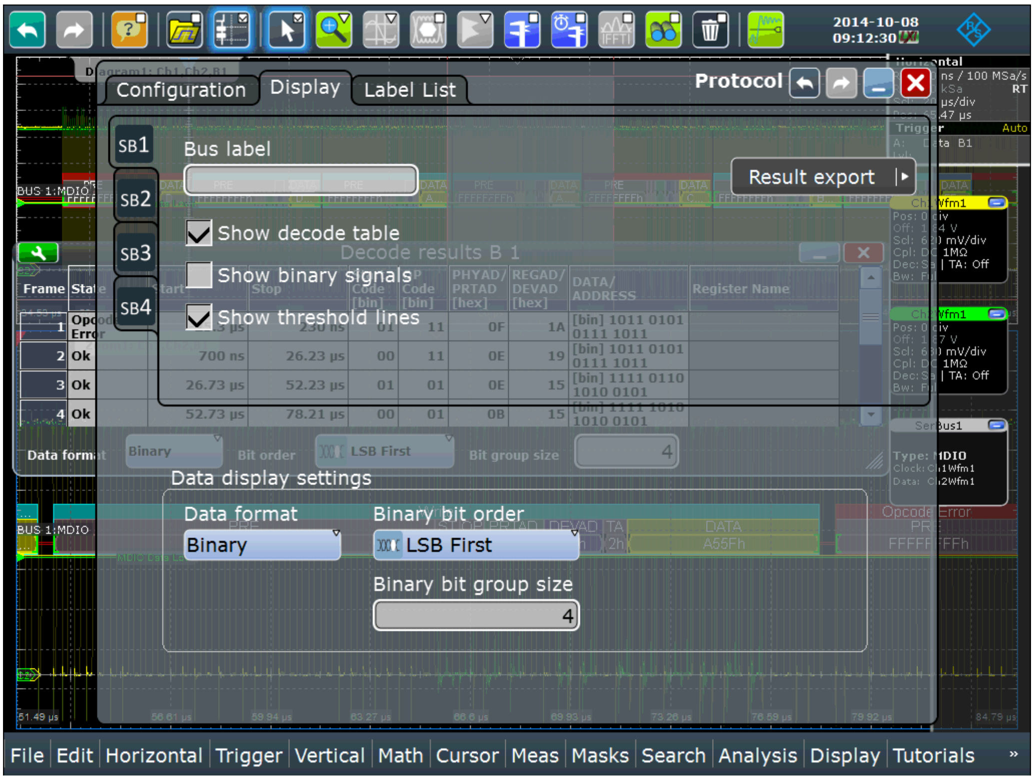


Figure 12-80: The data display settings can be configured in the Display tab of the Protocol dialog

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.15.3, "Decode Results", on page 1658.

12.14.6 Search on Decoded MDIO Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

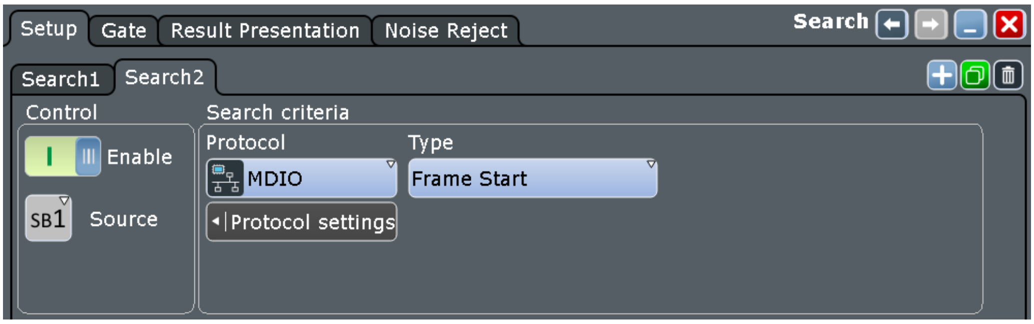
For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 396.

If you need information on how to get started with searching MDIO data, see Chapter 12.14.6.3, "Searching MDIO Data", on page 750. Otherwise proceed with the MDIO search setup.

12.14.6.1 MDIO Search Setup

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for MDIO

Search criteria
Use the "Search criteria" dialog to define the event types to be searched.



Available event types are "Frame Start", "Frame Stop", and "Data".

Only if search criteria type "Data" is selected, individual search parameters can be specified in the tabs below the "Search criteria" dialog. For these parameters, see "ST" on page 748, "OP" on page 748, "PHYAD/PRTAD" on page 749, "REGAD/DEVAD" on page 749, and "DATA/ADDRESS" on page 749.

Remote command:
`SEARch:TRIGger:MDIO:TYPE` on page 1663

ST
Selects the start of frame code of the frame pattern; available only in search criteria type "Data". Permissible frame patterns are: Clause 22, Clause 45, or Any

Remote command:
`SEARch:TRIGger:MDIO:ST` on page 1663

OP
Selects the Type of Frame code (or OP code, OpCode, operation code); available only in search criteria type "Data". Available frame types are: Address, Write, Read, Post Read, or Any

Remote command:
`SEARch:TRIGger:MDIO:FRAMetype` on page 1662

PHYAD/PRTAD
Sets the physical address or port address (5 bits) of the frame pattern; available only in search criteria type "Data".

Remote command:
SEARch:TRIGger:MDIO:PHYS on page 1663

REGAD/DEVAD
Sets the register address or device address (5 bits) of the frame pattern; available only in search criteria type "Data".

Remote command:
SEARch:TRIGger:MDIO:REGI on page 1663

DATA/ADDRESS
Defines the payload data pattern or address pattern (16 bits); available only in search criteria type "Data".

Remote command:
SEARch:TRIGger:MDIO:DATA on page 1662

12.14.6.2 MDIO Search Results

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:
- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

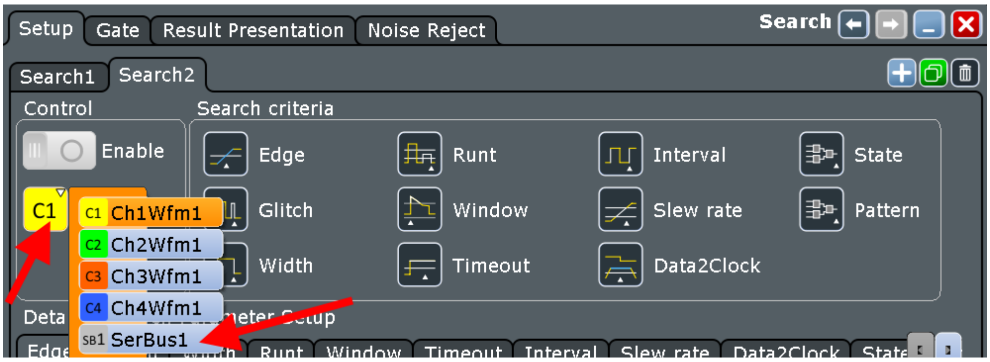
Remote commands:
- SEARch:RESult:MDIO:WCOunt? on page 1667
- SEARch:RESult:MDIO:WORD<m>:STATe? on page 1666
- SEARch:RESult:MDIO:WORD<m>:STARt? on page 1665
- SEARch:RESult:MDIO:WORD<m>:STOP? on page 1666
- SEARch:RESult:MDIO:WORD<m>:ST? on page 1665
- SEARch:RESult:MDIO:WORD<m>:TYPE? on page 1667
- SEARch:RESult:MDIO:WORD<m>:PHYS? on page 1664
- SEARch:RESult:MDIO:WORD<m>:REGI? on page 1665
- SEARch:RESult:MDIO:WORD<m>:DATA? on page 1664
- SEARch:RESult:MDIO:WORD<m>:SYMBol? on page 1667

12.14.6.3 Searching MDIO Data

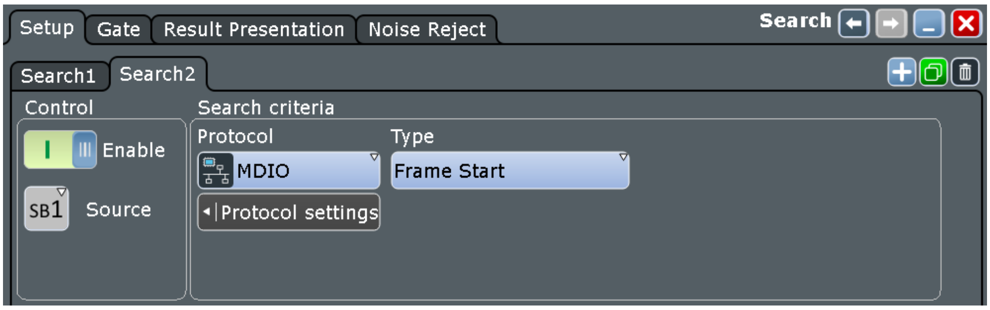
Prerequisite: A serial bus is configured for the MDIO signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press [Search] or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 411.
3. Tap "Source" and select the serial bus that is set to MDIO (e.g. "SB1", unless already selected).



The search dialog for MDIO protocol analysis is opened.



There are no additional search criteria to be specified.

4. To acquire a waveform, press [Single].

   The R&S RTP performs an MDIO decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
5. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog.

   The R&S RTP displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 417 and "Navigating search results" on page 398.

12.15 USB 3.1 Generation 1 (Option R&S RTP-K61)

R&S RTP-K61 is a firmware option that enables the R&S RTP to analyze Universal Serial Bus (USB) signals encoded by the USB 3.1 coding standard, generation 1.

NOTICE

Oscilloscope must range up to 5 GHz, at least

As the USB 3.1 Gen 1 protocol (see The USB 3.1 Protocol) is defined for data rates up to 5 GHz, the full functionality of option R&S RTP-K61 requires an instrument that covers this frequency range up to 5 GHz.

For analysis, USB 3.1 encoded signals can be triggered, decoded and searched.

This chapter describes:

12.15.1 The USB 3.1 Protocol

The USB 3.1 protocol standard was published on July 26th, 2013, strongly enhancing the performance of the USB 2.0 protocol. Compared to USB 2.0, USB 3.1 defines a new physical layout, better power distribution and higher data rates.

The USB 3.1 standard features two speed levels (generations):

- **USB 3.1 Gen 1** for 5 Gbps (also labeled "SuperSpeed" or "SS"), encompassing and superseding USB 3.0 (published on November 12th, 2008)
- **USB 3.1 Gen 2** for 10 Gbps (also labeled "SuperSpeedPlus" or "SSP")

While USB 3.1 Gen 2 is not yet very common, you can use a fast oscilloscope (minimum 5 GHz) with option **R&S RTP-K61** to analyze signals encoded according to the **USB 3.1 Gen 1** protocol.

NOTICE

Oscilloscope must range up to 5 GHz, at least

As the USB 3.1 Gen 1 protocol is defined for data rates up to 5 GHz, option R&S RTP-K61 requires a fast oscilloscope that covers this frequency range.

USB 3.1 supersedes the USB 3.0 standard but uses, for example, the USB 3.0 Standard-A connector design with 9 pins. Hence, USB 3.1 cables and connectors contain 5 additional wires and pins compared to USB 2.0.

Figure 12-81: USB 3.1 cable cross-section and Standard-A plug - backward compatible with USB 2.0

A = Shield (braid) / connector shell
B = USB 2.0 unshielded twisted pair
C = USB 3.0 / USB 3.1 shielded twisted pair
D = USB 3.0 / USB 3.1 shielded twisted pair
1 = Voltage bus V_{CC} power supply pin, +5 V
2 = Differential data signal D-
3 = Differential data signal D+
4 = Ground pin for power return
5 = SuperSpeed receiver differential pair Rx-
6 = SuperSpeed receiver differential pair Rx+
7 = Ground drain for signal return
8 = SuperSpeed transmitter differential pair Tx-
9 = SuperSpeed transmitter differential pair Tx+
* = Connector images courtesy of Wikipedia authors smial and Unconventional2

Table 12-19: Backward compatibility of USB 3.1 connectors

Connector type	USB 3.1	Compatibility	USB 2.0
Standard-A	plug	... is backward compatible with ...	receptacle
	receptacle	... is backward compatible with ...	plug
Standard-B	plug	... is **not** compatible with ...	receptacle
	receptacle	... is backward compatible with ...	plug
Micro-USB	plug	... is **not** compatible with ...	receptacle
	receptacle	... is backward compatible with ...	plug

To achieve the data throughput of USB 3.1, all involved components (host, cable, device and optional hub) must comply with USB 3.1 specifications. If any component only complies, for example, with USB 2.0 Hi-Speed specifications, the setup works, but limited to Hi-Speed USB data rates.

USB 3.1 also specifies a new connector format, called Type-C, with a reversible plug. This small and durable connector is, however, not mechanically compatible with USB 2.0 connectors.

USB 3.1 Type-C connector

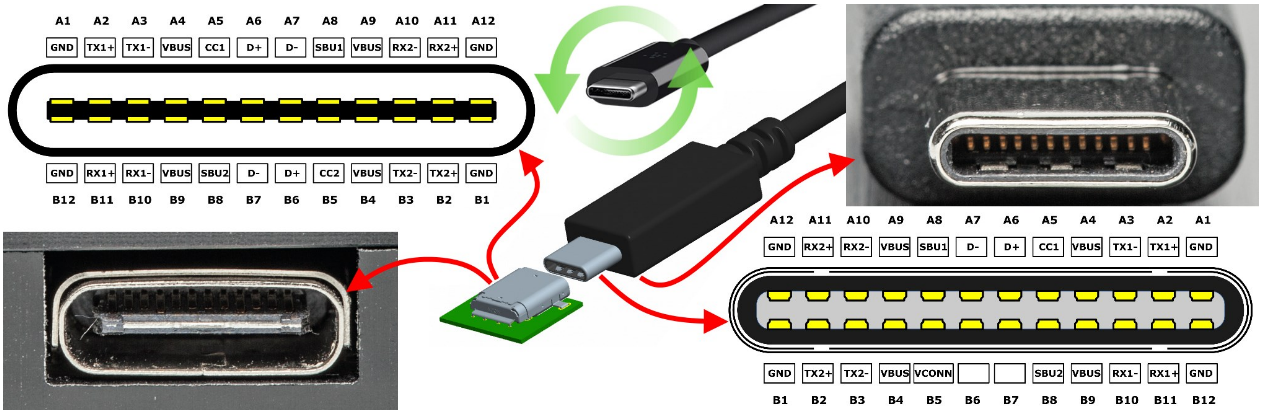


Figure 12-82: USB 3.1 Type-C receptacle and reversible plug

A1 to A12 = Twelve USB Type-C pins
B1 to B12 = The same USB Type-C pins as A1 to A 12, but in reverse order
* = Images courtesy of Heise Medien, Acon, phoneArena and Wikipedia author Chindi.ap

Specific protocol features

Key features of USB 3.1 Gen 1 that are addressed by option R&S RTP-K61 include:

- Since 5 Gbps is too fast for serial pattern triggering, the option uses a search-based software trigger
- The protocol uses a non-return-to-zero (NRZ) unclocked signal with **8b/10b encoding** (while USB 3.1 Gen 2 uses 128b/132b encoding)
- The signal is scrambled with a 32-bit minimum correlation sequence
- COMMA (K28.5), which occurs only during the reset phase, is the only unique bit sequence
  - COMMA is used for reset of the scrambling sequence, which has 32-bit minimum correlation
  - COMMA and packet framing are used for bit alignment
- The protocol uses a set of different frame types that are all covered by individual trigger and search dialogues of option R&S RTP-K61

Frame types

All frame types are listed below. The frame types are sorted in an almost alphabetical order, as in the oscilloscope's graphical user interface (GUI).

Each item in this list contains:

- the SCPI name of the frame
  (hence the name of the frame according to the related `remote control command (SCPI)`)
- the GUI name of the frame, which is sometimes identical with the SCPI name
  (the GUI names are highlighted in **bold** font and linked to one of Table 12-20 / Table 12-21 / Table 12-22)
- a brief description of the frame type

List of frame types

- ACK - **ACK** = Handshake packet indicating a positive acknowledgment.
- BCNT - **BCNT** = BERT count, with BERT = Bit Error Rate Test. BCNT is a K28.3 sequence followed by the error count symbol EC. See also BERC.
- BDAT - **BDAT** = BERT data, ordered set of a BERT command. This data sequence (output of the scrambler) is used for BER testing and is equivalent to the logical idle sequence, consisting of scrambled 0.
- BERC - **BERC** = BERT error count, ordered set of a BERT command that does not increment the error count register. BERC is not looped back to the receiver but replaced with BCNT.
- BRST - **BRST** = BERT reset, ordered set of a BERT command. Any time a BRST is received, the error count register EC is set to 0 and the linear feedback shift register (LFSR) for scrambling is set to 0FFFFh. Any number of consecutive BRST ordered sets may be received.
- BIAM - **Bus Interval Adjustment** = The bus interval is the period that establishes the integral boundary of service intervals. It is equivalent to the Microframe interval (THSFRAM) defined in the USB 2.0 specification.
- DPH - **DPH** = Data Packet Header, containing a type field, the data packet's address, route string, length, and other information about the packet, including a 2-byte checksum (CRC-16).
- DPP - **Data Packet Payload** = The packet's payload data and a 32-bit CRC.
- DPPA - **Data Packet Payload Abort** = Frame ordered set used to abort a data packet payload.
- ERDY - **ERDY** = The Endpoint Ready notification is a handshake packet indicating a positive acknowledgment.
- FWAKe - **Function Wake** = The function wake device notification is sent from a device (that is enabled for remote wakeup) to the host, if it wants to exit from "device suspend" or "function suspend".
- HRR - **Host Role Request** = This notification type is reserved for being issued by a SuperSpeed On-the-Go (SS-OTG) device, if its Role Swap Protocol (RSP) capability has been enabled.
- IDLE - **IDLE** = Logical Idle is a period of one or more symbol periods when no information (packets or link commands) is transferred on the link. The Idle Symbol (IS) is transmitted by a port at any time in the active (U0) state meeting the logical idle definition.
- ITP - **ITP** = Isochronous Timestamp Packet, sent periodically by a host to inform devices on the USB of the current bus time. ITPs are multicast on all active links.
- LTM - **Latency Tolerance** = Latency Tolerance Messaging is an optional normative USB power management feature that utilizes reported BELT (Best Effort Latency Tolerance) values to enable more power efficient platform operation.
- LC - **Link Command** = An eight-symbol sequence used for link-level flow control, retries, power management and device removal.
- LDM - **Link Delay Measurement** = A protocol for determining propagation delays through the USB topology with a high degree of accuracy (sometimes called "Precision Time Measurement").

- NRDY - **NRDY** = The Not Ready response is a handshake packet indicating a negative acknowledgment.
- PING - **PING** = This transaction packet can only be sent by the host, to transition all links, which are in the path to a device, back to the active (U0) state prior to initiating an isochronous transfer.
- PNGR - **PING_RESPONSE** = This transaction packet is sent by a device in response for each PING received from the host.
- PCAP - **Port Capability** = This link management packet describes each port's link capabilities and is sent by both link partners after the successful completion of training and link initialization.
- PCNF - **Port Configuration** = All Enhanced SuperSpeed ports that support downstream port capability can send this link management packet (LMP), which is similar to Port Capability. If a port, which was to be configured in the upstream facing mode, does not receive this LMP within a defined time after link initialization, then the upstream port shall transition to "eSS.Disabled" and a peripheral device shall try to connect at the other speeds this device supports.
- PCNR - **Port Configuration Response** = This link management packet is sent by the upstream port in response to a Port Configuration and indicates its acceptance or rejection.
- SKIP - **SKIP** = SKP compensates for different bit rates between two communicating ports. SKPs may be dynamically inserted or removed from the data stream. SKPEND marks the boundary between SKP symbols and the remainder of the SKP ordered set. (For SuperSpeedPlus operation, unscrambled.)
- STALL - **STALL** = This transaction packet can only be sent by an endpoint on the device. It is used to inform the host that the endpoint is halted or that a control transfer is invalid.
- STATUS - **STATUS** = This transaction packet can only be sent by the host to a control endpoint. It is used to inform a control endpoint that the host has initiated the Status stage of a control transfer.
- SLF - **Set Link Function** = This link management packet is used to configure functionality that can be changed without leaving the active (U0) state.
- SSPD - **Sublink Speed** = Speed of a sublink, which is the collection of receive or transmit lanes between a downstream facing port (DFP) and an upstream facing port (UFP).
- TS1T - **TS1** = Training sequences are ordered sets for initializing bit and symbol alignment and receiver equalization. Examples are TS1, TS2 and TSEQ.
- TS2T - **TS2** = See TS1
- TSEQ - **TSEQ** = See TS1
- U2IT - **U2 Inactivity Timeout** = This link management packet is used to define the timeout from U1 to U2.
- VDT - **Vendor Device Test** = Use of this link management packet is intended for vendor-specific device testing and shall not be used during normal operation of the link.

Other types

- ERRor - **Error** = This is not a frame type, but it is included as an artificial entry in the search and navigate dialog to allow selecting and activating the error search. If the host error bit is set to "1", this state indicates that the host was unable to accept the data. The reason can be a CRC error, length error, value out of range, packet incomplete or unknown error.
- UDEF - **Unknown** = Undefined data cannot be identified as any specific USB 3.1 frame, because the measured signal does not match with the specifications of any defined frame. Therefore, in this case the field is represented by a "?". You cannot search for "Unknown" or trigger on it, but these types are returned, if an unexpected (sub)type has been found. If some rough type identification is possible, the unknown data may fit one of the following descriptions of unknown types.
- UDVN - **Unknown Device Notification** = A Device Notification transaction packet can only be sent by a device, to inform the host of an asynchronous change in a device or interface state (e.g., to identify the function within a device that caused the device to perform a remote wake operation).
- UHP - **Unknown Header Packet** = An undefined header packet that starts with HPSTART, but then the type is invalid.
- ULMP - **Unknown LMP** = A Link Management Packet is a type of header packet primarily used to manage links by communicating information between links partners. LMPs only travel between pairs of directly connected ports.
- UTP - **Unknown TP** = A Transaction Packet is a type of header packet used to communicate information between a device and the host. TPs traverse all the links, directly connecting the host to a device. They have no payload data, instead they are used, e.g., to control the flow of data packets or configure devices and hubs.

The frames listed above consist of individual sets of fields. Some frames only contain one field, others are much longer: up to 29 fields (in case of the "ACK" frame).

We try to represent the structure of these frames. However, one single table that contains all frames and all fields would be very large: 30 by 40 cells. We have therefore split up the full table into the following four smaller tables:

- Table 12-20 contains the **short** frames that end with the "Link Control Word". (This table uses abbreviation, see below.)
- Table 12-21 contains the **long** frames that end with the "Link Control Word". (This table uses abbreviation, see below.)
- Table 12-22 contains the frames that do not end with the "Link Control Word". These frames have no additional fields other than those in the table.
- Table 12-23 contains the types that are no specified USB 3.1 frames.

The frames in both Table 12-20 and Table 12-21 are abbreviated. For the full set of fields, you must add to each frame the 2 fields "HPSTART" and "Type" in the beginning of the frame. Also add a "CRC" field and the 6 fields of the "Link Control Word" at the end of each frame. In Table 12-23, only the "Link Control Word" is abbreviated.

The 2-byte **"Link Control Word"** is used for both link level and end-to-end flow control. The fields in the Link Control Word are detailled in Table 12-21.

Table 12-20: Short frames that start with fields HPSTART and Type and end with CRC and the Link Control Word

Frame	Field3	Field4	Field5	Field6	Field7	Field8	Fld.9	Field10	Fld.11
Bus Interval Adjustment	Rsvd	Device Address	SubType	NotType	Rsvd	BusIntAdj	Rsvd		
Function Wake	Rsvd	Device Address	SubType	NotType	Interface	Rsvd	Rsvd		
Host Role Request	Rsvd	Device Address	SubType	NotType	RSP	Rsvd	Rsvd		
ITP	Counter	Delta	Adj Ctrl	Corr	Rsvd	Rsvd			
Latency Tolerance	Rsvd	Device Address	SubType	NotType	BELT	Rsvd	Rsvd		
Link Delay Measurement	SubType	LDM Type	LDMS	Rsvd	Response Delay	Rsvd	Rsvd		
NRDY	Rsvd	Device Address	SubType	Rsvd	D	EPTNum	Rsvd	StreamId	Rsvd
PING	Route String	Device Address	SubType	Rsvd	D	EPTNum	Rsvd	Rsvd	
PING_RESPONSE	Rsvd	Device Address	SubType	Rsvd	D	EPTNum	Rsvd	Rsvd	
Port Configuration	SubType	Link Speed	Rsvd	Rsvd	Rsvd				
Port Configuration Response	SubType	Response Code	Rsvd	Rsvd	Rsvd				
STALL	Rsvd	Device Address	SubType	Rsvd	D	EPTNum	Rsvd	Rsvd	
Set Link Function	SubType	SLF	Rsvd	Rsvd	Rsvd				
U2 Inactivity Timeout	SubType	U2 IT	Rsvd	Rsvd	Rsvd				
Vendor Device Test	SubType	VDT	Rsvd	Vendor Def	... for fields no. 1, 2 and n+x see Table 12-21				

Table 12-21: Long frames that start with fields HPSTART and Type and end with CRC and the Link Control Word

Frame	Fld.3	Field4	Fld.5	Field6	Fld.7	Fld.8	Field9	F.10	Fld.11	Fld.12	Fld.13	F.14	F.15	Fld.16	F.17	F.18	F.19	F.20	F.21	F.22
ACK	Route String	Device Address	Sub-Type	Rsvd	rty	D	EPT-Num	TT	HE	NumP	SeqNum	Rsvd	TPF	StreamId	Rsvd	SSI	WPA	DBI	PP	NBI
DPH	Route String	Device Address	Seq-Num	Rsvd	EOB	D	EPT-Num	TT	S	Length	StreamId	Rsvd	SSI	WPA	DBI	PP	NBI			
ERDY	Rsvd	Device Address	Sub-Type	Rsvd	D	EPT-Num	Rsvd	Num P	Rsvd	StreamId	Rsvd									
Port Capa-bility	Sub-Type	Link Speed	Rsvd	Num HP Buf	Rsvd	Dir	OTG	Rsvd	Tie-breaker	Rsvd	Rsvd									
STA-TUS	Route String	Device Address	Sub-Type	Rsvd	D	EPT-Num	Rsvd	Rsvd	PP	Rsvd										
Sublink Speed	Rsvd	Device Address	Sub-Type	Not-Type	Rsvd	TPF	Rsvd	LSE	ST	Rsvd	Lanes	LP	LSM							

	Field1	Field2	Field3	...
Ahead of **Field 3**, add these two fields (**Field1** + **Field2**):	HPSTART	Type	see above	...

	Field n+1	Field n+2	Field n+3	Field n+4	Field n+5	Field n+6	Field n+7
After the **last field (n)**, add CRC + the **"Link Control Word"**:	CRC	**Hdr#**	**Rsvd**	**Hub#**	**DLY**	**DFR**	**CRC**

Table 12-22: Frames without additional fields other than in this table

Frame	Field1	Field2	Field3	Field4	Field5	Field6	F.7	Fld.8	Field9
BCNT	BERC	EC							
BDAT	BDAT								
BERC	BERC								
BRST	COM	BRST							
Data Packet Payload	HPSTART	Data	CRC	DPPEND					
Data Packet Payload Abort	HPSTART	Data	CRC	DPPABORT					
IDLE	Idle								
Link Command	LCSTART	SubType	CRC	SubType	CRC				
SKIP	SKP								
TS1	COM	Rsvd	Train	Rsvd	Loop	Scramble	LL	Rsvd	TS1ID
TS2	COM	Rsvd	Train	Rsvd	Loop	Scramble	LL	Rsvd	TS2ID
TSEQ	COM	Symbol							

And finally the remaining types that are no specified USB 3.1 frames:

Table 12-23: Other types

Type	Field1	Field2	Field3	Field4	Field5	Field6	Field7	Field8	Field9
Error	CRC Error	Length Error	Unknown	Value out of range	Packet Incomplete				
Unknown	?								
Unknown Device Notification	HPSTART	Type	Rsvd	Device Address	SubType	NotType	?	CRC	**LCW**
Unknown Header Packet	HPSTART	Type	?	?	CRC	**LCW**			
Unknown LMP	HPSTART	Type	SubType	?	?	CRC	**LCW**		
Unknown TP	HPSTART	Type	Rsvd	Device Address	SubType	?	?	CRC	**LCW**
LCW = Link Control Word, see Table 12-21, occupies the last 6 fields.									

More information on the USB 3.1 protocol, including all specifications down to the field contents, is available in the "Universal Serial Bus 3.1 Specification" documentation. Refer to the online resources at www.usb.org.

12.15.2 USB 3.1 Configuration

If you need information on how to get started with configuring the USB setup, see Chapter 12.15.2.2, "Configuring USB 3.1 Signals", on page 761. Otherwise proceed with the configuration settings.

12.15.2.1 USB 3.1 Configuration Settings

Access: [Protocol] > "Decode" tab > "Protocol" = *USB3*

Make sure that the tab of the correct serial bus is selected on the left side.

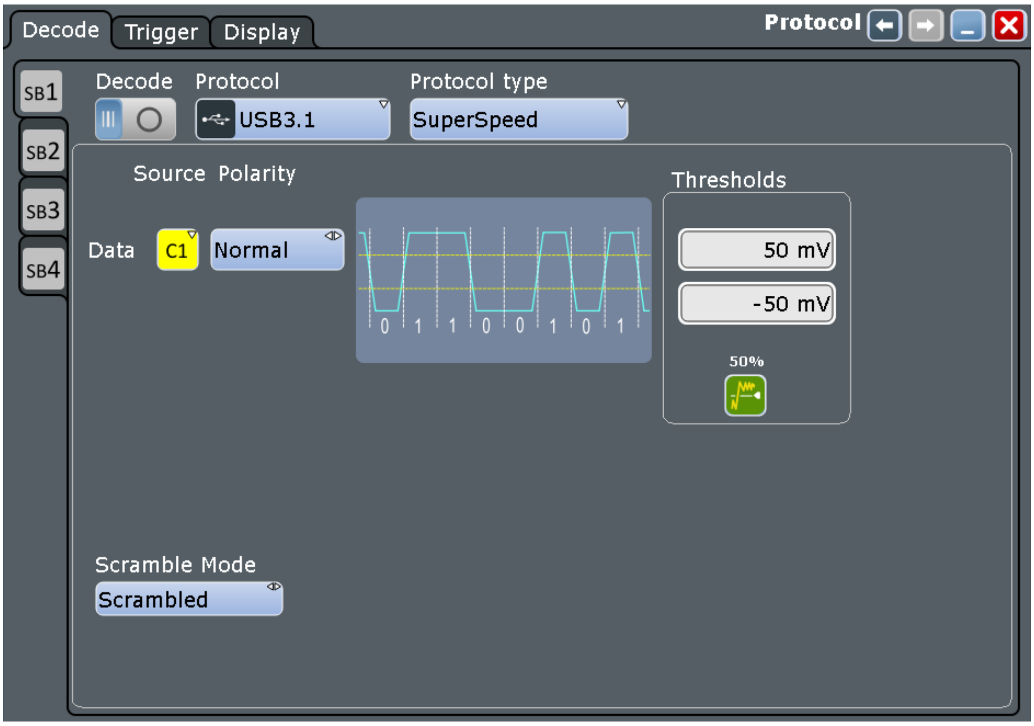


Figure 12-83: Serial bus protocol configuration dialog

For general information on how to configure protocol parameters, see also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Protocol type
Selects the USB 3.1 protocol type.

Remote command:
`BUS<m>:USBThree:TYPE` on page 1670

Data
Defines the source for the data signal. You can select analog channels "C1" to "C4", and also active math and reference waveforms as source. If you want to trigger on the serial bus, analog channel sources are required.

Remote command:
`BUS<m>:USBThree:SOURce` on page 1668

Polarity
Defines the signal polarity settings. Permitted selections are "Normal" and "Inverted".

Remote command:
`BUS<m>:USBThree:POLarity` on page 1668

Thresholds
Sets the threshold values for digitization of the analog signals.

The USB 3.1 standard uses 2-state signals with an upper and a lower voltage level. Permitted thresholds values are in the range of -2 V to +2 V, the default is -40 mV to +40 mV.

If the signal value on the line is higher than the upper threshold, the signal state is considered high. Otherwise, if the signal value is below the lower threshold, the signal state is considered low. The two threshold levels allow configuring a hysteresis setting.

There are two ways to set the threshold:
- "Threshold values"
  Enter the upper and lower values directly into the fields.
- "50%"
  Executes a measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude, adding a hysteresis offset for the high and low threshold.

Remote command:
`BUS<m>:USBThree:THRHigh` on page 1669
`BUS<m>:USBThree:THRLow` on page 1669
`BUS<m>:SETReflevels` on page 1299

Scramble Mode
Selects if the data pattern is scrambled or unscrambled. Scrambling as specified in the standard minimizes EMI emissions, the unscrambled mode can simplify testing and debugging.

Remote command:
`BUS<m>:USBThree:SCRMode` on page 1669

12.15.2.2 Configuring USB 3.1 Signals

For configuration, assign the lines to the input channels and define the active states and the logical thresholds.

Serial Bus Setup

1. Press the [Protocol] key on the front panel.
2. At the left hand-side, select the vertical tab of the serial bus (SB1–SB4) you want to set up.
3. Select the "Configuration" tab.
4. Tap "Protocol" and select the protocol: "USB3".
5. Optionally, you can enter a "Bus label" in the "Display" tab.
6. Switch to the "Trigger" tab, tap "Source" and select "Serial bus".

This prevents the use of Math and Ref waveforms as channel signals.

Note: For triggering on a serial bus, analog input channels are required.

7. Switch back to the "Decode" tab.
8. Set the logical thresholds: Either enter user-defined values directly in the "Threshold" fields, or set the thresholds to the middle reference levels with "50%".
9. Select "Decode" to activate the decode functionality.

For details on configuration settings, see Chapter 12.15.2.1, "USB 3.1 Configuration Settings", on page 760.

12.15.3 USB 3.1 Trigger

If you need information on how to get started with triggering on USB 3.1 Gen 1 signals, see Chapter 12.15.3.2, "Triggering on USB 3.1", on page 764. Otherwise proceed with the USB 3.1 trigger settings.

12.15.3.1 USB 3.1 Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = USB3"

In this section, all trigger settings for USB 3.1 Gen 1 are described. The user interface of the instrument guides you through the trigger setup.

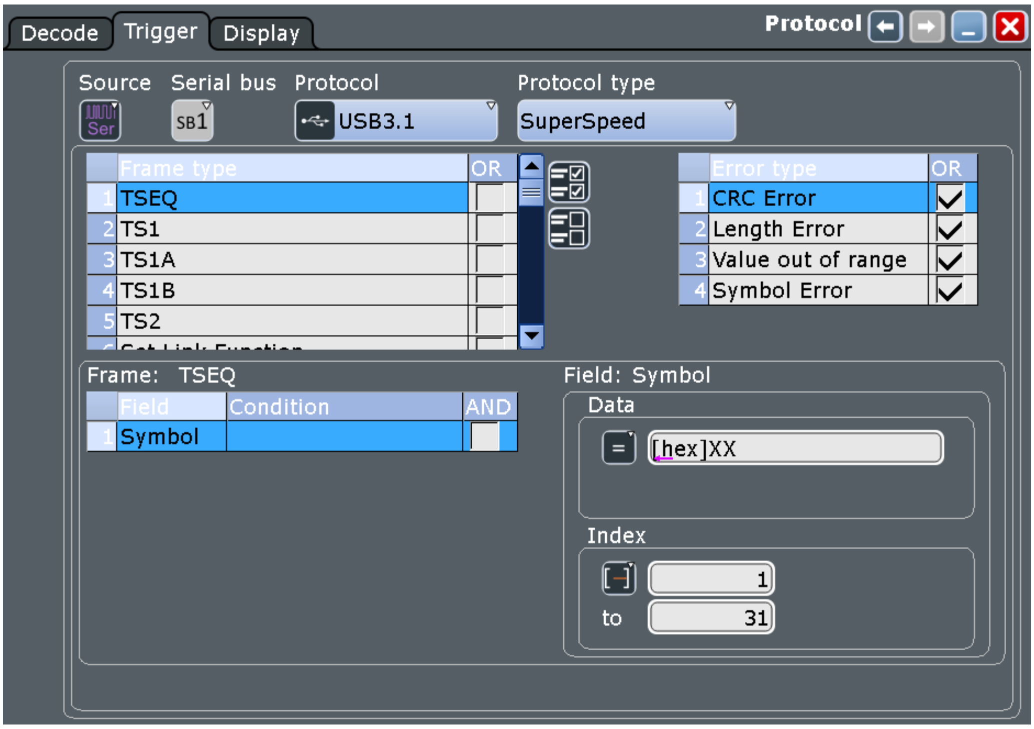


Figure 12-84: USB 3.1 trigger event settings dialog

Make sure that:
- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Protocol type
Selects the protocol type for the USB 3.1 Gen 1 analysis.

Frame type
Selects the frame type for USB 3.1 Gen 1 analysis. For the available frame types, see "Frame types" on page 753.

You can define individual checking parameters for the fields listed in the "Trigger type dependent settings".

To specify these parameters, select a field from this list and define the data and/or index operators and values, or the bit state.

The trigger instant is the last criterion that is fulfilled.

Remote command:
`TRIGger<m>:USBThree:FRENable` on page 1677
`TRIGger<m>:USBThree:FRAMe<n>:ENABle` on page 1677

Error types: Item name, Enable
The table lists the error types you can trigger on: "CRC Error", "Length Error", "Value out of range", "Symbol Error". Enable any error that you want to trigger on in the "OR" column.

Remote command:
`TRIGger<m>:USBThree:ERENable` on page 1677
`TRIGger<m>:USBThree:ERRor<n>:ENABle` on page 1677

Field name / Condition Summary / Enable
This table lists the field numbers and names in the selected frame together with a summary of the user settings of checking conditions for each field and a checkbox to enable the checking.

It also shows the user settings of checking conditions for each field and a checkbox to enable the checking.

Select a field in the table to specify the checking conditions for this field in the "Data", "BitState" and/or "Index" dialog (whichever applies). The condition is only applied, and the "Condition Summary" is only shown in the table, if "AND" is checked.

For an overview of frames and fields, see Frame types.

For an example of a table with displayed "Condition Summary" entries, see Figure 12-87.

Remote command:
`TRIGger<m>:USBThree:FIENable` on page 1677
`TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:ENABle` on page 1677

Data

Defines for the selected field, how a data check is executed.

"Condition" Defining specific data or a data range requires to set the operator to one of the following conditions: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies data or sets the start value of a data range.

"Max" Sets the end value of a data range, if "Condition" is set to "In range" or "Out of Range".

Remote command:
`TRIGger<m>:USBThree:DOPerator` on page 1678
`TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:DOPerator` on page 1678
`TRIGger<m>:USBThree:DMIN` on page 1679
`TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:DMIN` on page 1679
`TRIGger<m>:USBThree:DMAX` on page 1679
`TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:DMAX` on page 1679

Data BitState

Defines the data bit state to be checked for the selected field. Permitted bit states are "1", "0" or "X" (do not care).

Remote command:
`TRIGger<m>:USBThree:BIT` on page 1679
`TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:BIT` on page 1679

Index

Defines for the selected field, how an index check is executed.

"Condition" Defining a specific index or an index range requires to set the operator to one of the following conditions: equal, in range.

"Min" Specifies the index or sets the start value of an index range.

"Max" Sets the end value of an index range, if "Condition" is set to "In range".

Remote command:
`TRIGger<m>:USBThree:IOPerator` on page 1680
`TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:IOPerator` on page 1680
`TRIGger<m>:USBThree:IMIN` on page 1680
`TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:IMIN` on page 1680
`TRIGger<m>:USBThree:IMAX` on page 1681
`TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:IMAX` on page 1681

12.15.3.2 Triggering on USB 3.1

Prerequisite: A bus is configured for the USB 3.1 signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
   The "Protocol" selection is then automatically set to "USB3.1".
4. If you trigger on errors, enable the error types you want to find.
5. Select the frame types you want to trigger on.
6. For some frame types, you can define the frame fields.
   For information on the configuration settings, see Chapter 12.15.3.1, "USB 3.1 Trigger Settings", on page 762.

12.15.4 USB 3.1 Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Examples

The example in Figure 12-85 shows a simulated USB 3.1 Gen 1 message. Among the long line of decoded frames, the zoom has selected a "Sublink Speed" frame, followed by a DPH ("Data Packet Header") frame and a "Data Packet Payload" frame.

Figure 12-85: USB 3.1 Gen 1 protocol: decoded and binary signal

1st frame = Sublink Speed
2nd frame = Data Packet Header (DPH)
3rd frame = Data Packet Payload
Green brackets [...] = Start and end of frame
Dark purple field = Route string
Green field = Length
Light blue fields = CRC checksum
Orange fields = Payload data bits
Grey fields = Idle bits

The example in Figure 12-86 shows the same simulated USB 3.1 Gen 1 message as in Figure 12-85, but with overlaid decode results (upper table, showing frames) and decode results details (table below, showing decoded fields of the selected frame).

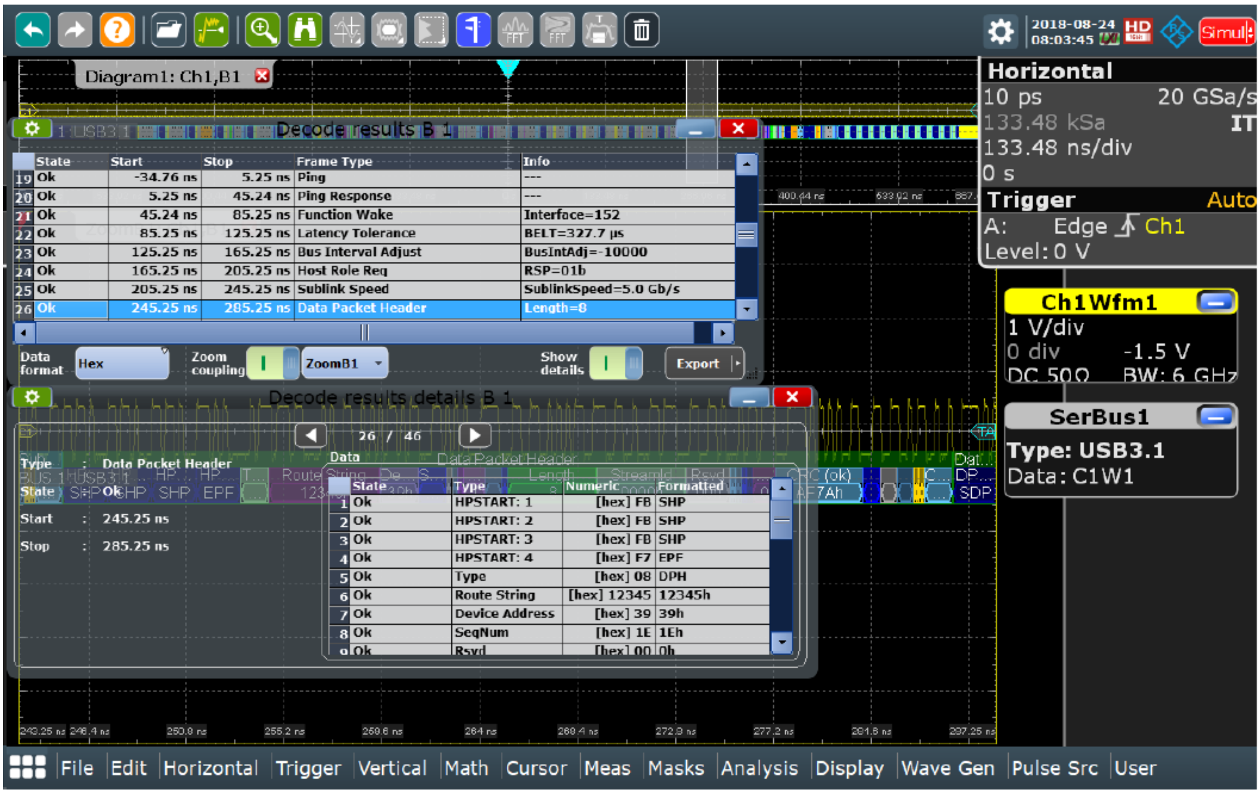


Figure 12-86: USB 3.1 Gen 1 protocol: decoded and binary signal, and decode results

Table 12-24: Content of the "Decode results" table

Column	Description
State	Overall state of the frame, for example "OK" or "Incomplete"
Start	Start time of the frame
Stop	Stop time of the frame
Frame Type	Type of the frame
Info	Specific frame information, for example result of the Link Speed Measurement = 5.0 Gb/s, or content of the Data Packet Payload
Data	Data of the frame

Table 12-25: Content of the "Decode results details" table

Column	Description
State	Overall state of the field
Start	Start time of the field
Stop	Stop time of the field
Type	Type (name) of field
Numeric value	The numeric value of the field
Formatted	Formatted content of the field, for example HPSTART "F7" = end packet framing (EPF)

If a frame is partially outside of the acquisition window, it cannot be completely decoded. However, as long as sufficient sample data are available, incomplete frames are partially decoded and do not appear as errors.

The trigger instant is the last criterion that is fulfilled.

For a description of the frames and for lists of their fields, see Chapter 12.15.1, "The USB 3.1 Protocol", on page 751, specifically Frame types.

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:
- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote control commands for retrieving decode results are described in Chapter 20.17.16, "USB 3.1 (Option R&S RTP-K61)", on page 1668.

Remote command:
- `BUS<m>:USBThree:RESult:FCOunt?` on page 1681
- `BUS<m>:USBThree:RESult:FRAMe<n>:INFO?` on page 1682
- `BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?` on page 1682
- `BUS<m>:USBThree:RESult:FRAMe<n>:STATe?` on page 1682
- `BUS<m>:USBThree:RESult:FRAMe<n>:STARt?` on page 1683
- `BUS<m>:USBThree:RESult:FRAMe<n>:STOP?` on page 1683
- `BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:TYPE?` on page 1683
- `BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:STATus?` on page 1684
- `BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:STARt?` on page 1684
- `BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:STOP?` on page 1684
- `BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:VAL?` on page 1685
- `BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:FVAL?` on page 1685

12.15.5 Search on Decoded USB 3.1 Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 396.

If you need information on how to get started with searching USB 3.1 data, see Chapter 12.15.5.3, "Searching USB 3.1 Data", on page 771. Otherwise proceed with the USB 3.1 search setup.

12.15.5.1 USB 3.1 Search Setup

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for USB 3.1

Search criteria
Use the "Search criteria" dialog to define the search type. If you search for frame content, define the frame type in which data is to be searched.

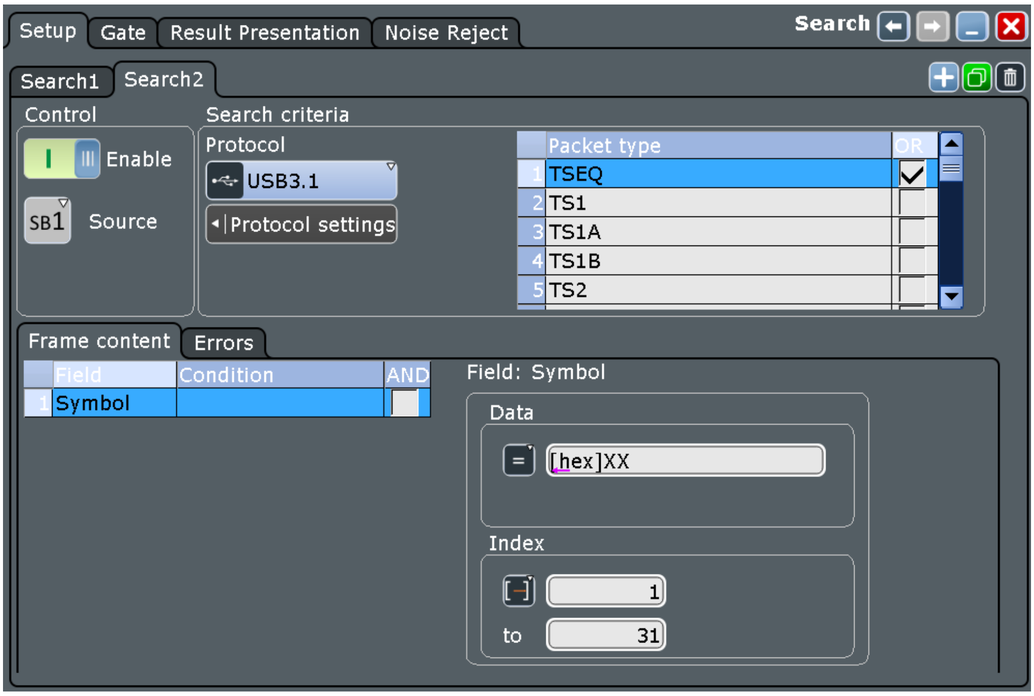


Figure 12-87: Example of search criteria for frame content in status frames

You can define individual search parameters for the fields of the selected frame in the table below the "Search criteria". To specify these parameters, select a field in the table and define the data and/or index operators and values, or the bit state.

For a description of how to set the search conditions, see Chapter 12.15.3.1, "USB 3.1 Trigger Settings", on page 762.

Remote command:
SEARch:TRIGger:USBThree:ERENable on page 1686
SEARch:TRIGger:USBThree:ERRor<m>:ENABle on page 1686
SEARch:TRIGger:USBThree:FRENable on page 1687
SEARch:TRIGger:USBThree:FRAMe<m>:ENABle on page 1687
SEARch:TRIGger:USBThree:FIENable on page 1687
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:ENABle on page 1687
SEARch:TRIGger:USBThree:DOPerator on page 1688
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:DOPerator on page 1688
SEARch:TRIGger:USBThree:DMIN on page 1688
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:DMIN on page 1688
SEARch:TRIGger:USBThree:DMAX on page 1689
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:DMAX on page 1689
SEARch:TRIGger:USBThree:BIT on page 1689
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:BIT on page 1689
SEARch:TRIGger:USBThree:IOPerator on page 1690
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IOPerator on page 1690
SEARch:TRIGger:USBThree:IMIN on page 1690
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMIN on page 1690
SEARch:TRIGger:USBThree:IMAX on page 1691
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMAX on page 1691

12.15.5.2 USB 3.1 Search Results

To get search results, "Enable" the search in the "Control" section of the "Search Setup" dialog. You can minimize, shift or close the search dialog to better see the "Search Results" table.

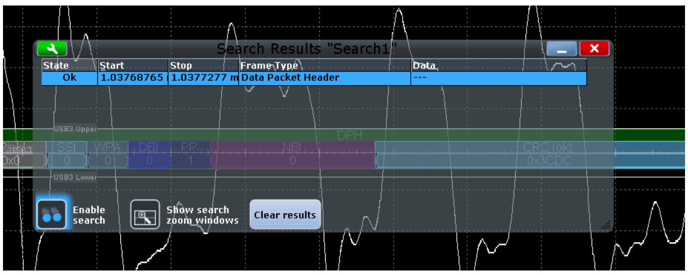


Figure 12-88: Search results table

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

Remote commands:

- SEARch:RESult:USBThree:FCOunt? on page 1692
- SEARch:RESult:USBThree:FRAMe<m>:TYPE? on page 1691
- SEARch:RESult:USBThree:FRAMe<m>:INFO? on page 1692
- SEARch:RESult:USBThree:FRAMe<m>:STATe? on page 1692
- SEARch:RESult:USBThree:FRAMe<m>:STARt? on page 1693
- SEARch:RESult:USBThree:FRAMe<m>:STOP? on page 1693
- SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:TYPE? on page 1693
- SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:STATus? on page 1694
- SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:STARt? on page 1694
- SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:STOP? on page 1695
- SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:VAL? on page 1695
- SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:FVAL? on page 1695

12.15.5.3 Searching USB 3.1 Data

Prerequisite: A serial bus is configured for the USB 3.1 Gen 1 signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press [Search] or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 411.
3. Tap "Source" and select the serial bus that is set to USB 3.1 (e.g. "SB1", unless already selected).

   The search dialog for USB3 protocol analysis is opened.
4. Specify search criteria according to Chapter 12.15.5.1, "USB 3.1 Search Setup", on page 769.

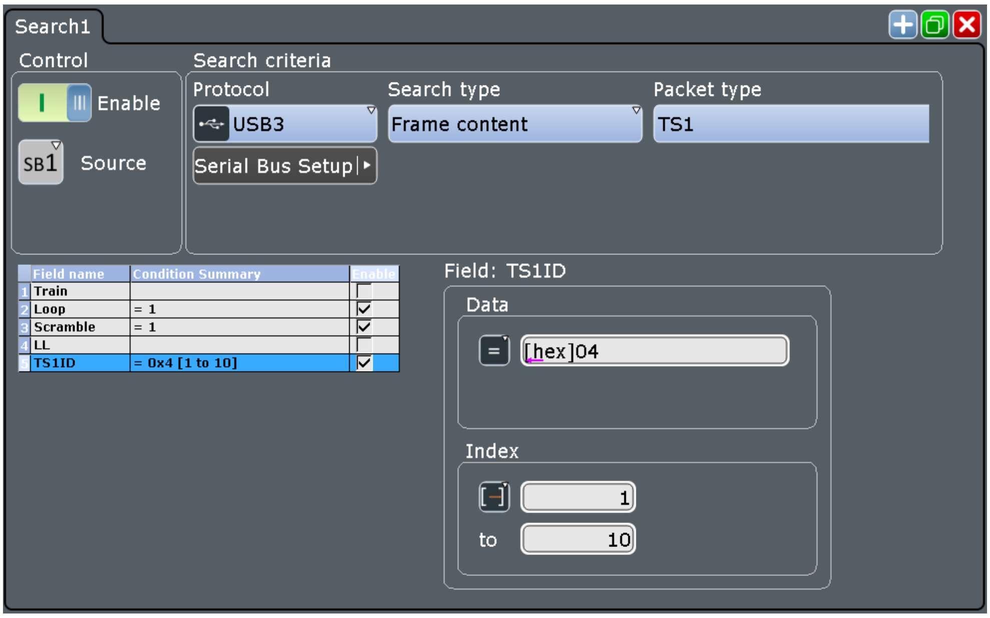


Figure 12-89: Example of search criteria for the frame "Training Sequence 1" (TS1)

5. To acquire a waveform, press [Single].

   The R&S RTP performs a USB 3.1 decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).

6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTP displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 417 and "Navigating search results" on page 398.

12.16 USBPD (Option R&S RTP-K63)

R&S RTP-K63 is a firmware option that enables the R&S RTP to analyze Universal Serial Bus Power Delivery (USBPD) signals.

For analysis, USBPD encoded signals can be triggered, decoded and searched.

This chapter describes:

12.16.1 The USB Power Delivery Protocol

The requirements on the USB have changed in the last years with the need of providing power through the USB port additionally to the data transfer. The USBPD specification aims to define standard for optimizing the power usage through the USB for the needs of the users.

USBPD characteristics

Main characteristics of USBPD are:

- Power direction is not fixed
- Negotiation of required power amount between devices
- Alternate modes can be defined through vendor defined messages, which allows for USB connector pins to be used for purposes other than USB

Message types

In the USBPD protocol, a power delivery connection can be made between a port that supplies power (source) and a port that consumes power (sink). They communicate with each other through messages. The USBPD specification defines three message types:

- Control messages: 16-bit messages used to control the messages between the port partners or transfer messages with no extra data. A control message consists of a message header and a CRC.
- Data messages: 48 bit to 240 bit messages used to transfer information between port partners. A data message consists of a message header and several data objects. The information that a data object carries is defined by the message type of the message header, see Table 12-26.
- Extended messages: can have a different length up to the defined maximum length of an extended message. It is used to transfer information between port partners. The information that the extended message carries is defined by the message type of the message header, see Table 12-26.

Frame packet types

All frame types are listed below. The frames listed above consist of individual sets of fields. Some frames only contain one field, others are much longer.

The frame types are sorted according to the message type.

Table 12-26: Frame packet types

SCPI	Description	Message type
ALRT	Alert message	Data
BATT	Battery status	Data
BIST	Built in self-test	Data
RQST	Request	Data
SINK	Sink capabilities message	Data

SCPI	Description	Message type
SRC	Source capabilities message	Data
VEND	Vendor defined message	Data
CTRL	Control	Control
DATA	Data	Data
LOWP	Low power	Low power
TEST	Test frame	Test
RESet	Reset frame	Reset
XBAC	Battery capabilities	Extended
XFRS	Firmware update response	Extended
XFRQ	Firmware update request	Extended
XGBC	Get battery cap	Extended
XGMI	Get manufacturer info	Extended
XGBS	Get battery status	Extended
XMFI	Manufacturer info	Extended
XMSG	Message	Extended
XSRC	Sources capabilities message	Extended
XSRS	Security response	Extended
XSRQ	Security request	Extended
XSTA	Status	Extended

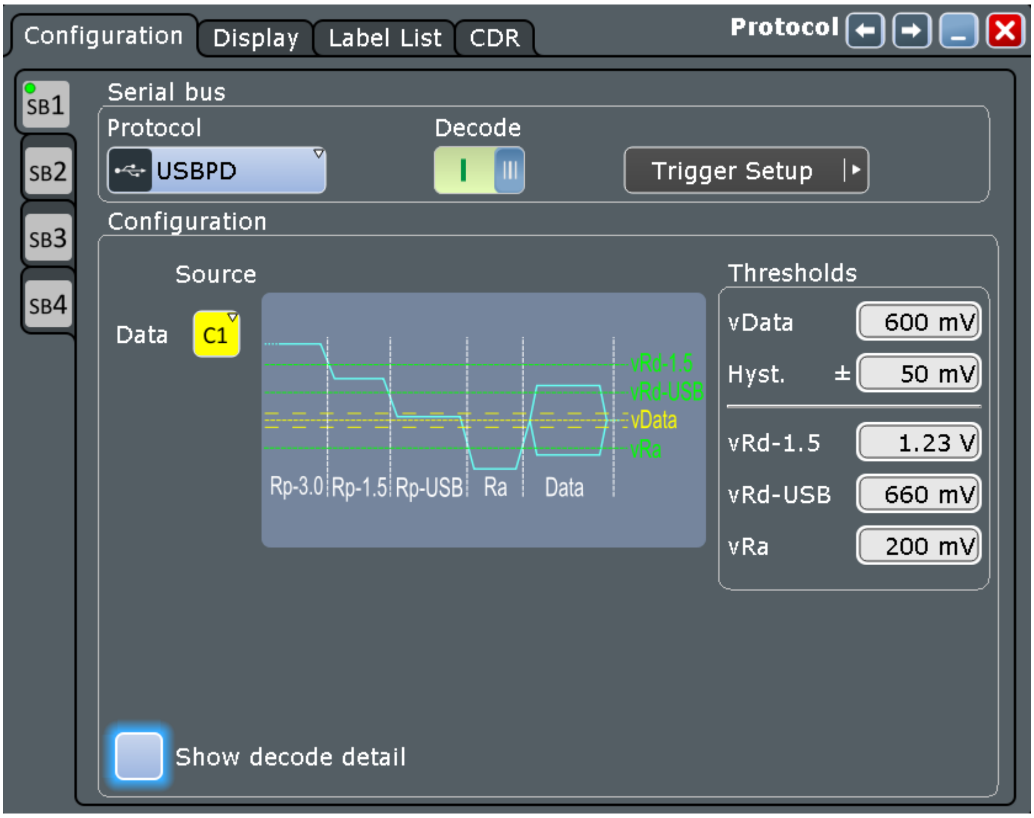
More information on the USBPD protocol, including all specifications down to the field contents, is available in the "Universal Serial Bus Power Delivery Specification" documentation. Refer to the online resources at www.usb.org.

12.16.2 USBPD Configuration

12.16.2.1 USBPD Configuration Settings

Access: [Protocol] key > "Decode" tab > "Protocol" = "USBPD"

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Data

Defines the source settings for the data signal. You can select analog channels "C1" to "C4", and also active math and reference waveforms as source. If you want to trigger on the serial bus, analog channel sources are required.

Remote command:

`BUS<m>:USBPd:SOURce` on page 1696

vData

Sets the threshold value of the data.

Remote command:

`BUS<m>:USBPd:THReshold` on page 1697

Hyst

Sets a value for the hysteresis of the data.

Remote command:

`BUS<m>:USBPd:HYSTeresis` on page 1696

Current advertisment thresholds

The signal level provides information about the current advertisement between the bursts. These thresholds determine the levels at which the current advertisement modes are defined.

"vRd-1.5" Sets the threshold at USB Type-C current of 1.5 A.

"vRd-USB"	Sets the threshold at default USB Type-C current.
"vRa"	Sets the threshold for the low current.

Remote command:
`BUS<m>:USBPd:THRBottom` on page 1697
`BUS<m>:USBPd:THRMid` on page 1697
`BUS<m>:USBPd:THRTop` on page 1698

Show decode detail
If enabled, the data words are broken down into sub-frames. If not enabled the data words are displayed as 32-bit data words.

If the "Show decode detail" is enabled, you cannot do a search and trigger on USBPD frames.

Remote command:
`BUS<m>:USBPd:DETail` on page 1696

12.16.2.2 Display Settings

Access: [Protocol] > "Configuration" tab > "Protocol = USBPD " > "Display" tab

To enhance the decode possibilities of the USBPD protocol, you can use an additional setting in the "Display" tab: "Decode layer".

Common display settings are explained in Chapter 12.1.2, "Display", on page 465.

Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Final"	...
"Edges"	...
"Bits"	...
"4b5b Symbols"	...

12.16.2.3 Configuring the USBPD Signals

For configuration, assign the lines to the input channels and define the logical thresholds and the hysteresis.

1. Press the [Protocol] key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "USBPD".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Select the data source.
7. Enter the "Thresholds".
8. Enable "Decode", if available.

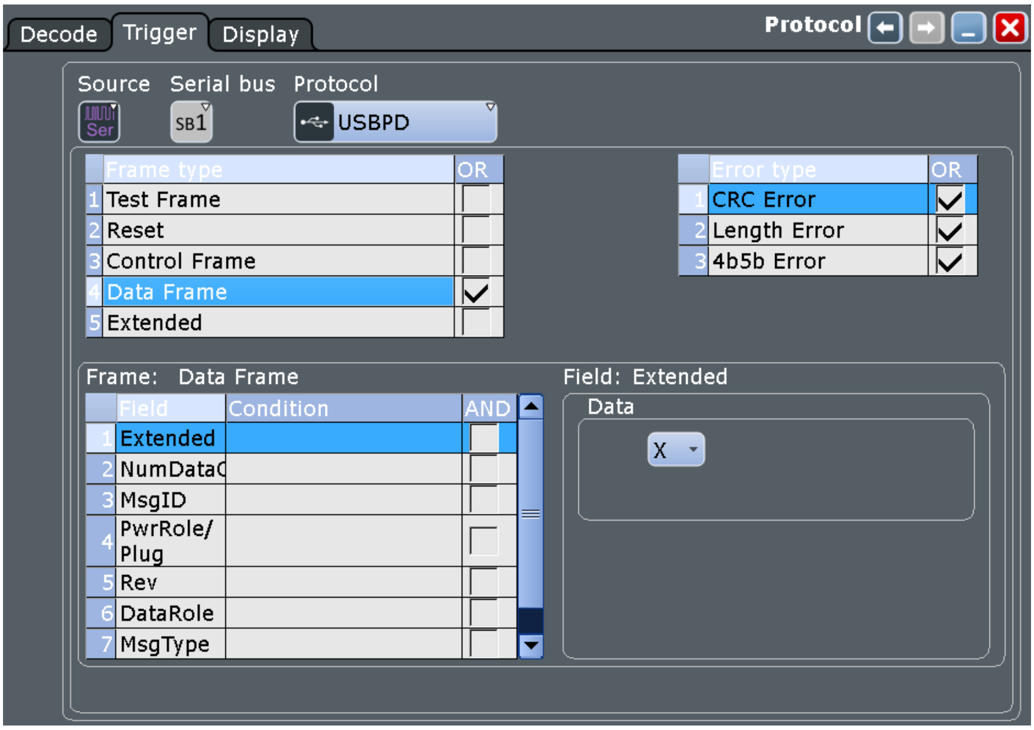
12.16.3 USBPD Trigger

If you need information on how to get started with triggering on USBPD signals, see Chapter 12.16.3.2, "Triggering on USBPD", on page 780. Otherwise proceed with the USBPD trigger settings.

12.16.3.1 USBPD Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = USBPD"

In this section, all trigger settings for USBPD are described. The user interface of the instrument guides you through the trigger setup.



Make sure that:

- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Frame Type

Selects the frame type for the USBPD analysis. For the available packet types, see "Frame packet types" on page 773.

You can define individual checking parameters for the fields listed in the "Trigger type dependent settings".

To specify these parameters, select a field from this list and define the data and/or index operators and values, or the bit state.

The trigger instant is the last criterion that is fulfilled.

Remote command:

`TRIGger<m>:USBPd:FRENable` on page 1700

`TRIGger<m>:USBPd:FRAMe<n>:ENABle` on page 1700

Field name / Condition Summary / Enable

This table lists the field numbers and names in the selected frame together with a summary of the user settings of checking conditions for each field and a checkbox to enable the checking.

Select a field in the table to specify the checking conditions for this field in the "Data", "BitState" and/or "Index" dialog (whichever applies). The condition is only applied, and the "Condition Summary" is only shown in the table, if "Enable" is checked.

For an overview of frames and fields, see "Frame packet types" on page 773.

Remote command:
`TRIGger<m>:USBPd:FIENable` on page 1701
`TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:ENABle` on page 1701

Error > Item name /Enable
The table lists the error types you can trigger on: "CRC Error", "Length Error", "4b5b Error". Enable any error that you want to trigger on in the "OR" column.

Remote command:
`TRIGger<m>:USBPd:ERENable` on page 1700
`TRIGger<m>:USBPd:ERRor<n>:ENABle` on page 1700

Data
Defines for the selected field, how a data check is executed.

"Condition" Defining specific data or a data range requires to set the operator to one of the following conditions: equal, not equal, less than, less than or equal, greater than, greater than or equal, in range, out of range.

"Min" Specifies data or sets the start value of a data range.

"Max" Sets the the end value of a data range, if "Condition" is set to `INRange` or `OORange`.

Remote command:
`TRIGger<m>:USBPd:DOPerator` on page 1702
`TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:DOPerator` on page 1702
`TRIGger<m>:USBPd:DMAX` on page 1702
`TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:DMAX` on page 1702
`TRIGger<m>:USBPd:DMIN` on page 1702
`TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:DMIN` on page 1702

Data BitState
Defines the bit state to be checked for the selected field. Permitted bit states are "1", "0" or "X" (don't care).

Remote command:
`TRIGger<m>:USBPd:BIT` on page 1701
`TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:BIT` on page 1701

Index
Defines for the selected field, how an index check is executed.

"Condition" Defining a specific index or an index range requires to set the operator to one of the following conditions: equal, in range.

"Min" Specifies the index or sets the start value of an index range.

"Max" Sets the the end value of an index range, if "Condition" is set to `INRange`.

Remote command:
`TRIGger<m>:USBPd:IOPerator` on page 1704
`TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:IOPerator` on page 1704
`TRIGger<m>:USBPd:IMAX` on page 1703
`TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:IMAX` on page 1703
`TRIGger<m>:USBPd:IMIN` on page 1703
`TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:IMIN` on page 1703

12.16.3.2 Triggering on USBPD

Prerequisite: A bus is configured for the USBPD signal to be analyzed.

In order to be able to trigger on an USBPD data, the "Show decode detail" field in the "Configuration" tab of the protocol setup should be disabled.

For the basic trigger settings, proceed in the following way:

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Tap "Serial bus" and select the serial bus that is set to USBPD, e.g.:
   The "Protocol" selection is then automatically set to "USBPD".
5. If you trigger on errors, enable the error types you want to find.
6. Select the frame types you want to trigger on.
7. For some frame types, you can define the frame fields.
   For information on how to proceed with the configuration settings, see Chapter 12.16.3.1, "USBPD Trigger Settings", on page 777.

12.16.4 USBPD Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".
2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Examples

The example in USBPD protocol: decoded and binary signal shows a simulated USBPD message. Among the long line of decoded frames, the zoom has selected a "Data" frame.

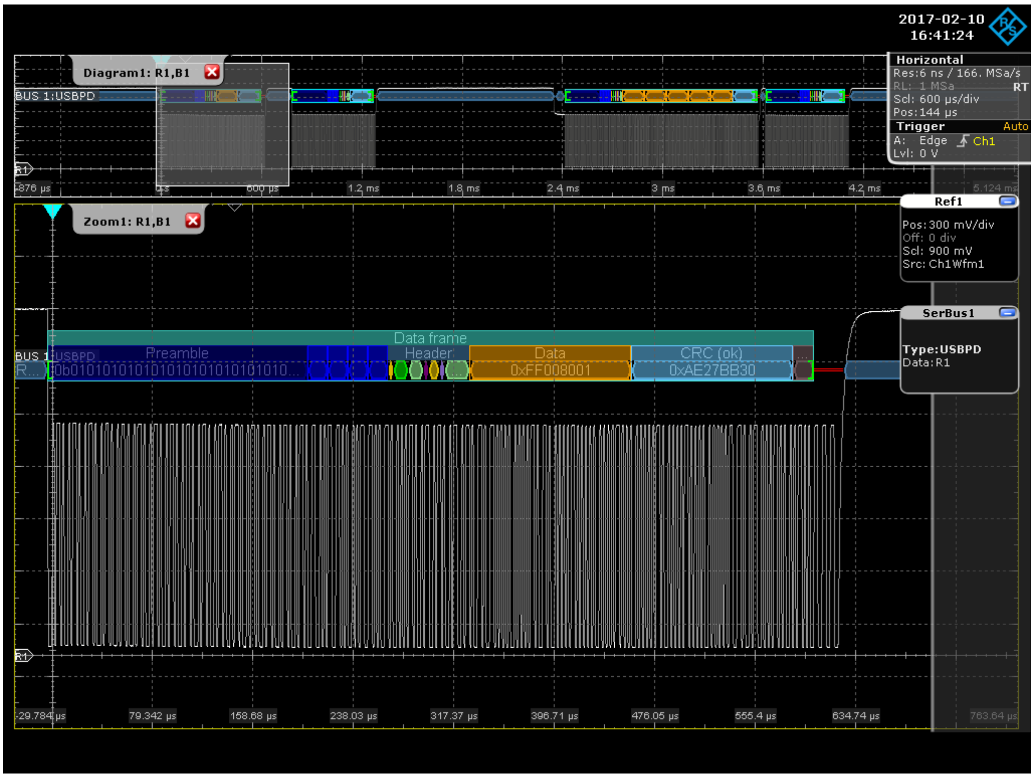


Figure 12-90: USBPD protocol: decoded and binary signal

Green brackets [...]	=	Start and end of frame
Dark green field	=	Header
Light blue fields	=	CRC checksum
Orange fields	=	Data bits

The example in USBPD protocol: decoded and binary signal, and decode results shows the same simulated USBPD message as in Figure 12-90, but with overlaid decode results (upper table, showing frames) and decode results details (table below, showing decoded fields of the selected frame).

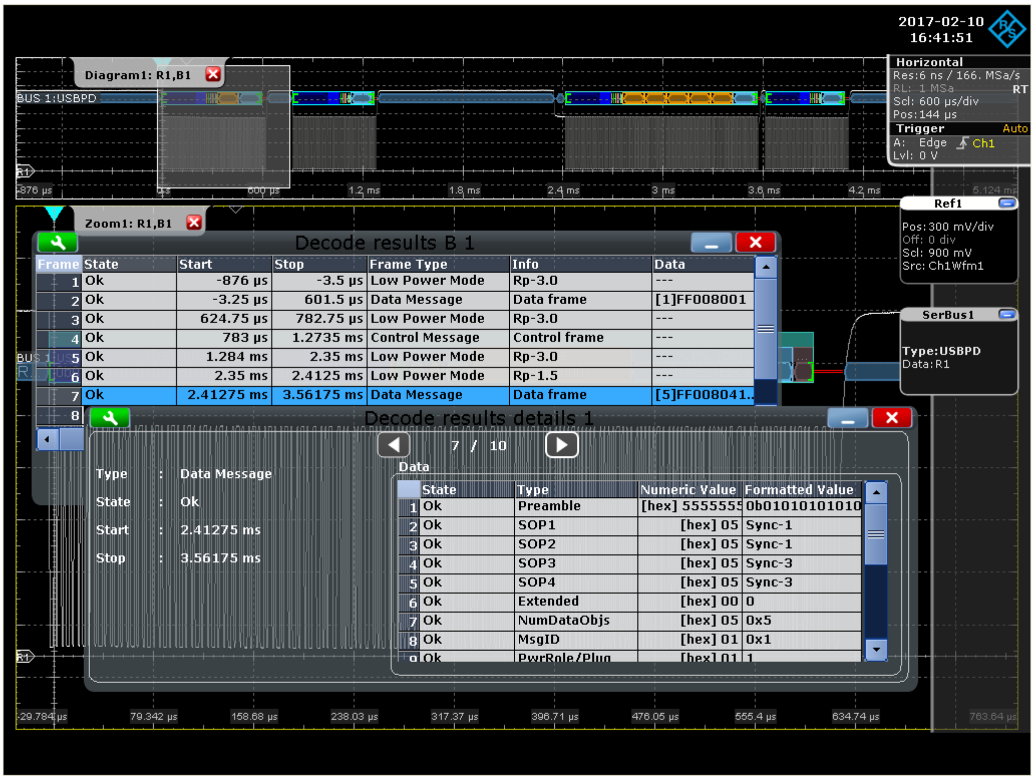


Figure 12-91: USBPD protocol: decoded and binary signal, and decode results

Table 12-27: Content of the "Decode results" table

Column	Description
State	Overall state of the frame
Start	Time of frame start
Stop	Time of frame stop
Frame Type	Type of the frame
Info	Information about the frame
Data	Data of the frame

Table 12-28: Content of the "Decode results details" table

Column	Description
State	Overall state of the field
Start	Start time of the field
Stop	Stop time of the field
Type	Type (name) of field
Numeric value	The numeric value of the field
Status	Status of the field: OK or error

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:

- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.17.3, "Decode Results", on page 1704.

- `BUS<m>:USBPd:RESult:FCOunt?` on page 1704
- `BUS<m>:USBPd:RESult:FRAMe<n>:DATA?` on page 1705
- `BUS<m>:USBPd:RESult:FRAMe<n>:INFO?` on page 1707
- `BUS<m>:USBPd:RESult:FRAMe<n>:STARt?` on page 1708
- `BUS<m>:USBPd:RESult:FRAMe<n>:STATe?` on page 1708
- `BUS<m>:USBPd:RESult:FRAMe<n>:STOP?` on page 1708
- `BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?` on page 1709
- `BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:FVAL?` on page 1705
- `BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:STATus?` on page 1705
- `BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:STARt?` on page 1706
- `BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:STOP?` on page 1706
- `BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:TYPE?` on page 1707
- `BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:VAL?` on page 1707

12.16.5 Search on Decoded USBPD Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

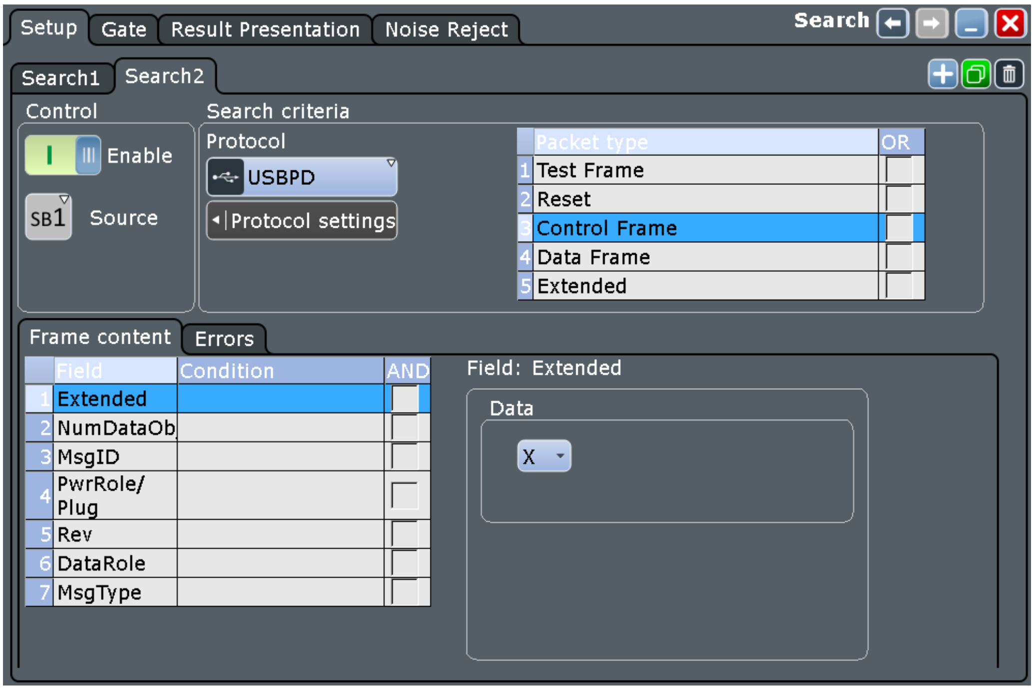
For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 396.

If you need information on how to get started with searching USBPD data, see Chapter 12.16.5.3, "Searching USBPD Data", on page 787. Otherwise proceed with the USBPD search setup.

12.16.5.1 USBPD Search Setup

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for USBPD

Search criteria
Use the "Search criteria" dialog to define the frame type in which data is to be searched.



You can define individual search parameters for individual fields in the table below the "Search criteria" dialog. To specify these parameters, select a field in this table and define the data and/or index operators and values, or the bit state.

For a description of how to set the search conditions, see Chapter 12.16.3.1, "USBPD Trigger Settings", on page 777.

Remote command:
`SEARch:TRIGger:USBPd:ERENable` on page 1710
`SEARch:TRIGger:USBPd:ERRor<m>:ENABle` on page 1710
`SEARch:TRIGger:USBPd:BIT` on page 1711
`SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:BIT` on page 1711
`SEARch:TRIGger:USBPd:DMAX` on page 1712

SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DMAX on page 1712
SEARch:TRIGger:USBPd:DMIN on page 1712
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DMIN on page 1712
SEARch:TRIGger:USBPd:DOPerator on page 1713
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DOPerator on page 1713
SEARch:TRIGger:USBPd:IMAX on page 1713
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IMAX on page 1713
SEARch:TRIGger:USBPd:IMIN on page 1714
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IMIN on page 1714
SEARch:TRIGger:USBPd:IOPerator on page 1714
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IOPerator on page 1714

12.16.5.2 USBPD Search Results

To get search results, "Enable" the search in the "Control" section of the "Search Setup" dialog. You can minimize, shift or close the search dialog to better see the "Search Results" table.

If the "Show decode detail" field in the "Configuration" tab of the protocol setup is enabled, then the "Enable" search button is disabled. Disable "Show decode detail" first, to be able to start the search.

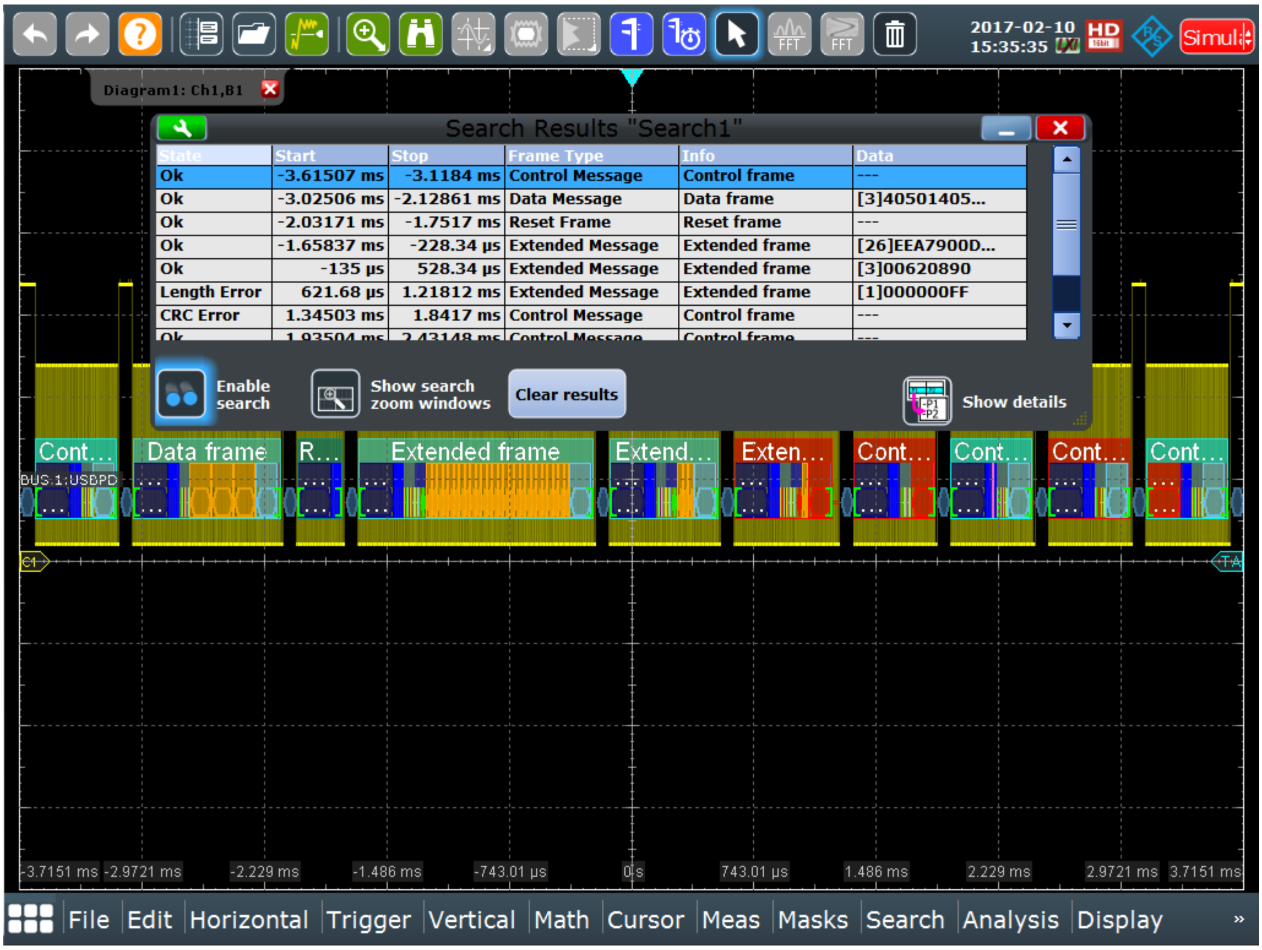


Figure 12-92: Search on USBPD frame

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

Remote commands:

- `SEARch:RESult:USBPd:FCOunt?` on page 1715
- `SEARch:RESult:USBPd:FRAMe<m>:DATA?` on page 1715
- `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 1719
- `SEARch:RESult:USBPd:FRAMe<m>:INFO?` on page 1718
- `SEARch:RESult:USBPd:FRAMe<m>:STATe?` on page 1719
- `SEARch:RESult:USBPd:FRAMe<m>:STARt?` on page 1718
- `SEARch:RESult:USBPd:FRAMe<m>:STOP?` on page 1719

- SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:TYPE? on page 1717
- SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:STATus? on page 1716
- SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:STARt? on page 1717
- SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:STOP? on page 1717
- SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:VAL? on page 1718
- SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:FVAL? on page 1716

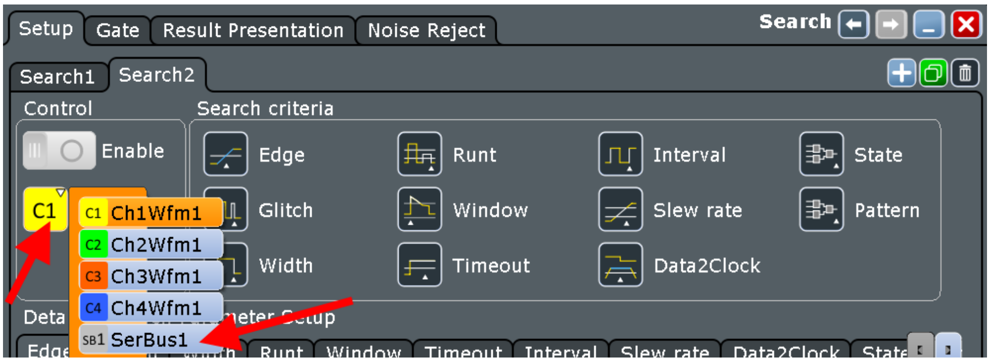
12.16.5.3 Searching USBPD Data

Prerequisite: A serial bus is configured for the USBPD signal to be decoded and analyzed.

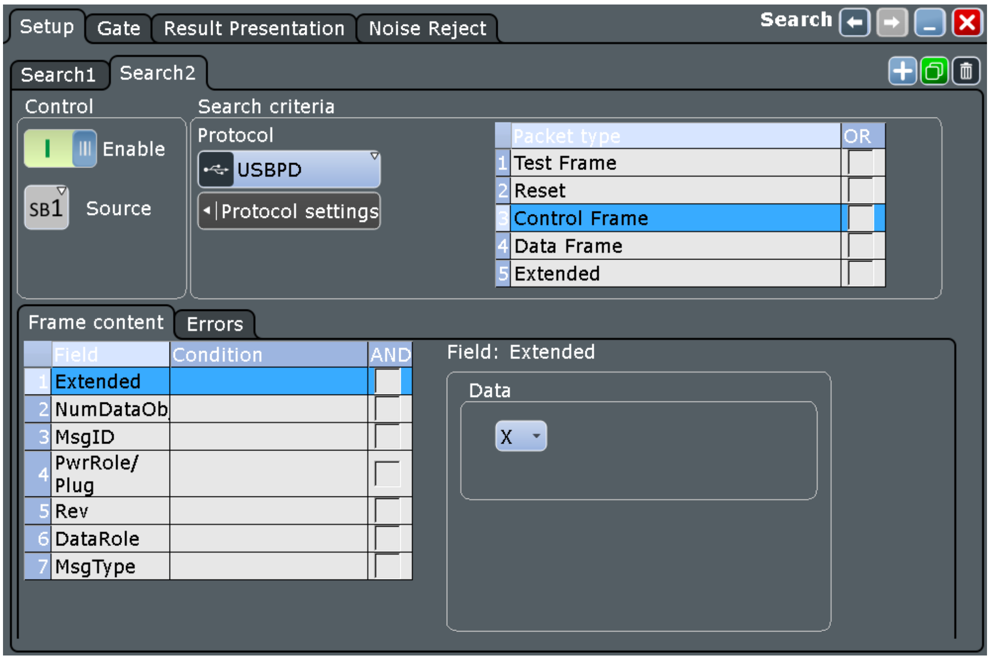
To be able to search for a USBPD data, the "Show decode detail" field in the "Configuration" tab of the protocol setup should be disabled. If "Show decode detail" is enabled, the "Enable" search button is disabled.

The search for events is set up in the following way:

1. Press [Search] or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 411.
3. Tap "Source" and select the serial bus that is set to USBPD (e.g. "SerBus1", unless already selected).



The search dialog for USBPD protocol analysis is opened.



4. Specify search criteria according to Chapter 12.16.5.1, "USBPD Search Setup", on page 784.
5. To acquire a waveform, press [Single].

   The R&S RTP performs a USBPD decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTP displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 417 and "Navigating search results" on page 398.

12.17 PCIe Gen 1/2 (Option R&S RTP-K72)

R&S RTP-K72 is a firmware option that enables the R&S RTP to analyze Peripheral Component Interconnect Express (PCIe) signals encoded by the PCIe standard, generation 1 and 2.

For analysis, PCIe Gen 1/2 encoded signals can be triggered, decoded and searched.

12.17.1 The PCIe Protocol

The PCIe is a high-speed serial computer expansion bus standard.

The communication between two PCIe devices is performed through logical connections called links. Each link consists of several lanes. The lanes contain one differential signaling pair for receiving data and the other for transmitting it.

PCIe logical layers

The PCIe has three logical layers:

- Transaction layer: assembles and disassembles transaction layer packets (TLPs). TLP transfer information like read and write and some event types.
- Data link layer: used for link management and data integrity. Error detection and correction are also done in this layer. The data link layer produces data link layer packets(DLLP).
- Physical layer: includes the circuitry for the interface operation.

PCIe Packet Types

The communication between the layers is done through packets. All packet types that can be decoded by the R&S RTP are listed below.

SCPI name	Description	Type
MRD32 / MRD64	Memory Read Request for 32 bit/ 64-bit addresssing packet format	TLP
MRDLK32 / MRDLK64	Memory Read Request-Locked for 32 bit/ 64-bit addresssing packet format	TLP
MWR32 / MWR64	Memory Write Request for 32 bit/ 64-bit addresssing packet format	TLP
IORD	I/O Read Request	TLP
IOWR	I/O Write Request	TLP
CFGRD0 / CFGRD1	Configuration Read Type 0/1	TLP Type
CFGWR0 / CFGWR1	Configuration Write Type 0/1	TLP
TCfgRd / TCfgWr	Deprecated TLP Type	TLP
MSG	Message Request	TLP
MSGD	Message Request with data payload	TLP
CPL	Completion without Data	TLP
CPLD	Completion with Data	TLP
CPLLK	Completion for Locked Memory Read without Data	TLP
CPLDLK	Completion for Locked Memory Read	TLP
FA32 / FA64	Fetch and Add AtomicOp Request for 32 bit/ 64-bit addresssing packet format	TLP

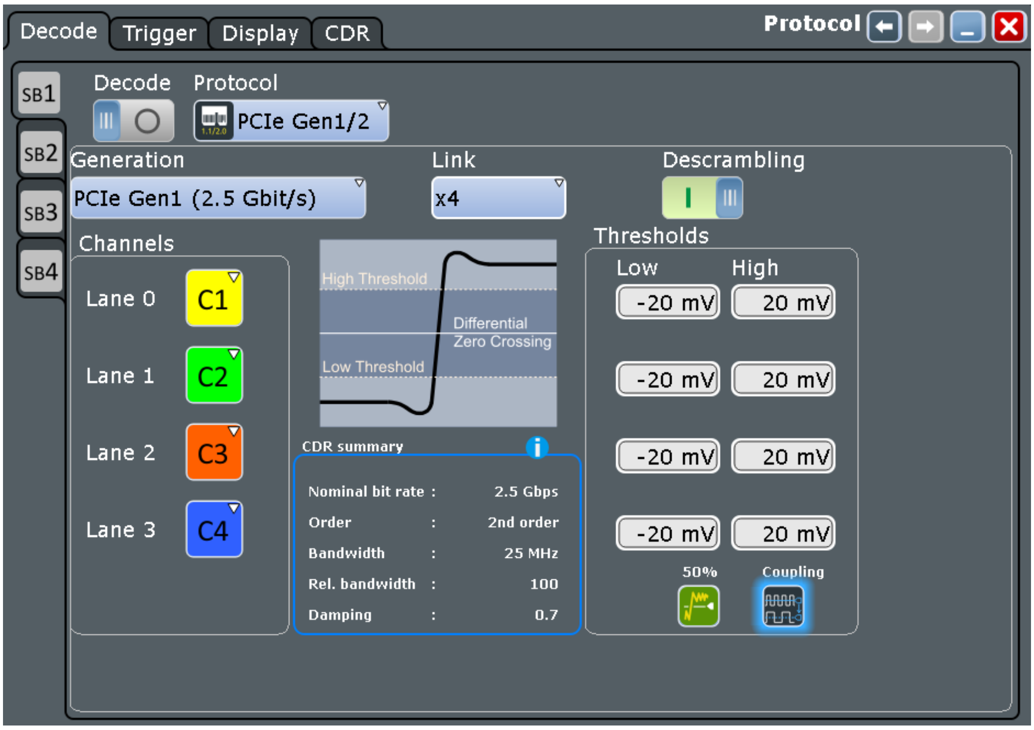
SCPI name	Description	Type
SWP32 / SWP64	Unconditional Swap AtomicOp Request for 32 bit/ 64-bit addresssing packet format	TLP
CAS32 / CAS64	Compare and Swap AtomicOp Request for 32 bit/ 64-bit addresssing packet format	TLP
LPRFX	Local TLP Prefix	TLP
EPRFX	End-End TLP Prefix	TLP
ACK	Acknowledgement	DLLP
NAK	Negative acknowledgment	DLLP
PMEL1 / PMEL23	Power management Enter L1/ L23	DLLP
PMASRL1	Power management Active State Request L1	DLLP
PMRA	Power management request acknowledgment	DLLP
VENDS	Vendor Specific	DLLP
IFC1P / IFC2P	Initialization flow control 1/2 posted requests	DLLP
IFC1NP / IFC2NP	Initialization flow control 1/2 non posted requests	DLLP
IFC1CPL / IFC2CPL	Initialization flow control 1/2 completions	DLLP
UPDFCP	Update flow control 1/2 posted requests	DLLP
UPDFCNP	Update flow control non posted requests	DLLP
UPDFCCPL	Update flow control completions	DLLP
SKPOS	SKP ordered set	Ordered Set
TS1OS / TS2OS	Training sequence 1/2 ordered set	Ordered Set
FTSOS	Fast training sequence ordered set	Ordered Set
EIOS	Electrical idle ordered set	Ordered Set
EIEOS	Electrical idle exit ordered set	Ordered Set
COMPL	Compliance pattern	Ordered Set
MCOMPL	Modified Compliance pattern	Ordered Set
MRIFC1 / MRIFC2	Multi-root initialization flow control 1/2	Multi-root DLLP
MRUPDFC	Multi-root update flow control	Multi-root DLLP
MRINIT	Multi-root initialization	Multi-root DLLP
MRRESET	Multi-root reset	Multi-root DLLP

12.17.2 PCIe Gen 1/2 Configuration

12.17.2.1 PCIe Gen 1/2 Configuration Settings

Access: [Protocol] > "Decode" tab > "Protocol" = "PCIe Gen 1/2"

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

Generation

Selects the generation of the PCIe technology.

"PCIe Gen1 (2.5 Gbit/s) "	Selects the PCIe generation 1.0, standard introduced in 2003. It has a transfer rate of 2.5 Gbit/s.
"PCIe Gen2 (5 Gbit/s) "	Selects the PCIe generation 2.0, standard introduced in 2007. It has a transfer rate of 5 Gbit/s.

Remote command:

`BUS<m>:PCIE:GEN` on page 1721

Link

Selects the link width, the number of lanes that are used for the transmission of the data.

Remote command:
BUS<m>:PCIE:LNKW on page 1721

Descrambling
Enables descrambling of the data.

Remote command:
BUS<m>:PCIE:DSCRambling on page 1720

Lane 0/1/2/3
Select the signal sources for the logical lanes.

Usually, the source is one of the analog channels. Reference and math waveforms are available as source if the trigger source is one of the analog channels but not the serial bus.

Remote command:
BUS<m>:PCIE:LZER:SOURce on page 1721
BUS<m>:PCIE:LONE:SOURce on page 1721
BUS<m>:PCIE:LTWO:SOURce on page 1721
BUS<m>:PCIE:LTHRee:SOURce on page 1721

Thresholds
Sets the threshold value for digitization of signals for each line.

Coupling ← Thresholds
Enables the same threshold value for all lanes.

Set to 50% ← Thresholds
Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Remote command:
BUS<m>:SETReflevels on page 1299

Thresholds Low ← Thresholds
Sets the lower threshold value for the respective lane.

Remote command:
BUS<m>:PCIE:LONE:THRLow on page 1722
BUS<m>:PCIE:LTHRee:THRLow on page 1722
BUS<m>:PCIE:LTWO:THRLow on page 1722
BUS<m>:PCIE:LZER:THRLow on page 1722

Thresholds High ← Thresholds
Sets the high threshold value for the respective lane.

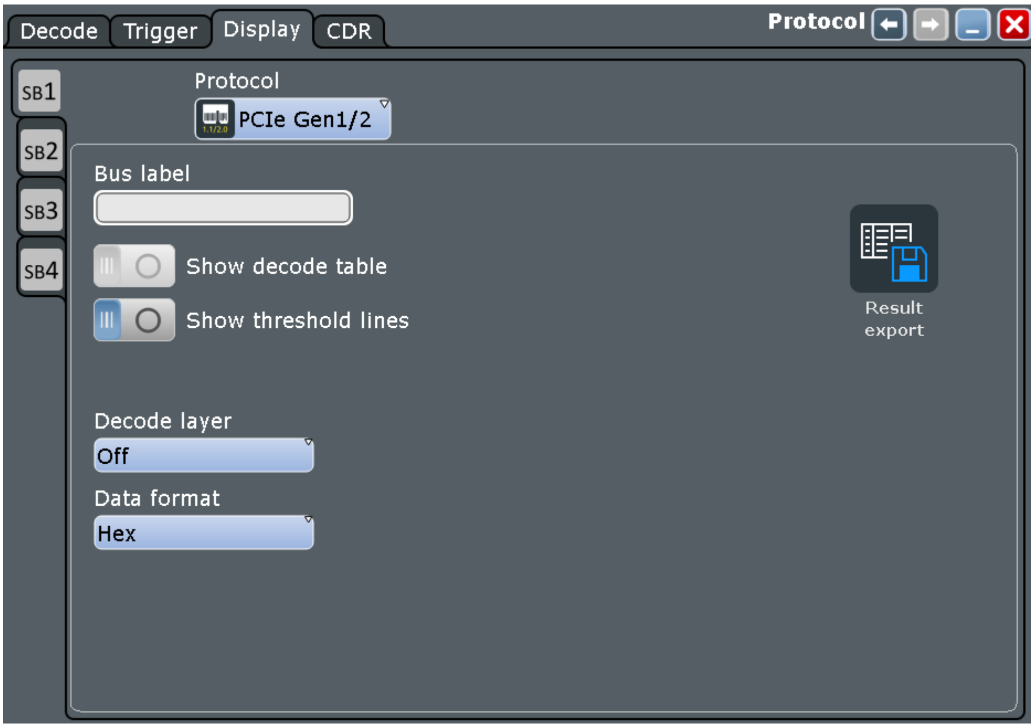
Remote command:
BUS<m>:PCIE:LONE:THRHigh on page 1722
BUS<m>:PCIE:LTHRee:THRHigh on page 1722
BUS<m>:PCIE:LTWO:THRHigh on page 1722
BUS<m>:PCIE:LZER:THRHigh on page 1722

CDR Summary
Displays a summary of the CDR values. You can set these settings in the "CDR" tab, see Chapter 12.17.3, "PCIe Gen 1/2 CDR Configuration Settings", on page 794.

12.17.2.2 Display Settings

Access: [Protocol] > "Configuration" tab > "Protocol" = "PCIe Gen 1/2" > "Display" tab

Common display settings are explained in Chapter 12.1.2, "Display", on page 465.



Decode layer
Selects the decode layer.

Decoding is performed in several steps, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Off"	...
"8b/10b"	...
"Descrambled 8b/10b"	...
"Bits"	...

12.17.2.3 Configuring PCIe Gen 1/2

For configuration, you assign the line to the input channel, set the threshold, the bitrate, and the sync symbol.

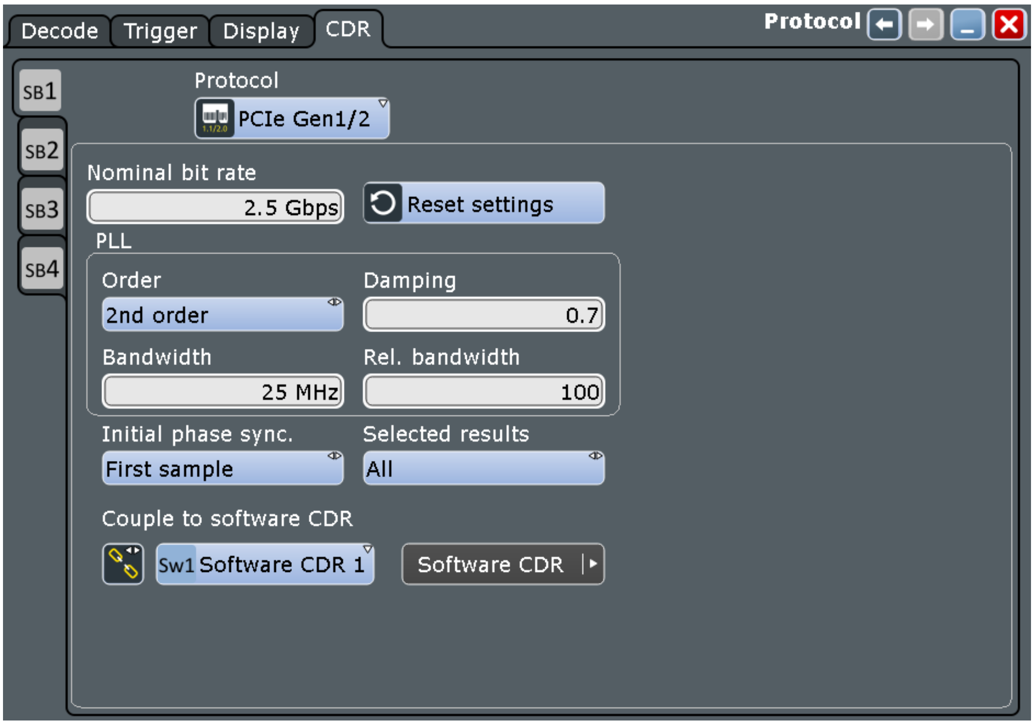
For details on configuration settings, see Chapter 12.17.2.1, "PCIe Gen 1/2 Configuration Settings", on page 791.

1. Press the [Protocol] key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Configuration" tab.
4. Tap the "Protocol" button and select the protocol: "PCIe Gen 1/2".
5. Tap the "Generation" button and select the PCIe protocol.
6. Tap the "Link" button and chose the link width.
7. Optionally, you can enter a "Bus label" on the "Display" tab.
8. Select the source for of the signal for each lane.
9. Check the threshold settings for each lane. Adjust the values if necessary.

12.17.3 PCIe Gen 1/2 CDR Configuration Settings

The process of clock data recovery (CDR) generates a reference clock from a high-speed serial data stream that is sent without a dedicated clock signal. The generated clock signal matches the frequency and is aligned to the phase of the data stream. The recovered clock can be used to sample the data stream and to obtain the sequence of transmitted bits.

Access: [Protocol] > "Configuration" tab > "Protocol" = "PCIe Gen 1/2" > "CDR" tab



Nominal bit rate
Sets the quiescent frequency of the PLL. It corresponds to the data rate of the data stream from which the clock is to be recovered.

Remote command:
`BUS<m>:CDR:BITRate` on page 1723

PLL settings
Phase-locked loop parameters are listed below.

Note: Nomial bit rate, bandwidth and relative bandwidth are interacting settings. Modifying one parameter also changes one of the dependent parameters.

"Order" Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.

"Bandwidth" Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization. The PLL bandwidth is usually defined by the transmission standard.

"Rel. bandwidth" Sets the relative bandwidth, that is the ratio of the nominal bit rate to the PLL bandwidth.

"Damping" Sets the damping factor, which is only relevant for second order PLL.

Remote command:
`BUS<m>:CDR:PLL:ORDer` on page 1723
`BUS<m>:CDR:PLL:BWIDth` on page 1723
`BUS<m>:CDR:PLL:RELBwidth` on page 1724
`BUS<m>:CDR:PLL:DAMPing` on page 1723

Initial phase sync.
Defines the phase reference for the first clock edge.

"First sample" The first clock edge matches the first sample of the waveform at the left border of the display.

"First data edge" The first clock edge matches the first edge of the data signal.

Remote command:
`BUS<m>:CDR:SYNC` on page 1724

Selected results
The PLL requires some time to synchronize to the phase of the data stream. You can select when the CDR algorithm returns clock edges:

"After initial sync." The clock edges of the synchronization time are discarded; results are gathered after initial synchronization of the CDR. Thus, meaningful TIE measurement results can be obtained.

"All" All clock edges are used.

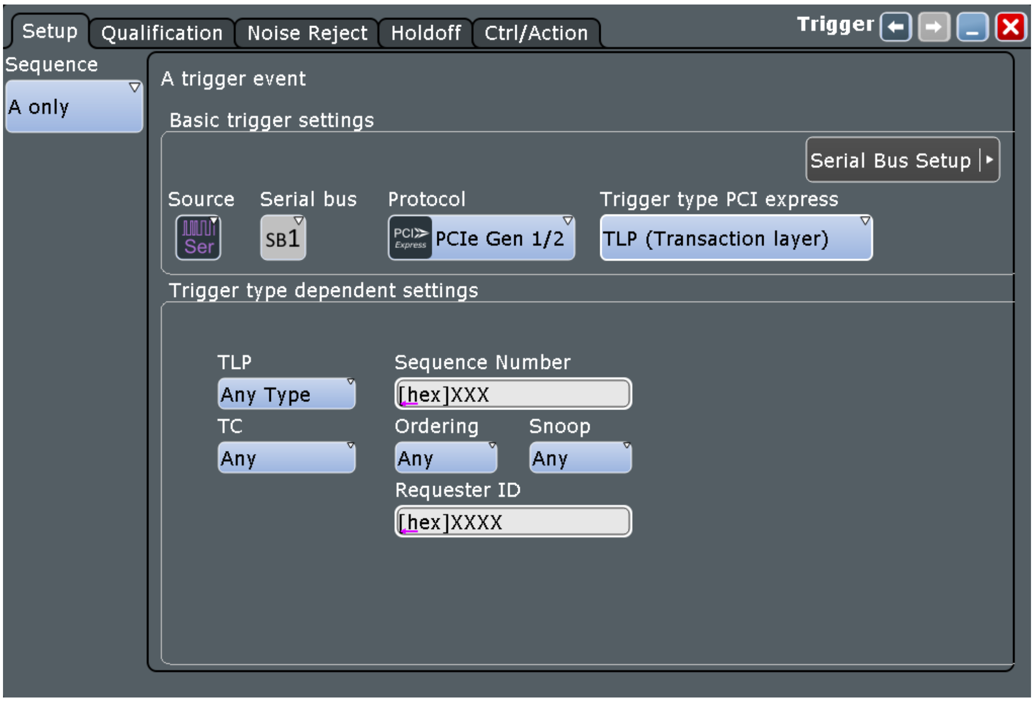
Remote command:
`BUS<m>:CDR:RESults` on page 1724

Couple to software CDR
Couples the protocol CDR to the selected software CDR. For more information about it see, Chapter 16.2, "Clock Data Recovery", on page 902.

12.17.4 PCIe Gen 1/2 Trigger

12.17.4.1 PCIe Gen 1/2 Trigger Settings

Access: [Protocol] > "Trigger" tab > "Source = Serial Bus" > select "Protocol = PCIe Gen 1/2"



Make sure that:
- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Trigger type PCI express
Selects the trigger type for the PCI express analysis.

"TLP (Transaction layer)" Sets the trigger on a defined type of the transaction layer packet.

"DLLP (Data link layer)" Sets the trigger on a defined type of the data link layer packet.

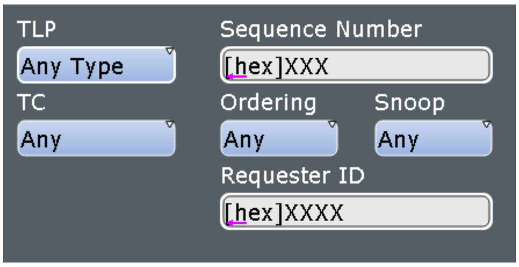
"Ordered Sets" Sets the trigger on a defined ordered set.

"Error Condition" Sets the trigger on a selection of error conditions.

Remote command:
TRIGger<m>:PCIE:TYPE on page 1732

TLP (Transaction layer)
Specifies the trigger conditions for the transaction layer type trigger.

TLP ← TLP (Transaction layer)
Triggers on a transaction type.



"Any type" Triggers on any transaction type.

"Mem" Triggers on memory transaction type used for data transfers to memory-mapped locations.

"IO" Triggers on I/O transaction type used for data transfers to I/O-mapped locations.

"Cfg" Triggers on configuration transaction type used to setup the device functions.

"Msg" Triggers on message transaction type used for transmitting diverse messages.

"Cpl" Triggers on completion without data.

"FetchAdd" Triggers on fetch and add atomic op request.

"Swap" Triggers on unconditional swap atomic op request.

"CAS" Triggers on compare and swap atomic op request transaction type.

Remote command:
TRIGger<m>:PCIE:TLP:TYPE on page 1732

Sequence Number ← TLP (Transaction layer)
Triggers on a sequence number, which indicates if any TLPs have been lost.

Remote command:
TRIGger<m>:PCIE:TLP:SNUM on page 1732

TC ← TLP (Transaction layer)
Triggers on a traffic class which is mapped on a specific virtual channel. The TC label is transmitted unmodified through the fabric.

Remote command:
TRIGger<m>:PCIE:TLP:TCHN on page 1732

Ordering ← TLP (Transaction layer)
Triggers on an ordering. The ordering can be relaxed or strong.

Remote command:
TRIGger<m>:PCIE:TLP:ORDE on page 1731

Snoop ← TLP (Transaction layer)
Triggers on a snoop state.

Remote command:
TRIGger<m>:PCIE:TLP:SNOO on page 1732

Requester ID ← TLP (Transaction layer)
Triggers on a requester ID, consisting of the requester's bus number, device number, and function number.

Remote command:
TRIGger<m>:PCIE:TLP:REID on page 1732

Device ID ← TLP (Transaction layer)
Triggers on a device ID, a field that can be assigned a value by the vendor for classifying root complex register blocks (RCRB). The Device ID is only valid for Configuration transaction. It is composed of 8-bit Bus number, 5-bit Device number and a 3-bit Function number.

Remote command:
TRIGger<m>:PCIE:TLP:DEID on page 1731

Read/Write ← TLP (Transaction layer)
Triggers on a read and/ or write state.

Remote command:
TRIGger<m>:PCIE:TLP:MERW on page 1731

Address Type ← TLP (Transaction layer)
Triggers on an address type. The address type can be 32 bit or 64 bit.

Remote command:
TRIGger<m>:PCIE:TLP:ADRT on page 1730

Type ← TLP (Transaction layer)
Triggers on a configuration type.

Remote command:
TRIGger<m>:PCIE:TLP:CFGT on page 1730

Routing ← TLP (Transaction layer)
Triggers on a selected message routing type.

Remote command:
TRIGger<m>:PCIE:TLP:MSGR on page 1731

Message Code ← TLP (Transaction layer)
Triggers on a specific message code.

Remote command:
`TRIGger<m>:PCIE:TLP:MSGC` on page 1731

Status ← TLP (Transaction layer)
Triggers on a completion status.

Remote command:
`TRIGger<m>:PCIE:TLP:CPLS` on page 1731

Completer ID ← TLP (Transaction layer)
Triggers on a completer ID, consisting of the completer's bus number, device number, and function number.

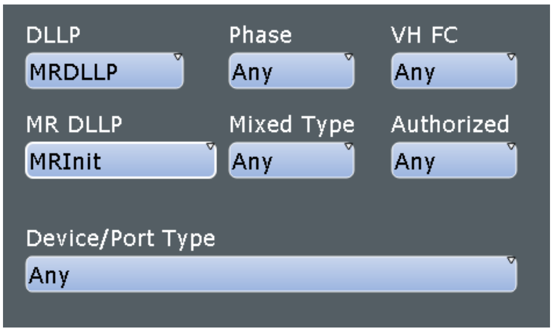
Remote command:
`TRIGger<m>:PCIE:TLP:CPID` on page 1730

DLLP Type
Sets the trigger to the type of DLLP. You can refine the settings for the different types according to their specifications.

Remote command:
`TRIGger<m>:PCIE:DLLP:TYPE` on page 1728

DLLP Any Type conditions
Sets the trigger to any type of DLLP.

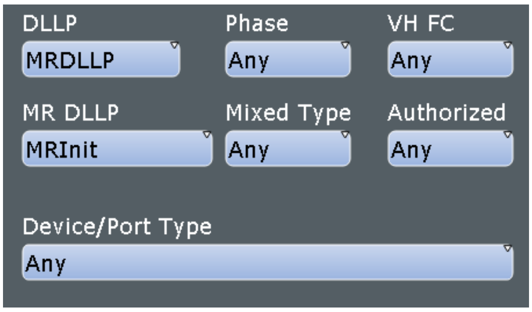
DLLP MRDLLP conditions
Specifies the conditions for the multi-root trigger.



MR DLLP ← DLLP MRDLLP conditions
Triggers on a multi-root type for the data link layer.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:TYPE` on page 1727

MRInit ← DLLP MRDLLP conditions
Specifies the conditions for the multi-root initialization protocol trigger.



Phase ← MRInit ← DLLP MRDLLP conditions
Triggers on a phase state.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:PHAS` on page 1727

VH FC ← MRInit ← DLLP MRDLLP conditions
Triggers on a virtual hierarchies flow control presence.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:VHFC` on page 1727

Mixed Type ← MRInit ← DLLP MRDLLP conditions
Triggers on a mixed type presence.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:MIXT` on page 1726

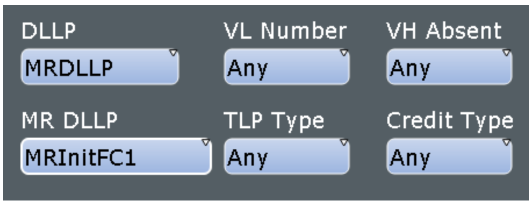
Authorized ← MRInit ← DLLP MRDLLP conditions
Triggers on an authorized state presence.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:AUTH` on page 1726

Device/Port Type ← MRInit ← DLLP MRDLLP conditions
Triggers on an device/port type.

Remote command:
`TRIGger<m>:PCIE:DLLP:MULT:DVPT` on page 1726

MRInitFC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Specifies the conditions for the multi-root initialization flow control protocol trigger.



VL Number ← MRInitFC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Triggers on a virtual link (VL) number.

Remote command:
TRIGger<m>:PCIE:DLLP:MULT:VLNR on page 1728

VH Absent ← MRInitFC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Triggers on absent virtual hierarchies (VH).

Remote command:
TRIGger<m>:PCIE:DLLP:MULT:HABS on page 1726

TLP Type ← MRInitFC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Triggers on a transaction layer type for a multi-root data link layer trigger type.

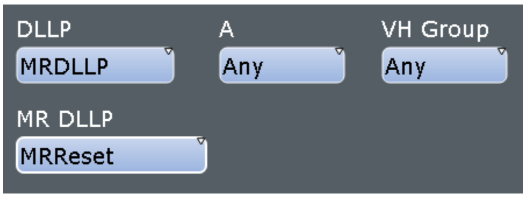
"Any"	Any transaction layer type.
"P"	Posted credit.
"N"	Non posted credit.
"Cpl"	Completion credit.

Remote command:
TRIGger<m>:PCIE:DLLP:MULT:TLPT on page 1727

Credit Type ← MRInitFC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Triggers on any, data or header credit type.

Remote command:
TRIGger<m>:PCIE:DLLP:MULT:CRET on page 1726

MRReset ← DLLP MRDLLP conditions
Specifies the conditions for the multi-root reset protocol trigger.



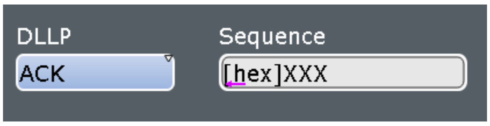
A ← MRReset ← DLLP MRDLLP conditions
Triggers on the value of the A bit (Ack/ Request).

Remote command:
TRIGger<m>:PCIE:DLLP:MULT:RESA on page 1727

VH Group ← MRReset ← DLLP MRDLLP conditions
Triggers on the selected virtual hierarchies group.

Remote command:
TRIGger<m>:PCIE:DLLP:MULT:VHGR on page 1728

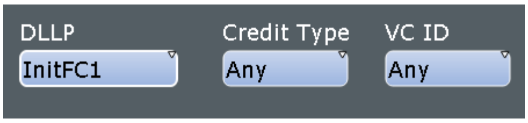
DLLP ACK/NAK conditions
Triggers on an acknowledgement (ACK)/ negative acknowledgment (NAK).



Sequence ← DLLP ACK/NAK conditions
Triggers on the sequence field indicating what TLPs are affected by the ACK/NAK.

Remote command:
TRIGger<m>:PCIE:DLLP:SEQ on page 1728

DLLP Init FC1/InitFC2/UpdateFC conditions
Triggers on flow control initialization/update conditions.



Credit Type ← DLLP Init FC1/InitFC2/UpdateFC conditions
Triggers on a credit type value.

"Any"	Triggers on any credit type.
"P"	Triggers on posted requests.
"NP"	Triggers on non posted requests.
"CPL"	Triggers on completions.

Remote command:
TRIGger<m>:PCIE:DLLP:FCTL:CRET on page 1725

VC ID ← DLLP Init FC1/InitFC2/UpdateFC conditions
Triggers on a virtual channel ID value.

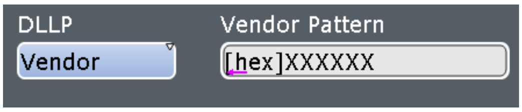
Remote command:
TRIGger<m>:PCIE:DLLP:FCTL:VCID on page 1726

DLLP PM conditions
Triggers on a specified power management conditions.

PM Type ← DLLP PM conditions
Triggers on a power management type.

Remote command:
TRIGger<m>:PCIE:DLLP:POWM on page 1728

DLLP Vendor conditions
Triggers on a specified vendor conditions.



Vendor Pattern ← DLLP Vendor conditions

Triggers on a vendor pattern.

Remote command:
TRIGger<m>:PCIE:DLLP:VPAT on page 1729

Ordered set condition

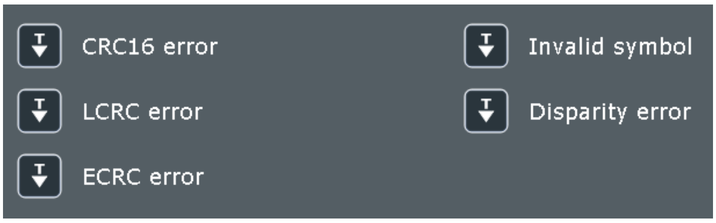
Triggers on an ordered set.

"SKP OS"	Triggers on an SKP ordered sets.
"Training Seq 1/2"	Triggers on a training sequence ordered set.
"Fast Training Seq"	Triggers on a fast training sequence ordered set.
"Electrical Idle OS"	Triggers on an electrical idle ordered set that must be send by the transmitter before it can enter the electrical idle.
"Electrical Idle Exit OS"	Triggers on an electrical idle exit ordered set.
"Compliance Pattern"	Triggers on a compliance pattern ordered set.

Remote command:
TRIGger<m>:PCIE:OSET:TYPE on page 1730

Error Condition

Triggers on enabled error condition.



"CRC16 error"	Triggers on 16-bit cyclic redundancy check (CRC) errors.
"LCRC error"	Triggers on link cyclic redundancy check (LCRC) errors.
"ECRC error"	Triggers on end-to-end cyclic redundancy checksum (ECRC) errors.
"Invalid symbol"	Triggers on invalid symbol errors.
"Disparity error"	Triggers on disparity errors.

Remote command:
TRIGger<m>:PCIE:ERRC:CRC on page 1729
TRIGger<m>:PCIE:ERRC:DISP on page 1729
TRIGger<m>:PCIE:ERRC:ECRC on page 1729

`TRIGger<m>:PCIE:ERRC:INVP` on page 1729
`TRIGger<m>:PCIE:ERRC:LCRC` on page 1729

12.17.4.2 Triggering on PCIe Gen 1/2

Prerequisite: A bus is configured for the PCIe Gen 1/2 signal to be analyzed.

For the basic trigger settings, proceed in the following way:

1. Press the [Protocol] key and select the "Trigger" tab.
2. Press the "Select" button. The "Source" button is shown.
3. Tap the "Source" button and select the "Serial bus" trigger source.
4. Tap "Serial bus" and select the serial bus that is set to PCIe Gen 1/2, e.g.:

   The "Protocol" selection is then automatically set to "PCIe Gen 1/2".
5. Tap "Trigger Type PCI express" and select the trigger type to be used for PCIe Gen 1/2 protocol analysis.
6. Depending on the selected trigger type, more setup conditions can be specified.

For information on how to proceed with the configuration settings, see Chapter 12.17.4.1, "PCIe Gen 1/2 Trigger Settings", on page 796.

12.17.5 PCIe Gen 1/2 Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Examples

The example in shows a simulated PCIe Gen 1/2 message.

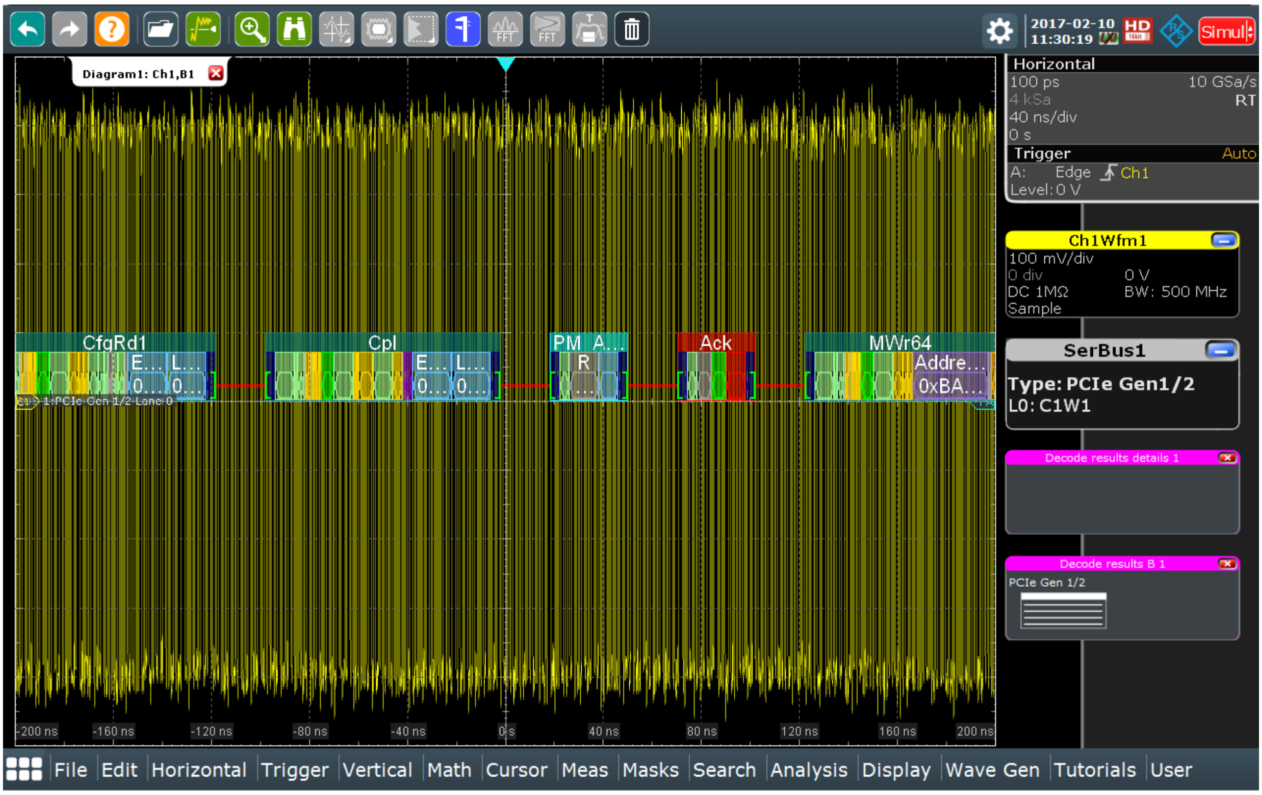


Figure 12-93: PCIeGen 1/2 protocol: decoded and binary signal

Green brackets [...]	= Start and end of frame
Dark green	= TLP type packet
Green	= DLLP type packet
Red field	= Error

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

The example in Figure 12-94 shows PCIe Gen 1/2 decode results (upper table, showing packets) and decode results details (table below, showing decoded fields of the selected packet).

Figure 12-94: PCIe Gen 1/2 protocol: decoded and binary signal, and decode results

Upper table = Decode results table, see Table 12-29
Lower table = Decode results details, see Table 12-30

Table 12-29: Content of the "Decode results" table

Column	Description
State	Overall state of the packet
Start	Start time of the packet
Stop	Stop time of the packet
Type	Type of packet
Sequence Number	Sequence number
Tag	Tag of the packet
Length	Length of packet
Address	Value of the address
HdrFC	Credit value of the header
DataFC	Credit value of the payload data
Completion status	Completion status field value
Requester ID	Requester ID
Completer ID	Completer ID

Table 12-30: Content of the "Details" table

Column	Description
State	State of the field
Type	Field type
Hex-Value	Hexadecimal value of the field
Formatted	Formatted content of the field

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:

- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

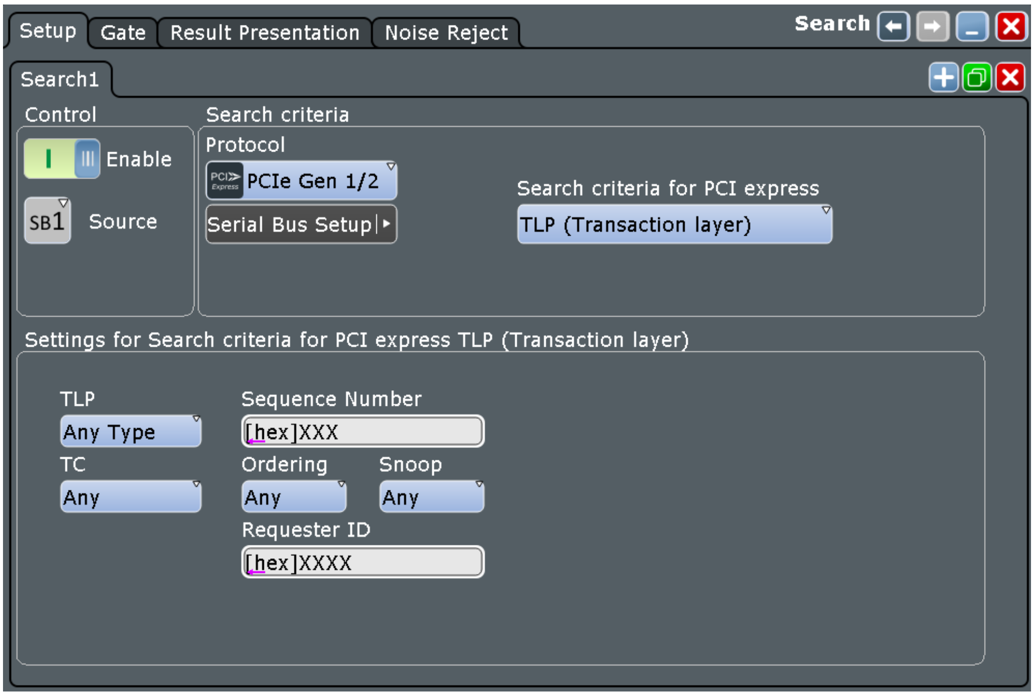
Remote commands

Remote commands to retrieve decode results are described in Chapter 20.17.18.4, "Decode Results", on page 1733.

12.17.6 PCIe Gen 1/2 Search

12.17.6.1 PCIe Gen 1/2 Search Settings

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for "PCIe"



Make sure that:

- The data source(s) of the serial bus are channel signals: [Protocol] > "Decode" tab.
- The trigger sequence is set to "A only": [Trigger] > "Sequence" tab.
- The trigger source is "Serial bus": [Trigger] > "Events" tab.
- The correct serial bus is selected: [Trigger] > "Events" tab.
- The correct protocol is selected: [Trigger] > "Events" tab.

Serial bus

Selects the serial bus to be triggered on. Make sure to select the correct bus before you enter the settings.

To trigger on a serial bus, the signals sources must be channel signals. If the data or clock source is a math or reference waveform, you cannot trigger on that bus.

Remote command:
`TRIGger<m>:SOURce:SBSelect` on page 1303

Protocol

Defines the protocol type of the selected serial bus.

Remote command:
`BUS<m>:TYPE` on page 1299

Searches for PCI express

Selects the search type for the PCI express analysis.

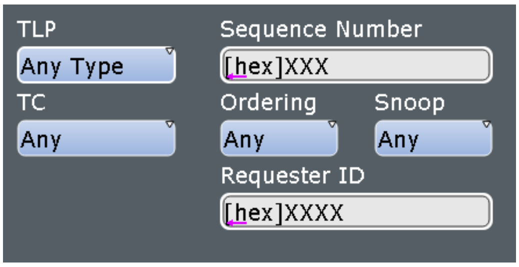
"TLP (Transaction layer)"	Sets the search on a defined type of the transaction layer packet.

"DLLP (Data link layer)"	Sets the search on a defined type of the data link layer packet.
"Ordered Sets"	Sets the search on a defined ordered set.
"Error Condition"	Sets the search on a selection of error conditions.

Remote command:
`SEARch:TRIGger:PCIE:TYPE` on page 1752

TLP (Transaction layer)
Specifies the search conditions for the transaction layer type search.

TLP ← TLP (Transaction layer)
Searches for a transaction type.



"Any type"	Searches for any transaction type.
"Mem"	Searches for memory transaction type used for data transfers to memory-mapped locations.
"IO"	Searches for I/O transaction type used for data transfers to I/O-mapped locations.
"Cfg"	Searches for configuration transaction type used to setup the device functions.
"Msg"	Searches for message transaction type used for transmitting diverse messages.
"Cpl"	Searches for completion without data.
"FetchAdd"	Searches for fetch and add atomic op request.
"Swap"	Searches for unconditional swap atomic op request.
"CAS"	Searches for compare and swap atomic op request transaction type.

Remote command:
`SEARch:TRIGger:PCIE:TLP:TYPE` on page 1752

Sequence Number ← TLP (Transaction layer)
Searches for a sequence number, which indicates if any TLPs have been lost.

Remote command:
`SEARch:TRIGger:PCIE:TLP:SNUM` on page 1752

TC ← TLP (Transaction layer)
Searches for a traffic class which is mapped on a specific virtual channel. The TC label is transmitted unmodified through the fabric.

Remote command:
SEARch:TRIGger:PCIE:TLP:TCHN on page 1752

Ordering ← TLP (Transaction layer)
Searches for an ordering. The ordering can be relaxed or strong.

Remote command:
SEARch:TRIGger:PCIE:TLP:ORDE on page 1751

Snoop ← TLP (Transaction layer)
Searches for a snoop state.

Remote command:
SEARch:TRIGger:PCIE:TLP:SNOO on page 1751

Requester ID ← TLP (Transaction layer)
Searches for a requester ID, consisting of the requester's bus number, device number, and function number.

Remote command:
SEARch:TRIGger:PCIE:TLP:REID on page 1751

Device ID ← TLP (Transaction layer)
Searches for a device ID, a field that can be assigned a value by the vendor for classifying root complex register blocks (RCRB). The Device ID is only valid for Configuration transaction. It is composed of 8-bit Bus number, 5-bit Device number and a 3-bit Function number.

Remote command:
SEARch:TRIGger:PCIE:TLP:DEID on page 1750

Read/Write ← TLP (Transaction layer)
Searches for a read and/ or write state.

Remote command:
SEARch:TRIGger:PCIE:TLP:MERW on page 1750

Address Type ← TLP (Transaction layer)
Searches for an address type. The address type can be 32 bit or 64 bit.

Remote command:
SEARch:TRIGger:PCIE:TLP:ADRT on page 1749

Type ← TLP (Transaction layer)
Searches for a configuration type.

Remote command:
SEARch:TRIGger:PCIE:TLP:CFGT on page 1749

Routing ← TLP (Transaction layer)
Searches for a selected message routing type.

Remote command:
SEARch:TRIGger:PCIE:TLP:MSGR on page 1751

Message Code ← TLP (Transaction layer)

Searches for a specific message code.

Remote command:

`SEARch:TRIGger:PCIE:TLP:MSGC` on page 1750

Status ← TLP (Transaction layer)

Searches for a completion status.

Remote command:

`SEARch:TRIGger:PCIE:TLP:CPLS` on page 1750

Completer ID ← TLP (Transaction layer)

Searches for a completer ID, consisting of the completer's bus number, device number, and function number.

Remote command:

`SEARch:TRIGger:PCIE:TLP:CPID` on page 1749

DLLP Type

Sets the trigger to the type of DLLP. You can refine the settings for the different types according to their specifications.

Remote command:

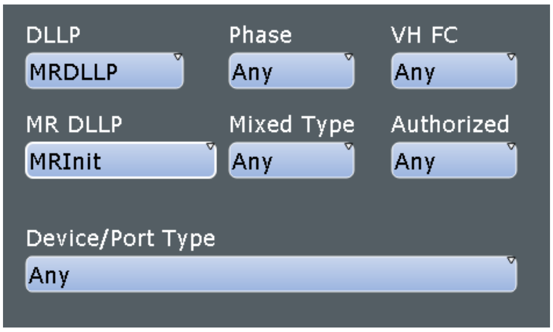
`SEARch:TRIGger:PCIE:DLLP:TYPE` on page 1745

DLLP Any Type conditions

Sets the trigger to any type of DLLP.

DLLP MRDLLP conditions

Specifies the conditions for the multi-root trigger.



MR DLLP ← DLLP MRDLLP conditions

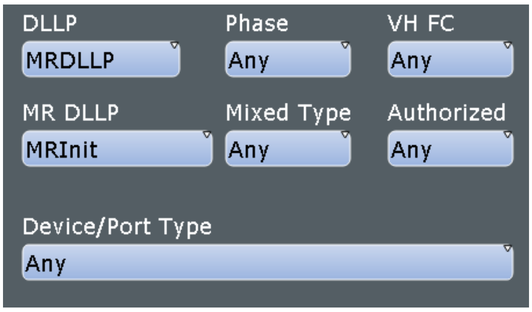
Searches for a multi-root type for the data link layer.

Remote command:

`SEARch:TRIGger:PCIE:DLLP:MULT:TYPE` on page 1744

MRInit ← DLLP MRDLLP conditions

Specifies the conditions for the multi-root initialization protocol search.



Phase ← MRInit ← DLLP MRDLLP conditions
Searches for a phase state.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:PHAS` on page 1743

VH FC ← MRInit ← DLLP MRDLLP conditions
Searches for a virtual hierarchies flow control presence.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:VHFC` on page 1744

Mixed Type ← MRInit ← DLLP MRDLLP conditions
Searches for a mixed type presence.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:MIXT` on page 1743

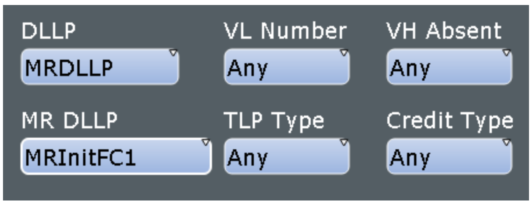
Authorized ← MRInit ← DLLP MRDLLP conditions
Searches for an authorized state presence.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:AUTH` on page 1742

Device/Port Type ← MRInit ← DLLP MRDLLP conditions
Searches for an device/port type.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:MULT:DVPT` on page 1742

MRInitInit FC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Specifies the conditions for the multi-root initialization flow control protocol search.



VL Number ← MRInitInit FC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Searches for a virtual link (VL) number.

Remote command:
SEARch:TRIGger:PCIE:DLLP:MULT:VLNR on page 1745

VH Absent ← MRInitInit FC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Searches for absent virtual hierarchies (VH).

Remote command:
SEARch:TRIGger:PCIE:DLLP:MULT:HABS on page 1742

TLP Type ← MRInitInit FC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Searches for a transaction layer type for a multi-root data link layer trigger type.

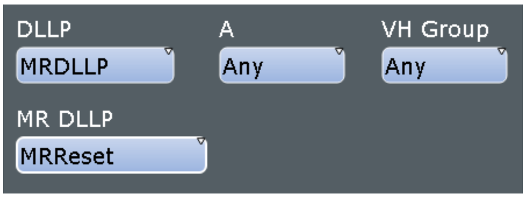
"Any"	Any transaction layer type.
"P"	Posted credit.
"N"	Non posted credit.
"Cpl"	Completion credit.

Remote command:
SEARch:TRIGger:PCIE:DLLP:MULT:TLPT on page 1743

Credit Type ← MRInitInit FC1/InitFC2/UpdateFC ← DLLP MRDLLP conditions
Searches for any, data or header credit type.

Remote command:
SEARch:TRIGger:PCIE:DLLP:FCTL:CRET on page 1741

MRReset ← DLLP MRDLLP conditions
Specifies the conditions for the multi-root reset protocol search.



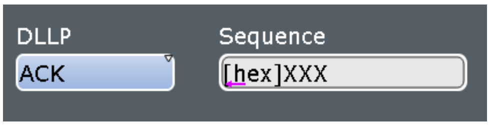
A ← MRReset ← DLLP MRDLLP conditions
Searches for the value of the A bit (Ack/ Request).

Remote command:
SEARch:TRIGger:PCIE:DLLP:MULT:RESA on page 1743

VH Group ← MRReset ← DLLP MRDLLP conditions
Searches for the selected virtual hierarchies group.

Remote command:
SEARch:TRIGger:PCIE:DLLP:MULT:VHGR on page 1744

DLLP ACK/NAK conditions
Searches for an acknowledgement (ACK)/ negative acknowledgment (NAK).



Sequence ← DLLP ACK/NAK conditions

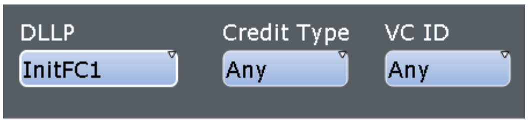
Searches for the sequence field indicating what TLPs are affected by the ACK/NAK.

Remote command:

SEARch:TRIGger:PCIE:DLLP:SEQ on page 1745

DLLP Init FC1/InitFC2/UpdateFC conditions

Searches for flow control initialization/update conditions.



Credit Type ← DLLP Init FC1/InitFC2/UpdateFC conditions

Searches for a credit type value.

"Any"	Searches for any credit type.
"P"	Searches for posted requests.
"NP"	Searches for non posted requests.
"CPL"	Searches for completions.

Remote command:

SEARch:TRIGger:PCIE:DLLP:FCTL:CRET on page 1741

VC ID ← DLLP Init FC1/InitFC2/UpdateFC conditions

Searches for a virtual channel ID value.

Remote command:

SEARch:TRIGger:PCIE:DLLP:FCTL:VCID on page 1741

DLLP PM conditions

Searches for a specified power management conditions.

PM Type ← DLLP PM conditions

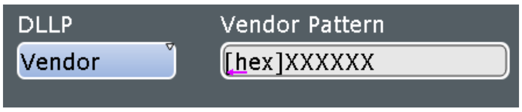
Searches for a power management type.

Remote command:

SEARch:TRIGger:PCIE:DLLP:POWM on page 1745

DLLP Vendor conditions

Searches for a specified vendor conditions.



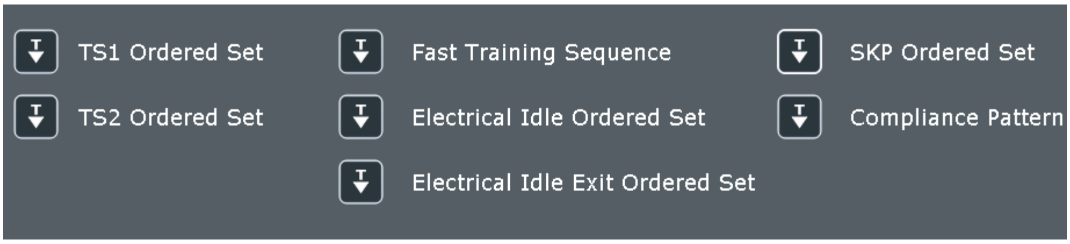
Vendor Pattern ← DLLP Vendor conditions

Searches for a vendor pattern.

Remote command:
`SEARch:TRIGger:PCIE:DLLP:VPAT` on page 1746

Ordered set condition

Searches for the enabled ordered sets.

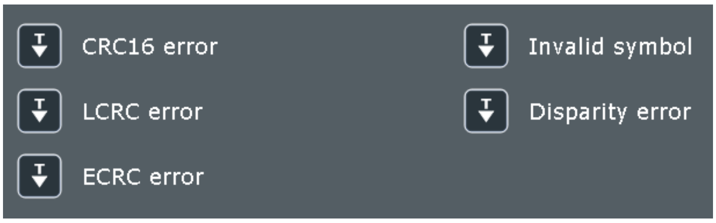


"SKP OS"	Searches for an SKP ordered sets.
"Training Seq 1/2"	Searches for a training sequence ordered set.
"Fast Training Seq"	Searches for a fast training sequence ordered set.
"Electrical Idle OS"	Searches for an electrical idle ordered set that must be send by the transmitter before it can enter the electrical idle.
"Electrical Idle Exit OS"	Searches for an electrical idle exit ordered set.
"Compliance Pattern"	Searches for a compliance pattern ordered set.

Remote command:
`SEARch:TRIGger:PCIE:OSET:COMP` on page 1747
`SEARch:TRIGger:PCIE:OSET:EIDE` on page 1747
`SEARch:TRIGger:PCIE:OSET:EIDL` on page 1748
`SEARch:TRIGger:PCIE:OSET:FTS` on page 1748
`SEARch:TRIGger:PCIE:OSET:SKIP` on page 1748
`SEARch:TRIGger:PCIE:OSET:TSONe` on page 1748
`SEARch:TRIGger:PCIE:OSET:TSTWo` on page 1749

Error Condition

Searches for enabled error conditions.



"CRC16 error"	Searches for 16-bit cyclic redundancy check (CRC) errors.
"LCRC error"	Searches for link cyclic redundancy check (LCRC) errors.
"ECRC error"	Searches for end-to-end cyclic redundancy checksum (ECRC) errors.
"Invalid symbol"	Searches for invalid symbol errors.
"Disparity error"	Searches for disparity errors.

Remote command:
`SEARch:TRIGger:PCIE:ERRC:CRC` on page 1746
`SEARch:TRIGger:PCIE:ERRC:DISP` on page 1746
`SEARch:TRIGger:PCIE:ERRC:ECRC` on page 1746
`SEARch:TRIGger:PCIE:ERRC:INVP` on page 1747
`SEARch:TRIGger:PCIE:ERRC:LCRC` on page 1747

12.17.6.2 PCIe Gen 1/2 Search Results

To get search results, "Enable" the search in the "Control" section of the "Search Setup" dialog. You can minimize, shift or close the search dialog to better see the "Search Results" table.

Figure 12-95: PCIe search result tables

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

Remote Commands:

- SEARch:RESult:PCIE:PCOunt? on page 1759
- SEARch:RESult:PCIE:PACKet<m>:ADDR? on page 1753
- SEARch:RESult:PCIE:PACKet<m>:CPID? on page 1753
- SEARch:RESult:PCIE:PACKet<m>:CPS? on page 1754
- SEARch:RESult:PCIE:PACKet<m>:DATA? on page 1754
- SEARch:RESult:PCIE:PACKet<m>:DFC? on page 1754
- SEARch:RESult:PCIE:PACKet<m>:FCOunt? on page 1754
- SEARch:RESult:PCIE:PACKet<m>:HFC? on page 1756
- SEARch:RESult:PCIE:PACKet<m>:LEN? on page 1756
- SEARch:RESult:PCIE:PACKet<m>:RQID? on page 1756
- SEARch:RESult:PCIE:PACKet<m>:SEQN? on page 1757
- SEARch:RESult:PCIE:PACKet<m>:STARt? on page 1757
- SEARch:RESult:PCIE:PACKet<m>:STATe? on page 1757
- SEARch:RESult:PCIE:PACKet<m>:STOP? on page 1758
- SEARch:RESult:PCIE:PACKet<m>:TAG? on page 1758
- SEARch:RESult:PCIE:PACKet<m>:TYPE? on page 1758
- SEARch:RESult:PCIE:PACKet<m>:FCOunt? on page 1754
- SEARch:RESult:PCIE:PACKet<m>:FLD<n>:FVAL? on page 1755
- SEARch:RESult:PCIE:PACKet<m>:FLD<n>:STATus? on page 1755
- SEARch:RESult:PCIE:PACKet<m>:FLD<n>:TYPE? on page 1755
- SEARch:RESult:PCIE:PACKet<m>:FLD<n>:VAL? on page 1756

12.17.6.3 Searching for PCIe Gen 1/2

Prerequisite: A serial bus is configured for the PCIe signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press [Search] or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 411.

3. Tap "Source" and select the serial bus that is set to PCIe (e.g. "SB1").
4. Specify the search criteria according to Chapter 12.17.6.1, "PCIe Gen 1/2 Search Settings", on page 807.
5. To acquire a waveform, press [Single].

   The R&S RTP performs an PCIe decode according to the thresholds and protocol settings of the associated serial bus source.
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:

   The R&S RTP displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and navigate the search results, see also "To display search zoom windows" on page 417 and "Navigating search results" on page 398.

12.18 DDR3 (Option R&S RTP-K91)

Double Data Rate Type 3 (DDR3) is a type of Synchronous Dynamic Random Access Memory (SDRAM). With option R&S RTP-K91 you can perform the following analysis on DDR3 data:

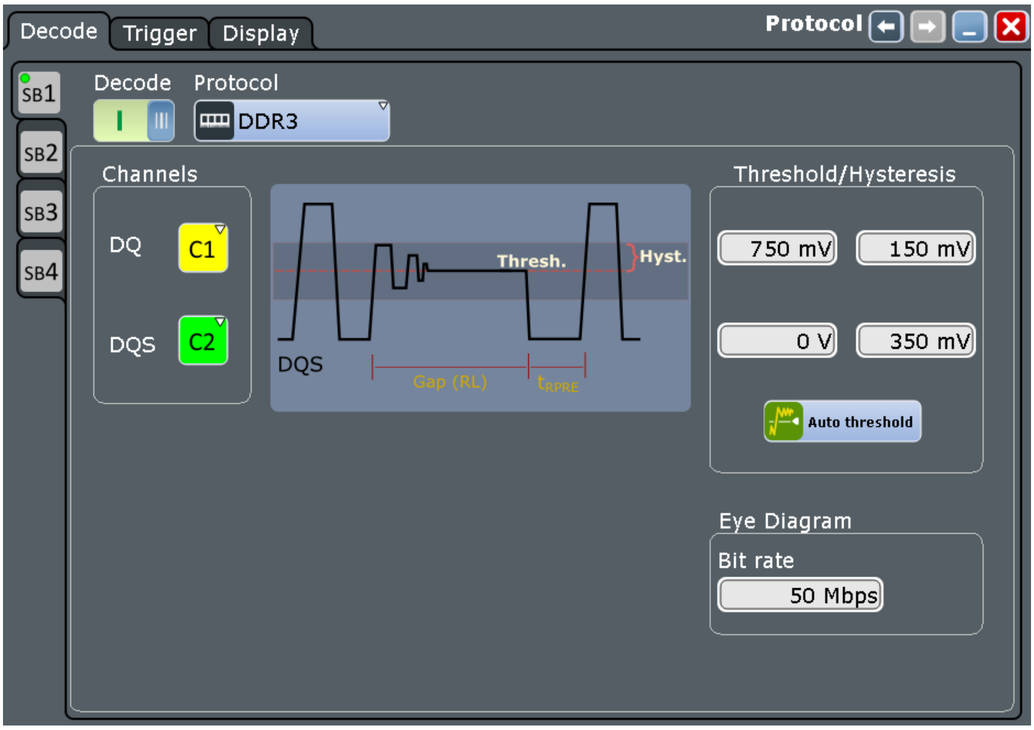
- Decode the signal.
  See:Chapter 12.18.1, "DDR3 Configuration", on page 818
- Create and analyze an eye diagram. This helps to separate the read and write cycle.
  See Chapter 12.18.4, "DDR Eye Diagram Analysis", on page 826.
- Together with the R&S ScopeSuite software you can perform a compliance test on the signal.
  For details refer to the "DDR3 Compliance Tests, Test Procedures Manual".

12.18.1 DDR3 Configuration

12.18.1.1 DDR3 Configuration Settings

Access: [Protocol] > "Decode" tab > "Protocol = DDR3"

Make sure that the tab of the correct serial bus is selected on the left side.



See also: Chapter 12.1.1, "Decode - General Settings", on page 464.

DQ

Sets the channel for the data output signal.

You can select analog channels "C1" to "C4", and also active math and reference waveforms as source.

Remote command:
`BUS<m>:DDRThree:DATA:SOURce` on page 1760

DQS

Sets the channel for the data strobe signal.

You can select analog channels "C1" to "C4", and also active math and reference waveforms as source.

Remote command:
`BUS<m>:DDRThree:STRBe:SOURce` on page 1760

Threshold

Sets the threshold value for the digitization of the DQ/DQS lane.

Remote command:
`BUS<m>:DDRThree:DATA:THReshold` on page 1760
`BUS<m>:DDRThree:STRBe:THReshold` on page 1761

Hysteresis

Sets a value for the hysteresis of the respective lane.

Remote command:
BUS<m>:DDRThree:DATA:HYSTeresis on page 1759
BUS<m>:DDRThree:STRBe:HYSTeresis on page 1760

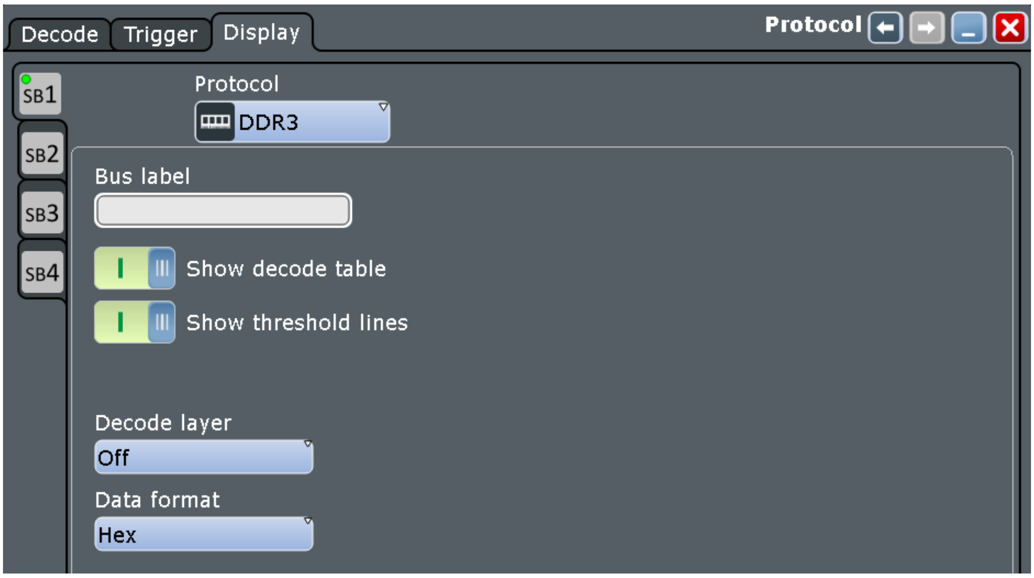
Bit rate
Declares the nominal bit rate of the data signal for the DDR3 eye diagram analysis.

See also, Bit rate, Range UI, Position UI.

12.18.1.2 Display Settings

Access: [Protocol] > "Configuration" tab > "Protocol = DDR3" > "Display" tab

To enhance the decode possibilities of the DDR3 protocol, you can use an additional setting in the "Display" tab: "Decode layer".



Common display settings are explained in Chapter 12.1.2, "Display", on page 465.

Decode layer
Selects the decode layer.

Decoding is performed in several layers, and the end results are presented in the decode table. The decode layer selects an interim step for which the decoding result is shown in the honeycomb display.

"Edges"	All edges of each lane in stage 1 decoding.
"Bits"	All bits of each lane in stage 1 decoding.
"Word"	All words of each lane in stage 1 decoding.

12.18.1.3 Configuring the DDR3 Signals

For configuration, assign the lanes to the input channels and define the logical thresholds and the hysteresis.

1. Press the [Protocol] key on the front panel.
2. At the left-hand side, select the vertical tab of the bus you want to set up.
3. Select the "Decode" tab.
4. Tap the "Protocol" button and select the protocol: "DDR3".
5. Optionally, you can enter a "Bus label" on the "Display" tab.
6. Set the channels for the "DS" and "DQS".
7. Set the "Threshold" and "Hysteresis" values.
8. Enable "Decode", if available.

12.18.2 Search on Decoded DDR3 Data

Using the search functionality, you can find various events in the decoded data. You can find the same events that you can trigger on, and even many more, since several event types can also be combined.

Before you can start the search, you have to configure the bus correctly and acquire decoded data.

To search on decoded data, set the search source to "SerBus" for the configured protocol.

For general information on how to handle the search functionality, see Chapter 10, "Search Functions", on page 396.

If you need information on how to get started with searching for DDR3 data, see Chapter 12.18.2.3, "Searching for DDR3 Data", on page 824. Otherwise proceed with the DDR3 search setup.

12.18.2.1 DDR3 Search Setup

Access: [Search] > "Setup" tab > "Source" = Serial bus configured for DDR3

Search criteria
Use the "Search criteria" dialog to define the search type. If you search for frame content, define the frame type in which data is to be searched.

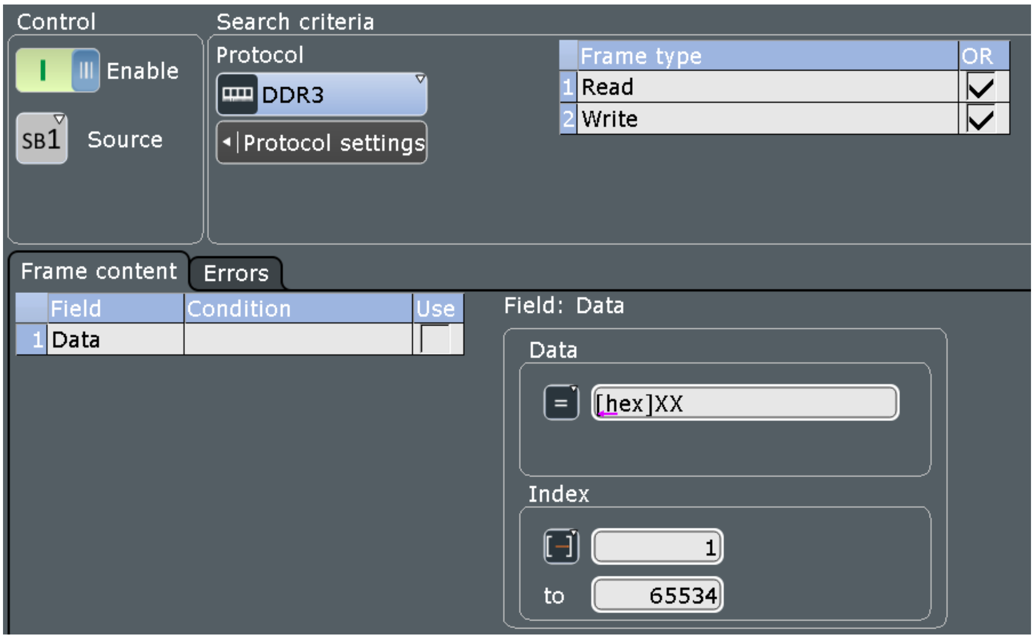


Figure 12-96: Example of search criteria for frame content in status frames

You can define individual search parameters for the fields of the selected frame in the table below the "Search criteria". To specify these parameters, select a field in the table and define the data and/or index operators and values.

You can also select the error type to be searched for.

Remote command:
`SEARch:TRIGger:DDRThree:ERRor<m>:ENABle` on page 1766
`SEARch:TRIGger:DDRThree:ERENable` on page 1766
`SEARch:TRIGger:DDRThree:FIENable` on page 1766
`SEARch:TRIGger:DDRThree:FRENable` on page 1768
`SEARch:TRIGger:DDRThree:DMAX` on page 1767
`SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DMAX` on page 1767
`SEARch:TRIGger:DDRThree:DMIN` on page 1767
`SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DMIN` on page 1767
`SEARch:TRIGger:DDRThree:DOPerator` on page 1767
`SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DOPerator` on page 1767
`SEARch:TRIGger:DDRThree:FRAMe<m>:ENABle` on page 1766
`SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:ENABle` on page 1768
`SEARch:TRIGger:DDRThree:IMAX` on page 1769
`SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IMAX` on page 1769
`SEARch:TRIGger:DDRThree:IMIN` on page 1769
`SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IMIN` on page 1769
`SEARch:TRIGger:DDRThree:IOPerator` on page 1769
`SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IOPerator` on page 1769

12.18.2.2 DDR3 Search Results

To get search results, "Enable" the search in the "Control" section of the "Search Setup" dialog. You can minimize, shift or close the search dialog to better see the "Search Results" table.

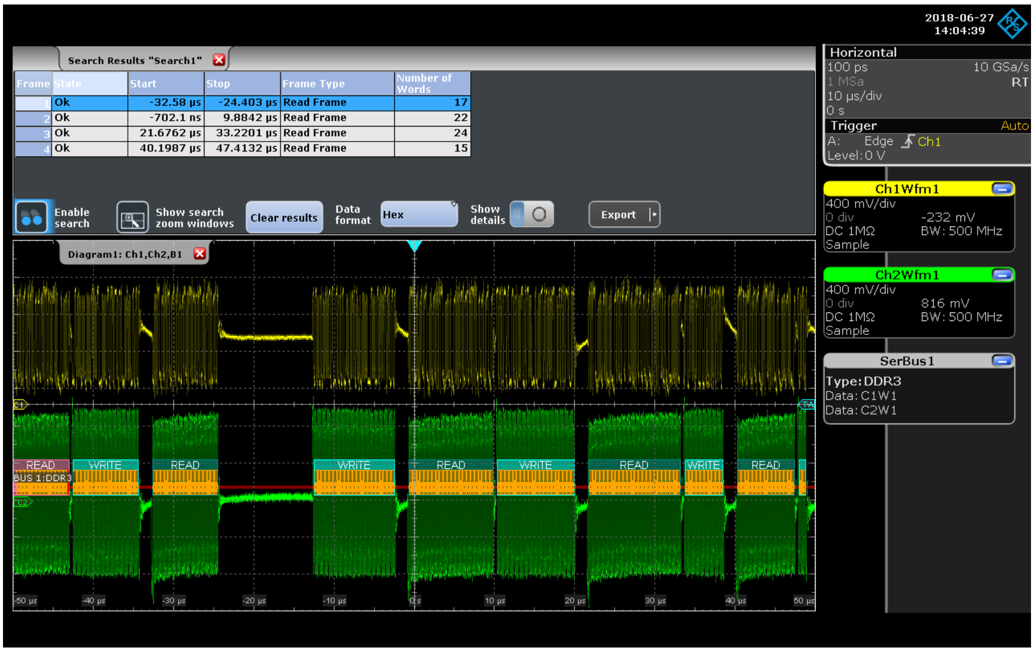


Figure 12-97: Search results with search table

The search results are listed in the search result table and marked in the waveform by blue lines.

The "Show search zoom windows" function allows you to analyze the search results in more detail. Search zoom and result table are synchronized; if you select a row in the result table, this result is shown in the search zoom.

For an introduction to search results, see:

- Chapter 10.1.2, "Search Results", on page 397
- Chapter 10.4, "Result Presentation", on page 414

Remote commands:

- `SEARch:RESult:DDRThree:FCOunt?` on page 1770
- `SEARch:RESult:DDRThree:FRAMe<m>:FLD<n>:FVAL?` on page 1771
- `SEARch:RESult:DDRThree:FRAMe<m>:FLD<n>:STARt?` on page 1771
- `SEARch:RESult:DDRThree:FRAMe<m>:FLD<n>:STATus?` on page 1771
- `SEARch:RESult:DDRThree:FRAMe<m>:FLD<n>:STOP?` on page 1772
- `SEARch:RESult:DDRThree:FRAMe<m>:FLD<n>:VAL?` on page 1772
- `SEARch:RESult:DDRThree:FRAMe<m>:NWRDs?` on page 1772
- `SEARch:RESult:DDRThree:FRAMe<m>:STARt?` on page 1773
- `SEARch:RESult:DDRThree:FRAMe<m>:STATe?` on page 1773

- SEARch:RESult:DDRThree:FRAMe<m>:STOP? on page 1773
- SEARch:RESult:DDRThree:FRAMe<m>:TYPE? on page 1774

12.18.2.3 Searching for DDR3 Data

Prerequisite: A serial bus is configured for the DDR3 signal to be decoded and analyzed.

The search for events is set up in the following way:

1. Press [Search] or tap "Search" > "Setup" in the menu bar.
2. If the dialog box does not contain a search entry, tap the icon to create one, as described in "To create a user-defined search" on page 411.
3. Tap "Source" and select the serial bus that is set to DDR3 (e.g. "SB1", unless already selected).
   The search dialog for DDR3 protocol analysis is opened.
4. Specify search criteria according to Chapter 12.18.2.1, "DDR3 Search Setup", on page 821.
5. To acquire a waveform, press [Single].
   The R&S RTP performs a DDR3 decode according to the thresholds and protocol settings of the associated serial bus source (here in our example SB1).
6. To start searching the acquired waveform for specific events, tap "Enable" in the search setup dialog:
   The R&S RTP displays the "Search Results" box that lists the detected events. For information on how to configure the search results presentation and how to navigate the search results, see also "To display search zoom windows" on page 417 and "Navigating search results" on page 398.

12.18.3 DDR3 Decode Results

When the configuration of the serial bus is complete, the signal can be decoded:

1. In the "Protocol" dialog > "Decode" tab, enable "Decode".

2. In the "Protocol" dialog > "Display" tab, select additional result display settings: "Show decode table" and "Show binary signals". For a description of the display settings, see also Chapter 12.1.2, "Display", on page 465

The instrument captures and decodes the signal according to the standard definition and the configuration settings.

The color-coding of the various protocol sections and errors simplifies the interpretation of the visual display. The decode information condenses or expands, depending on the horizontal scale. Various data formats are available to show the result values.

Example

The example shows a decoded DDR3 read and write cycles and the result tables.

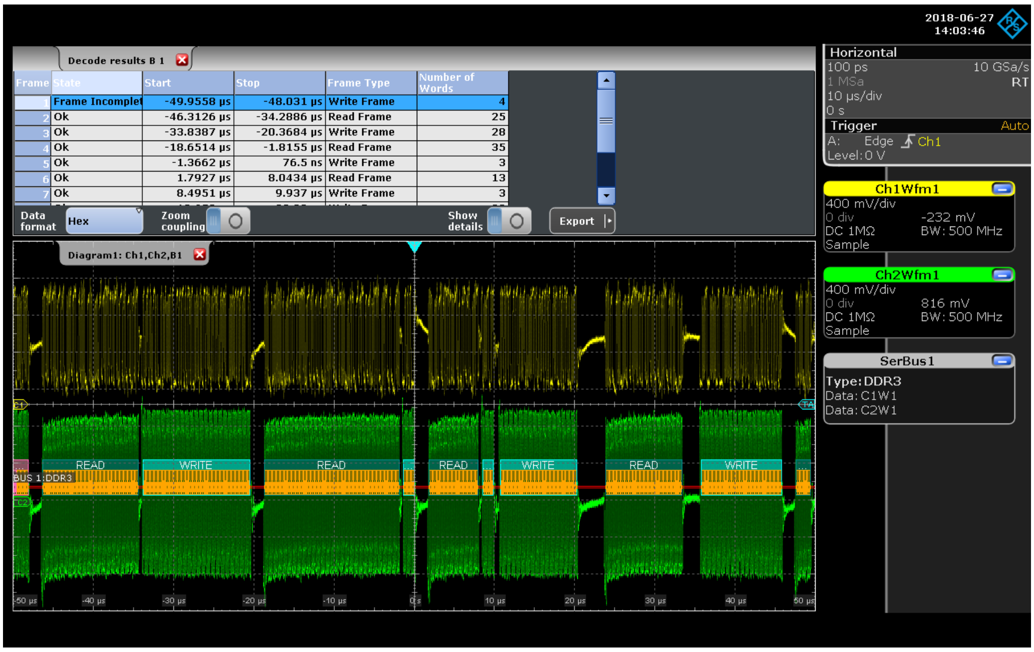


Figure 12-98: DDR3 : decoded signal and decode table

Table 12-31: Content of the decode result table

Column	Description
Frame	Frame count
State	Overall state of the frame indicating, for example, if the frame is valid or invalid
Start	Time of frame start in relation to the trigger point
Stop	Time of frame stop in relation to the trigger point
Frame Type	Frame identifier specifying the data or control frame name
Number of Words	Total number of words in the frame

Enable "Show details" in the decode table to display a more detailed analysis of the selected frame. All data bytes are listed (in hexadecimal format).

Zooming on decoded results

The zoom functions allow you to analyze the decode results in more detail. If "Zoom coupling" is enabled, the decode zoom and result table are synchronized; if you select a row in the result table, this result is shown in the decode zoom.

For an introduction to zoom settings and setup, see:

- Chapter 6.1.2, "Zoom Settings", on page 228
- Chapter 6.1.3, "Zooming for Details", on page 232

Export of decode results

You can export the decode results to a CSV or HTML file:

1. Press the [Save Recall] key on the left.
2. Select the "Waveforms/Results" tab > "Numeric" subtab.
3. Select the decode results to be exported, the file format, and the delimiter.
4. Tap "Save" or "Save as".

Remote commands

Remote commands are described in Chapter 20.17.19.2, "Decode Results", on page 1761.

12.18.4 DDR Eye Diagram Analysis

The main application of eye diagrams is the analysis of signal integrity and signal quality.

There are two ways to generate eye diagrams on the R&S RTP:

- Standard eye diagrams, which are a superposition of repetitively sampled digital data.
- DDR eye diagrams, which are generated by superimposing waveform slices from a multi-bit acquisition. To use DDR eye diagrams, option R&S RTP-K91 is required.

12.18.4.1 Calculation and Display of DDR Eye Diagrams

The R&S RTP with option R&S RTP-K91 generates eye diagrams for the DDR signals. To build DDR eyes, the oscilloscope acquires a long waveform containing many bits. The instrument uses the clock reference provided by the DQS channel to cut the waveform into slices of 1-bit length, and superimposes the individual slices. The superimposed slices of consecutive bits build the DDR eye. The clock reference defines the position of the individual data bits on the time axis, and so it provides the necessary timing marks to align and superimpose the waveform slices.

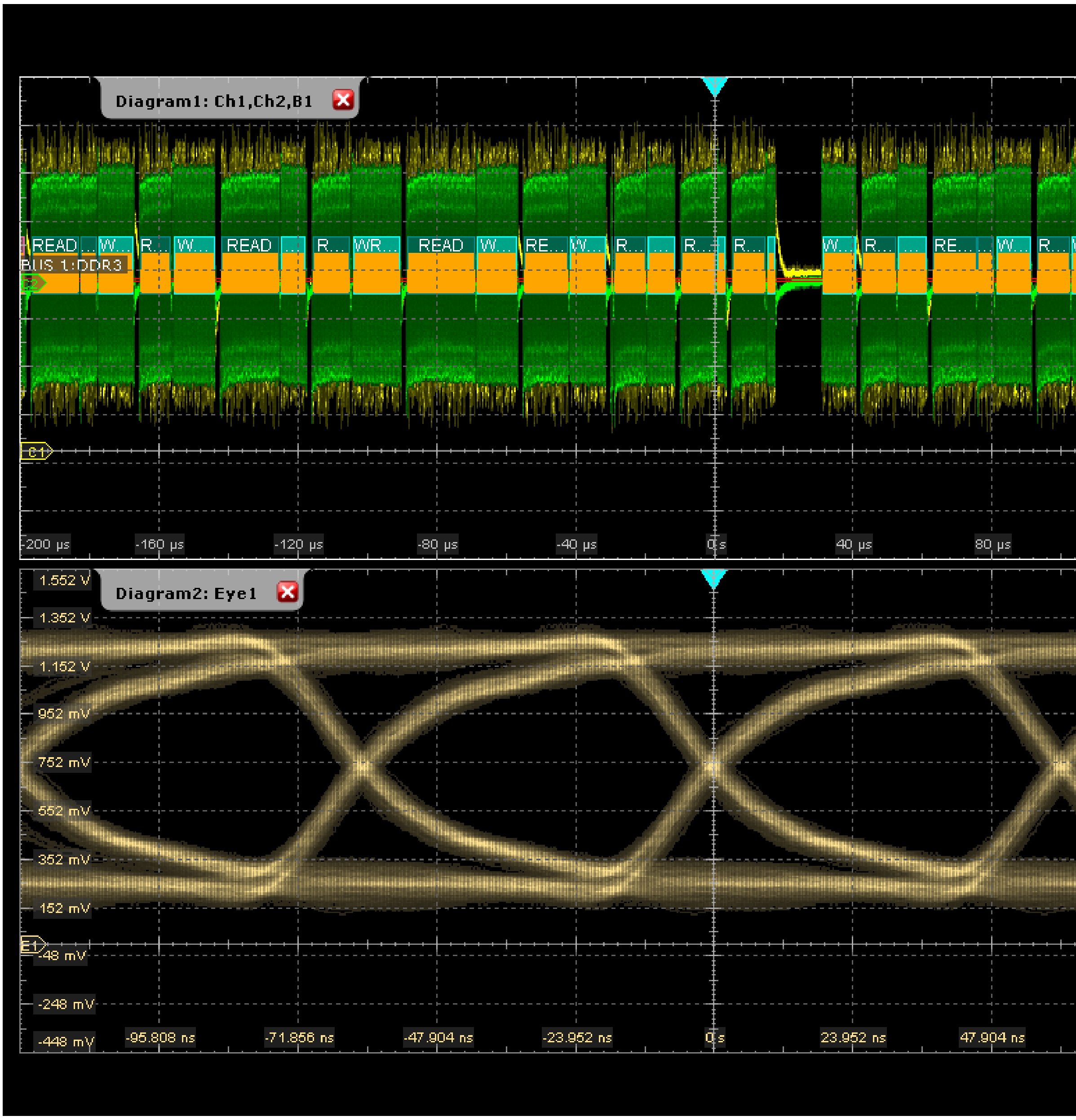


Figure 12-99: Eye diagrams of a DDR

You can define up to four eye diagrams and configure them independently. Each eye diagram is shown in a separate display diagram, which has its own signal icon. You can move and minimize eye diagrams like any waveform diagram and analyze all eye diagrams in parallel.

The following analysis functions are available for eye diagrams:

- Cursor measurements
- Automatic eye measurements
- Histograms
- Zoom

12.18.4.2 Eye Diagram Setup

This chapter describes the configuration of eye diagrams.

The configuration of an eye diagram mainly consists of the selection and setup of the input source and timing reference source. You can also adjust display settings and restrict the segments that contribute to the eye generation by various means.

There are two ways to set up the eye diagram:

- Use the step-by-step wizard that guides you through the setup.
- Use the "DDR Eye Diagram" dialog box.

You can configure and analyze up to four independent eye diagrams in parallel. Diagram "DdrEye1" is shortly named "E1" in the dialog boxes. Likewise, "DdrEye2" corresponds to "E2", and so on.

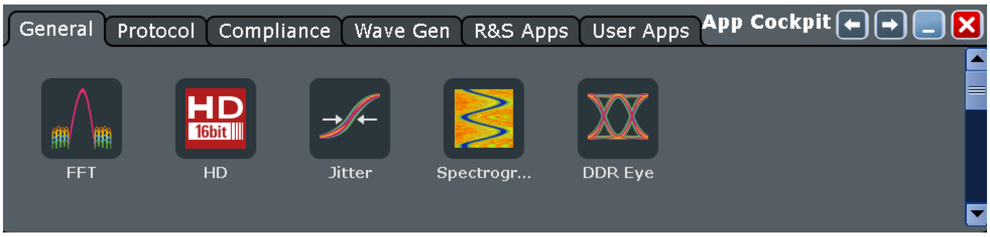
Eye Wizard

The eye wizard helps you to configure the eye diagram step by step. It provides and explains all required settings for the eye diagram.

All settings that are provided by the wizard are also available in the "DDR Eye Diagram" dialog box. They are explained in the following sections.

To use the eye wizard:

1. Open the app cockpit: key or icon in the menu.
2. Select "DDR3 Eye ".



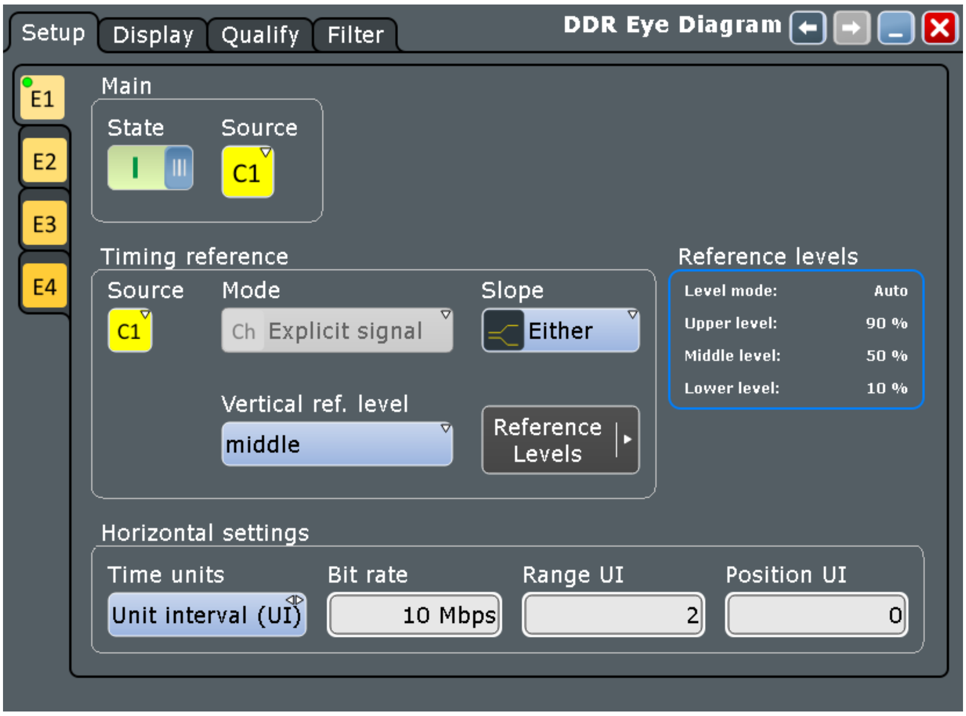
3. Follow the instructions of the wizard.

The "DDR Eye Diagram" dialog box provides four tabs with all settings that are required to configure eye diagrams.

Basic Setup

Access: "Analysis" menu > "DDR Eye Setup" > "Setup"

In the "Setup" tab, you configure the source, the timing reference, and horizontal scale settings of the eye diagram. The vertical scale of the eye diagram is coupled to the vertical scale of the data source.



You can configure and analyze up to four independent eye diagrams in parallel (vertical subtabs E1 to E4). Make sure to select the correct eye diagram subtab on the left before you adjust the settings.

State

Activates or deactivates the eye diagram.

Remote command:

`EYE<m>[:STATe]` on page 1774

Source (Main)

Selects the waveform from which the eye diagram is generated (data source).

Select the same channel for the DDR3 serial bus protocol configuration "DQ" data line and the input for the eye diagram.

Remote command:

`EYE<m>:SOURce` on page 1775

Source (Timing Reference)

Selects the waveform that is used to obtain the timing information required to slice the data source waveform.

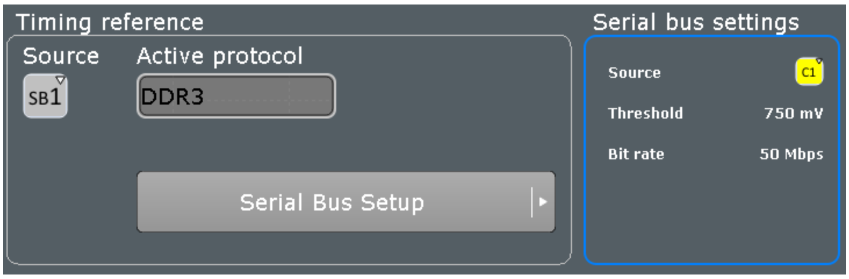
If you perform eye diagram analysis on the DDR3 serial protocol, select the serial bus here. The instrument determines the timing information according to protocol specifics.

Remote command:
`EYE<m>:TREFerence[:SOURce]` on page 1775

Mode
Selects the method to extract timing information from an analog timing source.

"Explicit signal" If a clock signal is available, the instrument can use it directly to set the segmentation timestamps. Configure Slope / Vertical ref. level (Timing reference) to define the point in time.

"Active protocol" The DDR3 source signal settings are used for the timing information. For the serial bus setup, see Chapter 12.18.1, "DDR3 Configuration", on page 818.



Slope / Vertical ref. level (Timing reference)
Sets the edge and reference level to define the timestamps for slicing the data waveform. A timestamp is set each time when the selected slope of the timing waveform crosses the selected reference level.

Remote command:
`EYE<m>:TREFerence:LEVel` on page 1775
`EYE<m>:TREFerence:SLOPe` on page 1775

Time units
Sets the method to define the horizontal scale of the eye diagram: as absolute time, or in unit intervals. You can use unit interval, if the nominal frequency of the clock signal is known.

Indirectly, the horizontal scale determines the size of one waveform slice. The waveform slice must be fully contained in the waveform acquisition to contribute to the eye diagram.

Remote command:
`EYE<m>:HORizontal[:UNIT]` on page 1776

Range, Position
Define the horizontal scale in absolute time ("Time units" = "Absolute time")

"Range" Time range that is covered by the eye diagram.

"Position" Place of the zero point in the diagram, in seconds. The zero point is the alignment point on which the slice timestamps are superimposed.

Remote command:
`EYE<m>:HORizontal:ABSolute:RANGe` on page 1776
`EYE<m>:HORizontal:ABSolute:POSition` on page 1776

Bit rate, Range UI, Position UI
Define the horizontal scale in unit intervals. A unit interval typically corresponds to a bit in the input data signal.

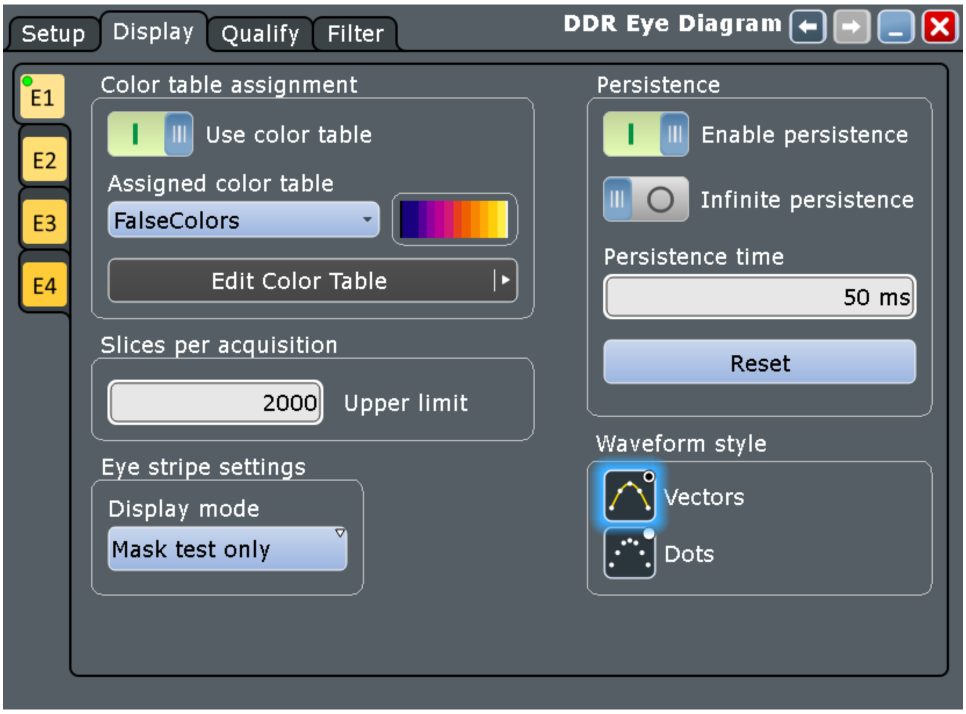
"Bit rate"	Nominal frequency or bit rate of the data signal.
"Range UI"	Number of unit intervals that are visible in the eye diagram.
"Position UI"	Place of the zero point in the diagram, in unit intervals. The zero point is the alignment point on which the segment timestamps are superimposed.

Remote command:
`EYE<m>:HORizontal:UINTerval:BITRate` on page 1776
`EYE<m>:HORizontal:UINTerval:RANGe` on page 1777
`EYE<m>:HORizontal:UINTerval:POSition` on page 1777

Display Settings

Access: "Analysis" menu > "DDR Eye Setup" > "Display"

In the "Display" tab, you define the appearance of the individual eye diagrams.



You can configure and analyze up to four independent eye diagrams in parallel (vertical subtabs E1 to E4). Make sure to select the correct eye diagram subtab on the left before you adjust the settings.

Color table assignment
Like any other waveform, you can show the eye waveform in solid color, or apply a color table. If you select solid color, the intensity of the waveform is proportional to the number Z of waveform slice points that hit a point (X,Y).

See also: Chapter 3.4.2.1, "Colors / Persistence", on page 89 and Chapter 3.4.2.2, "Color Tables", on page 92.

Persistence
Each eye diagram has its specific persistence settings, independent of the general waveform persistence.

For a description of the persistence settings, see Chapter 3.4.2.1, "Colors / Persistence", on page 89.

Slices per acquisition
Sets the number of waveform slices for a single acquisition.

Remote command:
EYE<m>:MSLices on page 1777

Display mode (Eye stripe)
Defines when the eye stripe is shown: always, never, or during mask tests.

The eye stripe is shown at the bottom of the main source waveform. It shows the part of the waveform that contributes to the eye. When a mask test is performed on the eye diagram, the eye stripe shows the position of the mask violations in red color.

Remote command:
EYE<m>:DISPlay[:MODE] on page 1777

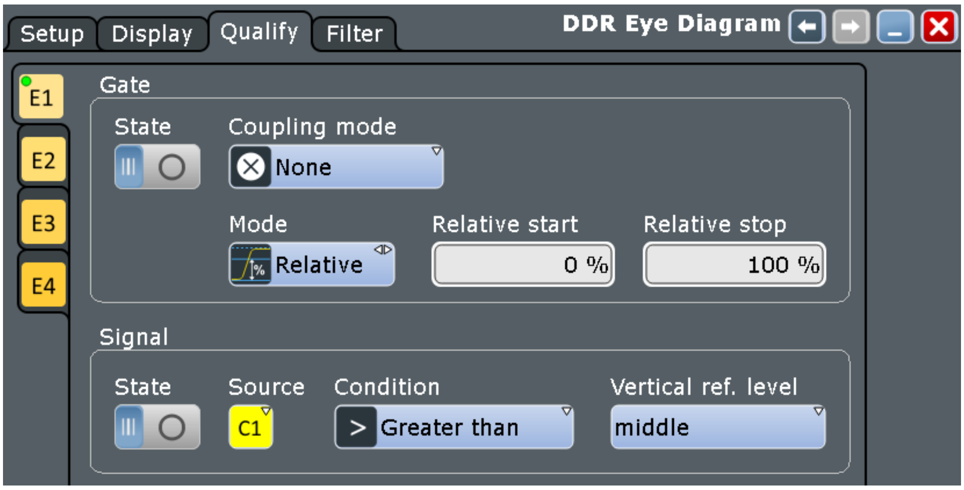
Waveform style
Each eye diagram has its own display style, independent of the general waveform style.

For a description of display style, see "Style" on page 91.

Qualify Settings

Access: "Analysis" menu > "DDR Eye Setup" > "Qualify"

Using the qualification settings, you can restrict the slices that contribute to the eye diagram. The restriction can be in horizontal direction (gate), or in vertical direction using the reference level.



You can configure and analyze up to four independent eye diagrams in parallel (vertical subtabs E1 to E4). Make sure to select the correct eye diagram subtab on the left before you adjust the settings.

Gate
Restricts the contributing slices in horizontal direction. Only the timestamps within the defined horizontal interval qualify for eye generation.

To apply the gate settings, enable the "State".

The gate definition is the same as gate definition for measurements, but the gates are independent. You can define the gate in one of these ways:

- Enter absolute time values for gate start and gate end: "Coupling mode = None" and "Mode = Absolute". Set "Start" and "Stop" time.
- Enter relative values for gate start and gate end: "Coupling mode = None" and "Mode = Relative". Set "Relative start" and "Relative stop" in percent.
- If a cursor measurement is active, you can use the vertical cursor lines as gate limits: "Coupling mode = Cursor". Select the cursor set.
- If a zoom is active, you can use the zoom limits as gate: "Coupling mode = Zoom". Select the zoom.

For details, see Chapter 7.2.3.2, "Gate Settings for Measurements", on page 292.

Remote command:
`EYE<m>:QUALify:GATE[:STATe]` on page 1778
`EYE<m>:QUALify:GATE:COUPling` on page 1778
`EYE<m>:QUALify:GATE:MODE` on page 1778
`EYE<m>:QUALify:GATE:ABSolute:STARt` on page 1779
`EYE<m>:QUALify:GATE:ABSolute:STOP` on page 1779
`EYE<m>:QUALify:GATE:RELative:STARt` on page 1779
`EYE<m>:QUALify:GATE:RELative:STOP` on page 1779
`EYE<m>:QUALify:GATE:CURSor` on page 1779
`EYE<m>:QUALify:GATE:ZDIagram` on page 1780

Signal

Sets a waveform-based qualification for the eye generation. The voltage level of a waveform is compared with a threshold, and only if this condition is fulfilled, the slices contribute to the eye generation.

To apply the signal qualification, enable the "State".

"Source" Selects the waveform to be compared.

"Condition" Selects the comparison condition: the waveform level must be greater or less than the threshold.

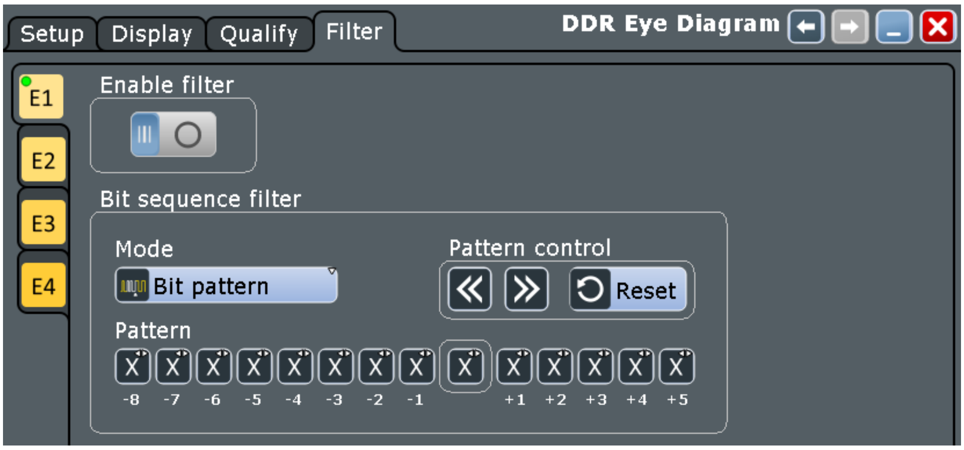
"Vertical ref. level"
Selects the threshold. You can use the lower, middle, or upper reference level. These levels are the reference levels that are defined for measurements, see Chapter 7.2.4, "Reference Levels", on page 294.

Remote command:
`EYE<m>:QUALify:SIGNal[:STATe]` on page 1780
`EYE<m>:QUALify:SIGNal:SOURce` on page 1780
`EYE<m>:QUALify:SIGNal:CONDition` on page 1781
`EYE<m>:QUALify:SIGNal:LSELect` on page 1781

Filter Settings

Access: "Analysis" menu > "DDR Eye Setup" > "Filter"

Filter settings allow you to select waveform slices for eye generation dependent on the bit status.



You can configure and analyze up to four independent eye diagrams in parallel (vertical subtabs E1 to E4). Make sure to select the correct eye diagram subtab on the left before you adjust the settings.

Enable filter

Applies the filter settings.

Remote command:
`EYE<m>:FILTer:STATe` on page 1781

Mode

Selects which bits contribute to the eye generation.

"All bits" All bits contribute to the eye diagram, same as "State" = off.

"Level transition" Only bits after a signal transition contribute (0 to 1, or 1 to 0).

"Constant level" Only bits without a preceding signal transition contribute (0 to 0, or 1 to 1).

"Bit pattern" Only bits contribute that match the defined pattern before and after the center eye. Use the bit pattern, for example, to measure the effect of data-dependent jitter on the eye diagram.

Remote command:
`EYE<m>:FILTer:BPATtern:MODE` on page 1782

Pattern

Defines the bit pattern if "Mode" = "Bit pattern". You can set up to 8 bits before and 5 bits after the center eye (reference bit).

Remote command:
`EYE<m>:FILTer:BPATtern:PREFix<1..8>` on page 1782
`EYE<m>:FILTer:BPATtern:CENTer` on page 1782
`EYE<m>:FILTer:BPATtern:SUFFix<1..5>` on page 1782

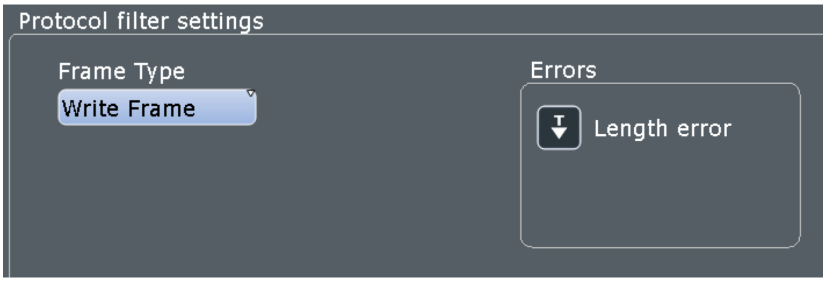
Pattern control

Shift the pattern bit by bit to the left or to the right, and reset to the default (X for all bits).

Remote command:
`EYE<m>:FILTer:BPATtern:SLEFt` on page 1782
`EYE<m>:FILTer:BPATtern:SRIGht` on page 1783
`EYE<m>:FILTer:BPATtern:RESet` on page 1783

Protocol filter settings

This setting is only available, if the "Source (Timing Reference)" is set to "SBx" and the "DDR3" serial bus analysis is enabled for the same bus.



Frame Type ← Protocol filter settings

Selects which frame types contribute to the eye diagram, write frames, read frames or any of them.

Errors ← Protocol filter settings

If enabled, the length errors contribute to the eye diagram.

12.18.4.3 Measurements and Zoom on Eye Diagrams

To analyze eye diagrams, you can use the following basic functions of the R&S RTP:

- **Cursor measurements**
  Cursors can be used on eye diagrams in the usual way. "Track waveform" is not supported.
  For details, see Chapter 7.1, "Cursor Measurements", on page 270.
- **Automatic eye measurements**
  Eye measurements can be used on eye diagrams in the usual way.
  For details, see Chapter 7.2.6, "Eye Diagram Measurements", on page 315.
- **Histograms**
  You can create histograms on eye diagrams as usual.
  For details, see Chapter 7.2.8, "Histograms and Histogram Measurements", on page 323.
- **Zoom**
  You can zoom into eye diagrams using the zoom functions.
  For details, see Chapter 6.1, "Zoom", on page 226.

12.18.4.4 Mask Testing on Eye Diagrams

Mask testing on eye diagrams allows you to test data signals against eye shapes that are required in the standards..

You can select the shape of the eye, enter its dimensions and position the eye on the display. For mask configuration details, see Chapter 9.4.1, "Test Definition for Eye Mask Tests", on page 393 and Chapter 9.4.2, "Eye Mask Definition", on page 393. The fail criteria for the test is defined as usual for R&S RTP mask tests, see "Fail condition, Violation tolerance" on page 374.

The eye mask definition cannot be saved as a mask test. You can save the settings as user defined preset and recall them by loading the preset file. See: Chapter 11.6, "Preset Setup", on page 459.

13 Mixed Signal Option (MSO, R&S RTP-B1)

The Mixed Signal Option R&S RTP-B1 adds logic analyzer functions to the classical oscilloscope functions. Using the MSO option, you can analyze and debug embedded systems with mixed-signal designs that use analog signals and correlated digital signals simultaneously.

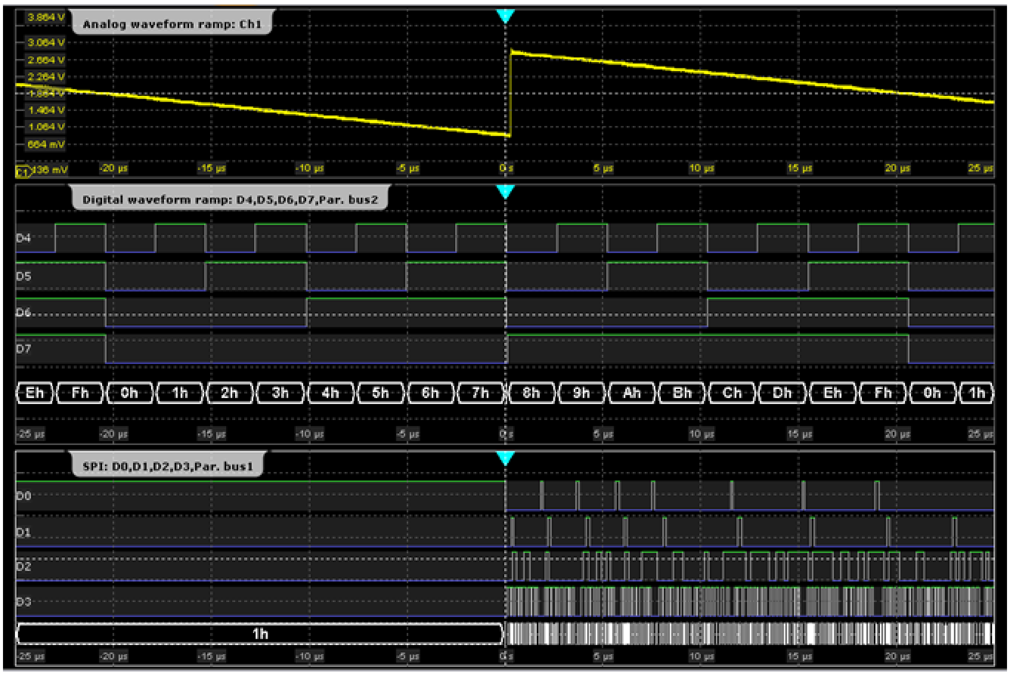
The Mixed Signal Option provides 16 digital channels grouped in two logic probes (pods) with 8 channels each. The instrument ensures that analog and digital waveforms are time-aligned and synchronized so that critical timing interactions between analog and digital signals can be displayed and tested. The automatic alignment compensates the skew between the probe connectors of the analog channels and the probe boxes of the digital channels.

13.1 Digital Channels and Parallel Buses

Each digital channel can be displayed on the screen and used as trigger source. Digital channels may be grouped and displayed as a parallel bus. Up to four parallel buses can be configured; and two bus types are supported: clocked bus and unclocked bus. The clocked bus is available only on parallel bus 1 and 2. Each digital channel can be assigned to one *active* parallel bus only, the instrument disables conflicting buses automatically.

You can display each bus and use it as trigger source, as well. For each active parallel bus, the corresponding signal icon appears on the sidebar and indicates the assigned digital channels. Individual digital channels do not have a signal icon.

If one or more parallel buses are active, the roll mode is not available.

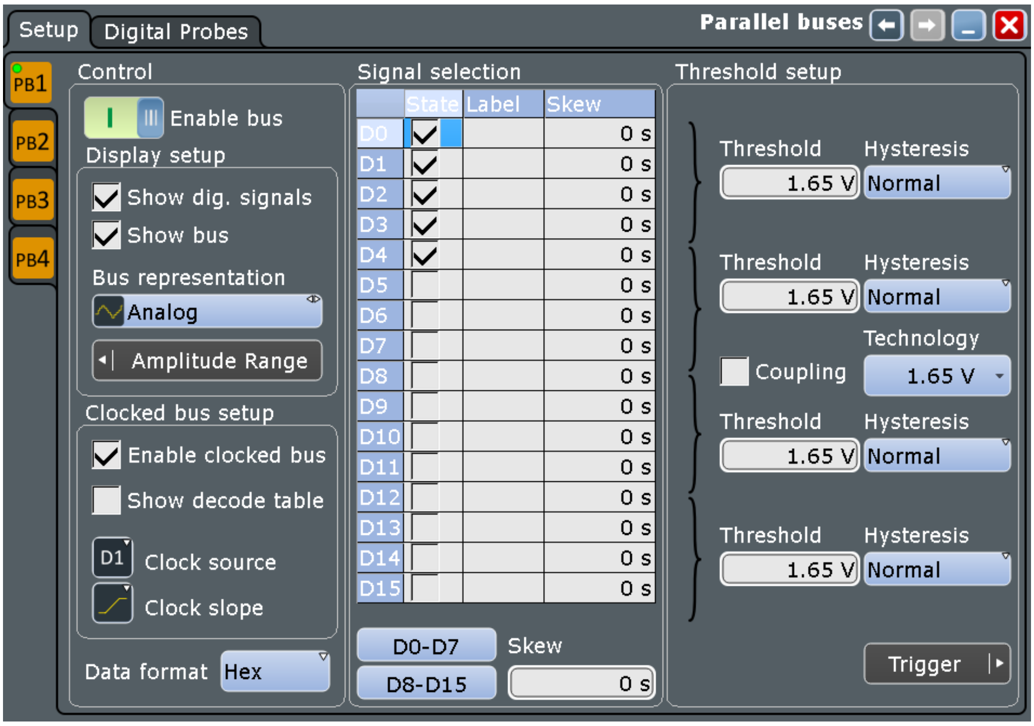


13.1.1 Parallel Buses - Configuration

Access: "Analysis" menu > "Parallel buses"

Digital channels can be displayed individually, and they can be grouped and displayed as a parallel bus. You can configure and enable up to 4 parallel buses. Each digital channel can be assigned to one *active* parallel bus only, the instrument disables conflicting buses automatically.

For clocked buses, you can display the decoded data in a result box.



If you have configured several parallel buses and you want to modify the settings, make sure that the tab of the correct bus is selected on the left side, and disable the bus before you change the settings.

Enable bus

Enables the selected parallel bus. The corresponding signal icon appears on the side-bar.

If another *active* bus already uses the same digital channel, the instrument disables the other bus and shows a message.

Remote command:

`BUS<m>:PARallel:STATe` on page 1788

Show dig. signals
If enabled, the selected digital channels are shown in the diagram. Each channel is displayed as a logic signal.

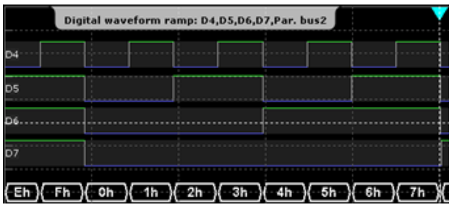
Remote command:
`BUS<m>:PARallel:DISPlay:SHDI` on page 1792

Show bus
If enabled, the resulting bus signal and bus values are displayed in the diagram. Select the presentation type for the bus signal with Bus representation.

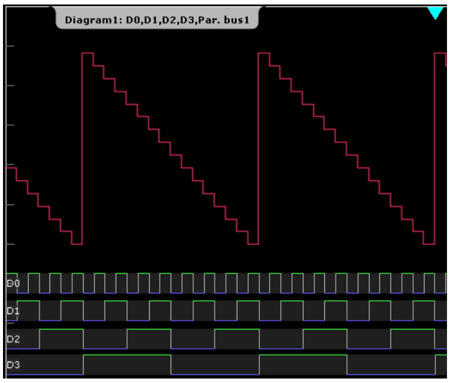
Remote command:
`BUS<m>:PARallel:DISPlay:SHBU` on page 1793

Bus representation
Defines how the parallel bus is displayed:

"Comb" Displays the decoded bus signal with bus values. When at least one digital channel changes its value, the bus value changes too.

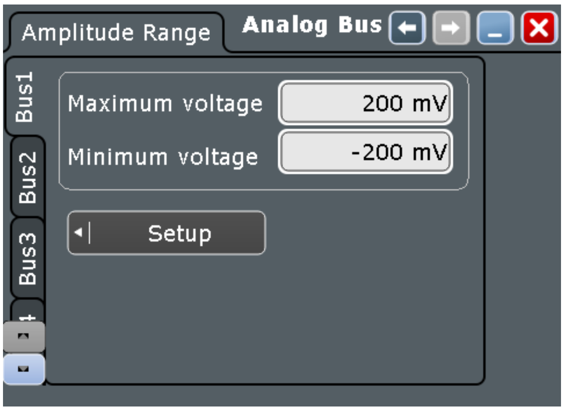


"Analog" Displays the bus values as signal amplitudes, similar to an analog waveform. Thus, a quasi-analog waveform is created.



Remote command:
`BUS<m>:PARallel:DISPlay:BTYP` on page 1793

Amplitude Range
If the bus representation is "Analog", the amplitude range defines the voltage range for the display of the analog bus. The highest bus value corresponds to the "Maximum voltage", and the lowest bus value to the "Minimum voltage".



See also: "Bus representation" on page 840

Clocked bus setup

If a bus is a clocked bus, one of the digital channels serves as clock of the bus.

For an unclocked bus, the logical state of the bus is determined for each sample. For a clocked bus, the logical state is determined only at the specified clock edges.

The settings are only available for "Bus1" and "Bus2".

"Enable clocked bus"	Enable this option, if the bus is a clocked bus.
"Show decode table"	The decode table is only available for clocked buses to check the data words. If enabled, a results box opens with decoded values of the bus signal and its time. Each clock edge corresponds to one row in the table.
"Clock source"	Selects the digital channel used as clock.
"Clock slope"	Selects the slope of the clock signal at which all digital channels of the bus are analyzed.

Remote command:
`BUS<m>:PARallel:CLON` on page 1793
`BUS<m>:PARallel:CLOCk` on page 1794
`BUS<m>:PARallel:CLSLope` on page 1794

Data format

Sets the data format of bus values, which are displayed in the decode table and on the comb bus display. Available formats are: Hex, ASCII, Octal, Binary, Signed, and Unsigned.

Signed and Unsigned are integer data types with maximum 16-bit length. Unsigned is used for positive integers. Signed is used for positive and negative integers.

If the target file format is BIN, you can save only signed and unsigned binary data. The data format "Signed" writes signed data; all other formats are saved as unsigned binary data.

Remote command:
`BUSFormat` on page 1301

Signal selection

In the table, you select and configure the digital channels that are used in the selected bus.

"State"	Enables a digital channel, and assigns it to the bus.
"Label"	You can enter a name for each digital channel. The name is displayed in the diagram.
"Deskew"	Sets an individual delay for each digital channel to time-align it with other digital channels. The deskew value compensates delays that are known from the circuit specifics or caused by the different length of cables. The skew between the probe boxes of the digital channels and the probe connectors of the analog channels is automatically aligned by the instrument. You can also set a value that is applied to all digital channels, see "Deskew offset" on page 842.

Remote command:
`BUS<m>:PARallel:BIT<n>[:STATe]` on page 1789 (all buses)
`DIGital<m>:DISPlay` on page 1785 (Bus1)
`BUS<m>:PARallel:BIT<n>:LABel` on page 1792 (all buses)
`DIGital<m>:LABel` on page 1787 (Bus1)
`BUS<m>:PARallel:BIT<n>:DESKew` on page 1791 (all buses)
`DIGital<m>:DESKew` on page 1788 (Bus1)

D0-D7, D8-D15 ← Signal selection

The buttons select or deselect all digital channels of a pod at once.

Deskew offset ← Signal selection

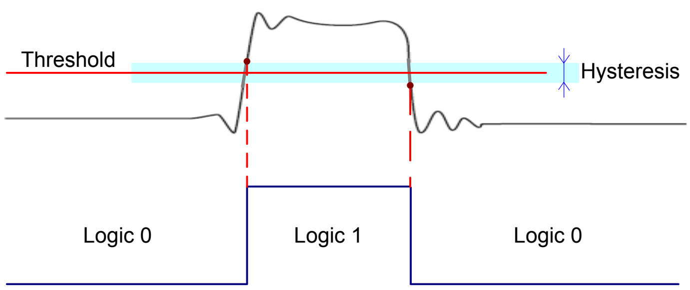
Sets a general delay for all digital channels. The resulting deskew of a digital channel is the sum of the general "Deskew offset" and the individual "Deskew".

Remote command:
`BUS<m>:PARallel:DESoffset` on page 1792

Threshold setup

Sets the logical threshold. For each sample, the instrument compares the input voltage with the threshold value. If the input voltage is above the threshold, the signal state "1" is stored. Otherwise, the signal state "0" is stored if the input voltage is below the threshold.

To avoid the change of signal states due to noise, a hysteresis is considered.



By default, same threshold and hysteresis value are used for all digital channels and all parallel buses: "Coupling" is enabled.

You can also set different thresholds for the individual channel groups: Disable "Coupling" and set the threshold value for each group. As long as the buses are disabled, you can set different thresholds for each bus. Active buses use the same threshold and hysteresis values, the settings of the last activated bus take effect.

The range of threshold levels and the minimum voltage swing is given in the data sheet.

"Threshold" Enter the value directly in the field.

"Technology" Selects the threshold voltage for various types of integrated circuits from a list and applies it to all digital channels. The value is set to "Manual" if a user-defined threshold was entered directly.

"Coupling" Sets the threshold and the hysteresis for all digital channels and all buses to the same value.

"Hysteresis" Defines the size of the hysteresis. Three values are available:
- Normal: the instrument sets a small value suitable for the signal and its settings. Use this setting for clean signals.
- Maximum: the instrument sets the maximum value that is possible and useful for the signal and its settings. Use this setting for noisy signals.

Remote command:
BUS<m>:PARallel:TECHnology on page 1790 (all buses)
DIGital<m>:TECHnology on page 1786 (bus1)
BUS<m>:PARallel:THReshold<n> on page 1789 (all buses)
DIGital<m>:THReshold on page 1786 (bus1)
BUS<m>:PARallel:THCoupling on page 1790 (all buses)
DIGital<m>:THCoupling on page 1786 (bus1)
BUS<m>:PARallel:HYSTeresis<n> on page 1791 (all buses)
DIGital<m>:HYSTeresis on page 1787 (bus1)

13.1.2 Parallel Buses - Digital Probes

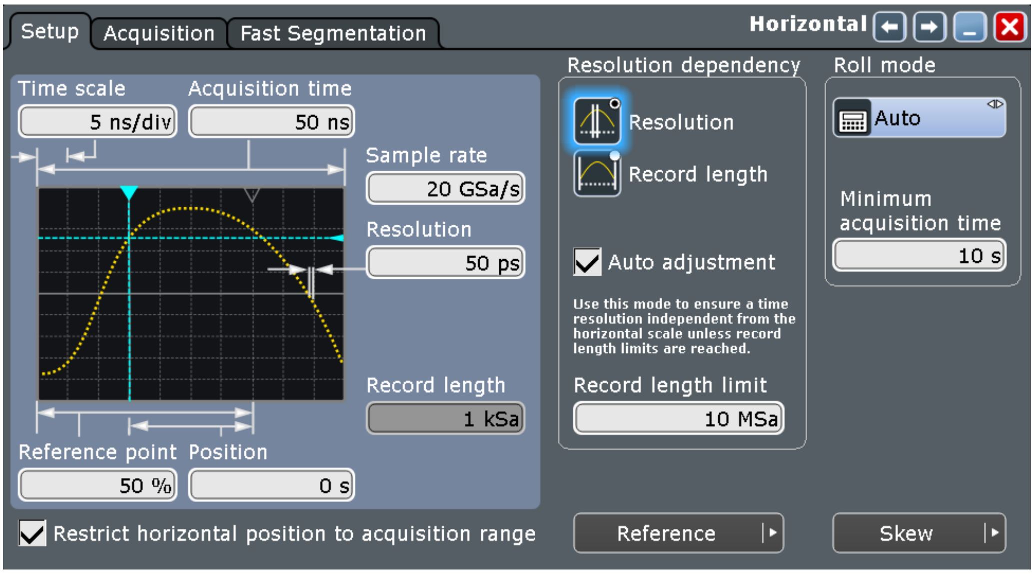
Access: "Analysis" menu > "Parallel buses" > "Digital Probes" tab

Logic probes provided by R&S are recognized by the instrument. The fields show the characteristics of each recognized probe (pod) for information. "Write EEPROM" and "Flash it" are service functions.

13.1.3 Digital Resolution

Access: [Res Rec Len] key

If an MSO option is installed and at least one digital channel is active, additional information appears on the "Setup" tab of the "Horizontal" dialog box.



Dig. resolution
Shows the current digital resolution of the digital channels. The maximum digital record length is always 200 MSa per digital channel. This number is independent of additionally installed memory.

Remote command:
`ACQuire:DRESolution?` on page 1795

13.1.4 Using Digital Probes

NOTICE

Ensuring accurate measurement results

The mixed-signal-option (MSO, R&S RTP-B1) with connected probe leads is considered as a test probe, according to EN 61326-2-1, clause 5.2.4.101. Therefore, the measurements are sensitive to electromagnetic interference. Consider additional shielding methods to avoid interference.

Consider the following guidelines for good probing practices:

- The ground lead from each digital channel group (D15–D8 and D7–D0) should be attached to the ground of the device under test if any channel within the group is being used for data capture. The ground lead improves signal fidelity to the oscilloscope, ensuring accurate measurements.
- For high-speed timing measurements (rise time < 3 ns), each digital channel probe should use its own ground.

1. Connect the digital probe cable to any of the MSO connectors on the rear panel of the instrument as shown on the Documentation Card delivered with the digital probe.

2. Connect the ground lead on each set of channels (each pod) with a probe grabber.
3. Connect a grabber to one of the probes leads.
4. Connect the grabber to a node in the circuit you want to test.
5. For high-speed signals, connect a ground lead to the probe lead. Connect the ground lead to ground in the device under test.
6. Repeat these steps until you have connected all points of interest.

13.1.5 Configuring Digital Channels and Parallel Buses

The configuration of a parallel bus includes the selection and setup of the digital channels, the configuration of the bus display, and, if necessary, the clock configuration.

For a detailed description of the settings, see Chapter 13.1.1, "Parallel Buses - Configuration", on page 838.

1. On the "Analysis" menu, tap "Parallel buses".
2. In the "State" column of the "Signal selection" table, enable the digital channels to be displayed and included in the bus.
   To enable or disable all channels of a pod at once, tap "D0-D7" or "D8-D15".

   Enabling one or more channels also enables the display of the signals - "Show dig. signals", and enables the parallel bus. If another active bus already uses the same digital channel, the instrument disables this bus and shows a message.
   The digital signals are shown in the diagram, and the signal icon of the parallel bus appears on the sidebar. Using this bus icon, you can minimize, arrange, and switch off the bus together with its channels in the same way as you do with any waveform.
3. Optionally, you can enter a "Label" for each digital channel, and a "Deskew" value to time-align the channel.
4. Set the logical thresholds as described in Chapter 13.1.6, "Setting the Logical Thresholds", on page 845.
5. If the bus has a clock signal, enable "Bus clocked" and select the "Clock source" and "Clock slope".

   Now the configuration of the parallel bus is completed.

13.1.6 Setting the Logical Thresholds

For a detailed description of the settings, see "Threshold setup" on page 842. Threshold settings are the same for all *active* parallel buses.

1. On the "Analysis" menu, tap "Parallel buses".
2. To set the thresholds, use one of the following ways:

- Use the same value for all digital channels and all parallel buses: Enable "Coupling" and set one threshold value, either select a predefined "Technology" value or enter a user-defined value.
- Set different thresholds for the individual channel groups: Disable "Coupling" and set the threshold value for each group. As long as the buses are disabled, you can set different thresholds for each bus. Active buses use the same threshold and hysteresis values.

3. Set the "Hysteresis" for each threshold to avoid the change of signal states due to noise.

13.2 Display

You can adjust the display of the parallel bus signals and the individual digital channels to optimize the analysis of bus data:

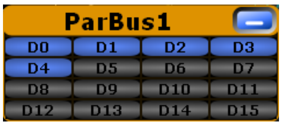
- Show the digital channels which are assigned to the bus, drag them to the optimal position, and scale them
- Show the decoded bus signal in different ways:
  – comb display with numeric bus values
  – analog display with bus values as amplitudes (quasi-analog waveform)

  You can also drag the bus waveforms on the display and scale them.
- Show the result box of the decoded clocked bus signal

Each parallel bus is shown in a separate diagram, and the diagrams can be minimized and arranged as usual.

The signal icon indicates the activities on the digital channels even if they are not displayed in the diagram, of if the acquisition has been stopped:

- Blue: channel is low
- Green: channel is high
- Gray: channel state is changing



The display update rate of the oscilloscope is adapted to the visual perception of human eyes, and it is slower than the acquisition rate. All analog and digital waveforms that are acquired during one display update cycle are overlapped and displayed at once. Thus you can see the cumulative occurrence of binary states and edge transitions on the screen at once. Bus signals are not overlapped.

The trigger point is always visible on the display, it cannot be moved outside ("Restrict horizontal position to acquisition range" is enabled automatically).

If digital channels are active, the trigger point is always visible on the display, it cannot be moved outside.

To access and analyze one or more specific acquisitions, you can use the History Viewer in the common way.

Furthermore, you can zoom in digital signals and bus signal in the same way as in analog waveforms.

See also:

- Chapter 6.4, "History", on page 259
- Chapter 6.1, "Zoom", on page 226

13.2.1 Parallel Bus - Decode Table

Decoding is available for clocked parallel buses.

The decode table shows the decoded data words of the bus signal and the corresponding time. Each clock edge corresponds to one row in the table. Below the table, you can select the data format of the bus values.

The results can be saved to a `.csv` or `.html` file, see Chapter 11.2.4, "Numeric Results", on page 442.

13.2.2 Adjusting the Display of Digital Channels and Parallel Buses

The display of digital channels and parallel buses is flexible, you can adjust it to your needs by combining the following settings:

1. Enable "Show bus" if you want to display the bus signal in the diagram. Under "Bus representation", select if you want to display the decoded bus signal with bus values ("Comb"), or show the bus values as amplitudes, similar to an analog waveform ("Analog").
2. Check the signal icon of the bus to monitor the activities on the digital channels even if they are not displayed in the diagram:
   - Blue: channel is low
   - Green: channel is high
   - Gray: channel state is changing
3. In the diagram, you can change the display order of the digital channels by dragging the individual channels to the required position.
4. To adjust the line height and vertical position of all digital channels at once, tap one of the digital channels and turn the vertical [Scale] and [Position] rotary knobs. In the same way, you can move and scale the bus signal.
5. If the bus signal is displayed as quasi-analog waveform, you can double-tap the waveform to open the "Parallel buses" dialog box.
6. To switch off the display of the digital channels, disable "Show signals".

13.3 Trigger

For digital trigger sources are all trigger types useful that require only one trigger level as trigger condition. This level is the logical threshold. Possible trigger sources are the individual digital channels, parallel bus signals, or any logical combination of digital channels. The following trigger types are available:

Table 13-1: Trigger types and digital trigger sources

Trigger type	Trigger source is		
	Digital channel	Logic combination of digital channels	Parallel bus
Edge	X	X	
Width	X	X	
Timeout	X	X	
State		X	X
Pattern (with holdoff)		X	X
Serial Pattern	X	X	

For details, see: Chapter 13.3.1, "Trigger Settings for Digital Signals and Parallel Buses", on page 848.

Additionally, you can define trigger holdoff conditions. See also Chapter 5.5, "Holdoff", on page 208.

13.3.1 Trigger Settings for Digital Signals and Parallel Buses

Depending on the selected source, the instrument provides the appropriate trigger types and the corresponding trigger settings.

The settings in the "Setup" tab are:

13.3.1.1 Basic Trigger Settings

The basic trigger settings for MSO are the trigger source and the trigger type. They are selected in the upper part of the "Trigger" dialog box.

Make sure that the trigger sequence is set to "A only".

Also, you can define trigger holdoff conditions. See also Chapter 5.5, "Holdoff", on page 208.

Source

If the Mixed Signal Option is installed, the variety of trigger sources of the A-event setup is enhanced with specific digital trigger sources. You can select as trigger source:

- One of the digital channels "D0" ... "D15"

- A logic combination of digital channels: "Logic"

- One of the parallel buses "Par. bus1" ... "Par. bus4"

Remote command:
`TRIGger<m>:SOURce` on page 1053

Type

Depending on the selected source, the instrument provides the appropriate trigger types and the corresponding trigger settings. For mixed signal analysis, the following trigger types are available:

- Edge, see page 849
- Width, see page 850
- Timeout, see page 852
- State, see page 853
- Pattern, see page 854
- Serial Pattern, see page 856

Remote command:
`TRIGger<m>:PARallel:TYPE` on page 1796

13.3.1.2 Edge

Using the edge trigger, you can also trigger on a single digital channel (a logic bit), and a logical combination of digital channels.

Depending on the selected trigger source, different trigger settings are available. The trigger level is already set - in MSO the logical threshold is used as trigger level.

Figure 13-1: Edge trigger settings for trigger source = logical combination of digital channels (Logic)

Slope

Defines the edge - the state transition - of the signal.

"Rising"	Means a 0 to 1 transition of the state.
"Falling"	Means a 1 to 0 transition of the state.
"Either"	Triggers on any activity on the selected trigger source.

Remote command:
`TRIGger<m>:PARallel:EDGE:SLOPe` on page 1797

Logical expression

Defines a logical combination of several digital channels as trigger condition if "Logic" is set for "Source".

If the "Slope" is rising, the trigger occurs when the logical expression comes true. If the "Slope" is falling, the trigger occurs when the logical expression comes false.

Remote command:
`TRIGger<m>:PARallel:EDGE:EXPRession[:DEFine]` on page 1797

13.3.1.3 Width

The width trigger detects positive and/or negative pulses of a pulse width (duration) inside or outside of a defined time limit. It can trigger on a single digital channel or a logical combination of digital channels.

The instrument triggers at the end of the detected pulse.

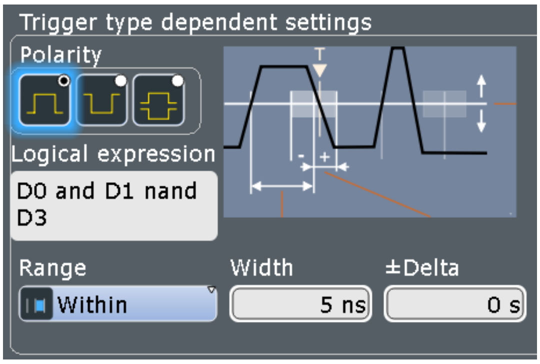


Figure 13-2: Width trigger settings for trigger source = logical combination of digital channels

Polarity
Sets the polarity of a pulse to "Positive", "Negative", or "Both".

When triggering on a positive pulse, the trigger event occurs on the high to low transition of the pulse if the timing condition is true. When triggering on a negative pulse, the trigger event occurs on the low to high transition of the pulse if the timing condition is true.

Remote command:
`TRIGger<m>:PARallel:WIDTh:POLarity` on page 1798

Logical expression
Defines a logical combination of several digital channels as trigger condition if "Logic" is set for "Source". As long as the digital signals match the logical expression (true), the pulse is positive. Otherwise, the pulse is negative.

Remote command:
`TRIGger<m>:PARallel:WIDTh:EXPRession[:DEFine]` on page 1797

Range
Selects how the range of a pulse width is defined:

"Within"	Triggers on pulses inside a given time range. The time limit is defined by *Width ± Delta*.
"Outside"	Triggers on pulses shorter or longer than a given time range. The time limit definition is the same as for "Within" range.
"Shorter"	Triggers on pulses shorter than the given "Width".
"Longer"	Triggers on pulses longer than the given "Width".

Remote command:
`TRIGger<m>:PARallel:WIDTh:RANGe` on page 1798

Width
For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits "±Delta".

Remote command:
`TRIGger<m>:PARallel:WIDTh:WIDTh` on page 1798

±Delta
Defines a range around the given width value.

The combination "Range" = Within and "±Delta" = 0 triggers on pulses with a pulse width that equals "Width".

The combination "Range" = Outside and "±Delta" = 0 means to trigger on pulse widths ≠ "Width".

Remote command:
`TRIGger<m>:PARallel:WIDTh:DELTa` on page 1798

13.3.1.4 Timeout

The timeout trigger event checks if the trigger source signal stays above or below the threshold voltage for a specified time lapse. In other words, the event occurs if the state condition remains unchanged for the specified time.

You can use the timeout trigger on a single digital channel, or a logical combination of digital channels.

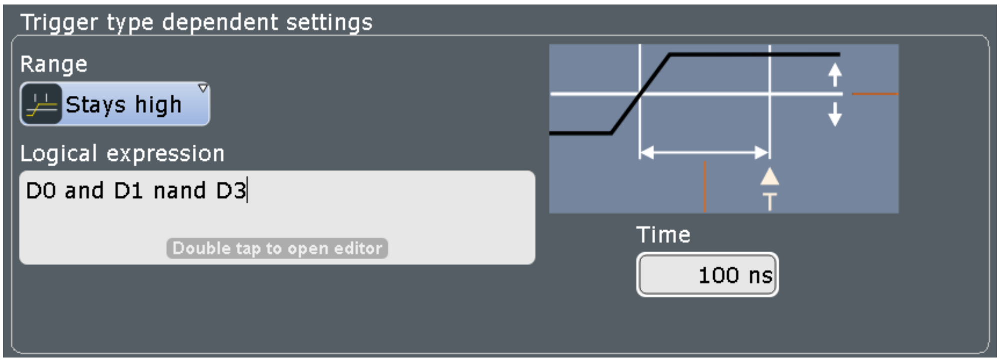


Figure 13-3: Timeout trigger settings for trigger source = logical combination of digital channels

Range
Sets the state condition:

"Stays high"	The level of a digital channel stays above the threshold, or the logical expression for "Logic" trigger source is true.
"Stays low"	The level of a digital channel stays below the threshold, or the logical expression for "Logic" trigger source is false.
"High or low"	The signal state remains unchanged.

Remote command:
`TRIGger<m>:PARallel:TIMeout:RANGe` on page 1799

Time
Defines the time limit for the timeout at which the instrument triggers.

Remote command:
`TRIGger<m>:PARallel:TIMeout:TIME` on page 1799

Logical expression
Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

Remote command:
`TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine]` on page 1797
`TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 1797
`TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine]` on page 1797
`TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine]` on page 1797

13.3.1.5 State

The state trigger detects the logical state of several logically combined digital channels at a given clock edge. The trigger source is a logical combination of digital channels or a parallel bus. The trigger occurs at the clock edge at which the state condition is true.

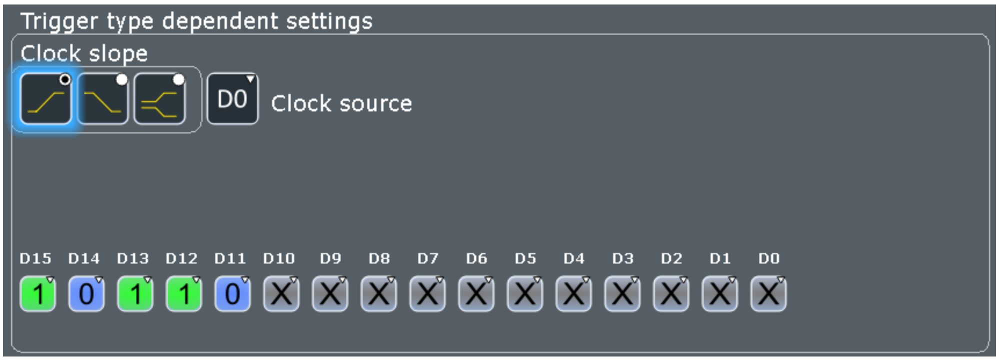


Figure 13-4: State trigger settings for trigger source = parallel bus

Clock source

Selects the digital channel of the clock signal.

Remote command:

TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue] on page 1797

TRIGger<m>:PARallel:STATe:CSOurce:VALue on page 1797

TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue] on page 1797

Clock edge

Sets the edge of the clock signal. The crossing of the clock edge and the logical threshold defines the time at which the logical states and the bus value are analyzed.

Remote command:

TRIGger<m>:PARallel:STATe:CSOurce:EDGE on page 1800

Channel states

For each digital channel that is used in the bus, set the required state: 1, 0, or X (don't care).

Remote command:

TRIGger<m>:PARallel:STATe:BIT<n> on page 1800

Logical expression

Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

Remote command:

TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine] on page 1797

TRIGger<m>:PARallel:STATe:EXPRession[:DEFine] on page 1797

TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine] on page 1797

TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine] on page 1797

13.3.1.6 Pattern

The pattern trigger identifies a logical state of several logically combined digital channels (pattern) and a time limitation (holdoff). The pattern definition is defined by the logical expression, if "Logic" is used for trigger source. For a parallel bus trigger source, the pattern is defined by setting the state of each digital channel.

The timing starts when the pattern comes true. The decision level is the logical threshold.

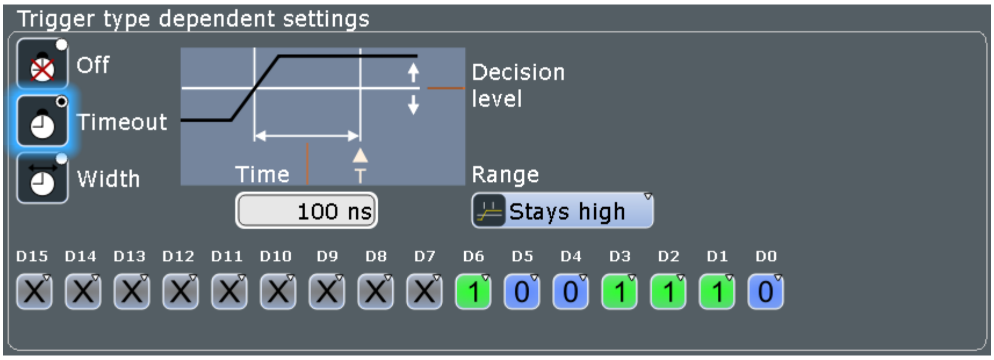


Figure 13-5: Pattern trigger settings for trigger source = parallel bus and timeout

Channel states

For each digital channel that is used in the bus, set the required state: 1, 0, or X (do not care).

Remote command:

`TRIGger<m>:PARallel:PATTern:BIT<n>` on page 1800

Logical expression

Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

Remote command:

`TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine]` on page 1797
`TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 1797
`TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine]` on page 1797
`TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine]` on page 1797

Timing mode: Off, Timeout, Width

Sets the mode of the timing condition.

"Off" No timing condition, only the logical pattern condition is relevant.

"Timeout" Defines a minimum time qualification to avoid triggering on unstable or transitional conditions. Even in best-designed systems, there are slight delays between the signal when digital signals change states. This means that there are always transitional state conditions when signals are switching.
See "Timeout settings" on page 855 for a description of the settings. The trigger event occurs when the pattern stays unchanged for the specified time.

"Width" Sets a pulse width as timing condition, see "Width settings" on page 855. The pulse starts when the pattern comes true, and the trigger event occurs when the pattern comes false during the specified time limit.
Using this mode, you can, for example, trigger exclusively on unstable conditions - if the pattern is present for less than a specified time.

Remote command:
`TRIGger<m>:PARallel:PATTern:MODE` on page 1800

Timeout settings
The timeout settings "Range" and "Time" appear if the timing mode is set to "Timeout".

Range ← Timeout settings
Sets the state condition:

"Stays high" The pattern stays true for the specified time.

"Stays low" The pattern stays false for the specified time.

"High or low" The pattern remains unchanged for the specified time.

Remote command:
`TRIGger<m>:PARallel:PATTern:TIMeout:MODE` on page 1801

Time ← Timeout settings
Defines the time limit for the timeout at which the instrument triggers.

Remote command:
`TRIGger<m>:PARallel:PATTern:TIMeout[:TIME]` on page 1801

Width settings
The width settings "Range", "Width" and "±Delta" appear if the timing mode is set to "Width".

Range ← Width settings
Selects how the range of a pulse width is defined:

"Within" Triggers when the pattern comes false inside a given time range. The time limit is defined by *Width ± Delta*.

"Outside" Triggers when the pattern comes false before or after the given time range. The time limit definition is the same as for "Within" range.

"Shorter" Triggers when the pattern comes false before the given "Width" has expired.

"Longer" Triggers when the pattern comes false after the given "Width" has expired.

Remote command:
`TRIGger<m>:PARallel:PATTern:WIDTh:RANGe` on page 1801

Width ← Width settings
For the ranges "Shorter" and "Longer", the width defines the maximum and minimum time limit, respectively.

For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits "±Delta".

Remote command:
TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh] on page 1802

±Delta ← Width settings
Defines a range around the given width value.

The combination "Range" = Within and "±Delta" = 0 triggers on pulses with a pulse width that equals "Width".

The combination "Range" = Outside and "±Delta" = 0 means to trigger on pulse widths ≠ "Width".

Remote command:
TRIGger<m>:PARallel:PATTern:WIDTh:DELTa on page 1802

13.3.1.7 Serial Pattern

The serial pattern trigger identifies a serial bit string trigger on a single digital channel, or for a logical combination of digital channels. The trigger requires a clocked bus; the bits are read at the specified clock edge. The trigger event occurs at the last clock edge of the serial bit string.

This trigger type allows you to trigger on specific address or data transmissions in serial input and output signals.

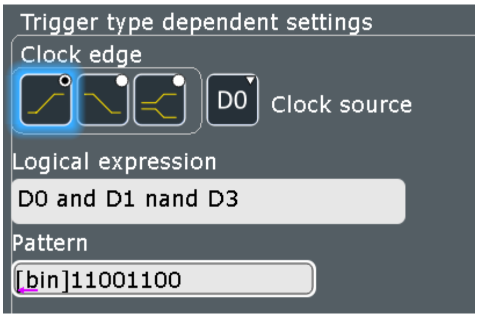


Figure 13-6: Serial pattern trigger settings for trigger source = logical combination of digital channels

Clock edge
Sets the edge of the clock signal. The bit value is determined at the crossing of the clock edge and the logical threshold.

Remote command:
TRIGger<m>:PARallel:SPATtern:CSOurce:EDGE on page 1802

Clock source
Selects the digital channel of the clock signal.

Remote command:
TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue] on page 1797
TRIGger<m>:PARallel:STATe:CSOurce:VALue on page 1797
TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue] on page 1797

Logical expression

Defines a logic combination of several digital channels as trigger condition if "Logic" is set for "Source". The "Qualification Editor" supports the entry of the expression.

Remote command:
TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine] on page 1797
TRIGger<m>:PARallel:STATe:EXPRession[:DEFine] on page 1797
TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine] on page 1797
TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine] on page 1797

Pattern

Defines the serial bit string on which to trigger. Touch and hold the "Pattern" field to open the "Bit Pattern Editor" where you can enter the pattern in various formats. The pattern has to be defined exactly, X (do not care) is not supported in binary format.

See also: Chapter 12.1.4, "Bit Pattern Editor", on page 470

Remote command:
TRIGger<m>:PARallel:SPATtern:PATTern on page 1803

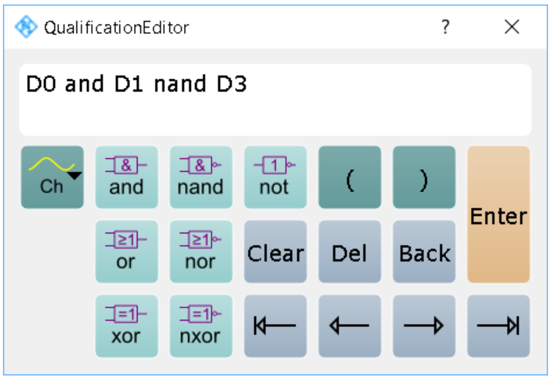
13.3.2 Triggering on Digital Signals and Parallel Buses

For a detailed description of the settings, see Chapter 13.3.1, "Trigger Settings for Digital Signals and Parallel Buses", on page 848.

1. Press the [Trigger] key and select the "Setup" tab.
2. Select the trigger "Source":
   - One of the digital channels "D0" ... "D15"
     

   - A logic combination of digital channels: "Logic"
     
   - One of the parallel buses "Par. bus1" ... "Par. bus4"
     

3. Select the trigger "Type".
4. Under "Trigger type dependent settings", configure the trigger.
5. For trigger source "Logic", enter the logical expression of the digital channel combination. Tap and hold the "Logical expression" field until the "Qualification Editor" opens. It provides all logic operators that can be used in the expression.



13.4 Measurements on Digital Channels

For measurements on digital channels, the number of measurement categories and types is reduced to applicable measurement.

These are:

- Period
- Frequency
- Positive and negative pulse
- Pulse count
- Delay
- Phase
- Positive and negative duty cycle
- Burst width
- Edge count

Except for delay measurement, the measurements have the same settings and results for analog and digital sources.

Delay measurement on digital channels is reduced to measure the time between two subsequent rising or two subsequent falling edges.

See also Chapter 7.2.5, "Amplitude/Time Measurements", on page 304.

13.5 Data Export

The data of digital channels and parallel buses can be saved to file in the same way as analog waveform data. One digital channel or bus per file can be saved.

The data format of the stored values is defined with "Analysis" > "Parallel Bus" > "Setup" tab >"Data format". If the data is written to XML or CSV files, the selected format is used. If the target file format is BIN, you can save signed and unsigned binary data. The data format "Signed" writes signed data; all other formats are saved as unsigned binary data.

Only y-values are exported, the "Interleaved x/y" setting is not available.

Export of a digital channel

If the data of digital channels is stored in BIN format, 1 bit is written for each sample. 8 data samples are written in 1 byte (data word). Thus, the file size is

File size = Number of samples / 8

For example, 100 MSa are written into a 12.5 MByte BIN file. After reading the file, you have to extract the samples from the data words.

If saved to BIN file, the digital channel can be imported as reference waveform.

Export of a parallel bus

A parallel bus can be exported to file if "Enable bus" and "Show bus" are both activated.

All data formats can be saved to XML, CSV, and BIN files. If you save binary format to XML or CSV, you can see the values of each line for each sample.

In BIN files, 4 Bytes are written for each sample.

Importing parallel buses from BIN files is only possible if the bus was saved with quasi-analog bus representation.

See also:

- Chapter 11.2.6, "Saving and Loading Waveform Data", on page 446
- Chapter 11.2.2, "Waveforms - Export Settings", on page 435

Remote commands for export to file:

- `EXPort:WAVeform:SOURce` on page 1281
  `BUSFormat` on page 1301
- `EXPort:WAVeform:NAME` on page 1282
- `EXPort:WAVeform:SAVE` on page 1282

Remote commands for remote export:

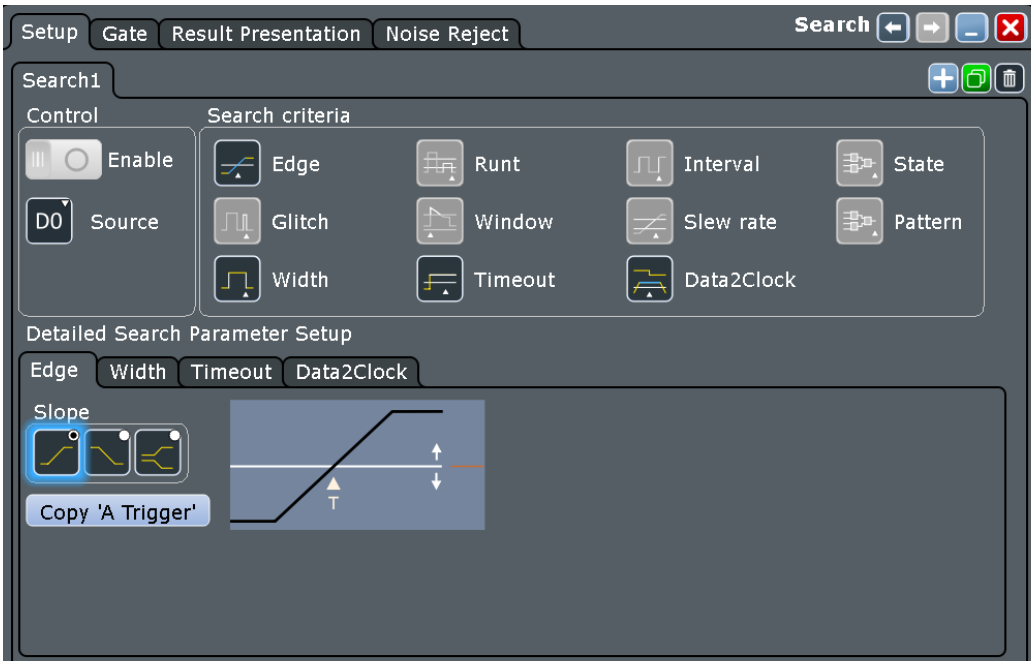
- `FORMat[:DATA]` on page 977
- `BUSFormat` on page 1301
- `BUS<m>:PARallel:DATA:HEADer?` on page 1804
- `BUS<m>:PARallel:DATA[:VALues]?` on page 1805
- `DIGital<m>:DATA:HEADer?` on page 1804
- `DIGital<m>:DATA[:VALues]?` on page 1804

13.6 Mathematics

A parallel bus that is displayed as quasi-analog waveform can be analyzed with FFT. To configure the FFT, use the "Advanced" mode and the formula editor.

13.7 Search

Access: [Search] > "Setup" tab.



It is also possible to search on digital channels for specified events. Search conditions use the same parameters as the trigger event definition, see Chapter 13.3.1, "Trigger Settings for Digital Signals and Parallel Buses", on page 848.

You can search for edge, width, timeout, and Data2Clock conditions.

14 Waveform Generator (Option R&S RTP-B6)

The R&S RTP includes an integrated waveform generator which can generate input signals and patterns during testing.

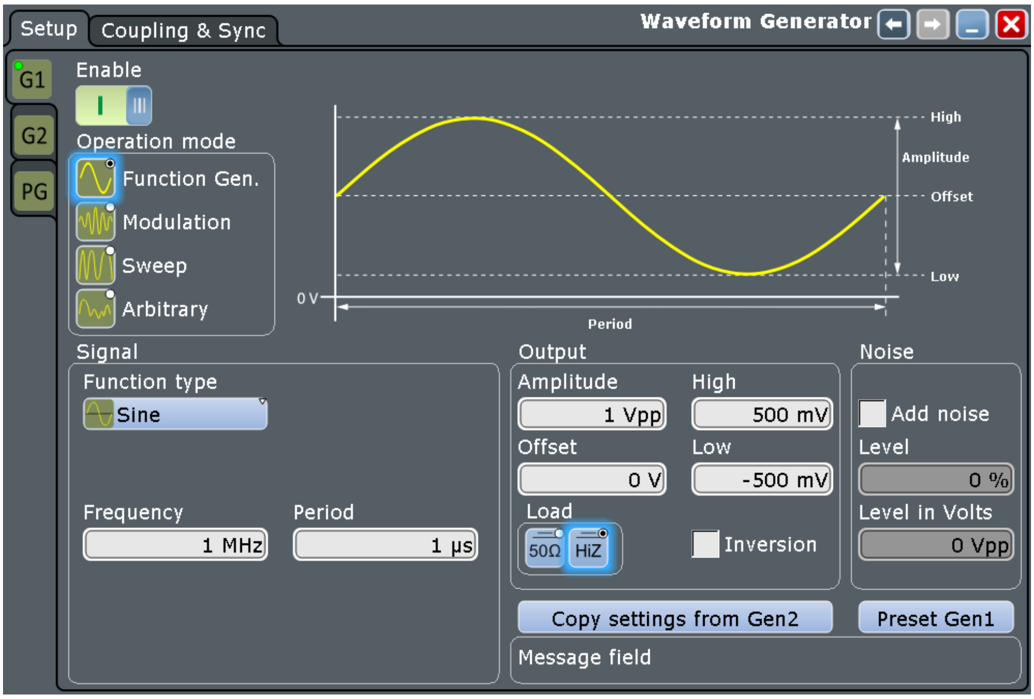
You can setup and output two waveform generators and a pattern generator. It is possible to couple and synchronize the settings of the different generators and enable them on a trigger signal. With each of the waveform generators, one can output simple functions, modulated sine waveform, arbitrary waveforms and sweep waveforms.

14.1 Setup of the Waveform Generator

Access: "Wave Gen" > "Setup" tab.

The "Setup" tab is divided into several sections:

- General settings like enabling and presetting the waveform generator
- Signal settings, depending on the selected Operation mode refer to one of the following:
  - Chapter 14.1.2, "Function Generator", on page 863
  - Chapter 14.1.3, "Modulation", on page 867
  - Chapter 14.1.4, "Sweep", on page 873
  - Chapter 14.1.5, "Arbitrary", on page 874
- "Output", including settings for defining the output see Chapter 14.1.6, "Output", on page 878
- "Noise", settings for adding noise to the waveform, see Chapter 14.1.7, "Noise", on page 879



Make sure that the tab of the correct waveform generator is selected on the left side.

The settings of the waveform generators are not affected by an instrument preset. Press "Preset Gen1/2" to preset the settings of the corresponding waveform generator.

14.1.1 General Settings

The general waveform generator settings are for enabling and presetting the generator and selecting the "Operation Mode".

Enable

Enables the waveform generator/ pattern generator and outputs the signal to the connectors.

Remote command:

`WGENerator<m>[:ENABle]` on page 1806

`PGENerator:ENABle` on page 1822

Operation mode

Selects the operation mode for the waveform generator. The "Signal" settings depend on the selected mode.

For the settings of the different operation modes, refer to:

- Chapter 14.1.2, "Function Generator", on page 863
- Chapter 14.1.3, "Modulation", on page 867

- Chapter 14.1.4, "Sweep", on page 873
- Chapter 14.1.5, "Arbitrary", on page 874

Remote command:
`WGENerator<m>:SOURce` on page 1806

Copy settings from Gen1/Gen2
Copies all settings from Gen1/Gen2 and applies them to Gen2/Gen1.

Remote command:
`WGENerator<m>:ACOPy` on page 1805

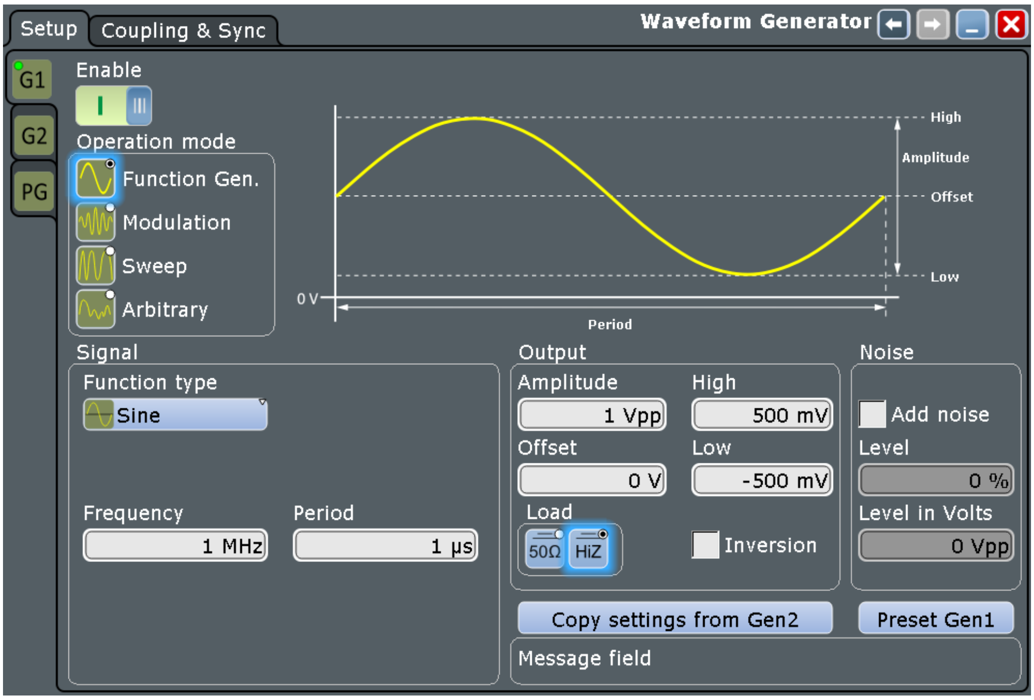
Preset Gen1/Gen2/Patt Gen
Sets the parameters of the generator to their default values. The settings of the generators are not affected by an instrument preset.

Remote command:
`WGENerator<m>:PRESet` on page 1806
`PGENerator:PRESet` on page 1823

Message
Displays relevant messages concerning the coupling and sync settings.

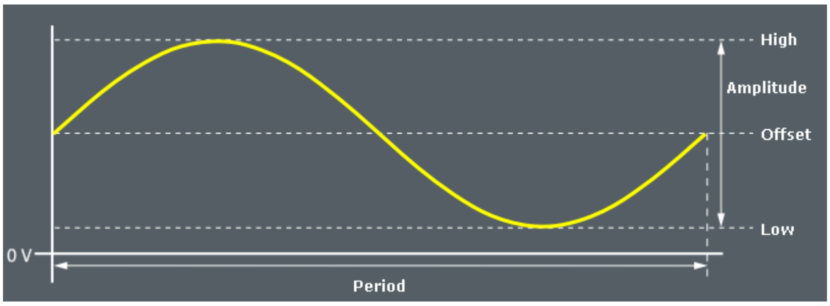
14.1.2 Function Generator

The R&S RTP function generator can generate input signals during testing. These signals can be used, for example, when testing circuits.

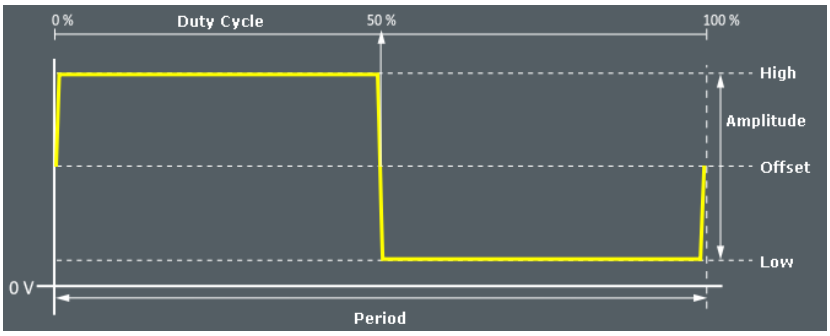


Function type
Selects the type of waveform to be generated for the function generator.

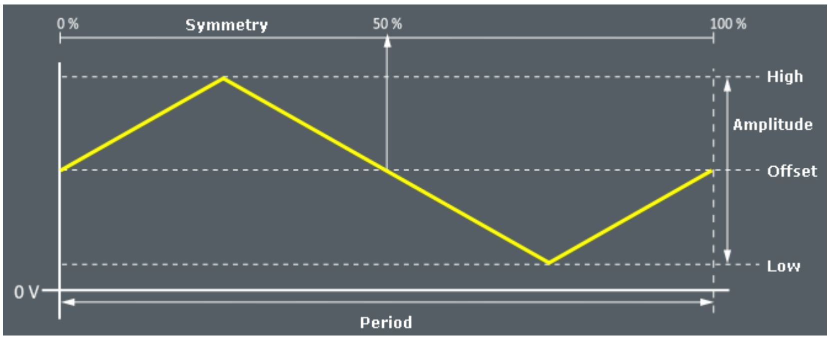
"Sine" Generates a sine wave. You can set its Frequency and Period.



"Square" Generates a square wave. You can set its Frequency, Period and Duty cycle.

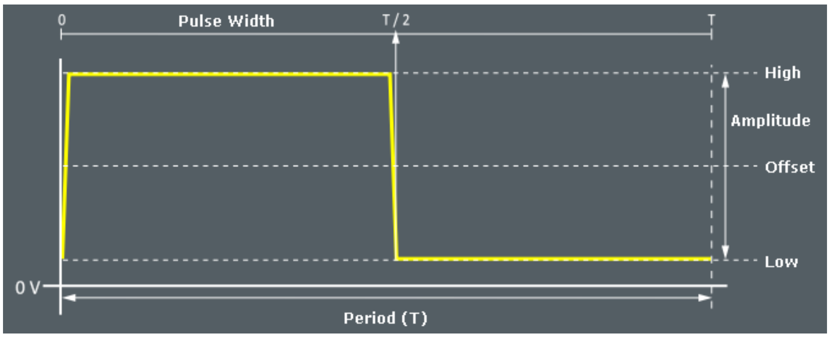


"Ramp" Generates a ramp signal. You can set its Frequency, Period and Symmetry.

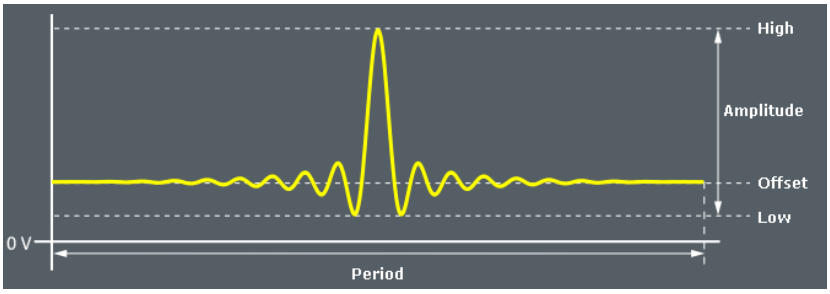


"DC" Generates a direct current (DC) signal. You can set the DC Level.

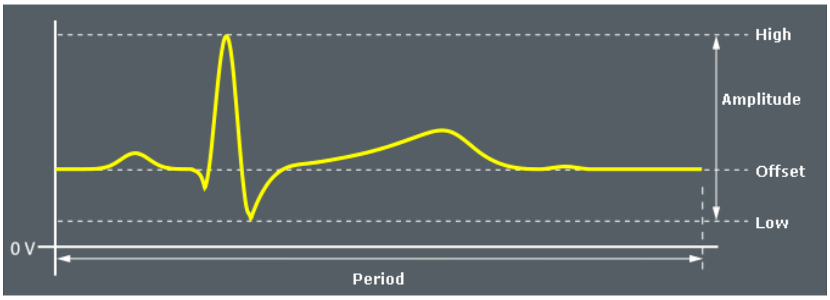
"Pulse" Generates a pulse signal. You can set the Frequency, Period and Pulse width.



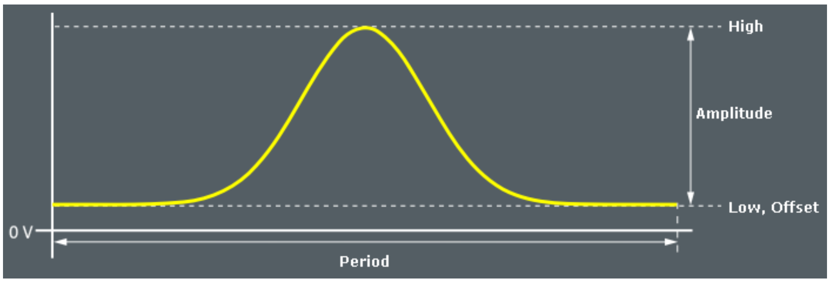
"Cardinal sine" Generates a cardinal sine wave. You can set the Frequency and Period.



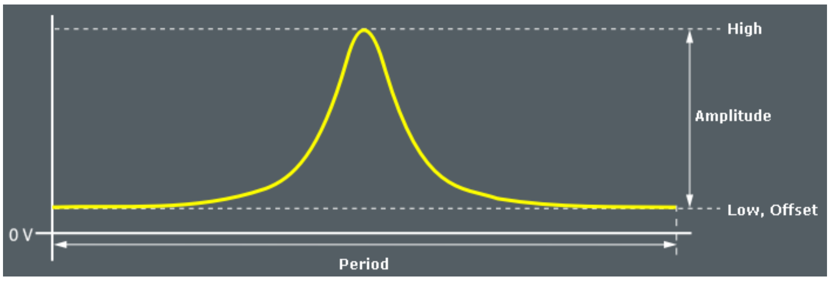
"Cardiac" Generates a cardiac signal. You can set the Frequency and Period.



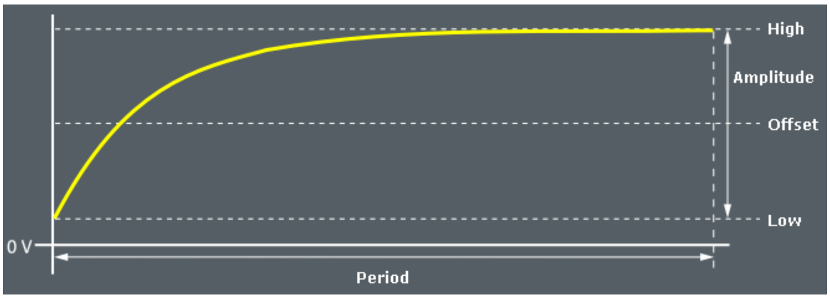
"Gauss" Generates a gauss signal . You can set the Frequency and Period.



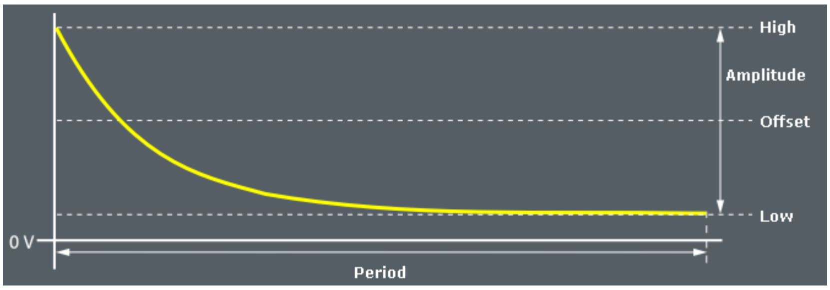
"Lorentz" Generates a Lorentz signal . You can set the Frequency and Period.



"Exp. rise" Generates an exponential rise signal. You can set the Frequency and Period.



"Exp. fall" Generates an exponential fall signal. You can set the Frequency and Period.



Remote command:
`WGENerator<m>:FUNCtion[:SELect]` on page 1806

Frequency

Sets the frequency of the waveform. The available frequency range depends on the selected "Function Type", see Frequency range of the function generator waveforms.

Table 14-1: Frequency range of the function generator waveforms

"Function type"	Min frequency	Max frequency
"Sine"	0.001 Hz	100 MHz
"Square"	0.001 Hz	30 MHz
"Ramp"	0.001 Hz	1 MHz
"DC"	-	-
"Pulse"	0.001 Hz	30 MHz
"Cardinal sine"	0.001 Hz	5 MHz

"Function type"	Min frequency	Max frequency
"Cardiac"	0.001 Hz	1 MHz
"Gauss"	0.001 Hz	25 MHz
"Lorentz"	0.001 Hz	10 MHz
"Exp.rise"	0.001 Hz	10 MHz
"Ep. fall"	0.001 Hz	10 MHz

The values of the "Frequency" and "Period" depend on each other, as:

Period = 1/ Frequency

Remote command:
`WGENerator<m>:FREQuency` on page 1807

Period
Sets the period of the waveform. The available period range depends on the selected "Function Type".

Remote command:
`WGENerator<m>:PERiod` on page 1807

Duty cycle
Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage of the period, the signal state is high.

Remote command:
`WGENerator<m>:FUNCtion:SQUare:DCYCle` on page 1808

Symmetry
Sets the symmetry of a ramp waveform, the percentage of time the waveform is rising. By changing the symmetry of the ramp, you can create, for example, triangular waveforms.

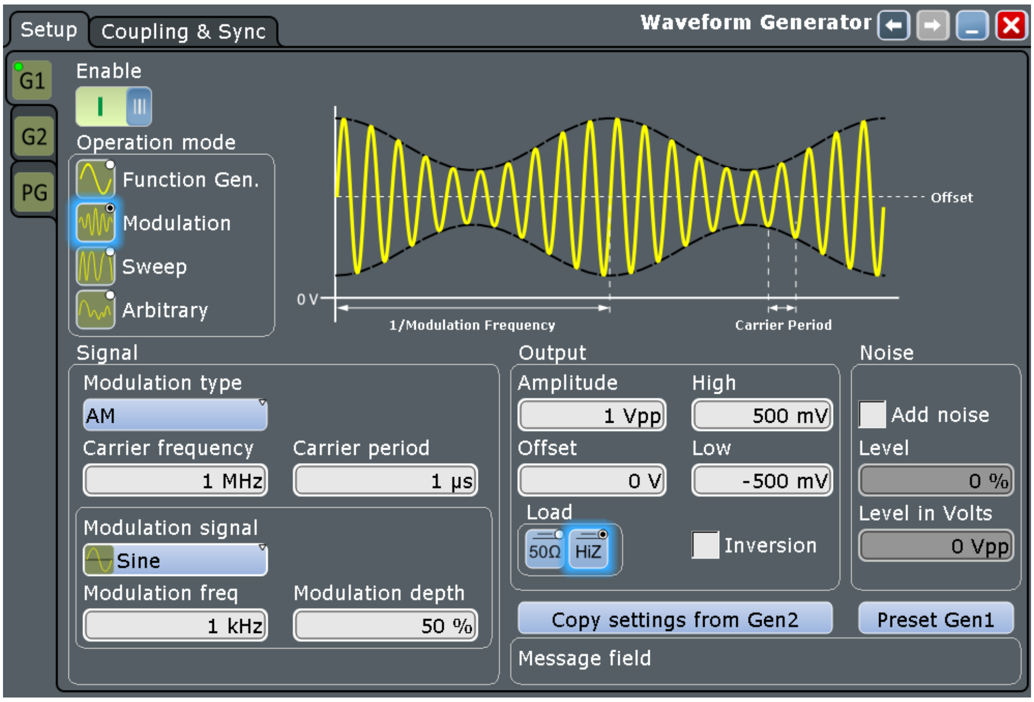
Remote command:
`WGENerator<m>:FUNCtion:RAMP[:SYMMetry]` on page 1807

Pulse width
Sets the pulse width, the pulse duration of the generated pulse waveform.

Remote command:
`WGENerator<m>:FUNCtion:PULSe[:WIDTh]` on page 1807

14.1.3 Modulation

Modulation is when properties of an original periodic waveform, the carrier signal, are varied according to a second modulating signal. The type of modulation used determines which properties are changed.



14.1.3.1 General Settings

Consists of settings for selecting the modulation type.

Modulation type

Selects the modulation type, which defines how the carrier signal is modified.

"AM" Amplitude modulation.
See: Chapter 14.1.3.2, "AM Modulation", on page 869.

"FM" Frequency modulation.
See: Chapter 14.1.3.4, "FM Modulation", on page 871.

"PWM" Pulse width modulation
See: Chapter 14.1.3.3, "PWM Modulation", on page 870

"FSK" Frequency shift keying (FSK) modulation.
See:Chapter 14.1.3.5, "FSK Modulation", on page 872.

Remote command:
`WGENerator<m>:MODulation:TYPE` on page 1808

Carrier frequency

Sets the frequency of the carrier signal.

Remote command:
`WGENerator<m>:MODulation:CARRier:FREQuency` on page 1810

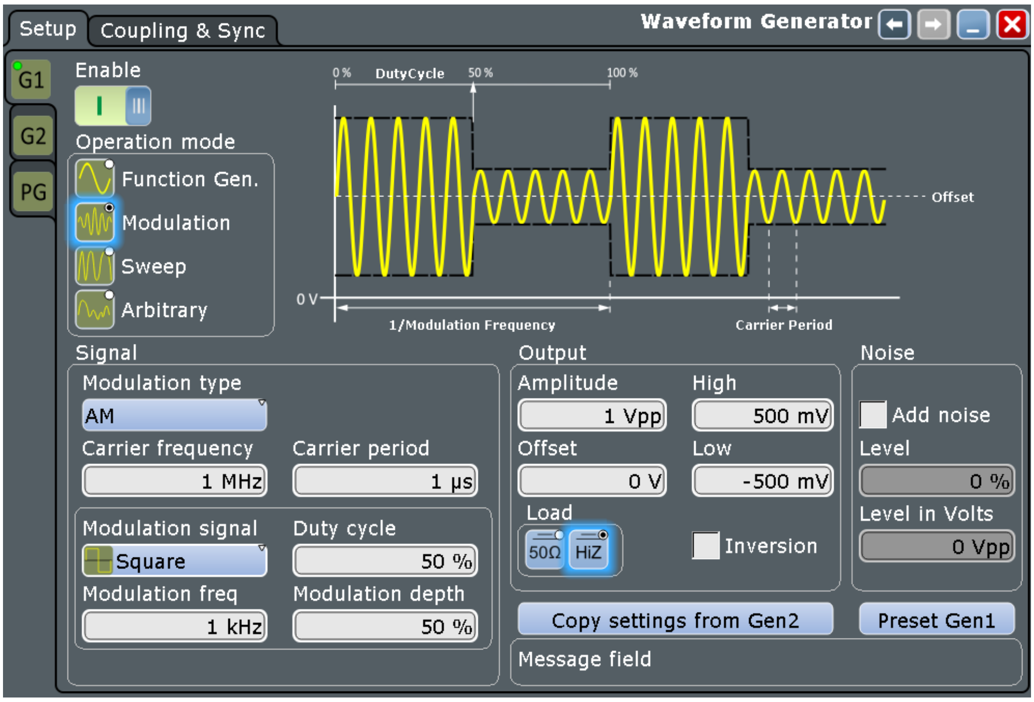
Carrier period

Sets the period of the carrier signal.

Remote command:
WGENerator<m>:MODulation:CARRier:PERiod on page 1810

14.1.3.2 AM Modulation

For amplitude modulation (AM), the amplitude of the carrier signal is varied according to the modulation signal.



Modulation signal
Selects the type of the modulation signal for the AM modulation types.

Remote command:
WGENerator<m>:MODulation:AM[:FUNCtion] on page 1810

Modulation freq
Sets the frequency of the modulation waveform.

Remote command:
WGENerator<m>:MODulation:AM:FREQuency on page 1809

Modulation depth
Sets the modulation depth, the percentage of the amplitude range that is used for the modulation.

Remote command:
WGENerator<m>:MODulation:AM:DEPTh on page 1809

Symmetry
Sets the symmetry for the ramp modulation waveform, the percentage of time that the waveform is rising.

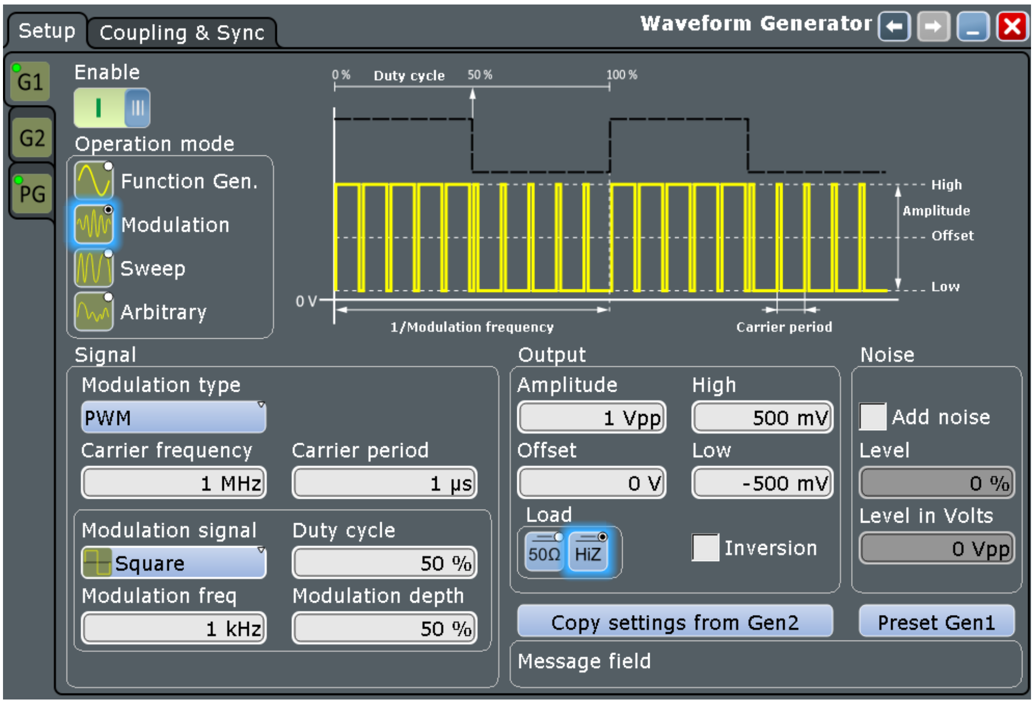
Remote command:
WGENerator<m>:MODulation:AM:SYMMetry on page 1810

Duty cycle
Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Remote command:
WGENerator<m>:MODulation:AM:DCYCle on page 1809

14.1.3.3 PWM Modulation

For pulse width modulation (PWM), the time for which the signal is in a high state is varied according to the modulation signal.



Modulation signal
Selects the type of the modulation signal for the PWM modulation types.

Remote command:
WGENerator<m>:MODulation:PWM[:FUNCtion] on page 1814

Modulation freq
Sets the frequency of the modulation waveform.

Remote command:
WGENerator<m>:MODulation:PWM:FREQuency on page 1813

Modulation depth
Sets the modulation depth, the percentage of the pulse width range that is used for the modulation.

Remote command:
WGENerator<m>:MODulation:PWM:DEPTh on page 1813

Symmetry
Sets the symmetry for the ramp modulation waveform, the percentage of time that the waveform is rising.

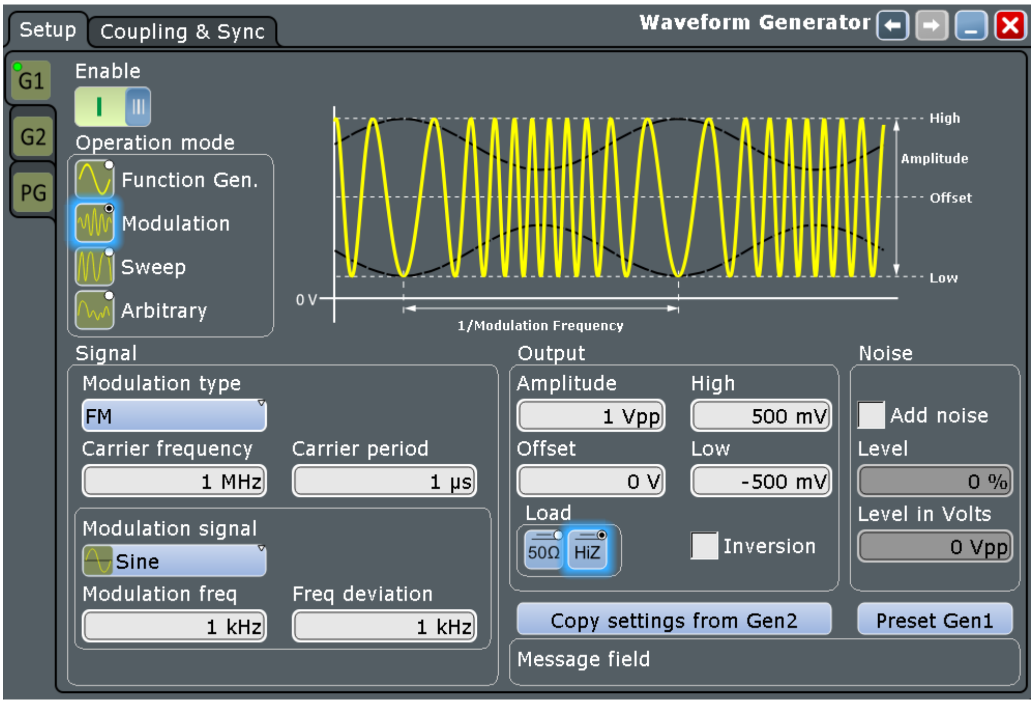
Remote command:
WGENerator<m>:MODulation:PWM:SYMMetry on page 1814

Duty cycle
Sets the duty cycle for a square waveform. The duty cycle expresses for what percentage fraction of the period, the waveform is active, i.e. the signal state is high.

Remote command:
WGENerator<m>:MODulation:PWM:DCYCle on page 1813

14.1.3.4 FM Modulation

For frequency modulation (FM), the frequency of the carrier signal is varied according to the modulation signal.



Modulation signal
Selects the type of the modulation signal for the FM modulation types.

Remote command:
WGENerator<m>:MODulation:FM[:FUNCtion] on page 1812

Modulation freq
Sets the frequency of the modulation waveform.

Remote command:
WGENerator<m>:MODulation:FM:FREQuency on page 1811

Symmetry
Sets the symmetry for the ramp modulation waveform, the percentage of time that the waveform is rising.

Remote command:
WGENerator<m>:MODulation:FM:SYMMetry on page 1811

Freq deviation
Sets the frequency deviation, the maximum difference between and FM modulated signal and the carrier signal.

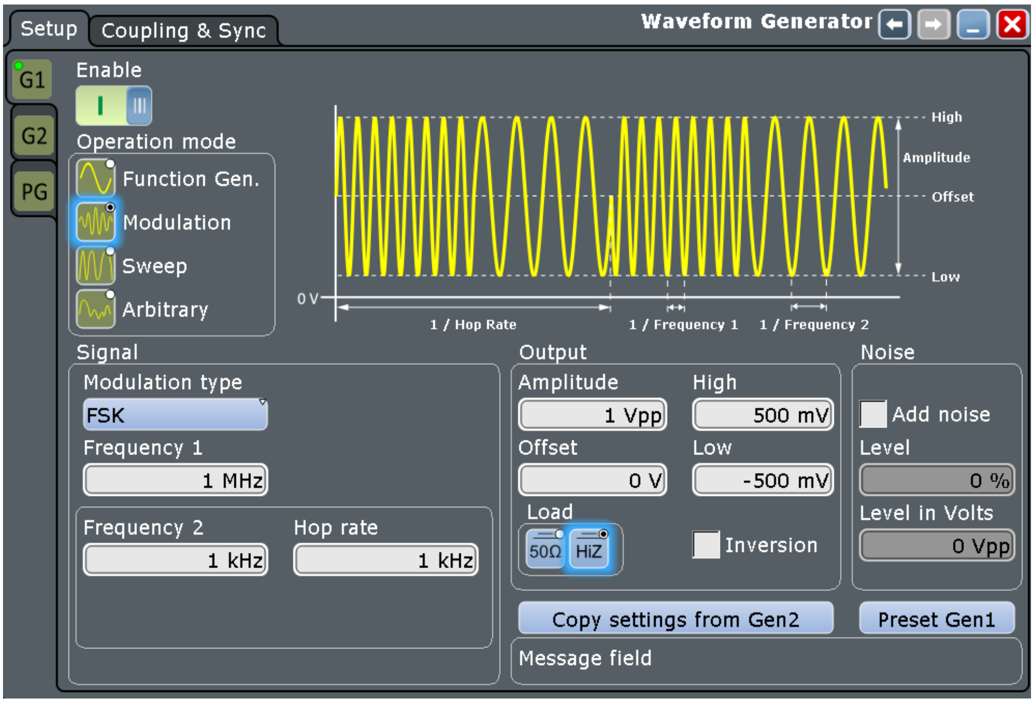
Remote command:
WGENerator<m>:MODulation:FM:DEViation on page 1811

Duty cycle
Sets the duty cycle for a square waveform. The duty cycle expresses the percentage of the period during which the waveform is active, i.e. the signal state is high.

Remote command:
WGENerator<m>:MODulation:FM:DCYCle on page 1811

14.1.3.5 FSK Modulation

For frequency shift keying (FSK) modulation, the signal switches between Frequency 1 and Frequency 2 at a Hop rate.



Frequency 1
Sets the frequency of the first signal in FSK modulated signal.

Remote command:
WGENerator<m>:MODulation:FSK:FONE on page 1812

Frequency 2
Sets the frequency of the second signal in FSK modulated signal.

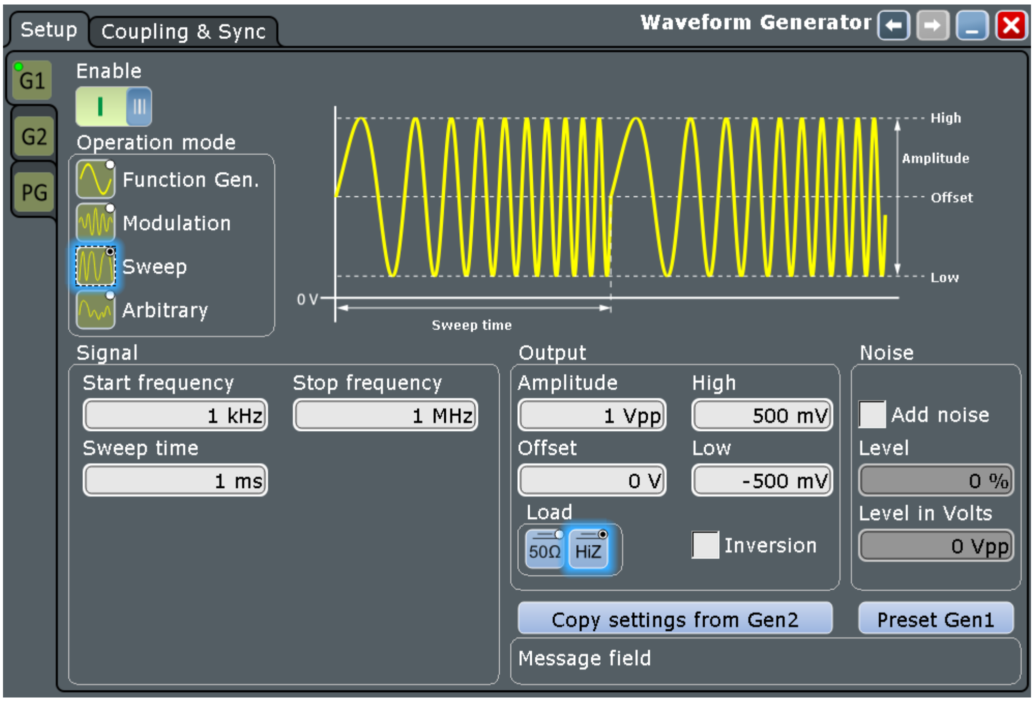
Remote command:
WGENerator<m>:MODulation:FSK:FTWO on page 1812

Hop rate
Sets the hop rate, the frequency at which signal switches between Frequency 1 and Frequency 2.

Remote command:
WGENerator<m>:MODulation:FSK[:RATE] on page 1813

14.1.4 Sweep

In the sweep mode, the R&S RTP generates a signal whose frequency gradually changes from the Start frequency to the Stop freuqency for a certain Sweep time.



Start frequency
Sets the start frequency of the sweep signal.

Remote command:
WGENerator<m>:SWEep:FSTart on page 1814

Stop freuqency

Sets the stop frequency of the sweep signal.

Remote command:
`WGENerator<m>:SWEep[:FEND]` on page 1815

Sweep time

Sets the duration of the sweep.

Remote command:
`WGENerator<m>:SWEep:TIME` on page 1815

14.1.5 Arbitrary

The arbitrary waveform generator allows you to output a user-defined waveform for testing your devices. You can output a waveform from a file or from the current R&S RTP reference curve format. Files in `*.csv` and `*.bin` formats are supported. This files must follow a defined structure. You can load `*.csv` files in an R&S Wave Gen format (see Content and format of the R&S wave gen *.csv files), Tektronix AFG format or Keysight WaveGen format.

Content and format of the R&S wave gen *.csv files

The R&S waveform generator format can contain the following values:

- Rate
- Time value
- Voltage value

If all the values are defined, the file format is as follows:

```
Rate = 5000000           //Sample rate of the arbitrary waveform.
0.000000E+000,-5.995    //Time value 1, Voltage value 1
1.237011E-005,-6.0      //Time value 2, Voltage value 2
.......
```

In this case, the rate is reflected in the "Sample Rate" field of the user interface. The total number of Time/Voltage values is reflected in the "Samples" of the user interface. Anything written after `//` is ignored as a comment.

You can define only some of the values. According to what you define, the file format looks different and is handled differently:

- With specified *Rate*:
  Time values are ignored. You can specify just rate and voltage values as below:

```
Rate = 5000000              //Sample rate of the arbitrary waveform
-5.995                      //Voltage value 1
-6.0                        //Voltage value 2
.......
```

- Without specified *Rate* and without specified *Time* values:

A sample rate of 1Mbps is used to calculate the waveform. You can change the "Sample rate" in the user interface. The voltage values are then played with this sample rate.

```
-5.995              //Voltage value 1
-6.0                 //Voltage value 2
.......
```

- Without specified *Rate* and wit specified *Time*:
  The timing information of the first 2 time values is used to calculate the sample rate.

Example:

Consider the following file:

```
0.000000E+000,-5.995    //Time value 1, Voltage value 1
1.237011E-005,-6.0      //Time value 2, Voltage value 2
```

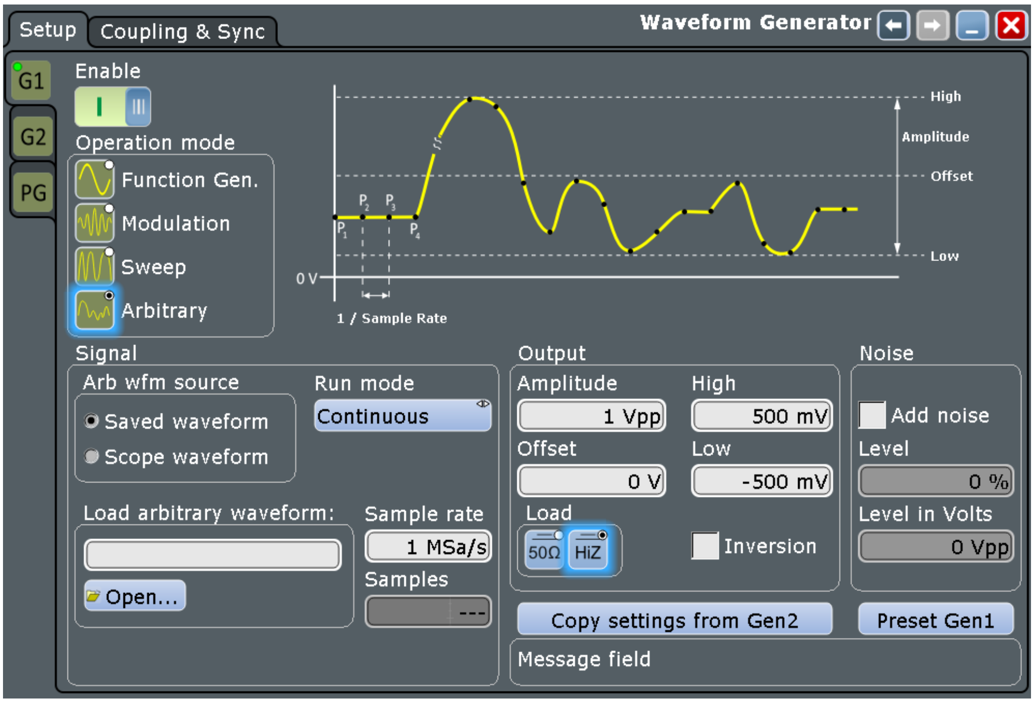
The sample rate is:

Sample rate = *1/ Time between first two samples* =1 / 1.237011E-005 = 80.840KSampe/sec

Content and format of the R&S arbitrary generator *.bin files

The file stream should contain the following information in the given order:

• Sample rate	[double format]
• Number of samples	[double format]
• Samples	[double format] * number of samples



14.1.5.1 General Settings

Arb wfm source

Selects the arbitrary waveform source. You can load an existing file or load the current oscilloscope waveform.

Remote command:

`WGENerator<m>:ARBGen[:SOURce]` on page 1818

Running mode

Selects the duration for which the signal of the arbitrary generator will be output after the trigger event. You can choose between a "Continuous" and "Single period" duration.

Remote command:

`WGENerator<m>:ARBGen:RUNMode` on page 1817

Sample rate

Sets the sample rate for the arbitrary waveform.

Remote command:

`WGENerator<m>:ARBGen:SRATe` on page 1818

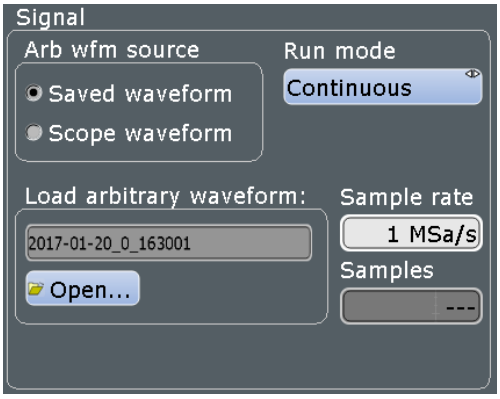
Samples

Displays the number of samples in the loaded waveform.

Remote command:

`WGENerator<m>:ARBGen:SAMPles?` on page 1817

14.1.5.2 Saved Waveform



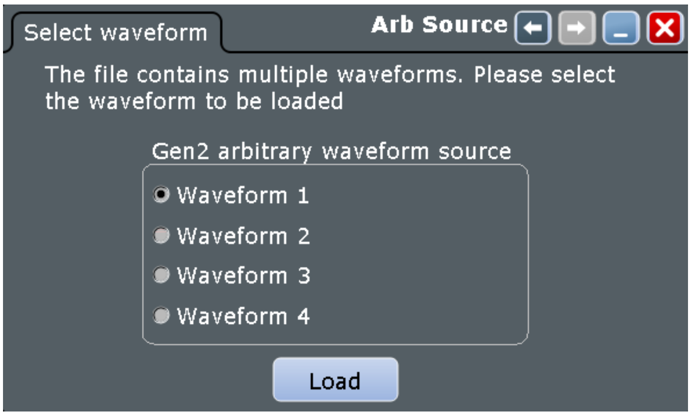
For a saved waveform, the following settings are available:

Load arbitrary waveform
Opens a file selection dialog box and loads the selected file. Supported are `.bin` and `.csv` extension files.

Remote command:
`WGENerator<m>:ARBGen:NAME` on page 1816
`WGENerator<m>:ARBGen:OPEN` on page 1817

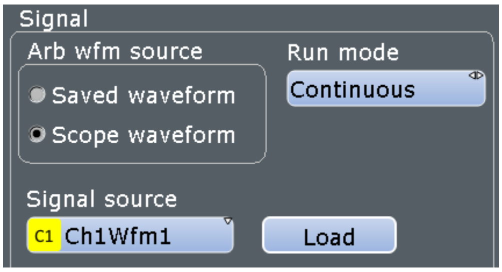
Select waveform
When a multichannel file is loaded into the arbitrary waveform generator, a dialog appears to select which waveform from the file is loaded.

Select the waveform and press "Load" to load it into the arbitrary waveform generator.



Remote command:
`WGENerator<m>:ARBGen:MULTichannel:NAME` on page 1816
`WGENerator<m>:ARBGen:MULTichannel:IMPort` on page 1816
`WGENerator<m>:ARBGen:MULTichannel:OPEN` on page 1816

14.1.5.3 Scope Waveform



For a scope waveform, the following settings are available:

Signal source
Selects the oscilloscope source, from which the arbitrary signal is loaded.

Remote command:
`WGENerator<m>:ARBGen:SELect` on page 1818

Load
Loads the waveform from the selected "Signal source".

Remote command:
`WGENerator<m>:ARBGen:COPY` on page 1815

14.1.6 Output

Amplitude
Sets the amplitude, peak to peak voltage, of the output waveform. It is defined as the voltage difference between the maximum ("High") and the minimum ("Low") voltage levels.

The "Amplitude" value is set for the currently selected "User Load". If the "User Load" is changed, the value of "Amplitude" is adapted to this new setting.

Remote command:
`WGENerator<m>:VOLTage[:VPP]` on page 1819

Offset
Sets a voltage offset

Remote command:
`WGENerator<m>:VOLTage:OFFSet` on page 1820

High
Sets the high signal level of the output waveform.

Remote command:
`WGENerator<m>:VOLTage:HIGH` on page 1819

Low
Sets the low signal level of the output waveform.

Remote command:
WGENerator<m>:VOLTage:LOW on page 1820

Inversion
Inverts the waveform at the offset level.

Remote command:
WGENerator<m>:VOLTage:INVersion on page 1820

User Load
Select the user load, the load of the DUT at its connection. You can select either a "50Ω" or a "HiZ" (high input impedance) load.

Remote command:
WGENerator<m>:OUTPut[:LOAD] on page 1819

DC Level
Sets the voltage DC level for the generated DC signal, for "Operation mode" >"Function Gen." and "Function type"> "DC".

Remote command:
WGENerator<m>:VOLTage:DCLevel on page 1819

14.1.7 Noise

Add Noise
Enables the adding of noise to the waveform.

Remote command:
WGENerator<m>:MODulation:NOISe on page 1821

Level
Sets the level of the noise in percentage of the set "Amplitude" output of the signal.

Remote command:
WGENerator<m>:MODulation:NLPCent on page 1821

Level in Volts
Displays the level of the noise in volts.

Remote command:
WGENerator<m>:MODulation:NLABsolute? on page 1821

Level
For "Function type">"DC" only.

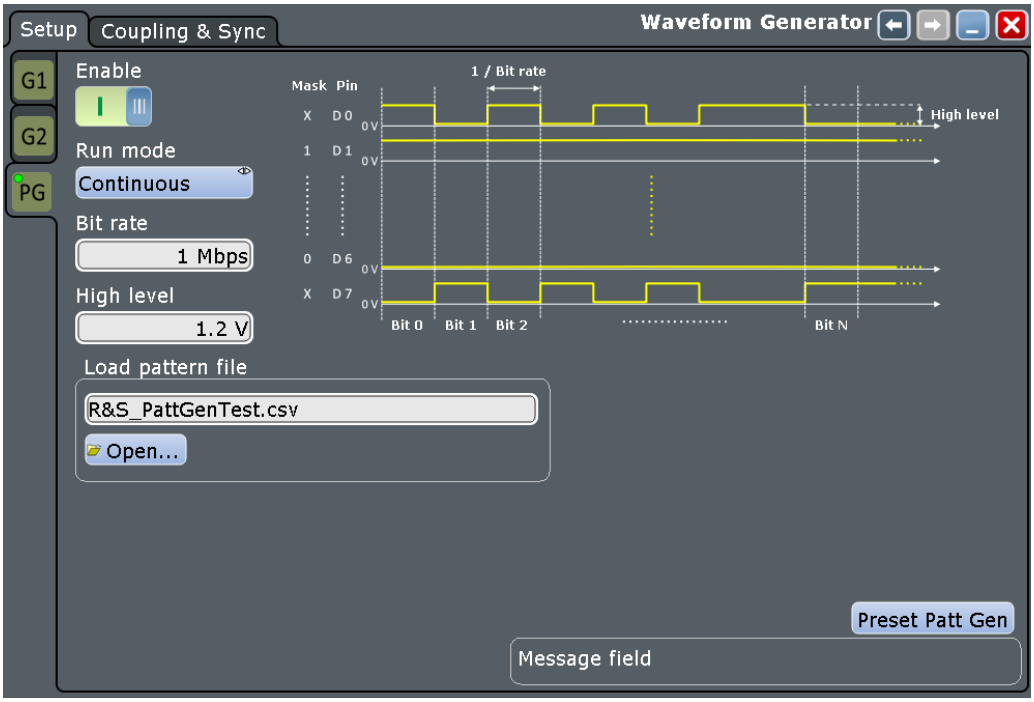
Sets the level for the DC signal.

Remote command:
WGENerator<m>:MODulation:NDCLevel on page 1821

14.2 Setup of the Pattern Generator

Access: "Wave Gen" > "PG" tab.

The pattern generator outputs parallel patterns.



NOTICE

Using pattern generator accessories

The pattern generator with connected Patt Gen Cable and Patt Gen Board (1329.7054.02) is considered as a test probe, EN 61326-2-1, clause 5.2.4.101, note 1. Therefore normal operation may display increased emissions above the limits as specified in EN 55011 and/or reduced interference resistance as required in EN 61326-1, table 1, basic requirements.

If the cable and the board are connected, other surrounding electronic devices may be disturbed. Furthermore, signals at the analog generator outputs Gen1 and Gen2 may be distorted by surrounding devices.

The settings of the pattern generator are not affected by an instrument preset. Press "Preset Patt Gen" to preset the settings of the pattern generator.

Content and format of the pattern generator files

The pattern generator supports `.bin` or `.csv` file formats.

Content and format of the R&S*.csv files

The file's header have the following structure:

- Bit rate [double]: the number of transmitted bits per second. The value is reflected in the user interface.
- High level [double]: the value is reflected in the user interface.
- Mask [string of 8 characters made up of "X"/"1"/"0"] : defines how the output of the pattern generator looks like. The following values are defined:
  – *1'* means that the pin output is always at high level
  – *0'* means that the pin output is always at low level (close to 0V)
  – *X* means that the pin output varies according to the given pattern
- Data sample format [HEX, BIN, OCT, DEC]: indicates how the samples are going to be interpreted. Each sample is represented as 8bit value (corresponding to the 8bit pattern generator) considering the selected format.

Example: Sample format HEX

```
Format= HEX         // Defines the format of the pattern values [HEX, DEC, BIN, OCT]
0F -> Data Sample 1
21 -> Data Sample 2
........
```

The samples are mapped on the 8 pins of the pattern generator as follows:

```
=> Pattern Samples are:
D7   D6   D5   D4  D3   D2  D1   D0
0    0    0    0   1    1   1    1
0    0    1    0   0    0   0    1
```

Example: .csv pattern generator file

```
R&S Pattern Generator File
Rate= 1000000        // Bit Rate [double]
HLevel= 1.5         // High Voltage Level [double]
Mask= X111000X      // Masks the Pins to be used in the Pattern Generator
                    // [0 => always LOW, 1 => always HIGH, X/x => used in the Pattern]
Format= DEC         // Defines the format of the pattern values [HEX, DEC, BIN, OCT]0
1
2
3
....
200
```

Content and format of the R&S pattern generator *.bin files

For the content of the fields, refer to "Content and format of the R&S*.csv files" on page 881.

The file stream should contain the following information in the given order:

• Bit rate	[double]
• High level	[double]
• Mask	[string of 8 characters made up of "X"/"1"/"0"]
• Number of samples	[UINT32]
• Data samples	[UINT8] * number of samples

Enable
Enables the waveform generator/ pattern generator and outputs the signal to the connectors.

Remote command:
`WGENerator<m>[:ENABle]` on page 1806
`PGENerator:ENABle` on page 1822

Run mode
Selects the duration for which the signal of the generator will be output after the trigger event. You can choose between a "Continuous" and "Single period" duration.

Remote command:
`PGENerator:RUNMode` on page 1823

Bit rate
Sets the number of transmitted bits per second for the pattern generator.

Remote command:
`PGENerator:BITRate` on page 1822

High level
Sets the high level of the signal.

Remote command:
`PGENerator:HLEVel` on page 1822

Load pattern file
Opens a dialog for selecting an existing pattern file. It is possible to load `.bin` or `.csv` files, see "Content and format of the pattern generator files" on page 880.

Remote command:
`PGENerator:FILE:OPEN` on page 1822
`PGENerator:FILE[:NAME]` on page 1822

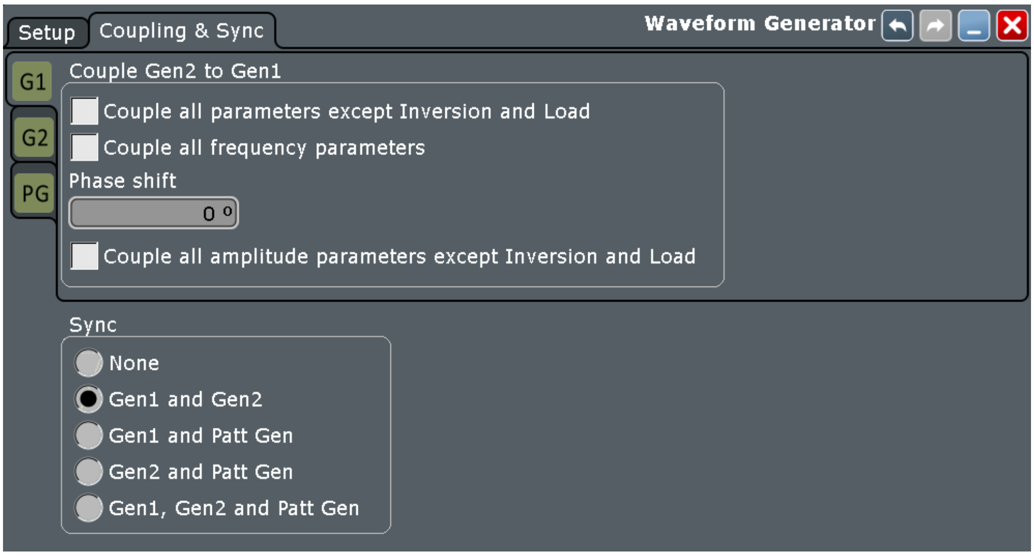
Preset Gen1/Gen2/Patt Gen
Sets the parameters of the generator to their default values. The settings of the generators are not affected by an instrument preset.

Remote command:
`WGENerator<m>:PRESet` on page 1806
`PGENerator:PRESet` on page 1823

14.3 Coupling and Sync Settings

Access: "Wave Gen" > "Coupling & Sync" tab.

In the R&S RTP, you can couple certain settings of the available waveform generators. If one of the available coupling options is enabled for one of the generators, then you cannot change the coupled parameters at the "Setup" tab of the other generator. The values for all coupled parameters are automatically taken from the master generator.



Couple Gen 2 to Gen1/ Couple Gen 1 to Gen 2

Enables the coupling of the selected parameters of "Gen1" to "Gen2"/"Gen2" to "Gen1".

"Couple all parameters except Inversion and Load"
All signal, output and noise parameters of the generators are coupled, except for "Load" and "Inversion".

"Couple all frequency parameters"
All frequency parameters of the generators are coupled:

- For "Operation Mode" > "Function Gen.": "Frequency" and "Period"
- For "Operation Mode" > "Modulation": "Carrier frequency", "Carrier period", "Modulation freq", "Freq deviation", "Frequency 1", "Frequency 2" and "Hop rate"
- For "Operation Mode" > "Sweep": "Start frequency", "Stop frequency" and "Sweep time".
- For "Operation Mode" > "Arbitrary": "Arb wfm source", "Load arbitrary waveform" and "Signal source"

You can still change the other settings of the generators independently.

"Phase shift"
Sets the phase shift between the waveform of "Gen1" and "Gen2" when the frequency parameters of the two waveforms are coupled.

"Couple all amplitude parameters except Inversion and Load"
All amplitude parameters of the generators are coupled:
- For all "Operation Mode": the output settings except of "Load" and "Inversion", "Amplitude", "High", "Offset" and "Low".
- For "Operation Mode" > "Function Gen.": "DC Level"
- For "Operation Mode" > "Modulation": "Modulation depth"

Remote command:
WGENerator<m>:COUPling:ALL on page 1823
WGENerator<m>:COUPling:AMPLitude on page 1823
WGENerator<m>:COUPling:PHASeshift on page 1823
WGENerator<m>:COUPling[:FREQuency] on page 1824

Sync
Selects, which signals generated from the waveform generator are synchronized.

Selecting one of the sync options indicates that the first samples of those signals are generated at the same time, irrespective of if the generators are on or off. Selecting one of the coupling options automatically syncs the signals generated by the two waveform generators.

Remote command:
GENerator:SYNC[:COMBination] on page 1824

14.4 Configuring the Waveform Generator

This chapter explains step-by-step how to configure the waveform generator.

14.4.1 Configuring a Function Waveform

1. Press the [Gen 1] key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Function Gen." button.
4. Select the "Function type" that you want to generate, e.g. "Sine".
5. Depending on the selected "Function type", configure the settings of the waveform like "Frequency" and "Period".
6. If necessary, change the "Output" settings or add "Noise" to the waveform.

7. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

14.4.2 Configuring a Modulation Waveform

Generating an AM modulated waveform

1. Press the [Gen 1] key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Modulation" button.
4. Tap "Modulation type" and select "AM".
5. Set the "Carrier frequency" and the "Carrier period".
6. Tap "Modulation signal" and select the required waveform.
7. Depending on the selected "Modulation signal", configure the settings of the waveform like "Modulation freq" and "Modulation depth".
8. If necessary, change the "Output" settings or add "Noise" to the waveform.
9. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

Generating an PWM modulated waveform

1. Press the [Gen 1] key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Modulation" button.
4. Tap "Modulation type" and select "PWM".
5. Set the "Carrier frequency" and the "Carrier period".
6. Tap "Modulation signal" and select the required waveform.
7. Depending on the selected "Modulation signal", configure the settings of the waveform like "Modulation freq" and "Modulation depth".
8. If necessary, change the "Output" settings or add "Noise" to the waveform.
9. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

Generating an FM modulated waveform

1. Press the [Gen 1] key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Modulation" button.

4. Tap "Modulation type" and select "FM".
5. Set the "Carrier frequency" and the "Carrier period".
6. Tap "Modulation signal" and select the required waveform.
7. Depending on the selected "Modulation signal", configure the settings of the waveform like "Modulation freq" and "Freq deviation".
8. If necessary, change the "Output" settings or add "Noise" to the waveform.
9. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

Generating an FSK modulated waveform

1. Press the [Gen 1] key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Modulation" button.
4. Tap "Modulation type" and select "FSK".
5. Set the "Frequency 1", "Frequency 2" and the "Hop rate".
6. If necessary, change the "Output" settings or add "Noise" to the waveform.
7. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

14.4.3 Configuring a Sweep Waveform

1. Press the [Gen 1] key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Sweep" button.
4. Set the "Start frequency", the "Stop frequency" and the "Sweep time".
5. If necessary, change the "Output" settings or add "Noise" to the waveform.
6. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

14.4.4 Configuring an Arbitrary Waveform

Generating an arbitrary waveform from a saved file

1. Press the [Gen 1] key on the front panel.
2. Select the "Setup" tab.

3. Under "Operation mode", enable the "Arbitrary" button.
4. Set the "Arb wfm source" to "Saved waveform".
5. Select the "Run mode".
6. Press "Open" and set the path to your saved arbitrary waveform.
7. Set the "Sample rate".
8. If necessary, change the "Output" settings or add "Noise" to the waveform.
9. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

Generating an arbitrary waveform from the scope waveform

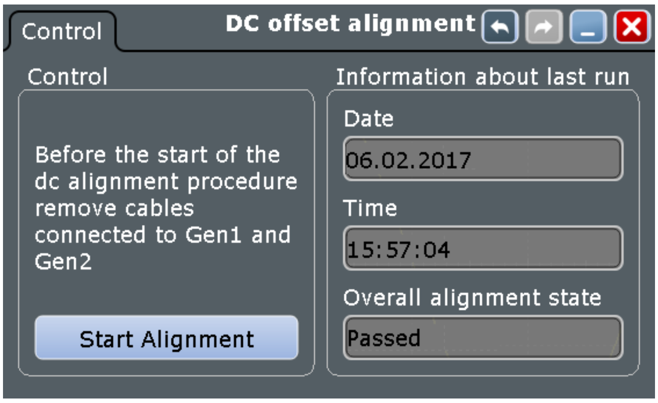
1. Press the [Gen 1] key on the front panel.
2. Select the "Setup" tab.
3. Under "Operation mode", enable the "Arbitrary" button.
4. Set the "Arb wfm source" to "Scope waveform".
5. Select the "Run mode".
6. Press the "Signal source" button and select the channel source for the waveform.
7. Set the "Sample rate".
8. If necessary, change the "Output" settings or add "Noise" to the waveform.
9. Press the "Enable" button, to output the waveform at the output connector of the waveform generator.

14.4.5 Configuring a Pattern Generator Waveform

1. Press the [Gen 1] key on the front panel.
2. At the left-hand side, select the vertical tab "PG".
3. Select the "Setup" tab.
4. Select the "Run mode".
5. Press "Open" and set the path to your saved pattern file.
6. Set the "Bit rate" and "High level".
7. Press "Open" and set the path to your saved arbitrary waveform.
8. Press the "Enable" button, to output the pattern at the output connector of the pattern generator.

14.5 DC Offset Alignment

Access: "Wave Gen" > "DC offset Allignment" tab



Start Alignement
Starts the alignment of the DC offset.

Remote command:
GENerator:ALIGnment:DC[:STARt] on page 1825

Date
Displays the date of the last performed DC offset alignment.

Remote command:
GENerator:ALIGnment:DC:RESult:DATE? on page 1824

Time
Displays the time of the last performed DC offset alignment.

Remote command:
GENerator:ALIGnment:DC:RESult:TIME? on page 1825

Overall alignment state
Displays the result of the DC offset alignment.

Remote command:
GENerator:ALIGnment:DC:RESult[:STATe]? on page 1825

15 Pulse Source (Option R&S RTP-B7)

The pulse source option R&S RTP-B7 provides a symmetrical differential pulse signal with steep rise time and configurable parameters. The hardware module of the option features four 2.92 mm connectors (K type), two for signal output (Out, $\overline{\text{Out}}$), and two for reference signal output (Ref, $\overline{\text{Ref}}$).

Beside the pulse source module, the option includes several accessories: SMA cables, 50 Ω terminations, adapters, and more. The accessory case provides also space for optional accessories. All included accessories are listed in the data sheet.

The module is installed at the front panel of the instrument. To ensure correct installation and calibration, send the instrument to a Rohde & Schwarz service center.

NOTICE

Usage of cables

When fastening the cable, observe the maximum torque of 0.9 Nm. Therefore, using a 0.9 Nm torque wrench is recommended (optional accessory 1328.8534.35).

To ensure accurate and reliable measurements, connect only cables with a maximum length of 3 m.

Always use cables to connect the DUT or test fixture to the pulse source outputs. Never connect the DUT or test fixture directly to the outputs.

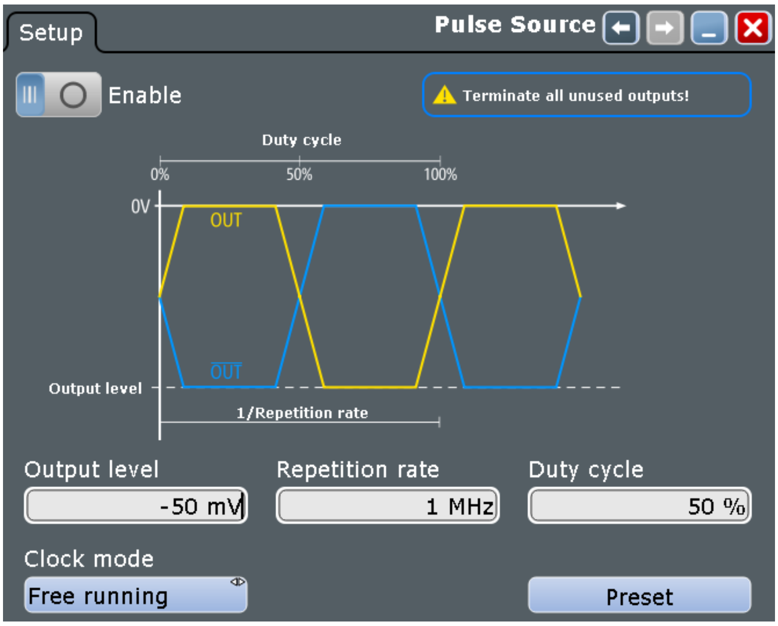
Typical applications of the pulse source are:

- Stimulus for devices under test, for example, as a precise clock
- Accurate source for deskewing cables and probes for differential measurements
- Analysis of time-transmission characteristics of a differential signal path

15.1 Settings for the Pulse Source

Access: "Pulse Src" menu > "Setup"

Terminate all unused outputs of the pulse source with 50 Ω terminating resistors.



Enable
Switches all four pulse source outputs on and off.

Remote command:
`PSRC[:STAT]` on page 1825

Output level
Sets the low level of the output pulse. The high level is 0 V and cannot be changed.

Remote command:
`PSRC:OUTPutlow` on page 1826

Repetition rate
Sets the pulse frequency, the repetition rate of the pulse. Available values depend on the selected clock mode.

Remote command:
PSRC:REPRate on page 1826

Duty cycle
Sets the duty cycle of the pulse in %, which is the ratio of the positive pulse width to the period of the signal.

For repetition rates > 5 MHz, the value is fixed at 50 %.

Remote command:
PSRC:DUTYcycle on page 1826

Clock mode
Sets the dependency of the pulse clock on the instrument's reference clock. The appropriate clock mode depends on the measurement application.

"Free running" The clock of the pulse source is independent. Deviations of the system do not affect the pulse clock, and deterministic conditions are avoided.
If the waveform aquisition is set to "Average", the "free running" clock mode can improve the measurement result. Internal spurious signals of the instrument are reduced by averaging, because they are not coherent to the pulse source signal. See also: "Wfm Arithmetic" on page 128.

"Locked" The pulse source is locked to the reference clock of the instrument.

Remote command:
PSRC:CLOCkmode on page 1826

Preset
Resets the pulse source to the default state. Pulse source settings are not stored in the user-defined preset.

Remote command:
PSRC:RST on page 1827

16 Jitter Analysis and Clock Data Recovery (Option R&S RTP-K12)

Jitter describes the timing errors in a system. It is a significant and undesired factor in high-speed serial communication designs because it causes transmission errors.

The jitter analysis option R&S RTP-K12 provides common analysis and visualization tools for signal integrity analysis and jitter characterization:

- Automated jitter measurements in time domain
- Track graph of jitter measurement results
- Jitter spectrum
- Eye mask definition and analysis
- Software-based clock data recovery

A wizard guides you through the configuration of most common jitter analysis tasks.

16.1 Jitter Measurements

The R&S RTP provides two ways to set up jitter measurements:

- The jitter wizard for most common jitter measurements
- The usual measurement setup in the "Jitter" category

Both ways are described in the following chapters.

16.1.1 Jitter Wizard

The jitter wizard guides you through the configuration of most common jitter analysis tasks:

- Period and frequency
- Cycle-to-cycle jitter
- Time interval error (TIE)
- Skew

After selecting and setting up the measurement, you can adjust the scaling and the reference levels, and decide which results you want to see:

- Source signals
- Track of measurement
- Histogram of measurement
- FFT spectrum of track

Other jitter measurements and more complex setups can be configured using the "Measurement" and "CDR Setup" dialog boxes, which are described in the following chapters.

16.1.2 Jitter Measurements

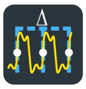
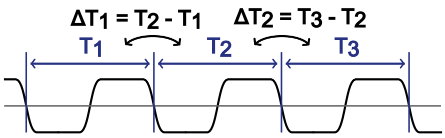
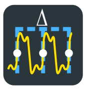
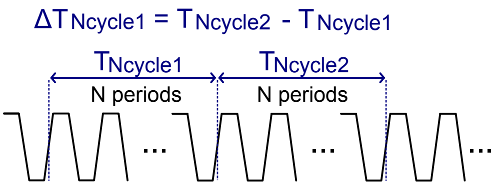
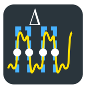
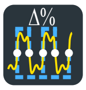
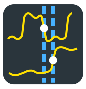
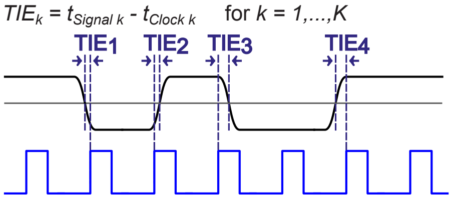
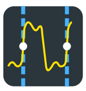
The measurement category "Jitter" gathers all measurements which are useful for jitter analysis. The category contains jitter-specific measurements. In addition, the following amplitude/time measurements are added to the jitter category, because they are useful for jitter analysis:

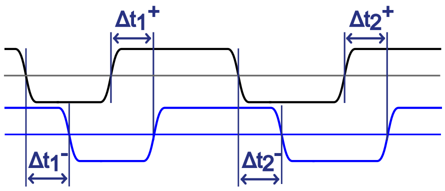
- Period
- Frequency
- Setup time
- Hold time
- Setup/Hold ratio

The amplitude/time measurements are described in "Time Measurements" on page 306.

The specific jitter measurements are described in Table 16-1.

Table 16-1: Jitter measurements

	Measurement	Description/Result
	Cycle-cycle jitter	Difference between the periods of two adjacent cycles. The measurement is based on the period measurement. You can select the slope and the reference level on which the period is measured. $\Delta T_{Period\ k} = T_{Period\ k+1} - T_{Period\ k}$ for $k = 1,...,K-1$  See also: Chapter 16.1.3.2, "Settings for Clock Measurements ", on page 896
	N-cycle jitter	Difference between the time of two adjacent groups of N cycles (periods) each. You can select the slope and the reference level on which the time is measured, and the number of periods in the groups. $\Delta T_{Ncycle\ k} = T_{Ncycle\ k+1} - T_{Ncycle\ k}$ for k = *cycle group index* 
	Cycle-cycle width	Difference between the pulse width of two adjacent cycles. The measurement is based on the pulse width measurement. You can select the pulse polarity to be measured. $\Delta T_{Pulse\ k} = T_{Pulse\ k+1} - T_{Pulse\ k}$ for $k = 1,...,K-1$
	Cycle-cycle duty cycle	Difference between the duty cycle of two adjacent cycles. The measurement is based on the duty cycle measurement. You can select the pulse polarity for the duty cycle measurement. $\Delta R_{Cyc\ k} = R_{Cyc\ k+1} - R_{Cyc\ k}$ for $k = 1,...,K-1$
	Time interval error	Time difference between the slope of the input signal and the slope of a reference signal. The reference signal can be a captured clock waveform, or a clock generated by clock data recovery (CDR, software algorithm or hardware generation). You can select the slope and the reference level on which the TIE is measured. $TIE_k = t_{Signal\ k} - t_{Clock\ k}$ for $k = 1,...,K$  See also: Chapter 16.1.3.3, "Data Measurement Settings", on page 898
	Unit interval	Period of the clock signal. If no clock signal is available, it is recovered by CDR. The period is calculated as the time difference between two consecutive clock edges of the same polarity. $UI_k = t_{Clock\ k+1} - t_{Clock\ k}$ for $k = 1,...,K-1$

	Measurement	Description/Result
	Data rate	Frequency of the clock signal. If no clock signal is available, it is recovered by CDR. The measurement is based on the unit interval measurement. $R_{Clock\ k} = 1 / UI_k$ for $k = 1,...,K-1$
	Skew delay	Delay between the edges of two interdependent waveforms. The measurement is a simplified variant of the "Delay" measurement assuming that both sources are similar except for the delay. $Skew\ delay = \Delta t_k = t_{Source2} - t_{Source1}$ for $k = 1,...,K$  See also: Chapter 16.1.3.4, "Delay Measurement Settings", on page 899
	Skew phase	Phase difference between the edges of two waveforms. $Skew\ phase = Skew\ delay / Period * 360° = \Delta t_k / \Delta T_{Period\ k} * 360°$

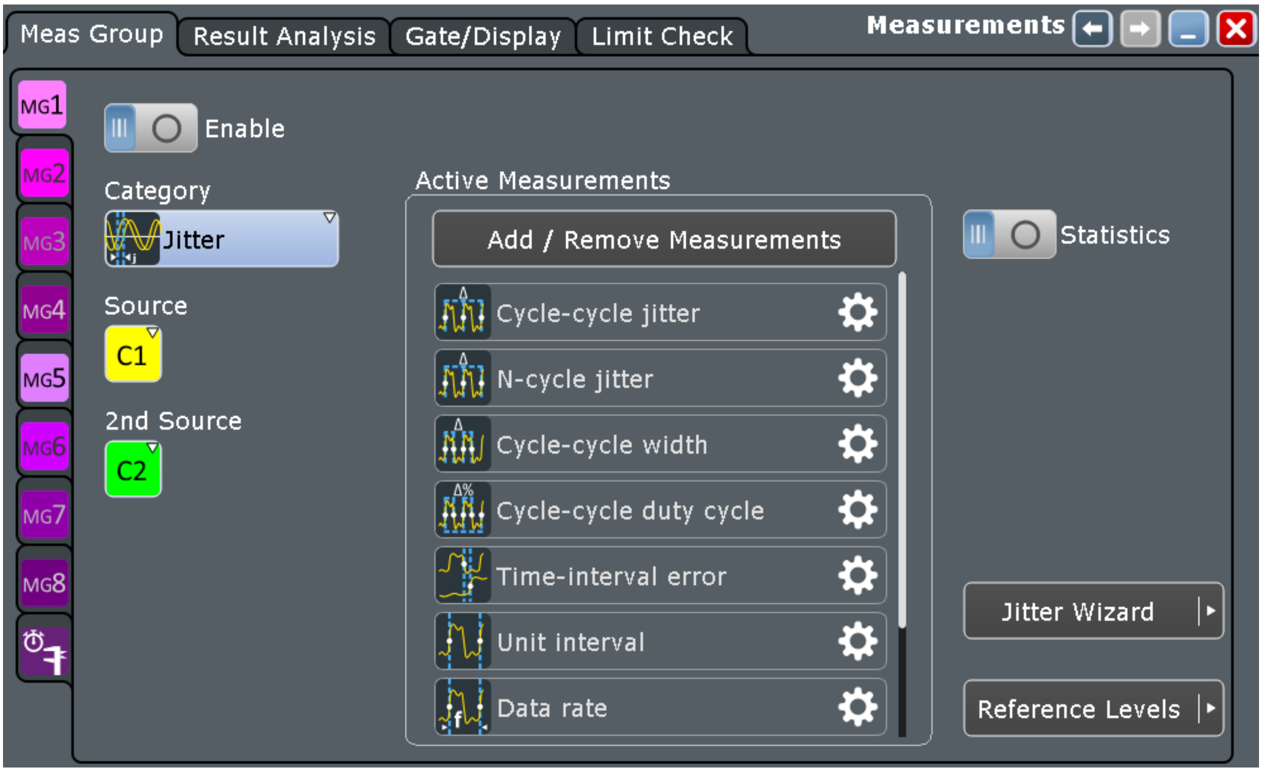
Limit and margin checks are also available for jitter measurements, see Chapter 7.2.11, "Limit and Margin Checks", on page 341. Limit and margin checks are based on the amplitude/time measurements.

16.1.3 Jitter Measurement Settings

16.1.3.1 Measurement Selection

Access: "Meas" menu > "Meas Group" > "Category" = "Jitter"

Jitter measurements are only available for sources in the time domain.



Active Measurements

The "Active Measurements" list shows the measurements that are selected in the selected category. At least, one measurement must be selected. If further settings are available for a measurement, a settings icon is shown beside the measurement's name.

To change the selection, tap "Add / Remove Measurements".

For details on the available measurements, see Chapter 16.1.2, "Jitter Measurements", on page 893.

Remote command:

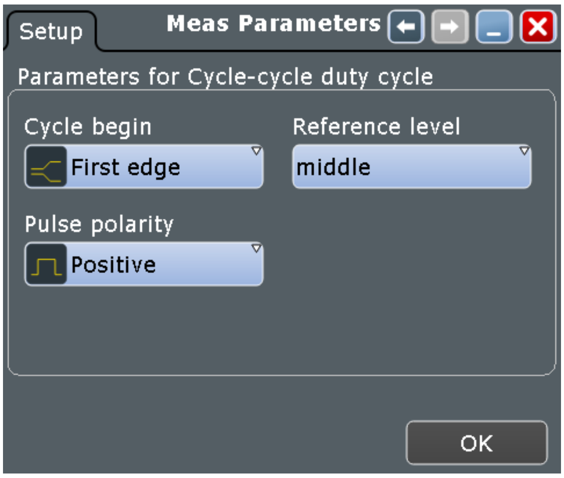
`MEASurement<m>:MAIN` on page 1138

`MEASurement<m>:ADDitional` on page 1139

16.1.3.2 Settings for Clock Measurements

The cycle-cycle measurements are intended to analyze the quality of clock signals. They require a few additional settings for period and pulse width measurement. See also: Table 16-1

► To configure a measurement, tap it in the "Active Measurements" list.



Cycle begin
Selects the slope at which the periods and thus the jitter is measured.

The setting is available for the following measurements: cycle-cycle jitter, N-cycle jitter, and cycle-cycle duty cycle.

"First edge"	Measures the period from the first edge that is found, no matter of its direction.
"Positive"	Measures the period at positive going edges.
"Negative"	Measures the period at negative going edges.
"Either"	Measures the period at both positive and negative going edges. This option is useful, for example, to check the clock stability of a double data rate clock.

Remote command:
`MEASurement<m>:JITTer:CCSLope` on page 1828

Data ref level / Reference level
The setting defines the "Data ref level" for setup and hold measurements, and for time-interval error measurements (option R&S RTP-K12). It selects the reference level of the data signal on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

For clock jitter measurements (option R&S RTP-K12), it sets the "Reference level" for the time measurement.

Remote command:
`MEASurement<m>:AMPTime:DATA<n>:LSELect` on page 1151

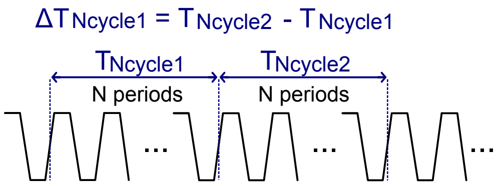
Pulse polarity
Sets the polarity of pulses for which the pulse width is measured to obtain the cycle-cycle width and the cycle-cycle duty cycle.

The setting is available for the following measurements: cycle-cycle width and cycle-cycle duty cycle.

"Positive"	Pulse width of positive pulses is measured.
"Negative"	Pulse width of negative pulses is measured.

Remote command:
`MEASurement<m>:JITTer:PULSe` on page 1828

Number of cycles
Sets the number of periods (cycles) that are accumulated to measure the N-cycle jitter.



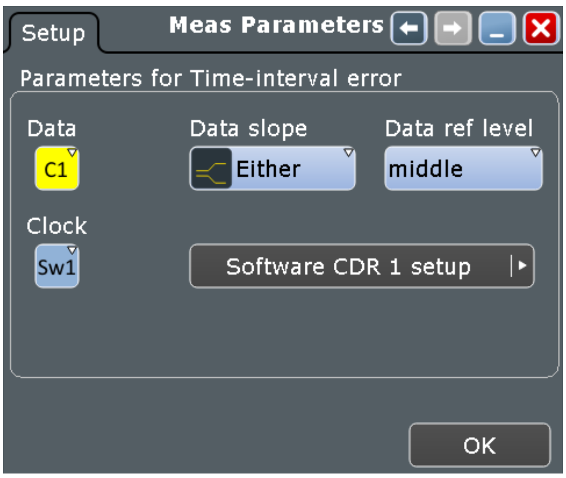
Remote command:
`MEASurement<m>:JITTer:NCYCles` on page 1829

16.1.3.3 Data Measurement Settings

The following measurements are intended to analyze serial data. The clock can be a captured clock signal, or it can be recovered from the data signal using one of the clock recovery algorithms:

- Time interval error
- Unit interval
- Data rate

► To configure a measurement, tap it in the "Active Measurements" list.



Clock
Defines the origin of the clock signal - either an existing clock signal or waveform, or a clock generated using one of the CDR methods.

The setting is available for the following measurements: time-interval error, unit interval and data rate.

"Explicit signal" The clock is an existing clock signal. Select the clock source, clock slope, and the reference level.

"Software CDR 1 / 2" The clock is generated by a software algorithm. The R&S RTP provides two setups for software CDR, which can be configured and used independently. To configure the CDR, tap the "CDR Setup" button.

Remote command:
MEASurement<m>:JITTer:CDRMode on page 1829

Clock slope / Data slope
Set the edges that are used for measurements.

The setting is available for the following measurements: time-interval error, unit interval and data rate.

"Data slope" is only relevant for time interval error measurements with real clock signal.

"Positive" The positive clock slope can be used, for example, for single data rate (SDR) signals with bit start at the positive clock edge.

"Negative" The negative clock slope can be used, for example, for SDR signals with bit start at the negative clock edge.

"Either" For clock edges, this option can be used for double data rate (DDR) signals.
For data edges, it is the most common setting.

Remote command:
MEASurement<m>:JITTer:SOURce<n>:TIESlope on page 1830

Clock ref level
Selects the reference level of the clock on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

The setting is used for setup and hold measurements, and for jitter measurements (option R&S RTP-K12).

Remote command:
MEASurement<m>:AMPTime:CLCK<n>:LSELect on page 1150

Data ref level / Reference level
The setting defines the "Data ref level" for setup and hold measurements, and for time-interval error measurements (option R&S RTP-K12). It selects the reference level of the data signal on which the time is measured. The intersection of slope and reference level defines the time point for measurements.

For clock jitter measurements (option R&S RTP-K12), it sets the "Reference level" for the time measurement.

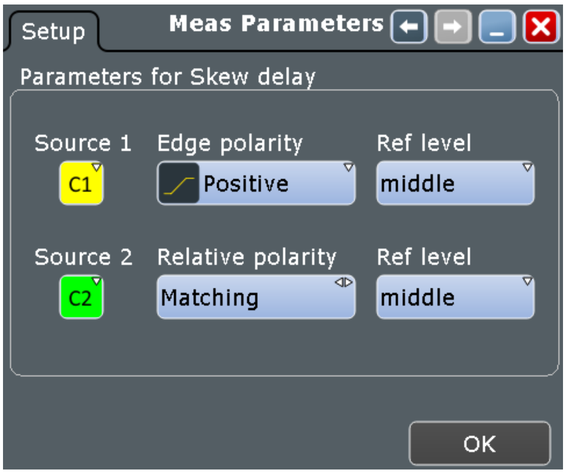
Remote command:
MEASurement<m>:AMPTime:DATA<n>:LSELect on page 1151

16.1.3.4 Delay Measurement Settings

Skew delay and skew phase measurements are intended to measure the time difference between the edges of two waveforms. The measurements are simplified variants of the "Delay" and "Phase" measurements assuming that both sources are similar except for the delay.

See also: Table 16-1

► To configure a measurement, tap it in the "Active Measurements" list.



Source 1, Source 2

"Source 1" is the reference signal, and "Source 2" is the signal compared to the reference signal.

Skew delay = $\Delta t_k = t_{Source2} - t_{Source1}$ for $k = 1,...,K$

Edge polarity

Sets the edge of the first waveform from which the skew delay or phase is measured: positive, negative or both.

Remote command:
MEASurement<m>:JITTer:SKWSlope on page 1830

Relative polarity

Sets the edge of the second waveform relative to the first waveform.

"Matching"	Measures from positive to positive edge or from negative to negative edge.
"Inverse"	Measures from positive to negative edge or from negative to positive edge.

Remote command:
MEASurement<m>:JITTer:SKWRelation on page 1831

Data ref level / Clock ref level

See "Data ref level / Reference level" on page 313 and "Clock ref level" on page 313.

16.1.4 Jitter Statistics and Histogram

Since jitter is a random component of all signals, statistical measurement results are required to characterize the jitter.

To get measurements statistics of a jitter measurement

Prerequisite: the jitter measurements are selected and configured, and the measurement group is active.

1. Tap the "Tools" icon in the "Meas Results" box.
2. In the sidebar, enable "Statistics".
3. Tap "Advanced Setup".
4. On the "Result Analysis" tab, enable "Measure all events in each acqu.".

The histogram plots the density of data. It shows the frequency of occurrence of the measurement values. The maximum count of a measurement value is assigned to the full height of the histogram diagram (= 1000). All other count values are displayed relative to the maximum.

To enable the histogram

1. On the "Result Analysis" tab, under "Histogram", tap "Enable".
2. If the histogram is not displayed as expected, disable "Continuous auto scale" and adjust the "Meas scale".

16.1.5 Track of Jitter Measurement Results

A track graph displays the results of the first jitter measurement from a single acquisition as a time-correlated waveform. To generate the track graph, multiple measurement points are required. Thus, enabling the track automatically activates "Measure all events in each acqu.".

You can measure amplitude and time on the track waveform: Configure a new measurement group, e.g. "MG2", that uses the track waveform as measurement source.

You can also zoom into the track waveform, perform cursor measurements on it, and export the track.

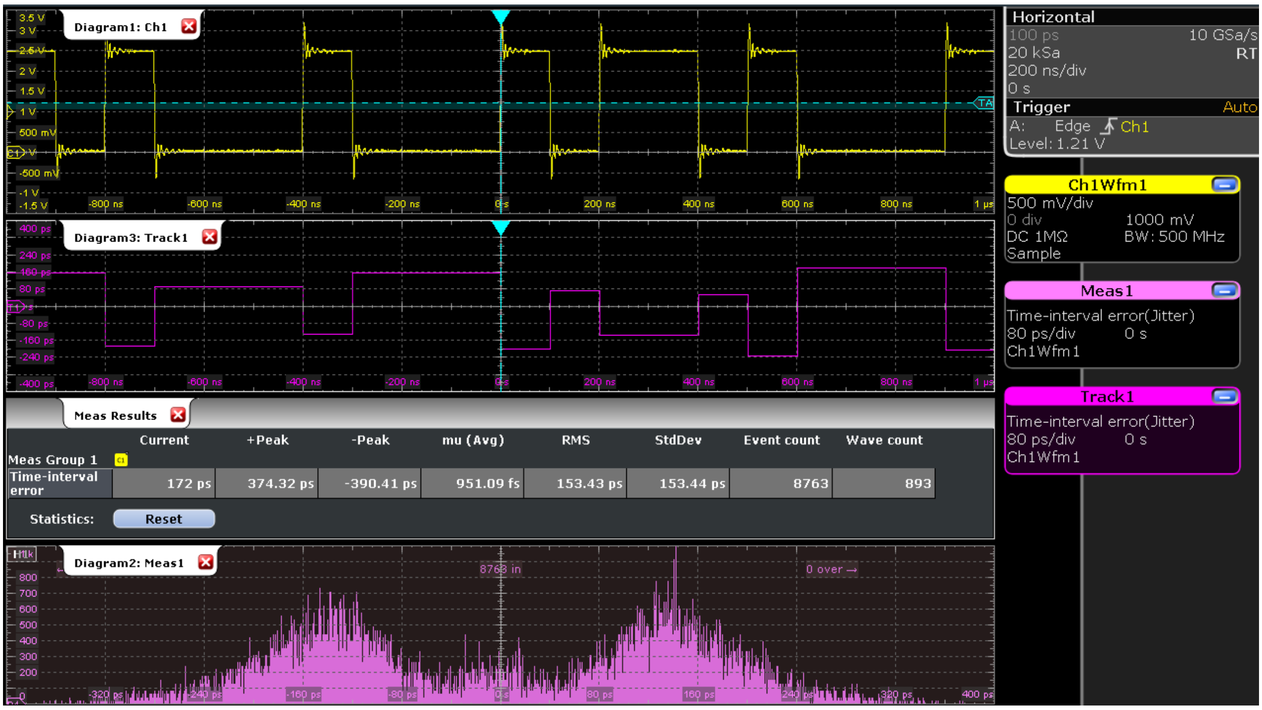


Figure 16-1: TIE measurement with CDR trigger, 10 Mbps, with track and histogram

16.1.6 Jitter Spectrum

An extension of jitter measurements is the FFT analysis of track waveforms of jitter measurements. The results are displayed in the frequency domain as a jitter spectrum. The modulation frequency is displayed on the horizontal axis, and the amplitude of modulation on the vertical axis. Using FFT, periodic components can be detected.

16.2 Clock Data Recovery

The process of clock data recovery (CDR) generates a reference clock from a high-speed serial data stream that is sent without a dedicated clock signal. The generated clock signal matches the frequency and is aligned to the phase of the data stream. The recovered clock can be used to sample the data stream, to obtain the sequence of transmitted bits, and to measure jitter parameters.

The Rohde & Schwarz uses software algorithms that calculate the clock from data signal edges.

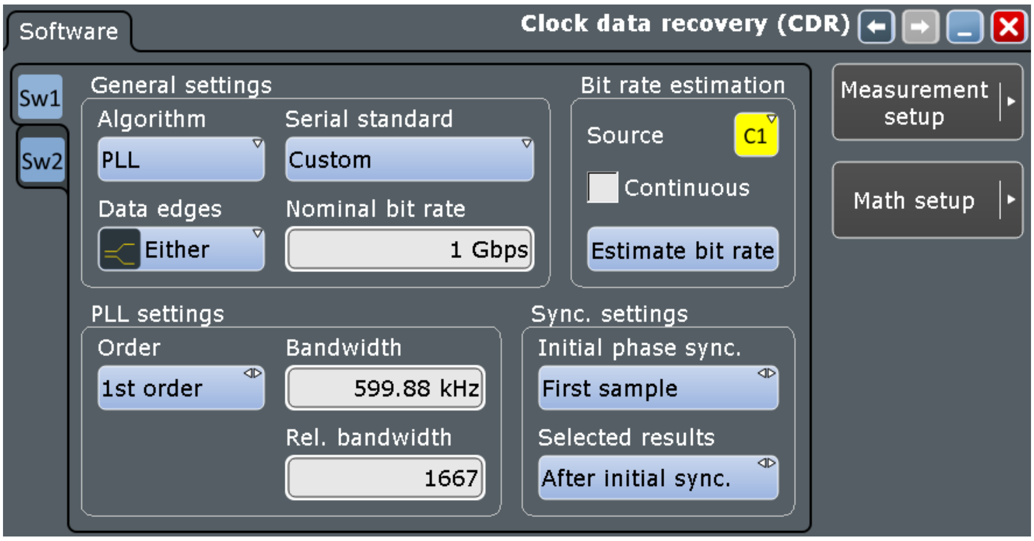
16.2.1 Software CDR

You can define two independent software CDR instances to recover clock signals. These clock signals are used for data timing measurements: time interval error, unit interval, and data rate (frequency of the clock signal).

Software CDR is based on acquired data, needs a synchronization time to set up the clock. To get correct measurement results, the data acquired during synchronization time has to be discarded.

You can also display the recovered clock signal as a math waveform, see Chapter 16.2.2, "Displaying the Recovered Clock Signal", on page 905.

Access: "Analysis" menu > "CDR"



Algorithm
Sets the software algorithm that is used for clock data recovery.

"PLL"	PLL is the phase-locked loop control system. It can follow slow deviations in the frequency of the data stream. Thus, it acts as highpass filter regarding the jitter that remains on the signal.
"Constant freq."	CDR uses the nominal bit rate to generate the clock signal. The method assumes that the frequency of the signal is constant during the complete acquisition.

Remote command:
`CDR:SOFTware<m>:ALGorithm` on page 1832

Serial standard
For some serial standards, the bit rate and bandwidth are known to the instrument. Select the standard, and the "Nominal bit rate" and bandwidth settings are set automatically, no estimation is required.

Nominal bit rate
Sets the quiescent frequency of the PLL. It corresponds to the data rate of the data stream from which the clock is to be recovered.

Remote command:
`CDR:SOFTware<m>:BITRate` on page 1832

Data edges
Selects the edges of the data stream that are used for the clock recovery.

- "Either": Both positive and negative edges are used
- "Positive / Negative": Only one edge direction is used. Use one of these settings if the other edge might deliver unreliable results.

Remote command:
`CDR:SOFTware<m>:ESLope` on page 1832

Bit rate estimation
Bit rate estimation analyzes the source signal based on the given "Nominal bit rate" and corrects the value.

"Source"	Selects the source of the data stream.
"Continuous"	Enables ongoing bit rate correction.
"Estimate bit rate"	Estimates the bit rate once, for the current acquisition.

PLL settings
Phase-locked loop parameters are listed below.

Note: Nomial bit rate, bandwidth and relative bandwidth are interacting settings. Modifying one parameter also changes one of the dependent parameters.

"Order"	Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.
"Bandwidth"	Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization. The PLL bandwidth is usually defined by the transmission standard.
"Rel. bandwidth"	Sets the relative bandwidth, that is the ratio of the nominal bit rate to the PLL bandwidth.
"Damping"	Sets the damping factor, which is only relevant for second order PLL.

Remote command:
`CDR:SOFTware<m>:PLL:ORDer` on page 1833
`CDR:SOFTware<m>:PLL:BWIDth` on page 1834
`CDR:SOFTware<m>:PLL:RELBwidth` on page 1834
`CDR:SOFTware<m>:PLL:DAMPing` on page 1834

Initial phase sync.
Defines the phase reference for the first clock edge.

"First sample"	The first clock edge matches the first sample of the waveform at the left border of the display.
"First data edge"	The first clock edge matches the first edge of the data signal.

Remote command:
`CDR:SOFTware<m>:SYNC` on page 1833

Selected results
The PLL requires some time to synchronize to the phase of the data stream. You can select when the CDR algorithm returns clock edges:

"After initial sync."	The clock edges of the synchronization time are discarded; results are gathered after initial synchronization of the CDR. Thus, meaningful TIE measurement results can be obtained.
"All"	All clock edges are used.

Remote command:
`CDR:SOFTware<m>:RESults` on page 1833

16.2.2 Displaying the Recovered Clock Signal

The clock signal that is recovered by CDR can be displayed as a math waveform. The generated waveform is time-correlated to the data waveform.

1. Prerequisite: Configure the CDR method.
2. Press the [Math] key.
3. On the "Setup" tab, select the "Advanced" subtab.
4. Double-tap the entry field to open the formula editor.
5. Tap "More", and again "More".
6. Tap "Clear".
7. Tap "CDR" and select the CDR method.
8. Complete the expression:
   SW CDR: e.g., CDR(sw1,Ch1Wfm1)
9. Tap "Enter".
10. Enable the math signal.

16.3 Mask Testing on Eye Diagrams

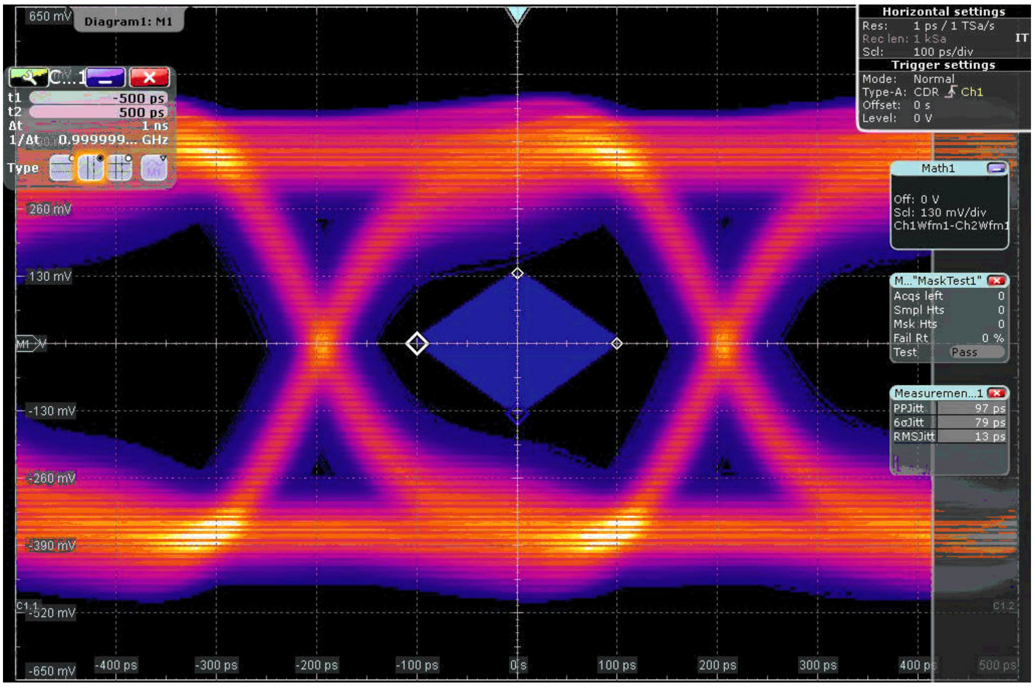
Mask testing on eye diagrams allows you to test data signals against eye shapes that are required in the standards. It is available with option R&S RTP-K12.

You can select the shape of the eye, enter its dimensions and position the eye on the display. For mask configuration details, see Chapter 9.4.1, "Test Definition for Eye Mask Tests", on page 393 and Chapter 9.4.2, "Eye Mask Definition", on page 393. The fail criteria for the test is defined as usual for R&S RTP mask tests, see "Fail condition, Violation tolerance" on page 374.

The eye mask definition cannot be saved as a mask test. You can save the settings as user defined preset and recall them by loading the preset file. See: Chapter 11.6, "Preset Setup", on page 459.

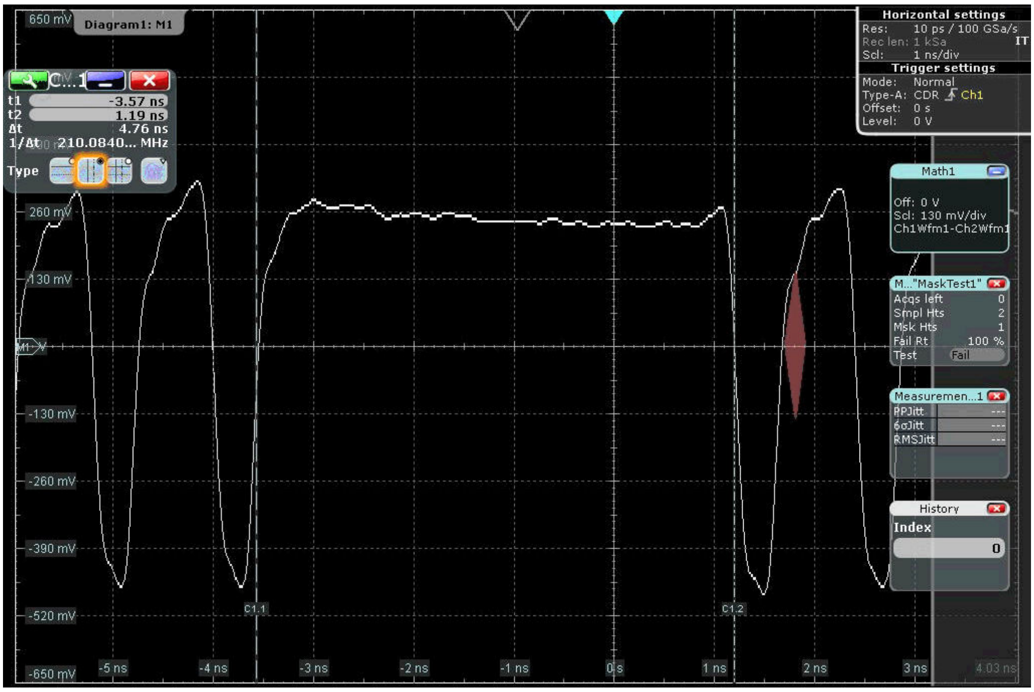
Example:

Eye pattern on a 2.5 Gb/s differential signal using PLL. The eye is open with a PRBS31 pattern.



Example:

The mask test is set to stop on violation. When an error occurred, the history mode is used to show the cause of the failure. In this case, a single bit transition after a long run caused the error (12 ones followed by a single zero).



17 Deembedding (Option R&S RTP-K121/-K122)

Deembedding removes the parasitic effects of the measurement setup from the measured signal. A simple measurement setup consists of a probe only, but more complex setups include also cables, fixtures and other components. The effects of these components on the measurement are typically increasing when signal frequency increases. Thus, deembedding is useful or even necessary when measuring signals of 4 GHz frequency or higher. Furthermore, you can virtually move the measurement point to a point in a circuit that cannot be reached by probing. In this case, the effects of the components between the real and ideal probe are deembedded.

The components of a measurement setup are usually multiports, and each multiport can be described by a scattering matrix. The elements of a scattering matrix are the S-parameters. The S-parameters of a multiport are usually measured using vector network analyzers (VNA), and they are saved in Touchstone files.

From the S-parameters of the measurement components, the deembedding option determines the transfer function for the measurement setup. Based on the transfer function, filter coefficients are calculated, and the filter is applied to the measured signal.

Option R&S RTP-K121 realizes the deembedding process in software. As the process requires some time, triggering on the corrected signal is not possible, and the acquisition rate decreases.

Option R&S RTP-K122 realizes the deembedding process in hardware. This process is fast, so you can trigger on the corrected signal, and the acquisition rate remains unchanged. However, deembedding by hardware is typically less precise but the accuracy is sufficient for most measurements.

17.1 Configuring the Measurement Setup for Deembedding

The R&S RTP provides an easy way to model the measurement setup on the instrument, and to enter the characteristics of the components. If you use an R&S RT-ZM modular probe, the setup is easy: The probe is recognized by the oscilloscope, and the oscilloscope knows the characteristics of the probe components. You select only the used tip module and the measurement mode.

Before you start, you need to know the following:

- Probing method: probing or terminating
- S-parameter files of the components of the measurement setup (Touchstone files). S-parameters can be listed as complex numbers (real and imaginary parts), or as magnitude and phase in the order of increasing frequency. The phase unit has to be degree (°).

Proceed as follows:

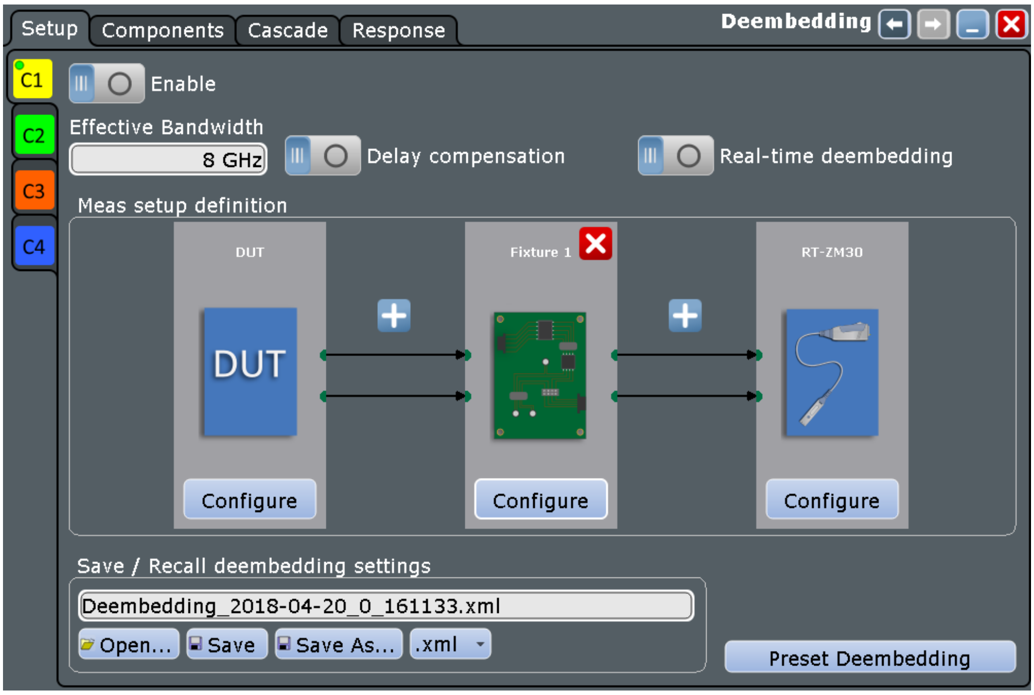
1. Open the "Analysis" menu.
2. Select "Deembedding".
3. Select the input channel to which the measurement setup is connected.
4. Add the components of the measurement setup:
   a) Tap the "+" icon.
   b) Select the component type.

   The component is added to the setup, and it is disabled by default (bypassed). The DUT and a probe or other input component are included by default.
5. Configure each component:
   a) Tap the "Configure" button.
   b) Enter the settings as required.
      All settings are described in Chapter 17.2, "Deembedding Settings", on page 908.
   c) If necessary, tap "Open" and load the S-parameters from file.
      As long as the configuration is incomplete or conflicting, the message "Invalid configuration" is shown.
   d) Enable the component to consider it during deembedding.
   e) Tap the subtab of the next component, and configure it in the same way.
6. On the "Setup" tab, set the Effective bandwidth and the Delay compensation.
7. Enable the deembedding.
8. If you want to keep the configuration for later use, save it to file.

17.2 Deembedding Settings

17.2.1 Measurement Setup

In the "Deembedding" > "Setup" tab, you add all components of the measurement setup and define all settings that are related to the complete path.



Enable
Activates the deembedding - the correction of parasitic effects of the measurement setup on the measured signal.

Remote command:
`DEEMbedding<m>[:STATe]` on page 1835

Effective bandwidth
Sets the maximum bandwidth until which the signal is corrected. This maximum value is the minimum bandwidth value of the probe bandwidth, tip module bandwidth (R&S RT-ZM) and oscilloscope bandwidth, and can not be higher than the highest frequency in a used S-parameter file. The setting is also coupled with the digital filter bandwidth if the cut-off frequency of the digital filter is at least 1 GHz.

Remote command:
`DEEMbedding<m>:BANDwidth` on page 1836

Delay compensation
Enables the compensation for the group delay of the complete measurement setup. If enabled, the calibration time reference point is the start point of the measurement setup. If disabled, the calibration time reference point is the oscilloscope's channel input.

Remote command:
`DEEMbedding<m>:CMPDelay` on page 1837

Realtime deembedding
Requires real-time extension option R&S RTP-K122.

If enabled, the deembedding calculation is done by the hardware in real time. You can trigger on the corrected signal, and the acquisition rate remains unchanged.

If disabled, the deembedding calculation is done by software. This method is slower, therefore, triggering on the corrected signal is not possible.

Remote command:
`DEEMbedding<m>:REALtime` on page 1836

Meas setup definition
Simulates the complete measurement setup with all components.

To add a component, tap the **+** icon and select the component type: cable, fixture, adapter, or others ("Custom"). The DUT component is always included in the deembedding. Also, a connected R&S RT-ZM, R&S RT-ZD or R&S RT-ZS probe with Rohde & Schwarz interface is automatically recognized and included in the deembedding.

The remark "bypassed" indicates that the component is disabled and not considered in the deembedding calculation.

Remote command:
`DEEMbedding<m>:ADD` on page 1835
`DEEMbedding<m>:REMove` on page 1836
`DEEMbedding<m>:CCOunt?` on page 1836

Save / recall deembedding settings
Saves the complete deembedding configuration, or loads a saved deembedding configuration. The file format is XML.

To save the deembedding configuration, enter a filename and tap "Save". Alternatively, tap "Save as" to open the file selection dialog box, see Chapter 11.7, "File Selection Dialog", on page 461.

To load a deembedding configuration, tap "Open" and select the required file.

Remote command:
`DEEMbedding<m>:NAME` on page 1837
`DEEMbedding<m>:SAVE` on page 1838
`DEEMbedding<m>:OPEN` on page 1838
`DEEMbedding<m>:DELete` on page 1838

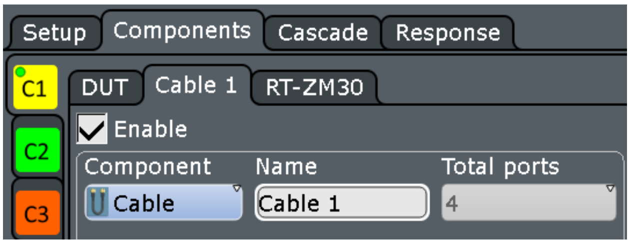
Preset Deembedding
Sets the complete deembedding configuration to the default values.

Remote command:
`DEEMbedding<m>:PRESet` on page 1837

17.2.2 Common Settings for Components

The "Components" tab has several subtabs to configure each component of the measurement setup that was defined on the "Setup" tab.

Settings that are available on all subtabs are described in this chapter. Other settings are component-specific and explained in the following chapters.



Enable
Enables the component for deembedding. As long as the configuration is incomplete or conflicting, the message "Invalid configuration" is shown, and enabling is not possible.

Remote command:
`DEEMbedding<m>:COMPonent<n>[:STATe]` on page 1839

Component
Selects the component type. The "DUT" and "Probe" types are predefined and shown for information. The other types ("Fixture", "Cable", "Adapter", and "Other") are selectable.

Remote command:
`DEEMbedding<m>:COMPonent<n>:TYPE` on page 1839

Name
Enter a name for the component that helps you identifying it.

Remote command:
`DEEMbedding<m>:COMPonent<n>:NAME` on page 1839

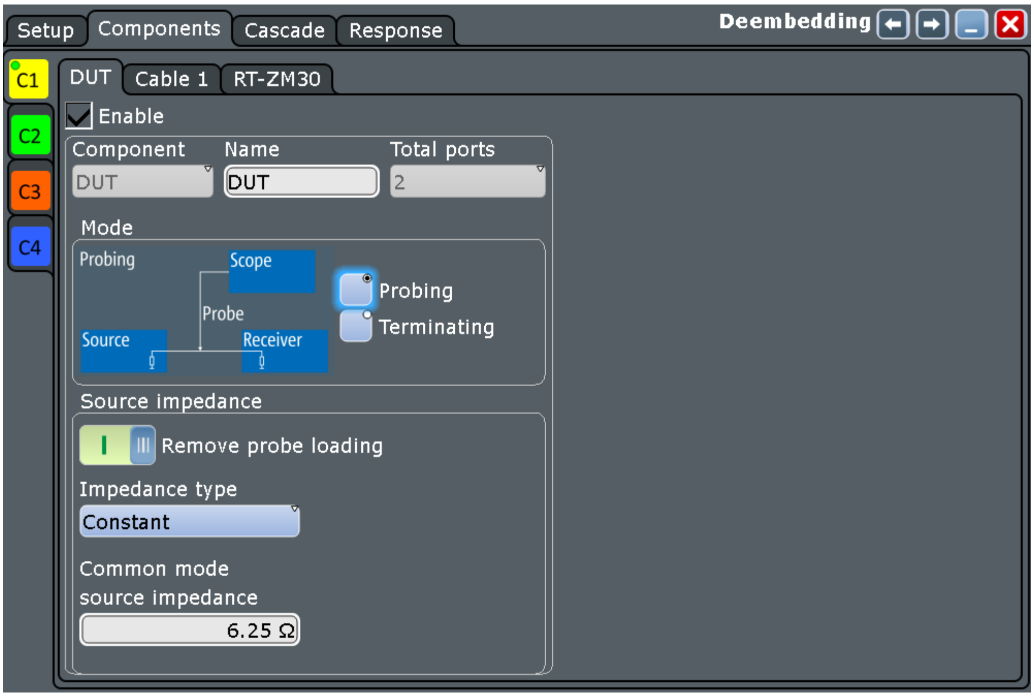
Total ports
Shows the number of all ports of the selected component (input ports and output ports).

The number of ports depends on the attached probe. If a modular probe R&S RT-ZM or differential probe R&S RT-ZD is used, the number of ports is 4. Otherwise, 2 ports are available.

Remote command:
`DEEMbedding<m>:COMPonent<n>:PCOunt?` on page 1840

17.2.3 DUT Settings

In the "Deembedding" > "Components" > "DUT" tab, you set the characteristics of the DUT.



Probing, Terminating

Sets the probing mode.

Select "Probing" if you use a high-ohmic probe and measure on an existing line in parallel to the load.

Select "Terminating" if the measuring equipment is the load of the line.

Remote command:

PROBe<m>:DEEMbedding:MODE on page 1032

DEEMbedding<m>:COMPonent<n>:MODE on page 1840

Remove probe loading

If "Probing" is selected, you can remove the loading of the probe.

If the probe loading is removed, you see the signal that would be at the measurement point if the probe's input impedance is ideal (infinite impedance).

Without removing the loading, you see the real signal at the measurement point, including the probe loading.

Remote command:

PROBe<m>:DEEMbedding:REMProbeload on page 1033

DEEMbedding<m>:COMPonent<n>:LOAD:REMProbeload on page 1841

Impedance type

Sets the impedance type of the DUT.

"Default" The default value depends on the selected probing mode and the measurement mode of the probe. The impedance is a constant value over frequency. If the default value does not match to the DUT, select "Constant" or "Touchstone".

"Constant" The source impedance is a constant value over frequency. Enter the value in Source impedance.

"Touchstone" Use this setting if the DUT impedance depends on the frequency. The impedance of the DUT over frequency is described by S-parameters, which are saved in a Touchstone file. S-parameters can be listed as complex numbers (real and imaginary parts), or as magnitude and phase in the order of increasing frequency. The phase unit has to be degree (°). Load the file to import the S-parameters.
Depending on the measurement setup, you need a `*.s2p` or `*.s1p` file. If the complete measurement setup is a 2-port (1 input and 1 output), you need a `*.s1p` file. This file contains 1 S-parameter, which describes the source impedance.
If the complete measurement setup is a 3-port (2 inputs and 1 output), you need a `*.s2p` file. The measurement setup is a 3-port if it includes a modular probe R&S RT-ZM or differential probe R&S RT-ZD. The `*.s2p` file contains 4 S-parameters, assuming that port 1 is connected to the p-input of the probe, and port 2 to the n-input. The file describes the impedance matching at the ports and the coupling between the ports.

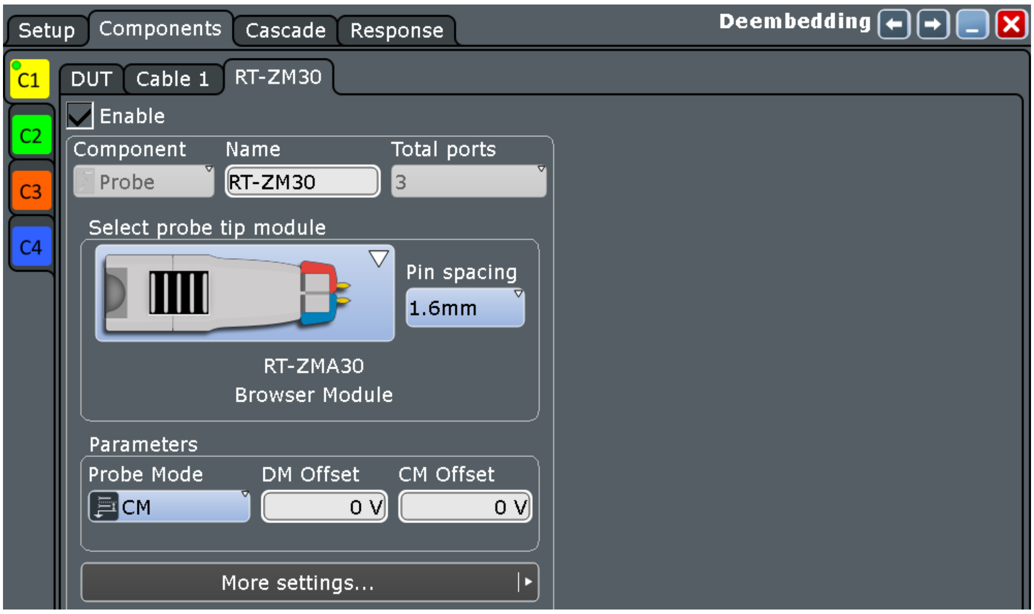
Remote command:
`PROBe<m>:DEEMbedding:LOAD[:TYPE]` on page 1033
`DEEMbedding<m>:COMPonent<n>:LOAD[:TYPE]` on page 1841
`PROBe<m>:DEEMbedding:LOAD:FILE` on page 1034
`DEEMbedding<m>:COMPonent<n>:LOAD:FILE` on page 1842

Source impedance
Impedance of the DUT. Shows the default source impedance or sets the user-defined constant impedance value. If an R&S RT-ZM probe is connected, the value depends on the selected probe mode: common mode, differential, or single-ended measurement.

Remote command:
`DEEMbedding<m>:COMPonent<n>:LOAD:IMPedance` on page 1842
`PROBe<m>:DEEMbedding:LOAD:IMPedance` on page 1034

17.2.4 R&S RT-ZM Probe Settings

If an R&S RT-ZM modular probe is connected to a channel input, the probe is detected by the oscilloscope and automatically added to the measurement path. The S-parameters of the probe, the tip modules, and the probe group delay are known to the oscilloscope and used for deembedding.



Probe settings that are important for deembedding can be set directly in the deembedding dialog.

To get all probe deembedding settings:

1. In the "Deembedding" > "Components" > "RT-ZMxx" tab, select "More Settings".
2. In the "Probes Setup" dialog box, select "Probe Deembedding".

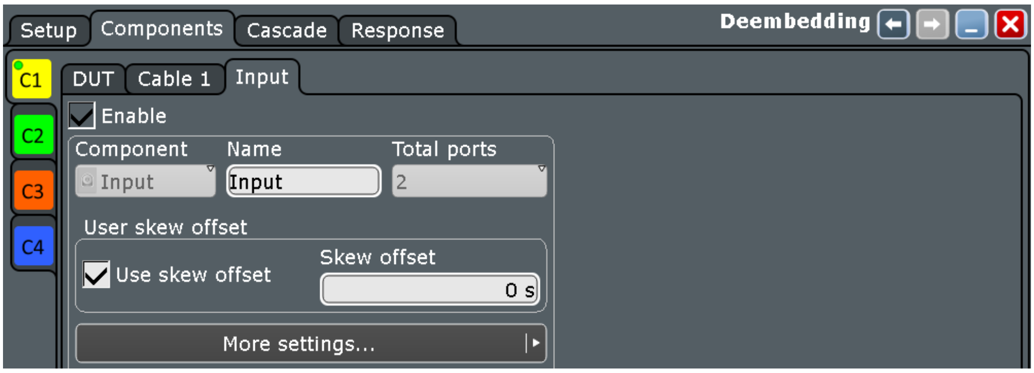
The "Probe Deembedding" dialog box is described in Chapter 4.5.5.2, "Deembedding for Modular Probes", on page 152.

For details on probe parameters, see:

- "Select probe tip module, Pin spacing" on page 153
- "Probe Mode" on page 151
- "DM Offset, CM Offset, P Offset, N Offset" on page 152

17.2.5 Input Settings for Other Probes

The "Input" component is used for all probes except for R&S RT-ZM, R&S RT-ZD andR&S RT-ZS probes with Rohde & Schwarz interface, and for cables or other components that are used to connect the measurement setup to the oscilloscope. For these input components, the horizontal skew and vertical settings are considered during deembedding. You can set the skew directly in the "Deembedding" > "Components" > "Input" tab, or in "Horizontal" menu > "Skew". The button "More Settings" opens the "Channels" settings.



For details, see:

- "Use skew offset" on page 174
- "Skew offset" on page 174

17.2.6 Cable, Adapter, Fixture and Custom Settings

If you have added a cable, adapter, test fixture or other component to the measurement setup, you set the characteristics in the corresponding subtabs of the "Deembedding" > "Components" tab.

The characteristics are the same for these component types. Configuration differs between 2-port and 4-port components, because 4-ports need additional settings. Generally, these components are configured by loading S-parameter files and analyzing its characteristics.

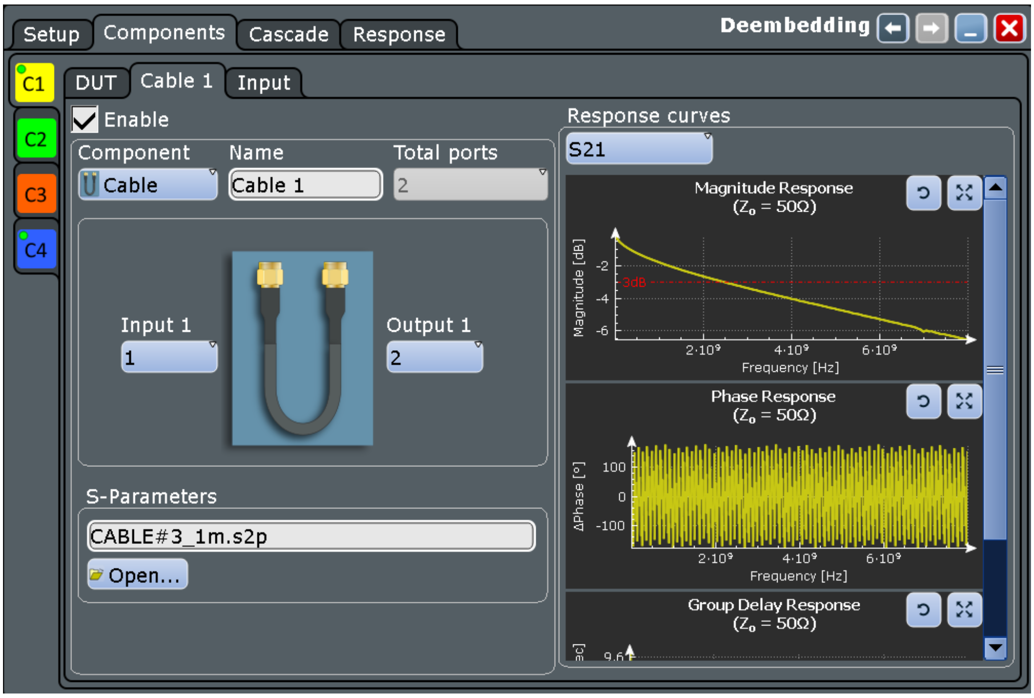


Figure 17-1: 2-port setup: deembedding settings for a cable

To configure a component in a single-ended 2-port setup

1. Tap "Open".
2. Select and load the `*.s2p` Touchstone file that contains the S-parameters of the component. The filetype is always `*.s2p`.
3. Assign the ports to the input and output of the component according to the data in the Touchstone file. See also: "Input 1, Input 2, Output 1, Output 2" on page 918.
4. Analyze the response curves of each S-parameter. The response curves are functions of magnitude, phase, and group delay over frequency.
   a) Select the S-parameter.
   b) Check the response curves. The display is based on a reference impedance of Z0 = 50 Ω.

   The response curves show:
   - The correctness of the S-parameter file.
   - The correct setting of the input and output ports ("Input 1", "Output 1")
   - The characteristics of the component.
5. If the component is configured correctly, tap "Enable" to include it in the deembedding setup.

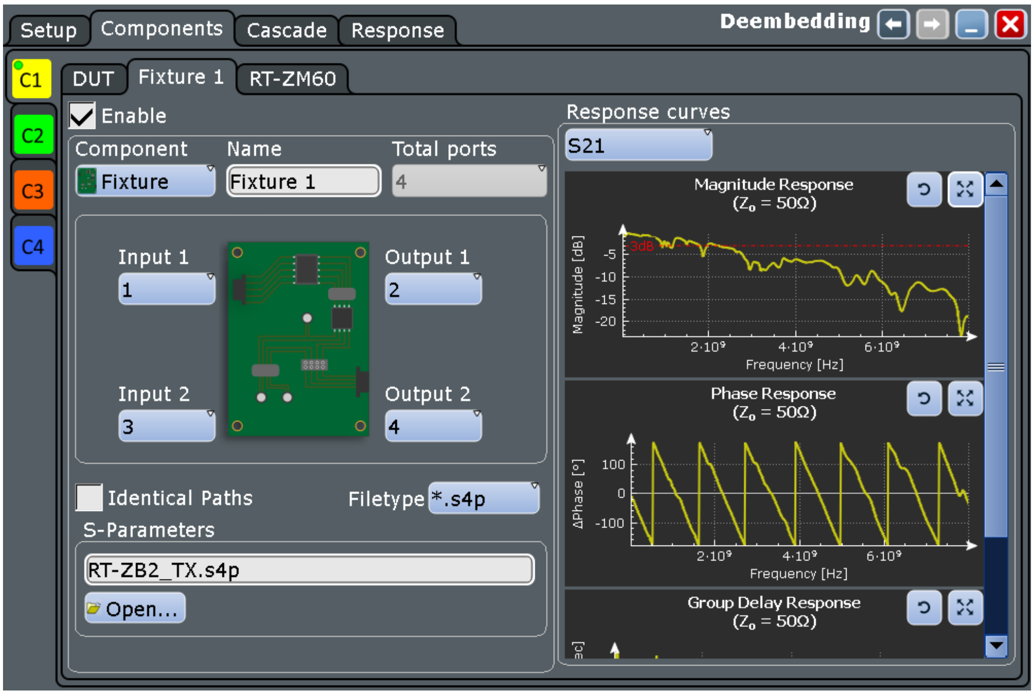


Figure 17-2: 4-port setup and 4-port component: deembedding settings of a fixture

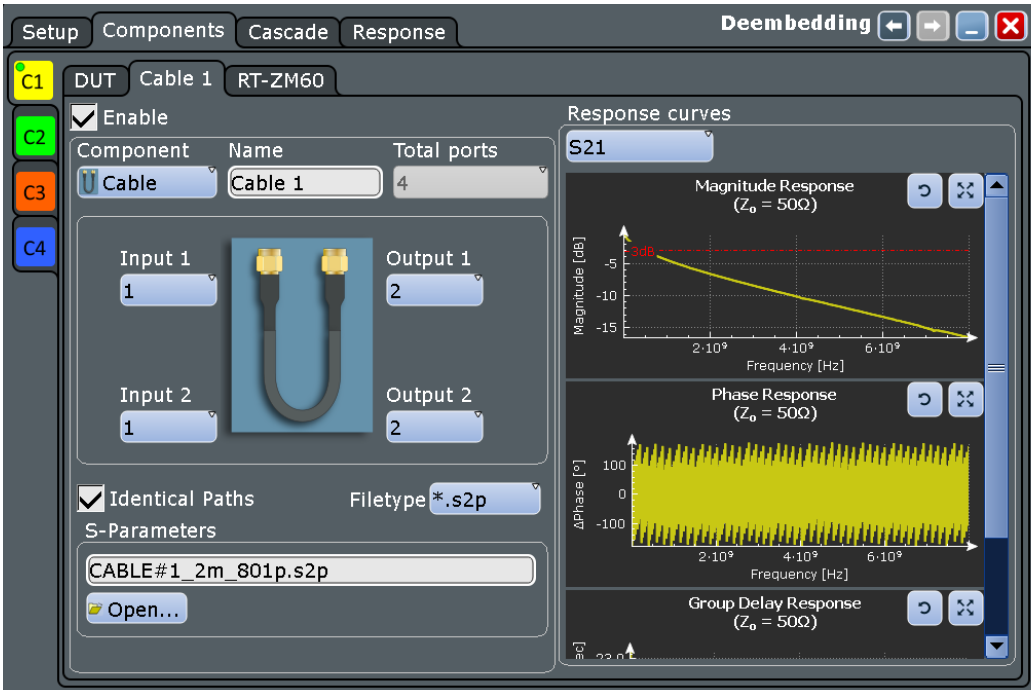


Figure 17-3: 4-port setup and 2-port component: deembedding settings of identical cables

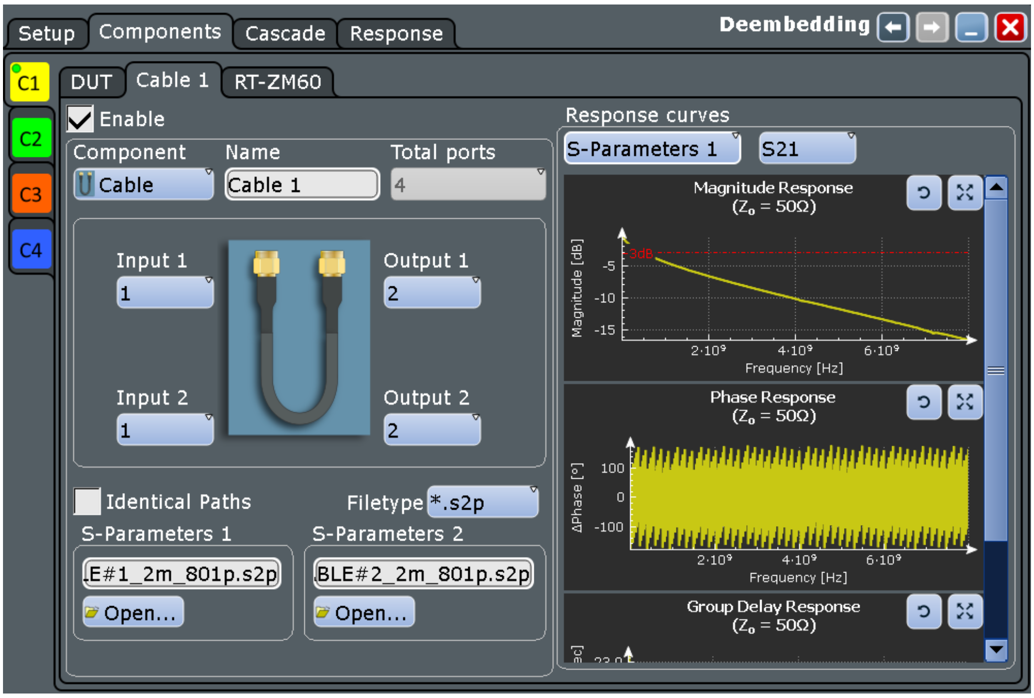


Figure 17-4: 4-port setup and 2-port component: deembedding settings of different cables

To configure a component in a single-ended 4-port setup

1. If the component is a 4-port, i.e. a fixture or custom block, load the `*.s4p` Touchstone file that contains the S-parameters of the component:

a) Tap "Open".
b) Select and load the *.s4p Touchstone file. The filetype is always *.s4p.

2. If the component is a 2-port, i.e. a cable or adapter, typically 2 cables or adapters are used. These components can be different or identical.
   a) If the components are identical, enable "Identical Paths" on page 919. You need 1 *.s2p Touchstone file.
      If the components are different, disable "Identical Paths" on page 919. You need 2 *.s2p Touchstone files, one for each component.
   b) Select the filetype *.s2p.
   c) Tap "Open".
   d) Select and load the *.s2p Touchstone file.
   e) If the components are different, load the second *.s2p Touchstone file in the same way.
3. Assign the ports to the input and output of the component according to the data in the Touchstone file. See also: "Input 1, Input 2, Output 1, Output 2" on page 918.
4. Analyze the response curves of each S-parameter. You can analyze magnitude, phase and group delay response, which are functions of frequency.
   a) Select the S-parameter.
   b) Check the response curves. The display is based on a reference impedance of Z0 = 50 Ω.
      The response curves show:
      - The correctness of the S-parameter file.
      - The correct setting of the input and output ports ("Input 1", "Output 1")
      - The characteristics of the component.
5. If the component is configured correctly, tap "Enable" to include it in the deembedding setup.

Response curves are described in Chapter 17.3.1, "Responses of the Component Cascade ", on page 919.

Input 1, Input 2, Output 1, Output 2
Assign the ports to the input and output of the component according to the data in the Touchstone file. This information is not directly written in the file. You need background information how the S-parameters were determined, i.e. which port was input and which port was output. If in doubt, the response curves help assigning the ports correctly.

Remote command:
`DEEMbedding<m>:COMPonent<n>:IPONe` on page 1844
`DEEMbedding<m>:COMPonent<n>:IPTWo` on page 1844
`DEEMbedding<m>:COMPonent<n>:OPONe` on page 1844
`DEEMbedding<m>:COMPonent<n>:OPTWo` on page 1844

Identical Paths

The setting is relevant if the measurement setup is a 4-port, and the component is a 2-port. Usually, these components are cables and adapters, which are described by `*.s2p` files. If there is a 4-port setup, 2 cables or 2 adapters are used. If there is no crosstalk in-between, each cable or adapter can be described by a `*.s2p` file.

If both components are different, each is described by its own `*.s2p` file. If they are identical, for example, when a matched-pair cable is used, they can be described by the same file. In this case, enable "Identical Paths".

Remote command:
`DEEMbedding<m>:COMPonent<n>:IDENtical` on page 1844

S-Parameters, Filetype

Loads the Touchstone file that contains the S-parameters of the component.

If the measurement setup is a 2-port, the filetype is always `*.s2p`.

If the measurement setup is a 4-port, the selection depends on the component. Fixtures and custom blocks are usually 4-ports, and they are described by `*.s4p` S-parameter files.

Cables and adapters are usually 2-ports, and they are described by `*.s2p` S-parameter files. If there is a 4-port setup, 2 cables or 2 adapters are used. You need 2 different files if the components are different, or only 1 file if they are identical (see also "Identical Paths" on page 919).

Remote command:
`DEEMbedding<m>:COMPonent<n>:SPONe` on page 1845
`DEEMbedding<m>:COMPonent<n>:SPTWo` on page 1845

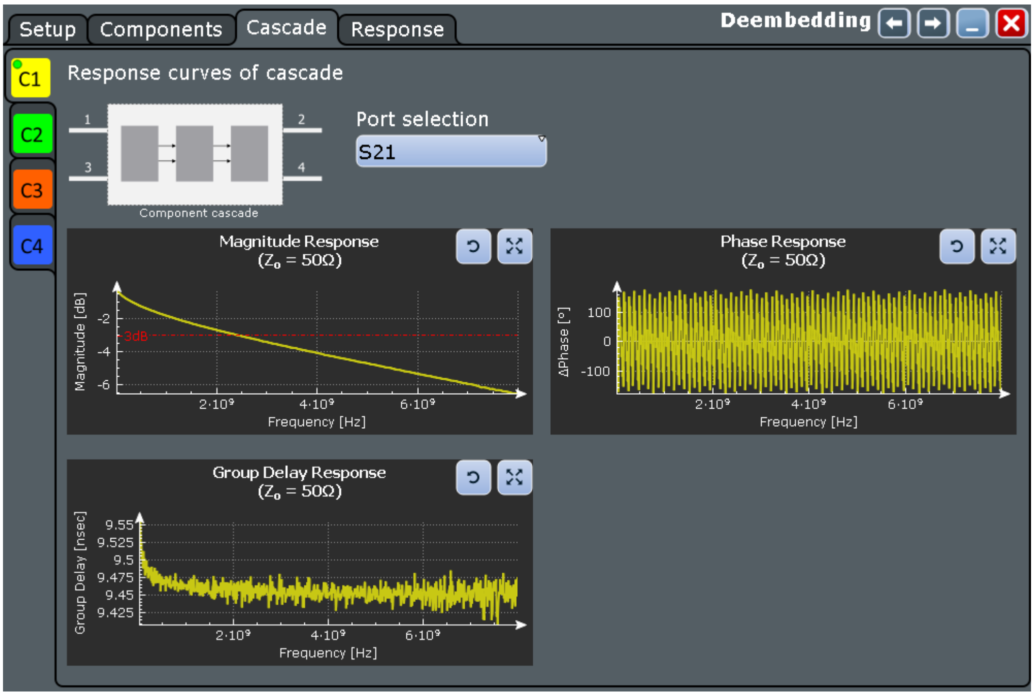
17.3 Responses

17.3.1 Responses of the Component Cascade

The "Deembedding" > "Cascade" tab combines the S-parameters of all included components and shows the response curves of the measurement setup for each S-parameter:

- Magnitude response
- Phase response
- Group delay response

While the response curves on the component tabs show the S-parameter characteristics of a single component, the cascade shows the combined characteristics for all components including the mismatch between the components. The DUT is not considered.



Port selection
Selects the S-parameter. The response curves (magnitude, phase, and group delay response) of the setup cascade for the selected parameter are shown. You can refresh each graphic, and display it on full screen.

17.3.2 Responses of the Measurement Setup

On the "Deembedding" > "Response" tab, you see the resulting transfer function characteristics of the deembedded measurement setup. These response curves include also the characteristics of the DUT and its interaction with the input connector of the oscilloscope.

You can see the following characteristics:

- Magnitude response
- Phase response
- Group delay response
- Step response

Using these response curves, you can assess the correction of the signal by deembedding. In particular, you can compare realtime deembedding with software deembedding and check whether the accuracy of the realtime deembedding is sufficient for the measurement task.

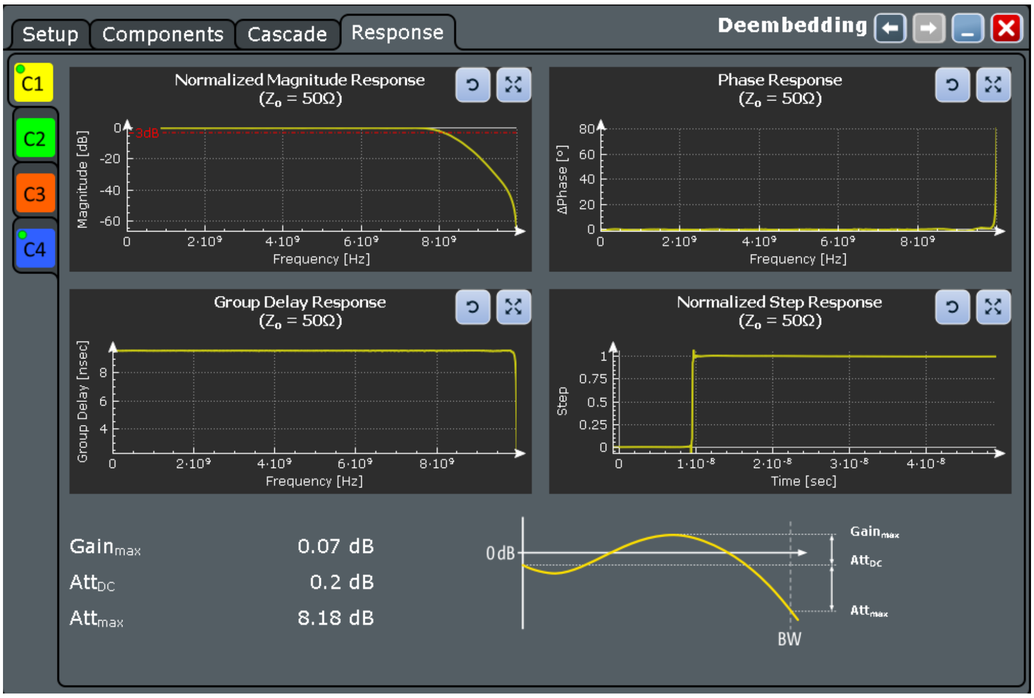


Figure 17-5: Characteristics of the deembedded measurement setup

► To see more details in a response graphic, tap the upper right button in the graphic.

The graphic opens in full view, where you can analyze the response function: zoom in and out, use the cursor.

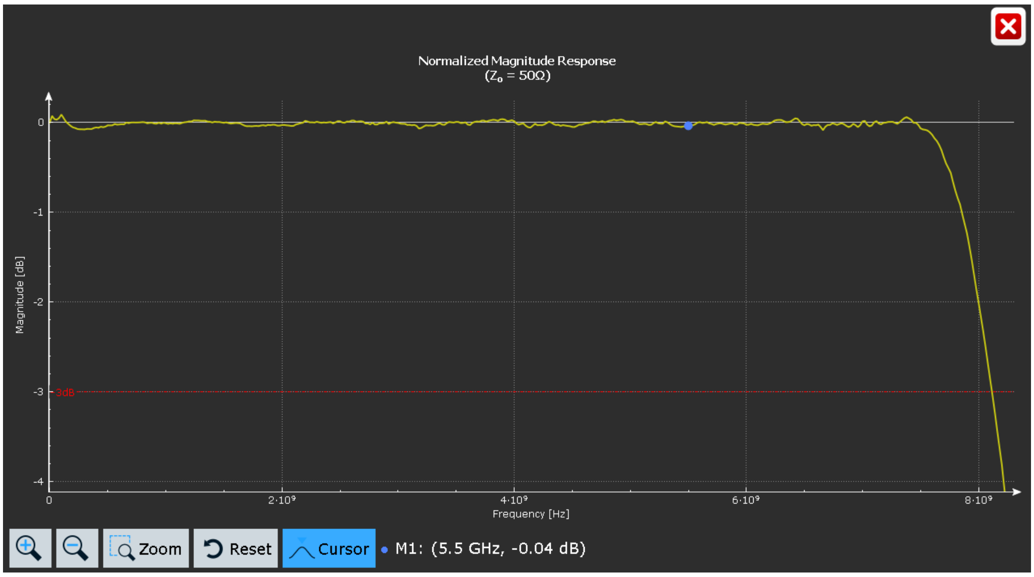


Figure 17-6: Full view of the step response

On the "Response" tab, you see also some parameters of the uncorrected measurement setup including the DUT. All parameters are related to a frequency range from DC to the configured effective bandwidth.

Att_{max}
Maximum attenuation of the measurement setup before deembedding, with reference to a frequency response normalized at DC to 0 dB. The deembedding filter must amplify the amplitude response by the "Att_{max}" value, and thus also increases the noise by this value. The value also helps to decide whether deembedding is useful for the defined effective bandwidth.

Remote command:
`DEEMbedding<m>:MATTenuation?` on page 1845

Att_{DC}, $Gain_{DC}$
Maximum attenuation or gain of the measurement setup before deembedding at DC. This value is the expected basic attenuation or gain, which is corrected by deembedding.

Remote command:
`DEEMbedding<m>:CADC?` on page 1845

$Gain_{max}$
Maximum gain of the measurement setup before deembedding, with reference to a frequency response normalized at DC to 0 dB. The deembedding filter must attenuate the amplitude response by this value. The value helps also to avoid an overload of the ADC.

Remote command:
`DEEMbedding<m>:MGAin?` on page 1846

18 Compliance Tests

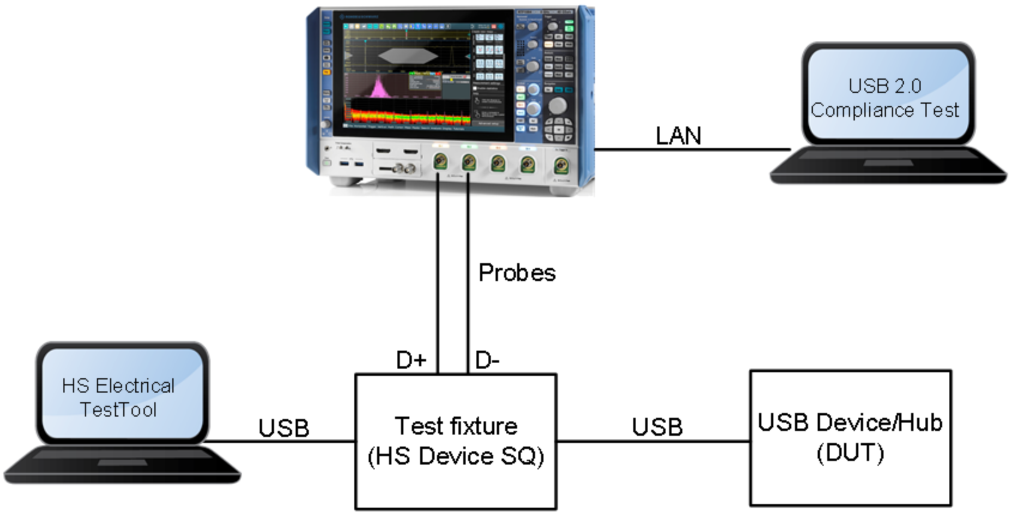
Thanks to the high measurement accuracy of the R&S RTP, the oscilloscope can be used for reliable compliance testing on the physical layer of high-speed bus interfaces. For fast and easy compliance testing, you need the free-of-charge R&S ScopeSuite. The software guides you step-by-step through the test sequences, configures the oscilloscope, automatically performs measurements and compiles the results in a measurement report. Detailed, image-based instructions make it easy to connect the oscilloscope and the probes to the test fixture set and the device under test.

The R&S ScopeSuite can be installed on a test computer or directly on the R&S RTP. If the R&S ScopeSuite is installed on the oscilloscope, you can start it directly in the firmware menu: "Analysis" menu > "Start Compliance Test".

18.1 USB 2.0 Compliance Test (Option R&S RTP-K21)

The R&S RTP-K21 option enables the automatic testing of USB 2.0 compliance (high-speed) as well as USB 1.1 (full-speed) and USB 1.0 (low-speed).

As an example, the test setup for USB device tests is shown below.



The test fixture and the USB compliance test procedures are described in separate manuals:

- "USB 2.0 Compliance Tests, Test Procedures Manual"
- "R&S®RT-ZF1 USB 2.0 Compliance Test Fixture Set, Manual"

18.1.1 Test Equipment

For USB 2.0 compliance tests, the following test equipment is recommended:

- R&S RTP oscilloscope with 4 channels and at least 2 GHz bandwidth.

For full speed and low speed compliance tests, a 4-channel R&S RTP with less than 2 GHz bandwidth is sufficient.

- R&S RT-ZF1 USB 2.0 compliance test fixture set, which consists of the load board and the signal quality board.
- Probes:
  – 2x single-ended active probes with at least 2 GHz bandwidth
  – 1x differential active probe with at least 2 GHz bandwidth
- R&S RTO-B6/R&S RTP-B6/HMF2550/Tabor WX2182B/WX2182C arbitrary waveform generator for automatic receiver sensitivity tests.
  For manual receiver sensitivity tests, any AWG can be used.
- R&S ScopeSuite software, which can be installed on a computer or directly on the R&S RTP.
- R&S RTP-K21 USB 2.0 compliance test option (required option, installed on the R&S RTP)
- Make sure that you use the latest version of the USBHSET tool. Check the following websites for downloads:
  – USB 3.0 host: www.usb.org/developers/tools/
  – USB 2.0 host: www.usb.org/developers/tools/usb20_tools/

  Regularly check the USB-IF website compliance.usb.org/index.asp?UpdateFile=Electrical&Format=Standard for USB-IF compliance updates.

18.2 Ethernet Compliance Tests (Option R&S RTP-K22/K23/K25/K86)

The Ethernet compliance test options enable the automatic testing of various Ethernet standards like 10BASE-T, 100BASE-TX, 1000BASE-T, 2.5GBASE-T, 5GBASE-T, 10GBASE-T.

The test fixture and the Ethernet compliance test procedures are described in the separate manuals:

- Ethernet Compliance Tests, Test Procedures Manual"
- "R&S®RT-ZF2 Ethernet Compliance Test Fixture Set, Manual"

18.2.1 Test Equipment

For Ethernet compliance tests, the following test equipment is needed:

- **10/100/1000BASE-T Ethernet compliance tests:**
  – R&S RTO/R&S RTP oscilloscope with at least 600 MHz bandwidth
  – Differential probe with at least 1 GHz bandwidth
  – R&S RTO/R&S RTP-K22 10/100/1000BASE-T Ethernet compliance test option (required option, installed on the osilloscope)
  – R&S RT-ZF2 Ethernet test fixture set

- For energy-efficient Ethernet tests, in addition:
  R&S RTP-K86 EEE test option
  R&S RT-ZF5 Ethernet test fixture set for 100/1000BASE-T EEE tests
  R&S RT-ZF4 test fixture for 10BASE-Te tests

- **2.5GBASE-T Ethernet compliance tests:**
  - R&S RTO/R&S RTP oscilloscope with at least 600 MHz bandwidth
    For precise power spectral density and power level measurements up to 1 GHz, it is recommended to use an oscilloscope and a differential probe with 1 GHz bandwidth each.
  - Differential probe with at least 1GHz bandwidth
  - R&S RTO/R&S RTP -K25 2.5/5GBASE-T Ethernet compliance test option (required option, installed on the R&S RTP)
  - R&S RT-ZF2 Ethernet test fixture set
- **5GBASE-T Ethernet compliance tests:**
  - R&S RTO/R&S RTP oscilloscope with at least 1 GHz bandwidth
    For precise power spectral density and power level measurements up to 1.5 GHz, it is recommended to use an oscilloscope and a differential probe with 1.5 GHz bandwidth each.
  - Differential probe with at least 1.5 GHz bandwidth
  - R&S RTO/R&S RTP -K25 2.5/5GBASE-T Ethernet compliance test option (required option, installed on the R&S RTP)
  - R&S RT-ZF2 Ethernet test fixture set
- **10GBASE-T Ethernet compliance tests:**
  - R&S RTO/R&S RTP oscilloscope with at least 2 GHz bandwidth
    For precise power spectral density and power level measurements up to 3 GHz, it is recommended to use an oscilloscope and a differential probe with 3 GHz bandwidth each.
  - Differential probe with at least 3 GHz bandwidth
  - R&S RTO/R&S RTP-K23 10GBASE-T Ethernet compliance test option (required option, installed on the R&S RTP)
  - R&S RT-ZF2 Ethernet test fixture set
- **100BASE-T1 compliance tests:**
  - R&S RTO/R&S RTP oscilloscope with at least 600 MHz bandwidth
  - Differential probe with 1 GHz bandwidth
  - R&S RTO/R&S RTP -K24 100BASE-T1 compliance test option (required option, installed on the R&S RTP)
  - R&S RT-ZF2 Ethernet test fixture set
  - R&S RT-ZF3 Frequency converter for test cases that require an ARB generator
- **1000BASE-T1 compliance tests:**
  - R&S RTO/R&S RTP oscilloscope with at least 2 GHz bandwidth
  - Differential probe with 2 GHz bandwidth
  - R&S RTO/R&S RTP-K87 100BASE-T1 compliance test option (required option, installed on the R&S RTP)

  - R&S RT-ZF2 Ethernet test fixture set
  - R&S RT-ZF3 Frequency converter for test cases that require an ARB generator
- The free-of-charge R&S ScopeSuite software, which can be installed on a computer or directly on the oscilloscope.
- R&S RTO-B6/R&S RTP-B6/HMF2550/Tabor WX2182B/WX2182C arbitrary waveform generator for automatic disturber tests.
- R&S ZVL/ZNB/ZNC/ZND vector network analyzer for automatic return loss measurements.
  For manual measurements, also other AWGs and VNAs can be used.

18.3 D-PHY Compliance Tests (Option R&S RTP-K26)

The option R&S RTP-K26 enables the automatic processing of D-PHY compliance tests.

The D-PHY compliance test procedures are described in a separate manual:

- MIPI D-PHY Compliance Tests, Test Procedures Manual"

18.3.1 Test Equipment

For D-PHY compliance tests, the following test equipment is needed:

- R&S RTP oscilloscope with 4 channels and at least 4 GHz bandwidth
- For measuring the clock signal (+ and -): either 1 differential probe or 2 single-ended probes with at least 4 GHz bandwidth. However, note that D-PHY Group 2 and Group 4 tests require 2 probes for the clock signal.
- For measuring the data signal (+ and -): 2 probes with at least 4 GHz bandwidth
- R&S RTP-K26 D-PHY compliance test option (required option, installed on the oscilloscope)
- Recommended test fixture for LP-TX tests: MIPI D-PHY Capacitive Load (C_{LOAD}) Fixture from The University of New Hampshire InterOperability Laboratory (UNH-IOL)
- Recommended termination board for HS-TX tests: MIPI D-PHY Reference Termination Board (RTB) from The University of New Hampshire InterOperability Laboratory (UNH-IOL)
- The free-of-charge R&S ScopeSuite software, which can be installed on a computer or directly on the oscilloscope.

19 Network and Remote Operation

This chapter describes the usage of the embedded operating system on the instrument, the setup of network connections, and the interfaces and protocols used for remote control. It also explains how to start a remote control session.

This chapter contains the following sections:

19.1 Operating System

The R&S RTP has a Windows operating system.

The operating system has been configured according to the instrument's features and needs. To ensure that the instrument software functions properly, certain rules must be observed when using the operating system.

NOTICE

Risk of rendering instrument unusable

The instrument is equipped with the Windows operating system. You can install additional software on the instrument, however, additional software can impair instrument function. Thus, run only programs that Rohde & Schwarz has tested for compatibility with the instrument software.

The drivers and programs used on the instrument under Windows are adapted to the instrument. Only install update software released by Rohde & Schwarz to modify existing instrument software.

Changes in the system setup are only required if the network configuration does not comply with the default settings (see Chapter 19.2.1, "Connecting the Instrument to the Network", on page 930).

19.1.1 Virus Protection

Take appropriate steps to protect your instruments from infection. Use strong firewall settings and scan any removable storage device used with a Rohde & Schwarz instrument regularly. It is also recommended that you install anti-virus software on the instrument. Rohde & Schwarz does NOT recommend running anti-virus software in the background ("on-access" mode) on Windows-based instruments, due to potentially degrading instrument performance. However, Rohde & Schwarz does recommend running it during non-critical hours.

For details and recommendations, see the following Rohde & Schwarz white paper:

- 1EF96: Malware Protection Windows 10

19.1.2 Service Packs and Updates

Microsoft regularly creates security updates and other patches to protect Windows-based operating systems. These are released through the Microsoft Update website and associated update server. Instruments using Windows, especially those that connect to a network, should be updated regularly.

For details and recommendations, see the following Rohde & Schwarz white paper:

- 1EF96: Malware Protection Windows 10

19.1.3 Logon

Windows requires that users identify themselves by entering a user name and password in a logon window.

If the instrument is connected to the network, you are automatically logged on to the network when you log on to the operating system. As a prerequisite, the user name and the password must be identical under Windows and on the network. The instrument provides an auto-logon function that can be configured for standard user and administrator access. The configuration requires the user name and password. See also: "Log on as" on page 81

The R&S RTP provides two user accounts:

- "Instrument": an administrator account with unrestricted access to the computer/domain (default user)
- "NormalUser": a standard user account with limited access

For both users, the initial password is "894129". It is recommended that you change the password for both users after initial login. You can change the password in the Windows configuration :"Start" menu > "Settings" > "Accounts" > "Sign-in options". Make sure to change the password also in the auto-logon of the R&S RTP, see below.

By default, the instrument logs on with administrator account and standard password. To restrict the access to system functions, you can change the autologon to "NormalUser".

The following tasks require administrator rights:

- Configuration of a LAN settings, network connection, and firewall settings
- Date and time setup
- Printer installation
- Firmware update
- BIOS update
- Using the web browser

- Touchscreen calibration
- Installation of options
- Moving portable licenses

To configure the auto-logon for a standard user

Default situation: the auto-logon is configured for the administrator ("Instrument").

1. Press the Setup key and select the "System" tab.
2. Set "Logon as" to "User autologon".
3. Enter the "User name": *NormalUser*.
4. Enter the password of the standard user.
5. Restart the instrument.

To configure the auto-logon for administrator

Starting situation: the auto-logon is configured for a standard user ("NormalUser").

1. Press the Setup key and select the "System" tab.
2. Set "Logon as" to "None".
3. Exit the firmware.
4. Sign out from the operating system. and
5. Log in as administrator ("Instrument").
6. Set the "Logon as" to "Admin autologon". Enter the "User name": *Instrument* and the administrator's password.
7. Restart the instrument.

19.1.4 Accessing Windows Functionality

All required Windows settings can be changed using the touchscreen and the on-screen keyboard that is part of the Windows system. However, modification is easier if you connect a mouse and/or keyboard to the instrument.

To access Windows

► On the "File" menu, select "Minimize application".

The application is minimized to the task bar and the "Start" menu becomes available.

To access Windows using an external keyboard

1. To open the "Start" menu, press the Windows key or the CTRL + ESC key combination on your keyboard.
2. To access the desktop, press the Windows key + D on your keyboard.

To access Windows settings directly from the firmware

Important Windows settings can be accessed directly from the R&S RTP interface.

1. Press the Setup key and tap the "System" tab.
2. Select one of the settings buttons to access the corresponding Windows dialog box. Note that modification of most system settings requires administrator rights.

   Once you have opened a Windows dialog box, the task bar and the "Start" menu are also available.

19.2 Setting Up a Network (LAN) Connection

A LAN connection is the prerequisite for all network operations. The LAN connection settings can be configured directly in the Windows operating system.

The R&S RTP is equipped with a network interface and can be connected to an Ethernet LAN (local area network). Provided the network administrator has assigned you the appropriate rights and adapted the Windows firewall configuration, you can use the interface, for example:

- To transfer data between a controlling device and the test device, e.g. to run a remote control program.
- To access or control the measurement from a remote computer using the "Remote Desktop" application (or a similar tool)
- To connect external network devices (e.g. printers)
- To transfer data from a remote computer and back, e.g. using network folders

This section describes how to configure the LAN interface. It includes the following topics:

- Chapter 19.2.1, "Connecting the Instrument to the Network", on page 930
- Chapter 19.2.2, "Assigning the IP Address", on page 931

Only users with administrator rights can configure network connections.

19.2.1 Connecting the Instrument to the Network

There are two methods to establish a LAN connection to the instrument:

- A non-dedicated network (Ethernet) connection from the instrument to an existing network made with an ordinary RJ-45 network cable. The instrument is assigned an IP address and can coexist with a computer and with other hosts on the same network.
- A dedicated network connection (Point-to-point connection) between the instrument and a single computer made with a (crossover) RJ-45 network cable. The computer must be equipped with a network adapter and is directly connected to the

instrument. The use of hubs, switches, or gateways is not required, however, data transfer is still performed using the TCP/IP protocol. You must assign an IP address to the instrument and the computer, see Chapter 19.2.2, "Assigning the IP Address", on page 931.

NOTICE

Risk of network failure

Consult your network administrator before performing the following tasks:

- Connecting the instrument to the network
- Configuring the network
- Changing IP addresses
- Exchanging hardware

Errors can affect the entire network.

► To establish a non-dedicated network connection, connect a commercial RJ-45 cable to one of the LAN ports.
To establish a dedicated connection, connect a (crossover) RJ-45 cable between the instrument and a single PC.

If the instrument is connected to the LAN, Windows automatically detects the network connection and activates the required drivers.

The network card can be operated with a 10/100/1000 Mbps Ethernet IEEE 802.3u interface.

19.2.2 Assigning the IP Address

Depending on the network capacities, the TCP/IP address information for the instrument can be obtained in different ways.

- If the network supports dynamic TCP/IP configuration using the Dynamic Host Configuration Protocol (DHCP), all address information can be assigned automatically.
- If the network does not support DHCP, or if the instrument is set to use alternate TCP/IP configuration, the addresses must be set manually.

By default, the instrument is configured to use dynamic TCP/IP configuration and obtain all address information automatically. This means that it is safe to establish a physical connection to the LAN without any previous instrument configuration.

NOTICE

Risk of network errors

Connection errors can affect the entire network. If your network does not support DHCP, or if you choose to disable dynamic TCP/IP configuration, you must assign valid address information before connecting the instrument to the LAN. Contact your network administrator to obtain a valid IP address.

Assigning the IP address on the instrument

1. Press the [Setup] key.
2. Select the "System" tab.
3. Tap "Network".
4. Select "Ethernet".
5. Select "Properties".
6. On the "Networking" tab, select "Internet Protocol Version 4 (TCP/IPv4)", and then select "Properties".
7. Select "Use the following IP address".
8. Enter the address information as obtained from the network administrator.

19.2.3 Using Computer Names

In a LAN that uses a DNS server (Domain Name System server), each PC or instrument connected in the LAN can be accessed via an unambiguous computer name instead of the IP address. The DNS server translates the host name to the IP address. This is especially useful when a DHCP server is used, as a new IP address may be assigned each time the instrument is restarted.

Each instrument is delivered with an assigned computer name, but this name can be changed.

The default instrument name is a non-case-sensitive string with the following syntax:

<Type><variant>-<serial_number>

The serial number can be found on the rear panel of the instrument. It is the third part of the device ID printed on the bar code sticker:

ID: 1419.0035K02 - 102030 - Zd

Serial Number

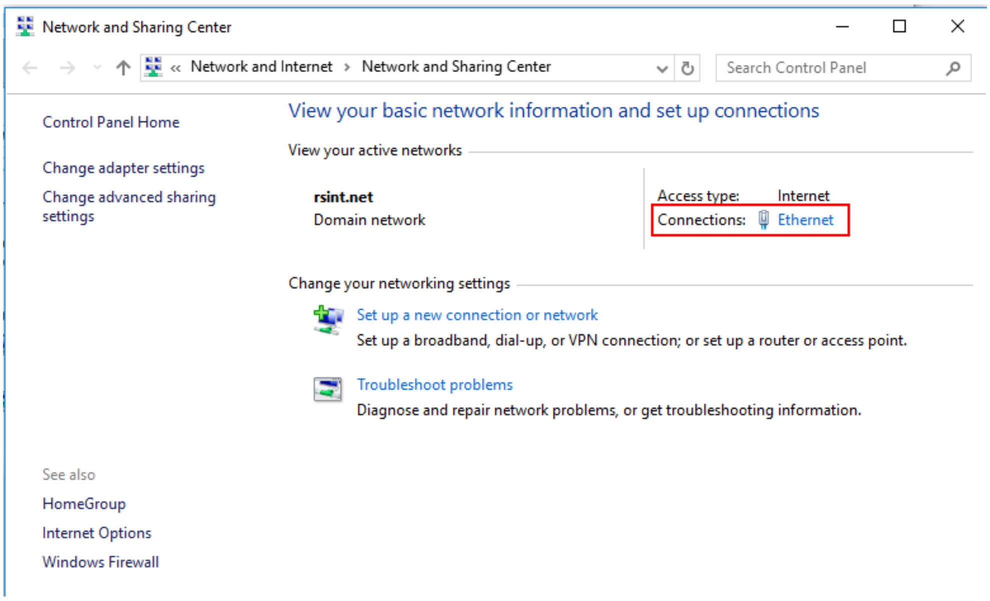
To change the computer name

1. Press the [Setup] key and select the "System" tab.
   The current computer name is displayed and can be edited.
2. Alternatively, tap "System" on the "System" tab.
3. Select "Change", enter the new computer name and confirm the entry.

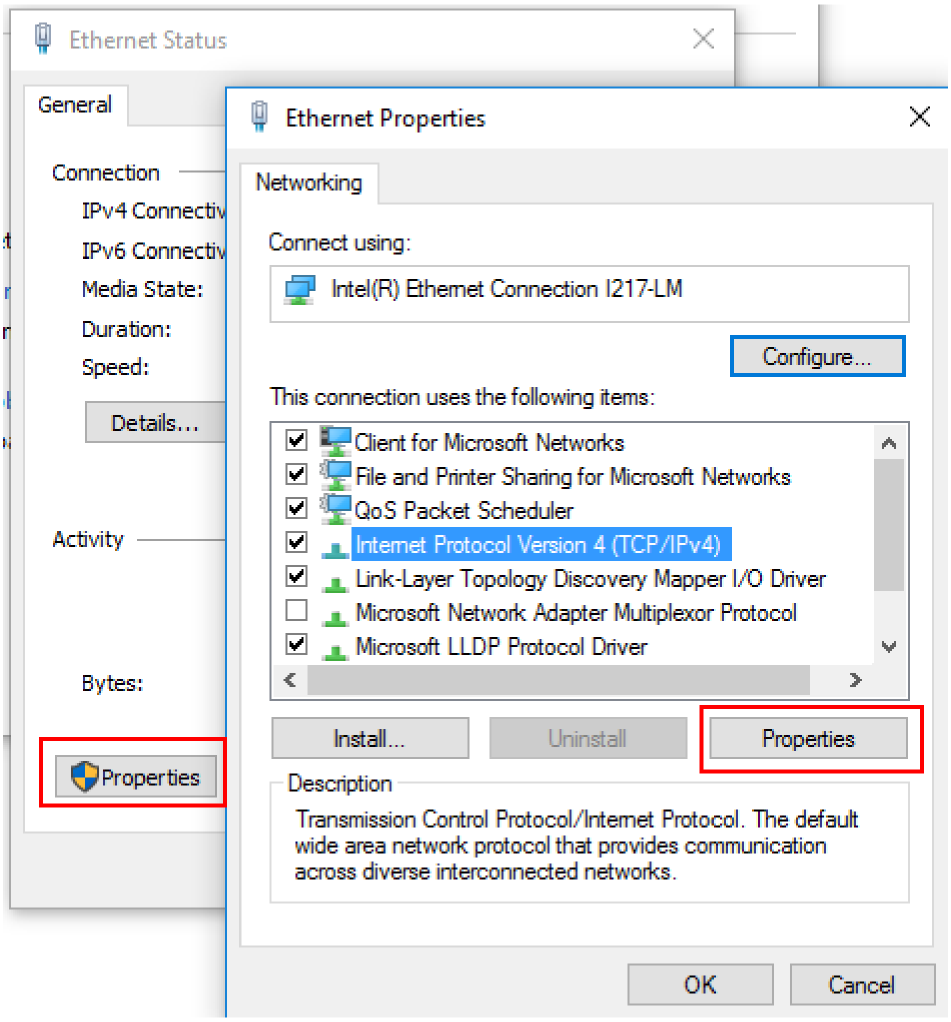
Using a DNS server to determine the IP address

If a DNS server is configured on the R&S RTP, the server can determine the current IP address for the connection using the permanent computer name.

1. Obtain the name of your DNS domain and the IP addresses of the DNS and WINS servers on your network.
2. Press the [Setup] key.
3. Select the "System" tab.
4. Tap "Network".
5. Select "Ethernet".



6. On the "Networking" tab, select "Internet Protocol Version 4 (TCP/IPv4)", and then select "Properties".



7. On the "General" tab, select "Use the following DNS server addresses" and enter your own DNS addresses.

   For more information, refer to the Windows operating system help.

19.2.4 Changing the Windows Firewall Settings

A firewall protects an instrument by preventing unauthorized users from gaining access to it through a network. Rohde & Schwarz highly recommends the use of the firewall on your instrument. Rohde & Schwarz instruments are shipped with the Windows firewall enabled and preconfigured in such a way that all ports and connections for remote control are enabled.

For more details on firewall configuration, see the following Rohde & Schwarz White Paper:

- 1EF96: Malware Protection Windows 10

Note that changing firewall settings requires administrator rights.

19.3 Web Interface

If the R&S RTP is connected to a computer via LAN, you can operate the instrument from a computer. No additional tools are required, you need only a web browser.

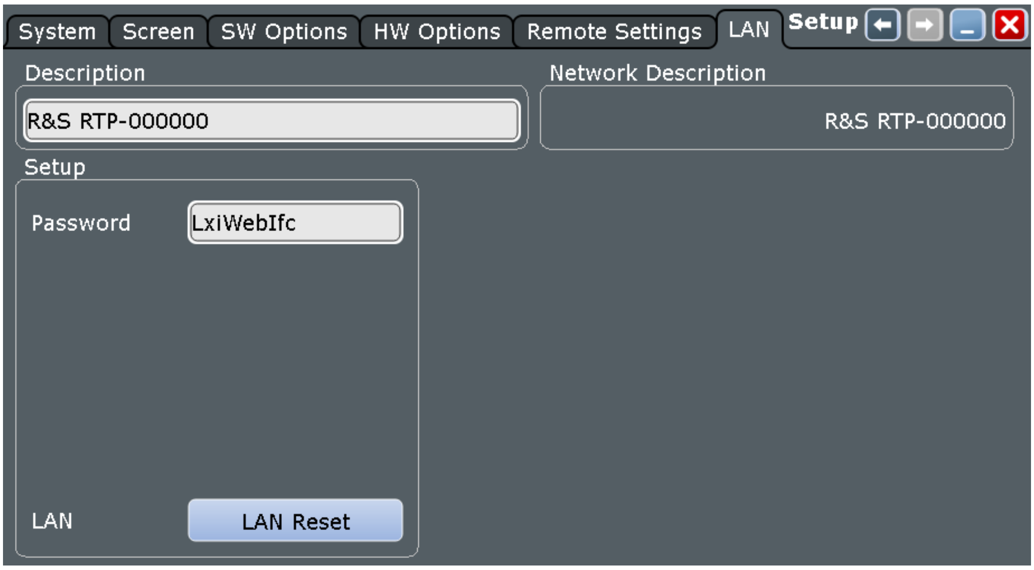
19.3.1 Settings on the R&S RTP

Access: "File" menu > "Setup" >"LAN" tab.

The LAN status icon on the toolbar of the R&S RTP indicates the status of the LAN connection. A green icon indicates that the instrument is connected to the LAN; a red symbol indicates an error - mostly the LAN cable is not connected.

The "LAN" tab of the "Setup" dialog box provides network information.

Only users with administrator rights can change LAN settings.



Description
Instrument description of the R&S RTP.

Password
Password for LAN configuration. The default password is *LxiWebIfc*.

LAN Reset
Resets the LAN configuration to its default settings using the network configuration reset mechanism (LCI) for the instrument. The following parameters are reset:

Parameter	Value
TCP/IP mode	DHCP + auto IP address
Dynamic DNS	Enabled
ICMP ping	Enabled
Password for LAN configuration	LxiWebIfc

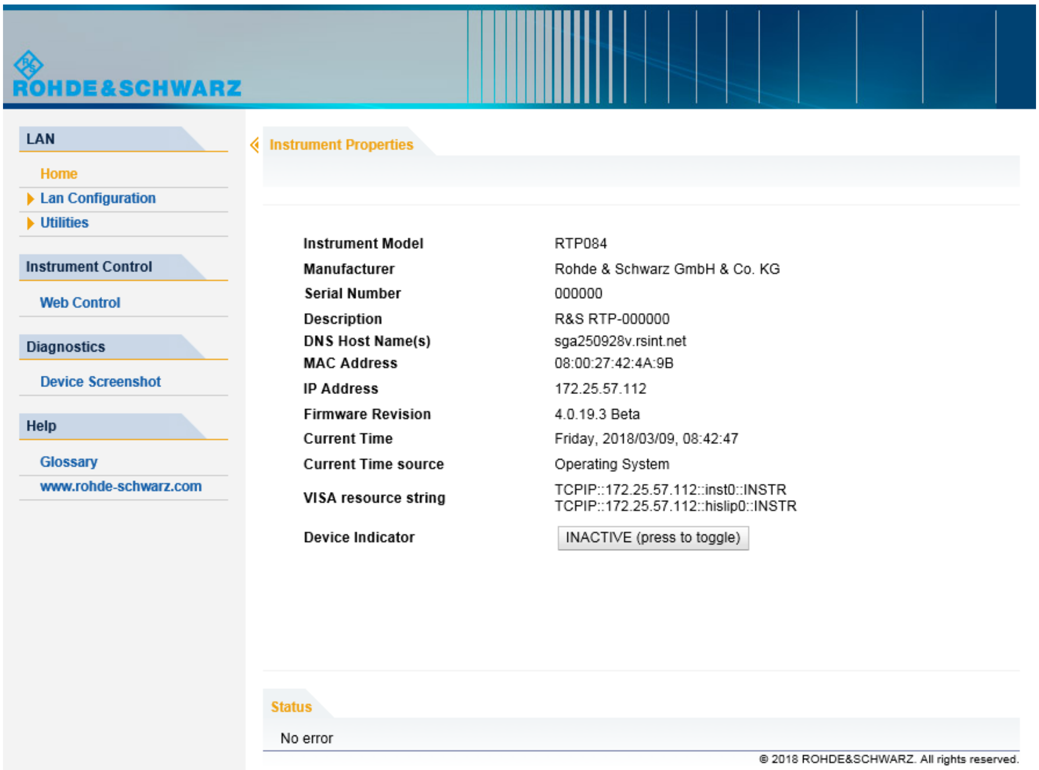
The LAN settings are configured using the instrument's web browser.

19.3.2 Web Browser

The instrument's web interface works with all W3C compliant browsers. Only users with administrator rights on the instrument can use the web interface.

1. Open a web browser on the computer.
2. Type the instrument's host name or IP address in the address field of the browser on your PC, e.g. "http://10.113.10.203".

   The instrument home page opens.



The instrument home page displays the device information required by the LAN standard including the VISA resource string in read-only format.

► To update the "Host Name", press the "Device Indicator" button. The "Device Indicator" is not password-protected.

The most important items in the navigation menu of the browser interface are the following :

- "LAN Configuration" opens the menu with configuration pages.
- "Status" displays information about the status of the instrument.
- "Utilities > Logging" shows log messages and provides buttons to download or clear the logfile.
- "Web Control" emulates the front panel and shows the instrument display. You see a live image of the instrument, and you can operate the instrument remotely. You can use the keys, the knobs and the menus in the same way as directly on the instrument.
- "Device Screenshot": creates a screenshot of the display.
- "Help" provides a glossary of terms related to the standard, and a link to the Rohde & Schwarz Internet site.

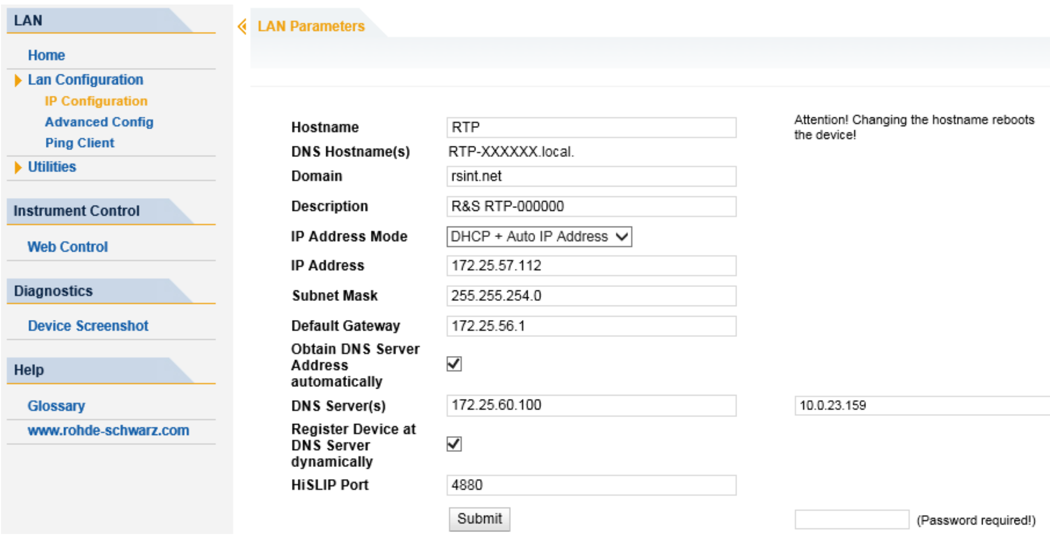
19.3.2.1 LAN Configuration

The LAN configuration consists of three parts:

- "IP configuration" provides all mandatory LAN parameters.
- "Advanced LAN Configuration" provides LAN settings that are not declared mandatory by the standard.
- "Ping Client" provides the ping utility to verify the connection between the instrument and other devices.

IP Configuration

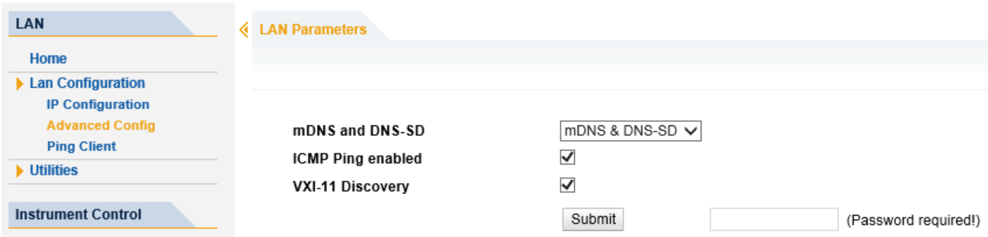
The "LAN Configuration > IP configuration" web page displays all mandatory LAN parameters and allows their modification.



The "TCP/IP Mode" configuration field controls how the IP address for the instrument gets assigned (see also Chapter 19.2.2, "Assigning the IP Address", on page 931). For the manual configuration mode, the static IP address, subnet mask, and default gateway are used to configure the LAN. The automatic configuration mode uses DHCP server or Dynamic Link Local Addressing (automatic IP) to obtain the instrument IP address.

Changing the LAN configuration is password-protected. The password is *LxiWebIfc* (notice upper and lower case characters). This password cannot be changed in the current firmware version.

Advanced Config



The "LAN Configuration > Advanced Config" parameters are used as follows:

- mDNS and DNS-SD are two additional protocols: Multicast DNS and DNS Service Discovery. They are used for device communication in zero configuration networks working without DNS and DHCP
- "ICMP Ping" must be enabled to use the ping utility.
- "VXI-11" is the protocol that is used to detect the instrument in the LAN.

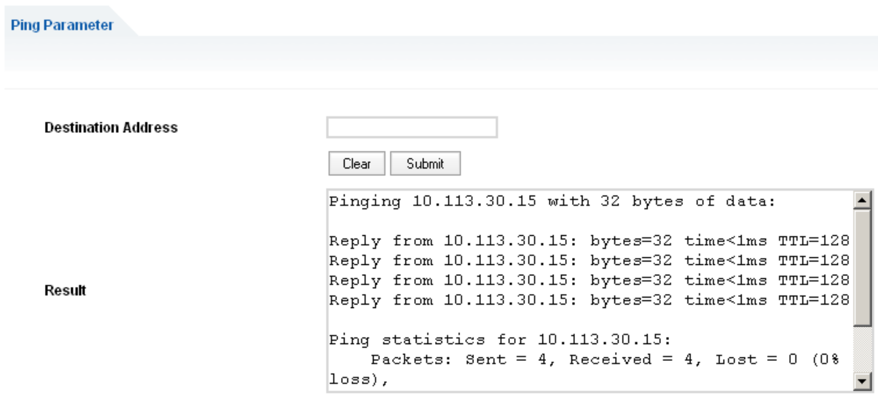
Ping Client

Ping is a utility that verifies the connection between the instrument and another device. The ping command uses the `ICMP` echo request and echo reply packets to determine whether the LAN connection is functional. Ping is useful for diagnosing IP network or router failures. The ping utility is not password-protected.

To initiate a ping between the compliant instrument and a second connected device:

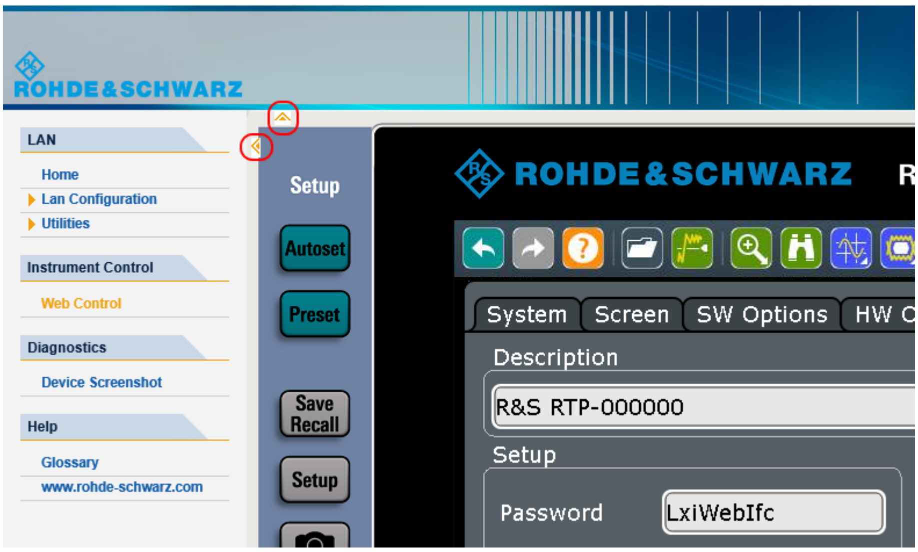
1. Enable "ICMP Ping" on the "Advanced Config" page (enabled by default).
2. On the "Ping Client" page, enter the IP address of the second device **without the ping command and without any further parameters** into the "Destination Address" field (e.g. *10.113.10.203*).

3. Click "Submit".



19.3.2.2 Web Control

"Web Control" emulates the front panel and shows the instrument display. You see a live image of the instrument, and you can operate the instrument remotely. You can use the keys, the knobs and the menus in the same way as directly on the instrument. The Web control replaces VNC as control tool for remote operation.

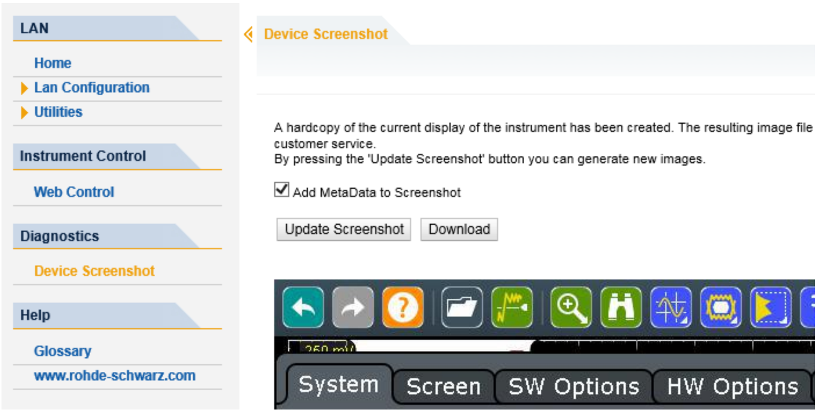


In the upper left corner of the emulated display, you see two arrows:

- The up/down arrow hides or shows the front panel.
- The left/right arrow hides or shows the menu.

19.3.2.3 Device Screenshot

If you click "Device Screenshot", a screenshot of the current instrument display is shown on the computer.



Add MetaData to Screenshot
Adds the instrument information to PNG and JPG files. Meta information is saved as EXIF information and can be read, for example, using the ExifTool, see "Meta information in screenshots" on page 449.

Update Screenshot
Updates the display.

Download
Saves the screenshot to the download directory of the computer. By default, JPG format is saved.

To save the screenshot in PNG format, select "Save as", select "All files" as type, and enter the filename with extension *.png*.

19.4 Remote Desktop Connection

Remote Desktop is a Windows application, which can be used to access and control the instrument from a remote computer through a LAN connection. While the instrument is in operation, the contents of the instrument screen are displayed on the remote computer. Remote Desktop provides access to all applications, files, and network resources of the instrument. Thus, remote operation of the instrument is possible.

NOTICE

Risk of unauthorized access

If you enable the Windows Remote Desktop application on the instrument, anyone using the network who knows the computer name and login data can access it. To prevent unauthorized access, make sure that the Remote Desktop application on the instrument is disabled: "Start" > "Settings" > "Control Panel" > "System"

To set up a Remote Desktop connection

1. Enable remote desktop control on the instrument. See "Enabling remote desktop control on the instrument" on page 941 for details.
2. Connect the instrument and the remote computer to a LAN. See Chapter 19.2.1, "Connecting the Instrument to the Network", on page 930 for details.
3. Set up the Remote Desktop connection between the remote computer and the instrument.

Remote Desktop Connection is part of the operating system and can be accessed via "Start > Windows Accessories > Remote Desktop Connection.".

Enabling remote desktop control on the instrument

1. Press the [Setup] key and select the "System" tab.
2. Tap "System".
3. Select "Remote settings".

   The "Remote" tab of the "System Properties" is shown.
4. Under "Remote Desktop", activate "Allow remote connections to this computer".

   Note: Remote Desktop access and firewall settings.
   When you enable or disable the Windows Remote Desktop option (in the "System Properties"), the associated firewall settings are adapted automatically.
5. If necessary, click "Select Users" and select users who are allowed to access the R&S RTP via Remote Desktop.

   The user account under which configuration is carried out is automatically enabled for Remote Desktop.

Setting up the Remote Desktop connection on the remote computer

1. On the remote computer, select "Start > Windows Accessories > Remote Desktop Connection".
2. Enter the instrument's name or IP address in the dialog box.
   See also Chapter 19.2.2, "Assigning the IP Address", on page 931.
3. Enter the user ID and password for the instrument. See Chapter 19.1, "Operating System", on page 927 for details.
4. Click "Connect".

   When the connection has been set up, the instrument's screen appears on the remote computer.

For detailed information about Remote Desktop and the connection, refer to the Windows Help.

Helpful settings for Remote Desktop

The following settings for the Remote Desktop connection can make working on the remote PC more convenient.

1. When setting up the connection to the instrument, you can configure the connection settings in the "Remote Desktop Connection" dialog box.
   Click the "Show Options".

   The dialog box is expanded to display the configuration data.
2. Customize the settings:
   a) On the "Experience" tab, select the appropriate connection to optimize the connection speed.
   b) On the "Local Resources" tab:
      - To use printers connected to the remote PC while accessing them from the instrument, activate "Printers" under "Local devices and resources".
      - If you want access drives of the remote PC from the instrument, e.g. to store settings or to copy files from the PC to the instrument:
        – Select "More" under "Local devices and resources".
        – Select the "Drives" that are needed.
          Windows maps the selected drives of the remote PC to corresponding network drives. When a connection is established, a warning on the PC indicates that the drives are enabled for access from the instrument.
   c) On the "Display" tab:
      - Use the slider to set the size of the R&S RTP window on the remote PC desktop.
      - Activate "Display the connection bar when in full screen mode".
        A bar with the network address of the instrument is displayed on the screen, which you can use to reduce, minimize or close the window.
   d) On the "General" tab, you can save the connection settings for later use: click "Save As".

Terminating Remote Desktop Control

A Remote Desktop connection can be terminated either on the R&S RTP or on the remote PC. The connection can be established again any time as long as remote control is enabled on the instrument. Consider the notice "Risk of unauthorized access" on page 940.

► To terminate the connection on the remote PC, close the "Remote Desktop" window, or select "Start > Disconnect".

19.5 Remote Control Interfaces and Protocols

The instrument supports different interfaces for remote control. The following table gives an overview.

Table 19-1: Remote control interfaces and protocols

Interface	Protocols, VISA address string	Remarks

Local Area Network (LAN)	**Protocol HiSLIP**
	VISA address string:
	`TCPIP::<host address>::hislip0[,<port>][::INSTR]`
	Protocol VXI-11
	VISA address string:
	`TCPIP::<host address>[::inst0]::[INSTR]`
		The LAN connector is located on rear panel of the instrument.
		The interface is based on TCP/IP and supports various protocols.
		See also:
		• Chapter 19.5.2.2, "VXI-11 Protocol", on page 945
		• Chapter 19.5.2.3, "HiSLIP Protocol", on page 945
		• Chapter 19.5.1, "VISA Libraries", on page 943

GPIB (IEC/IEEE Bus Interface)	VISA address string: GPIB::primary address[::INSTR] (no secondary address)	The optional GPIB bus interface according to standard IEC 625.1/IEEE 488.1 is located on the rear panel of the instrument. See also: Chapter 19.5.3, "GPIB Interface (IEC/IEEE Bus Interface)", on page 945.

Within this interface description, the term GPIB is used as a synonym for the IEC/IEEE bus interface.

SCPI (Standard Commands for Programmable Instruments)

SCPI commands - messages - are used for remote control. Commands that are not taken from the SCPI standard follow the SCPI syntax rules. The instrument supports the SCPI version 1999. The SCPI standard is based on standard IEEE 488.2 and aims at the standardization of device-specific commands, error handling and the status registers. The tutorial "Automatic Measurement Control - A tutorial on SCPI and IEEE 488.2" from John M. Pieper (R&S order number 0002.3536.00) offers detailed information on concepts and definitions of SCPI.

19.5.1 VISA Libraries

VISA is a standardized software interface library providing input and output functions to communicate with instruments. Instrument access via VXI11 protocol is usually achieved from high level programming platforms using VISA as an intermediate abstraction layer. VISA encapsulates the low level VXI or even GPIB function calls and thus makes the transport interface transparent for the user.

The I/O channel (LAN or TCP/IP, USB, GPIB,...) is selected at initialization time by the channel–specific address string ("VISA resource string") indicated in Table 19-1, or by an appropriately defined VISA alias (short name). A VISA installation is a prerequisite for remote control of R&S RTP.

For more information about VISA, refer to the VISA user documentation.

19.5.2 LAN Interface

To be integrated in a LAN, the instrument is equipped with a LAN interface, consisting of a connector, a network interface card and protocols. For remote control via a network, the PC and the instrument must be connected via the LAN interface to a common network with TCP/IP network protocol. They are connected using a commercial RJ45 cable. The TCP/IP network protocol and the associated network services are preconfigured on the instrument. Software for instrument control and the VISA program library for specified protocols must be installed on the controller.

19.5.2.1 IP Address

Only the address of the instrument is required to set up the connection. It is part of the "VISA resource string" used by programs to identify and control the instrument. The VISA resource string has the form:

`TCPIP::<host address>::hislip0[,<port>][::INSTR]` for HiSLIP protocol

`TCPIP::<host address>[::inst0][::INSTR]` for VXI-11 protocol

Where:

- `host address` identifies the instrument in the network, usually the IP address. If the LAN is supported by a DNS server, the host name can be used instead of the IP address. The DNS server (Domain Name System server) translates the host name to the IP address.
- `hislip0` indicates the HiSLIP protocol
- `inst0` is the default LAN device name. VISA supports several devices running on the instrument. On R&S RTP, only one device is configured, so the LAN device name can be omitted.
- `INSTR` specifies a VISA resource of the type INSTR. By default, the VISA resource name control is set to the INSTR class.

Example: HiSLIP

IP address is *192.1.2.3*: the valid resource string is: `TCPIP::192.1.2.3::hislip0`

Instrument name is *RSRT1*: the valid resource string is: `TCPIP::RSRT1::hislip0`.

DNS host name is *RTP-123456*: the valid resource string is: `TCPIP::RTP-123456::hislip0`.

Example: VXI-11

IP address is *192.1.2.3*: the valid resource string is: `TCPIP::192.1.2.3`

Instrument name is *RSRT1*: the valid resource string is: `TCPIP::RSRT1`.

DNS host name is *RTP-123456*: the valid resource string is: `TCPIP::RTP-123456`.

See also:

- Find IP address: [Setup] > "System" tab, see "System" on page 80
- Chapter 19.2.2, "Assigning the IP Address", on page 931

19.5.2.2 VXI-11 Protocol

The VXI-11 standard is based on the ONC RPC (Open Network Computing Remote Procedure Call) protocol which in turn relies on TCP/IP as the network/transport layer. The TCP/IP network protocol and the associated network services are preconfigured. TCP/IP ensures connection-oriented communication, where the order of the exchanged messages is adhered to and interrupted links are identified. With this protocol, messages cannot be lost.

19.5.2.3 HiSLIP Protocol

The HiSLIP (**Hi**gh **S**peed **L**AN **I**nstrument **P**rotocol) is the successor protocol for VXI-11 for TCP-based instruments specified by the IVI foundation. The protocol uses two TCP sockets for a single connection - one for fast data transfer, the other for non-sequential control commands (e.g. `Device Clear` or `SRQ`).

HiSLIP has the following characteristics:

- High performance as with raw socket network connections
- Compatible IEEE 488.2 support for Message Exchange Protocol, Device Clear, Serial Poll, Remote/Local, Trigger, and Service Request
- Uses a single IANA registered port (4880), which simplifies the configuration of firewalls
- Supports simultaneous access of multiple users by providing versatile locking mechanisms
- Usable for IPv6 or IPv4 networks

Using VXI-11, each operation is blocked until a VXI-11 device handshake returns. However, using HiSLIP, data is sent to the device using the "fire and forget" method with immediate return. Thus, a successful return of a VISA operation such as `viWrite()` does not guarantee that the instrument has finished or started the requested command, but is delivered to the TCP/IP buffers.

For more information see also the application note:

1MA208: Fast Remote Instrument Control with HiSLIP

19.5.3 GPIB Interface (IEC/IEEE Bus Interface)

To be able to control the instrument via the GPIB bus, the instrument and the controller must be linked by a GPIB bus cable. A GPIB bus card, the card drivers and the program libraries for the programming language used must be provided in the controller. The controller must address the instrument with the GPIB bus address.

Characteristics

- Up to 15 instruments can be connected

- The total cable length is restricted to a maximum of 15 m; the cable length between two instruments should not exceed 2m.
- A wired "OR"-connection is used if several instruments are connected in parallel.

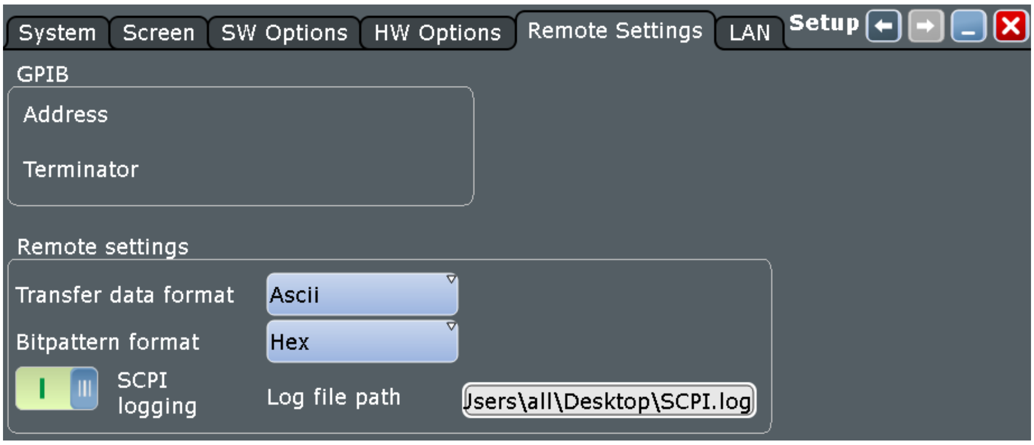
19.5.3.1 GPIB Instrument Address

To operate the instrument via remote control, it must be addressed using the GPIB address. The remote control address is factory-set to 20, but it can be changed in the network environment settings. For remote control, addresses 0 through 30 are allowed. The GPIB address is maintained after a reset of the instrument settings.

See also: "Address" on page 946.

19.6 Remote Settings

Access: "File" menu > "Setup" >"Remote Settings" tab.



The settings on this tab are required for remote control of the instrument via a connected computer.

Address
Indicates the GPIB address of the instrument.

The address can be edited here. Be aware that changing the address has major effects on the communication to the remote computer. See also: Chapter 19.5.3, "GPIB Interface (IEC/IEEE Bus Interface)", on page 945.

Remote command:
`GPIB:ADDRess` on page 979

Terminator
Specifies the symbol that is used as a terminator in GPIB communication.

Remote command:
`GPIB:TERMinator` on page 980

Transfer data format
Selects the data format that is used for transmission of waveform data from the instrument to the controlling computer.

Waveform data can be retrieved using the following commands:
- `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?`
- `CALCulate:MATH<m>:DATA[:VALues]?`
- `REFCurve<m>:DATA[:VALues]?`
- `DIGital<m>:DATA[:VALues]?`

The content of the data stream can be defined with [Save Recall] > "Save/Recall > Waveforms > Interleaved X/Y" (or `EXPort:WAVeform:INCXvalues`).

"Ascii"	Data values are returned in ASCII format as a list of comma separated values in floating point format.
"FLOAT"	Binary format. The data is stored as binary data (Definite Length Block Data according to IEEE 488.2).
"INT8"	Signed integer data with length 8 bit.
"INT16"	Signed integer data with length 16 bit. The Byte order can be set using . For details on the formats, refer to the description of the remote command.

Remote command:
`FORMat[:DATA]` on page 977

Byte order
Sets the endianess for INT16 data:
- LSB first: little endian, least significant byte first
- MSB first: big endian, most significant byte first

Remote command:
`FORMat:BORDer` on page 978

Bit pattern format
Sets the format for all bit pattern queries.

Remote command:
`FORMat:BPATtern` on page 979

SCPI logging
If enabled, all received remote commands are written into a text file. Enter the path and filename with extension (log, txt, or csv) in "Log file path".

19.7 Starting and Stopping Remote Control

19.7.1 Starting a Remote Control Session

When you switch on the instrument, it is always in manual operation state ("local" state). It can be operated via the front panel, the touch screen and external keyboard and/or mouse.

► To start remote control:
- Send a command from the controller.
- VXI-11 protocol (LAN or USB interface): Use `&GTR` interface message.

While remote control is active, the instrument settings are optimized for maximum measurement speed; the display is switched off. Operation via the front panel is disabled.

On the touch screen, two buttons appear in the upper left corner: "Local" and "View".

19.7.2 Using the Display during Remote Control

You can observe the screen while a remote control script is executed. This is helpful for program test purposes but tends to slow down the measurement. Therefore it is recommended that you switch off the display in real measurement applications where a tested program script is to be executed repeatedly.

► To switch on the display, do one of the following:
- Tap the "View" button in the upper left corner of the touch screen.
- Use the `SYSTem:DISPlay:UPDate ON` command.

► To switch off the display, do one of the following:
- Tap the "View" button again.
- Use the `SYSTem:DISPlay:UPDate OFF` command.

19.7.3 Returning to Manual Operation

The instrument switches back to manual operation when the remote connection is closed. Besides, you can return to manual operation manually or via remote control.

► To return to manual operation:
- Tap the "Local" button in the upper left corner of the touch screen.
- VXI-11 protocol: Use `&GTL` interface message.

20 Remote Control Commands

This chapter describes all remote commands available for R&S RTP and provides examples and information how to use the commands.

Further information on remote control:

- Chapter 19.5, "Remote Control Interfaces and Protocols", on page 942
- Chapter 19.7, "Starting and Stopping Remote Control", on page 948
- Chapter B, "Remote Control - Basics", on page 1866
- Chapter C, "Remote Control - Status Reporting System", on page 1880

20.1 Conventions used in Remote Command Description

Note the following conventions used in the remote command descriptions:

- **Command usage**
  If not specified otherwise, commands can be used both for setting and for querying parameters.
  If a command can be used for setting or querying only, or if it initiates an event, the usage is stated explicitly.
- **Parameter usage**
  If not specified otherwise, a parameter can be used to set a value and it is the result of a query.
  Parameters required only for setting are indicated as **Setting parameters**.
  Parameters required only to refine a query are indicated as **Query parameters**.
  Parameters that are only returned as the result of a query are indicated as **Return values**.
- **Conformity**
  Commands that are taken from the SCPI standard are indicated as **SCPI confirmed**. All commands used by the R&S RTP follow the SCPI syntax rules.
- **Asynchronous commands**
  A command which does not automatically finish executing before the next command starts executing (overlapping command) is indicated as an **Asynchronous command**.
- **Reset values (*RST)**
  Default parameter values that are used directly after resetting the instrument (`*RST` command) are indicated as ***RST** values, if available.
- **Default unit**

The default unit is used for numeric values if no other unit is provided with the parameter.

20.2 Finding the Appropriate Command

In the following chapters, the commands are sorted according to the menu and dialog structure of the instrument.

A list of all commands in alphabetical order ist given in the "List of Commands" at the end of this documentation.

To find the appropriate command for a setting easily, you can use the context help:

1. Enable the "Tooltip" icon on the toolbar.

2. Tap the parameter for which you need information.

   The tooltip opens.

3. Tap the "Show Help" button in the lower right corner of the tooltip.

   The "Help" window opens and displays the comprehensive description and the corresponding remote command.

4. Tap the remote command link to open the command description.

20.3 Programming Examples

20.3.1 Display

20.3.1.1 Creating Zoom Diagrams

The example creates a zoom diagram, sets the relative size of the zoom area, and removes the zoom diagram.

Command description in: Chapter 20.10.1, "Zoom", on page 1097.

```
LAYout:ZOOM:ADD 'Diagram1', VERT, OFF, -10e-9, 20e-9, -0.1, 0.05, 'MyZoom1'
// Create an new zoom diagram for Diagram1
LAYout:ZOOM:HORZ:MODE? 'Diagram1', 'MyZoom1'
<--ABS
// Query the horizontal zoom mode - return value: ABS
LAYout:ZOOM:HORZ:MODE 'Diagram1', 'MyZoom1', REL
// Set horizontal zoom mode to relative
LAYout:ZOOM:HORZ:REL:SPAN 'Diagram1', 'MyZoom1', 10
// Set horizontal zoom span in percent
LAYout:ZOOM:HORZ:REL:POS 'Diagram1', 'MyZoom1', 15
// Set horizontal zoom position in percent
LAYout:ZOOM:REM 'Diagram1', 'MyZoom1'
// Remove zoom diagram
```

20.3.2 Automatic Measurements

20.3.2.1 Performing Amplitude/Time Measurements

Command description is given in Chapter 20.12.1, "General Settings", on page 1134 and Chapter 20.12.2, "Results", on page 1140

Simple Frequency and Amplitude Measurement

```
SING;*OPC?              //Asynchronous command
MEAS1:SOUR C1W1         // Configure frequency measurement
MEAS1:MAIN FREQ
MEAS1 ON
MEAS2:SOUR C1W1         // Configure amplitude measurement
MEAS2:MAIN AMPL
```

```
MEAS2 ON
*OPC?                 // Wait for operation complete - read result of *OPC?
MEAS1:RES:ACT?        // Get frequency result
MEAS2:RES:ACT?        // Get amplitude result
```

20.3.2.2 Setting Reference Levels

Command description in Chapter 20.12.12, "Reference Levels", on page 1187

Manual reference level definition using relative values

Reference levels are set to 15%, 50%, and 85% of the high signal level for waveform Ch2Wfm1 (= suffix 5).

```
REFLevel5:LDETection MANual
REFLevel5:LMODe REL
REFLevel5:RELative:MODE USER
REFLevel5:RELative:LOWer 15
REFLevel5:RELative:MIDDle 50
REFLevel5:RELative:UPPer 85
```

Manual reference level definition using absolute values

Set reference levels manually for waveform C1W1 (= suffix 2), defining high and low signal levels and the distances between signal and reference levels.

```
REFLevel2:LDETection MANual
REFLevel2:LMODe ABS
REFLevel2:ABSolute:HIGH 0.12
REFLevel2:ABSolute:TDIStance 0.03
REFLevel2:ABSolute:Low -0.12
REFLevel2:ABSolute:BDIStance 0.04
REFLevel2:ABSolute:MLEVel?
<-- 0
```

Set reference levels manually for waveform C1W1 (= suffix 2) by defining upper and lower reference levels and the distances between signal and reference levels.

```
REFLevel2:LDETection MANual
REFLevel2:LMODe ABS
REFLevel2:USRLevel UREF
REFLevel2:ABSolute:LLEVel 0
REFLevel2:ABSolute:BDIStance 0.02
REFLevel2:ABSolute:ULEVel 0.2
REFLevel2:ABSolute:TDIStance 0.03
REFLevel2:ABSolute:MLEVel?
<-- 0.1
```

Automatic level detection, peak probability

Reference levels are set to the signal levels with the highest probability values for waveform C3W1 (= suffix 8).

```
REFLevel8:LDETection Auto
REFLevel8:AUTO:MODE PPRobability
```

20.3.2.3 Waveform Histograms

Creating and Reading Histograms

The example creates a histogram, activates two measurements (mean and standard deviation measurements of Histogram1), and queries the results of both measurements.

Command description in:

- Chapter 20.12.1, "General Settings", on page 1134
- Chapter 20.12.6.2, "Histogram Measurement", on page 1168
- Chapter 20.12.2, "Results", on page 1140

```
LAY:HIST:ADD 'Histogram1', C1W1, -2.5E-007, 2.5E-007, -1.32, 5.35, OFF, VERT

MEAS1 ON
MEAS1:HIST:SEL 'Histogram1'
MEAS1:CAT HIST
MEAS1:MAIN HME

MEAS2 ON
MEAS2:HIST:SEL 'Histogram1'
MEAS2:CAT HIST
MEAS2:MAIN HSTD

MEAS1:RES:ACT?

MEAS2:RES:ACT?
```

Exporting Histogram Data to File

The example writes the absolute data values of Histogram1 to `C:\Histograms\Hist1.xml` in XML format.

Command description in Chapter 20.16.6, "Waveform Histogram Export to File", on page 1287.

```
EXPort:HISTogram:SELect 'Histogram1'
EXPort:HISTogram:INCidence ABS
EXPort:HISTogram:NAME 'C:\Histograms\Hist1.xml'
EXPort:HISTogram:SAVE
```

Transferring Histogram Data

The example transfers the absolute values of Histogram1 to a controlling computer in ASCII format.

Command description in Chapter 20.16.6, "Waveform Histogram Export to File", on page 1287.

```
EXP:HIST:SEL 'Histogram1'
EXP:HIST:INC ABS
FRM ASC
EXP:HIST:DATA?
<--0,0,0,0,0,2037,5754804,4683496,3100169,2874565,...
```

20.3.2.4 Long Term Measurements

Exporting Long Term Measurement Data to File

The example writes the long term data of Meas1 to `C:\Measurements\Meas1.csv` in CSV format.

Command description in Chapter 20.16.8, "Long Term Measurement Results and Measurement Histogram Export to File", on page 1289.

```
EXPort:MEASurement:SEL MEAS1
EXPort:MEASurement:TYPE LONGTERM
EXPort:MEASurement:NAME 'C:\Measurements\Meas1.csv'
EXPort:MEASurement:SAVE
```

Transferring Long Term Measurement Data

The example transfers the long term data of Meas1 to a controlling computer in ASCII format.

Command description in Chapter 20.16.8, "Long Term Measurement Results and Measurement Histogram Export to File", on page 1289.

```
MEASurement:LTM ON
MEASurement:STAT ON
EXPort:MEASurement:SELect MEAS1
EXPort:MEASurement:TYPE LONGTERM
FORM ASC
EXPort:MEASurement:DATA?
<--50,0.24901185771,0.24731225296,0.24703557312,0.00069270717936,0,50,....
```

20.3.3 Mask Testing

20.3.3.1 Creating a user mask

Creates a new user mask "MyMask" with one inner segment, and turns the mask test on.

Command description in: Chapter 20.14, "Mask Testing", on page 1214.

```
MTEST:ADD 'MyMask'
MTEST:SEGM:ADD 'MyMask'
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 0, -20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 0, -0.1
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 1, -20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 1, 0.1
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 2, 20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 2, 0.1
MTEST:SEGM:POIN:ADD 'MyMask', 0
MTEST:SEGM:POIN:X 'MyMask', 0, 3, 20e-9
MTEST:SEGM:POIN:Y 'MyMask', 0, 3, -0.1
MTEST:SEGM:REG 'MyMask', 0, INNER
MTEST:STAT 'MyMask', ON; *OPC?
```

20.3.4 Search

20.3.4.1 Searching for a pulse of specified width

Search for positive pulses with pulse width 12 ± 10 µs (2 µs to 22 µs).

Command description in: Chapter 20.15, "Search", on page 1234.

The usage of asynchronous commands is described in Chapter B.3, "Command Sequence and Synchronization", on page 1877.

```
SEAR:ADD 'MySearch'                   // Create a new search
SEAR:TRIG:WIDT:STAT 'MySearch',1      // Configure search type
SEAR:SOUR 'MySearch',M1               // Configure search source - here Math1
SEAR:TRIG:WIDT:RANG 'MySearch',WITH   // Configure search parameters
SEAR:TRIG:WIDT:WIDT 'MySearch',7e-6   // Configure search parameters
SEAR:TRIG:WIDT:DELT 'MySearch',1e-6   // Configure search parameters
SEAR:RES:LIM 'MySearch',1             // Set number of result lines in table to 1
SEAR:ALL 'MySearch'; *OPC?            // Initiate search for all events, asynchronous command
```

20.3.5 Data Management

20.3.5.1 Saving a Screenshot to File

Saves three display images in png format to the files `Print.png`, `Print_001.png`, and `Print_002.png` in the directory `C:\Temp`. To get a correct screenshot, turn on the display first.

Command description in: Chapter 20.16.9, "Screenshots", on page 1291.

The usage of asynchronous commands is described in Chapter B.3, "Command Sequence and Synchronization", on page 1877.

```
SYST:DISP:UPD ON
HCOP:DEST 'MMEM'
HCOP:DEV:LANG PNG
MMEM:NAME 'C:\Temp\Print.png'
HCOP:IMMediate; *OPC?          \\Asynchronous command
HCOP:IMM:NEXT; *OPC?           \\Asynchronous command
HCOP:IMM:NEXT; *OPC?           \\Asynchronous command
```

20.3.5.2 Exporting Waveform Data to File

Command description in:

- Chapter 20.16.5, "Waveform Data Export to File", on page 1280
- Chapter 20.16.1, "Instrument Settings", on page 1271
- Chapter 20.10.4, "History", on page 1117

Exporting a Single Waveform to XML File

Saves a single analog waveform completely to an XML file. Data logging is off.

The usage of asynchronous commands is described in Chapter B.3, "Command Sequence and Synchronization", on page 1877.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
RUNSingle;*OPC?              \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.xml'
EXPort:WAVeform:RAW OFF
```

```
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.xml'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.xml'
```

Exporting Raw Data of a Single Waveform to BIN File

Saves the data of a single analog waveform in integer 8 bit format (raw data) to a BIN file. Data logging is off.

Data conversion is described in "Raw (ADC direct)" on page 439.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
RUNSingle; *OPC?              \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.bin'
EXPort:WAVeform:RAW ON
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.bin'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.bin'
```

Exporting Raw Data of a Measurement Gate to BIN File

Saves the data of a measurement gate in integer 8 bit format (raw data) to a BIN file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
MEASurement2:CATegory AMPT
MEASurement2:MAIN MEAN
MEASurement2:ENABle 1
MEASurement2:SOURce C1W1
MEASurement2:GATE:MODE ABS
MEASurement2:GATE:ABS:STARt -0.00012
MEASurement2:GATE:ABS:STOP -5e-06
MEASurement2:GATE:STATe On
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe GATE
EXPort:WAVeform:MEAS Meas2
RUNSingle;*OPC?                  \\Asynchronous command
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.bin'
EXPort:WAVeform:RAW ON
EXPort:WAVeform:INCXvalues OFF
```

```
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.bin'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.bin'
```

Exporting Interleaved x/y Data of a Single Waveform to CSV File

Saves the x- and y- values of a single analog waveform to a CSV file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
RUNSingle;*OPC?                  \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.csv'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues ON
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.csv'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.csv'
```

Exporting Interleaved x/y Data of a Zoom to CSV File

Saves the x- and y- values that is displayed in a zoom diagram to a CSV file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
LAYout:ZOOM:ADD 'Diagram1',HORIZONTAL,OFF,-0.00012,-5e-06,0.308,-0.092,'ExportAreaZoom'
RUNSingle;*OPC?                  \\Asynchronous command
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe ZOOM
EXPort:WAVeform:ZOOM 'Diagram1', 'ExportAreaZoom'
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.csv'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues ON
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.csv'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.csv'
```

Exporting Multiple Running Acquisitions of a Single Waveform to XML File

Saves the data of 5 subsequent acquisitions of a single analog waveform to an XML file. Data logging is on.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.xml'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues OFF
ACQuire:COUNt 5
EXPort:WAVeform:DLOGging ON
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
RUNSingle;*OPC?                   \\Asynchronous command
MMEM:DATA? 'C:\Data\DataExportWfm_analog.xml'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.xml'
```

Exporting a Single Acquisition of the History to BIN File

Saves the oldest acquisition of the history to a BIN file. Data logging is off.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.bin'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging OFF
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
ACQuire:COUNt 5             \\Acquire 5 waveforms
RUNSingle;*OPC?             \\Asynchronous command
CHANnel1:WAV1:HISTory:STATe ON
CHANnel1:WAV1:HISTory:CURRent -4;*OPC?  \\Oldest waveform of 5 has index -4
EXPort:WAVeform:SAVE
MMEM:DATA? 'C:\Data\DataExportWfm_analog.bin'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.bin'
```

Exporting Multiple Acquisition of the History to XML File

Saves the data of 5 subsequent acquisitions of the history to an XML file. Data logging is on.

```
STOP;*OPC?
EXPort:WAVeform:FASTexport ON
CHANnel1:WAVeform1:STATe 1
EXPort:WAVeform:SOURce C1W1
EXPort:WAVeform:SCOPe WFM
EXPort:WAVeform:NAME 'C:\Data\DataExportWfm_analog.xml'
EXPort:WAVeform:RAW OFF
EXPort:WAVeform:INCXvalues OFF
EXPort:WAVeform:DLOGging ON
MMEM:DEL 'C:\Data\DataExportWfm_analog.*'
```

```
ACQuire:COUNt 5               \\Acquire 5 waveforms
RUNSingle;*OPC?               \\Asynchronous command
CHANnel1:WAV1:HISTory:STATe ON
CHANnel1:WAV1:HISTory:STARt -4
CHANnel1:WAV1:HISTory:STOP 0
CHANnel1:WAV1:HISTory:REPLay OFF
CHANnel1:WAV1:HISTory:PLAY;*OPC? \\Asynchronous command
MMEM:DATA? 'C:\Data\DataExportWfm_analog.xml'
MMEM:DATA? 'C:\Data\DataExportWfm_analog.wfm.xml'
```

Exporting and Reconstructing Multiple Raw Acquisitions of the History file

This example captures and exports 100 waveforms acquired in fast segmentation mode (minimize blind time). The data is transferred in blocks using SCPI commands.

```
// --- Set data format to signed integers, 1 byte
FORMat:DATA INT,8

// --- Create history data (assuming on channel 1) ---
CHANnel1:WAVeform1:STATe 1           //turn on channel 1
ACQuire:COUNt 100                    //acquire 100 waveforms
ACQuire:SEGMented:STATe ON; *OPC?
//turn on fast segmentation, acquisition is started and data is stored in the memory


// --- Set Export variables and export data ---
EXPort:WAVeform:SOURce C1W1          //specify source for data export
EXPort:WAVeform:SCOPe WFM            //specify range: complete acq. time
MMEM:DEL "C:\Users\Public\Documents\Rohde-Schwarz\RTx\Temp\DataExportWfm_analog.*"
        //delete data from previous runs of this script
EXPort:WAVeform:NAME "C:\Users\Public\Documents\Rohde-Schwarz\RTx\Temp\DataExpWfm.bin"
        //store data in this path and filename
EXPort:WAVeform:RAW ON
//export as raw ADC integer values (saves memory) --> data needs to be converted later
EXPort:WAVeform:INCXvalues OFF
//disable time values in data file. Time can be constructed from the header file
CHANnel1:WAV1:HISTory:STATe ON       //switch to history view
EXPort:WAVeform:DLOGging ON          //enable data logging & history
EXPort:WAVeform:TIMestamps ON        //enable relative time stamp for each acq.
CHANnel1:WAV1:HISTory:STARt -99      //oldest waveform of n acq. has index =(-1)*(n-1)
CHANnel1:WAV1:HISTory:STOP 0         //newest waveforms has index 0
CHANnel1:WAV1:HISTory:REPLay OFF
CHANnel1:WAV1:HISTory:PLAY; *OPC?    //exports waveforms to defined file location.
//2 files are created: header file *.bin and waveform data file *.Wfm.bin


// --- Put files into output buffer of scope and collect ---
// The following code lines are mostly Pseudo Code.
//Sorting out the binary waveform data is more complex and require additional coding
binaryFormat = '1 byte'
//Pseudo Code, tell your language how to interpret the binary data,
```

```
//e.g. 'int8' for MATLAB
MMEM:DATA? "C:\Users\Public\Documents\Rohde-Schwarz\RTx\Temp\DataExpWfm.bin"
//Put header file into output buffer
header = readSCPIBinary(visaInstrument, binaryFormat);
//Pseudo Code, use appropriate command from your programming language,
//e.g. binblockread in MATLAB
MMEM:DATA? "C:\Users\Public\Documents\Rohde-Schwarz\RTx\Temp\DataExpWfm.Wfm.bin"
//Put data file into output buffer
//(your input buffer of the VISA resource might need to be increased)
wfmRaw = readSCPIBinary(visaInstrument, binaryFormat)
//Pseudo Code, use appropriate command from your programming language,
//e.g. binblockread in MATLAB.
//Note: Sort different acquisitions into an array separately after file transfer.


// --- Convert raw ADC values into voltage floating point values ---
// header is assumed to be a struct and the members are accessed via "." syntax.
vertOffsetByPosition = header.VerticalScale * header.VerticalPosition
conversionFactor = (1/header.NofQuantisationLevels) *
  header.VerticalScale * header.VerticalDivisionCount
for(i = 0; i<100; i++){
    wfmVolt(i) = wfmRaw(i) * conversionFactor +
      header.VerticalOffset - vertOffsetByPosition
}
// Note: Depending on settings, the waveform can contain more samples than the
//record length. Remove leading and trailing samples from the waveform.
```

20.3.5.3 Exporting Measurement Results to File

See:

- "Exporting Histogram Data to File" on page 958
- "Transferring Histogram Data" on page 958
- "Exporting Long Term Measurement Data to File" on page 959
- "Transferring Long Term Measurement Data" on page 959

20.3.6 Protocol Analysis

20.3.6.1 RFFE (Option R&S RTP-K40)

Configuring RFFE Bus

Example 1: 1.8 V bus

The usage of asynchronous commands is described in Chapter B.3, "Command Sequence and Synchronization", on page 1877.

```
//Configure source and thresholds for 1.8 V bus
STOP;*OPC?
BUS1:TYPE RFFE
BUS1:LABel "RFFE Test 2"
BUS1:RFFE:CLOCk:SOUR C2W1
BUS1:RFFE:DATA:SOUR C1W1
BUS:RFFE:PRESet V18

//Load a label list and switch on
BUS1:NEWList 'C:\Protocols\RFFE.csv'
BUS1:SYMBols ON

//Initiate single sweep
CHANnel1:STATe ON
CHANnel2:STATe ON
BUS1 ON
RUNSingle;*OPC?              //asynchronous command
```

Example 2: User-defined thresholds with threshold coupling

```
//Configure source and user-defined thresholds
STOP;*OPC?
BUS1:TYPE RFFE
BUS1:LABel "RFFE Test 1"
BUS1:RFFE:CLOCk:SOUR C2W1
BUS1:RFFE:DATA:SOUR C1W1
BUS1:RFFE:COUPling ON
BUS1:RFFE:CLOCk:THReshold:HYSTeresis 0.2
BUS1:RFFE:CLOCk:THReshold:HIGH 0.72
BUS1:RFFE:CLOCk:THReshold:LOW  0.48
```

Triggering on RFFE Bus

Trigger on sequence start of sequences that have the slave address 0010, 0011, or 0100

```
//Set trigger source to serial bus
TRIGger1:SOURce SBUS
TRIGger:MODE NORMal

//Trigger on sequence start of all sequences with slave address range
TRIGger1:RFFE:TYPE STARt
TRIG1:RFFE:SADD:CONDition INR
TRIG1:RFFE:SADD:MIN #H2  //SAD = 0010
TRIG1:RFFE:SADD:MAX #H4  //SAD = 0100
```

Searching RFFE Data

Search for sequence ends of sequences if last bit of slave address is 1

```
STOP;*OPC?
SEARch:ADD 'RFFESearch1'
```

```
SEARch:SOURce 'RFFESearch1',SBUS1
SEARch:TRIGger:RFFE:TYPE 'RFFESearch1',STOP
SEARch:TRIGger:RFFE:SADD:COND 'RFFESearch1', EQU
SEARch:TRIGger:RFFE:SADD:MIN 'RFFESearch1', 'XXX1'
RUNSingle;*OPC?              //asynchronous command
SEARch:ALL 'RFFESearch1';*OPC?
SEARch:RESult:RFFE:FCOunt? 'RFFESearchCh1'

SEARch:RESult:RFFE:SEQuence1:STATe?  'RFFESearchCh1'
<--OK    //First sequence is valid
SEARch:RESult:RFFE:SEQuence1:TYPE?  'RFFESearchCh1'
<--ERRL  //Extended Register Read Long sequence
```

20.4 Frequently Used Parameters and Suffixes

This chapter describes in general those parameters and suffixes that are used in several subsystems.

20.4.1 Waveform Suffix

The numeric waveform suffix is used in some commands, for example, to indicate the source waveform number from which the reference level is taken, and to assign color tables to waveforms.

Depending on the command, not all suffix values are supported. For example, in REFLevel commands, only suffixes 2...21 are allowed. The range of supported suffix numbers is indicated in the description of the individual commands.

NOTICE

Suffix 1

Suffix 1 means that no waveform is assigned. The first waveform C1W1 corresponds to suffix number 2.

Waveform number	Description
1	None
2	C1W1 (channel 1, waveform 1)
3	C1W2 (channel 1, waveform 2)
4	C1W3 (channel 1, waveform 3)
5	C2W1 (channel 2, waveform 1)
6	C2W2 (channel 2, waveform 2)

Waveform number	Description
7	C2W3 (channel 2, waveform 3)
8	C3W1 (channel 3, waveform 1)
9	C3W2 (channel 3, waveform 2)
10	C3W3 (channel 3, waveform 3)
11	C4W1 (channel 4, waveform 1)
12	C4W2 (channel 4, waveform 2)
13	C4W3 (channel 4, waveform 3)
14...17	Math waveforms: M1, M2, M3, M4
18...21	Reference waveforms: R1, R2, R3, R4
22...25	XY-waveforms: XY1, XY2, XY3, XY4
26...33	Measurement results: MRESult1, MRESult2, MRESult3, MRESult4, MRESult5, MRESult6, MRESult7, MRESult8 MRESult1 are the results of measurement group 1 and so on.
34...35	not used
36...39	Serial buses: SBUS1, SBUS2, SBUS3, SBUS4
40...55	Digital channels: D0...D15 (option R&S RTP-B1)
56...59	Digital buses: MSO1, MSO2, MSO3, MSO4 (option R&S RTP-B1)
60	not used
61...68	Track waveforms: TRK1, TRK2, TRK3, TRK4, TRK5, TRK6, TRK7, TRK8 Available for options R&S RTP-K5 or K12.
69...71	not used
72...75	Spectrograms: SG1, SG2, SG3, SG4 Available for option R&S RTP-K37
76...83	Timeline spectrums: SG1TL1, SG1TL2, SG2TL1, SG2TL2, SG3TL1, SG3TL2, SG4TL1, SG4TL2 TL1 is timeline 1, TL2 is timeline 2 Available for option R&S RTP-K37
88...91	Voltage input channels of multi-channel probe R&S RT-ZVC (probe 1) R&S RT-ZVC04: Z1V1 | Z1V2 | Z1V3 | Z1V4 R&S RT-ZVC02: Z1V1 | Z1V2. Suffixes 90...91 are not available.
92...95	Current input channels of multi-channel probe R&S RT-ZVC (probe 1) R&S RT-ZVC04: Z1I1 | Z1I2 | Z1I3 | Z1I4 R&S RT-ZVC02: Z1I1 | Z1I2. Suffixes 94...95 are not available.
96...99	Voltage input channels of multi-channel probe R&S RT-ZVC (probe 2) R&S RT-ZVC04: Z2V1 | Z2V2 | Z2V3 | Z2V4 R&S RT-ZVC02: Z2V1 | Z2V2. Suffixes 98...99 are not available.

Waveform number	Description
100...103	Current input channels of multi-channel probe R&S RT-ZVC (probe 2) R&S RT-ZVC04: Z2I1 | Z2I2 | Z2I3 | Z2I4 R&S RT-ZVC02: Z2I1 | Z2I2. Suffixes 102...103 are not available.
104...107	not used

20.4.2 Waveform Parameter

Many commands requires one of the waveforms to be specified as source. The following table lists all waveforms. For each command using a waveform parameter, the available waveforms are specified in the command description.

Waveform	Description
M1 | M2 | M3 | M4	Math waveforms
R1 | R2 | R3 | R4	Reference waveforms
XY1 | XY2 | XY3 | XY4	XY-waveforms
MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8	Measurement results
SBUS1 | SBUS2 | SBUS3 | SBUS4	Serial buses
D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15	Digital channels (option R&S RTP-B1)
MSOB1 | MSOB2 | MSOB3 | MSOB4	Digital buses (option R&S RTP-B1)
TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8	Track waveforms (option R&S RTP-K5 or K12)
CDRSW1 = CDRSw1, CDRSW2 = CDRSw2	Generated clock signals
SG1 | SG2 | SG3 | SG4	Spectrograms (option R&S RTP-K37)
Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Z1V1 | Z1V2 | Z1I1 | Z1I2 | Z2V1 | Z2V2 | Z2I1 | Z2I2	Input channels of multi-channel probe R&S RT-ZVC04 Input channels of multi-channel probe R&S RT-ZVC02

20.4.3 Slope Parameter

The slope parameter is used with several trigger and search condition commands.

Slope	Description
POSitive	Rising edge, that is a positive voltage change.
NEGative	Falling edge, that is a negative voltage change
EITHer	rising as well as the falling edge.

20.4.4 Polarity Parameter

The polarity parameter is used with several trigger and search condition commands.

Polarity	Description
POSitive	Positive going pulses.
NEGative	Negative going pulses.
EITHer	Both positive and negative going pulses.

20.4.5 Event Parameter

The event parameter is used with commands defining an action for mask testing, limit checks and margin checks.

Event	Description
NOACtion	The action is not initiated.
SUCCess	The action is initiated if the operation finished successfully: • Limits or margins were not exceeded during the entire measurement • Mask test passed
VIOLation	The action is initiated if the operation finished with error: • Limits or margins were violated during the measurement • Mask test failed

20.4.6 Bit Pattern Parameter

Bit pattern parameter are required with commands triggering on address, identifier, or data pattern.

To set the pattern value, you can use either a numeric parameter as defined in the SCPI standard, or a string parameter.

Bit pattern in numeric parameter

In a numeric parameter, the values are listed byte-by-byte, with bytes separated by commas and MSB first. The default numeral format is decimal, other formats can be indicated by a format identifier (#B = binary, #H = hexadecimal, #Q = octal). Currently, no format for signed values is available.

Example: Parameter with three bytes, decimal byte values are 10, 20, 30. The examples are given for CAN, the bit pattern in other commands is defined in the same way.

- `TRIGger:CAN:DMIN 10,20,30`
- `TRIGger:CAN:DMIN #B00001010,#B00010100,#B00011110`
- `TRIGger:CAN:DMIN #H0A,#H14,#H1E`
- `TRIGger:CAN:DMIN #Q012,#Q024,#Q036`

Bit pattern in string parameter

In a string, the complete binary pattern is written without separation of bytes, for example:

`TRIGger:CAN:DMIN '000010100001010000011110'`

Unlike a numeric parameter, the string parameter accepts wildcards for single bits (X = don't care). Whether wildcards can be used or not depends on the remote command. Usually, address and identifier parameter require unique patterns while data parameters may contain wildcards.

Mostly the length of the bit pattern is defined, for example, by the I²C address type, the CAN identifier type, or the data length code. In theses cases, it is recommended that you enter the complete bit pattern. If you enter a shorter pattern, the instrument fills up the pattern with X bits to the right of the defined pattern.

Example: You want to trigger on an 11 bit CAN address and enter the bit pattern '11100011' (8 bits only). The instrument uses the pattern '11100011XXX' for triggering.

Query for a pattern

The pattern format for the return value of a pattern is defined by the `FORMat:BPATtern` command.

20.5 Common Commands

Common commands are described in the IEEE 488.2 (IEC 625-2) standard. These commands have the same effect and are employed in the same way on different devices. The headers of these commands consist of "*" followed by three letters. Many common commands are related to the Status Reporting System.

Available common commands:

***CAL?**

Performs a self-alignment of the instrument and then generates a status response. Return values ≠ 0 indicate an error.

Return values:

<State> 0: no error
1: alignment failed
2: not aligned, e.g. init
3: device needs longer warmup time before selfalignment can start
4: input signal connected during selfalignment

Usage: Query only

***CLS**

Clear status

Sets the status byte (STB), the standard event register (ESR) and the `EVENt` part of the `QUEStionable` and the `OPERation` registers to zero. The command does not alter the mask and transition parts of the registers. It clears the output buffer.

Usage: Setting only

***ESE** <Value>

Event status enable

Sets the event status enable register to the specified value. The query returns the contents of the event status enable register in decimal form.

Parameters:

<Value> Range: 0 to 255

***ESR?**

Event status read

Returns the contents of the event status register in decimal form and then sets the register to zero.

Return values:

<Contents> Range: 0 to 255

Usage: Query only

***IDN?**

Identification

Returns the instrument identification.

Return values:

<ID> "Rohde&Schwarz,<device type>,<serial number>,<firmware version>"

Example: `Rohde&Schwarz,RTP,1320.5007k44/200153,4.0.1.2`

Usage: Query only

***IST?**

Individual status query

Returns the contents of the IST flag in decimal form. The IST flag is the status bit which is sent during a parallel poll.

Return values:

<ISTflag> 0 | 1

Usage: Query only

***OPC**

Operation complete

Sets bit 0 in the event status register when all preceding commands have been executed. This bit can be used to initiate a service request. The query writes a "1" into the output buffer when all preceding commands have been executed, which is useful for command synchronization.

***OPT?**

Option identification query

Queries the options included in the instrument. For a list of all available options and their description, refer to the data sheet.

Return values:

<Options> The query returns a list of options. The options are returned at fixed positions in a comma-separated string. A zero is returned for options that are not installed.

Usage: Query only

***PCB** <Address>

Pass control back

Indicates the controller address to which remote control is returned after termination of the triggered action.

Setting parameters:

<Address> Range: 0 to 30

Usage: Setting only

***PRE** <Value>

Parallel poll register enable

Sets parallel poll enable register to the indicated value. The query returns the contents of the parallel poll enable register in decimal form.

Parameters:

<Value> Range: 0 to 255

***PSC** <Action>

Power on status clear

Determines whether the contents of the `ENABle` registers are preserved or reset when the instrument is switched on. Thus a service request can be triggered when the instrument is switched on, if the status registers ESE and SRE are suitably configured. The query reads out the contents of the "power-on-status-clear" flag.

Parameters:

<Action> 0 | 1

0
The contents of the status registers are preserved.

1
Resets the status registers.

***RCL** <Number>

Recall

Loads the instrument settings from an intermediate memory identified by the specified number. The instrument settings can be stored to this memory using the command `*SAV` with the associated number.

***RST**

Reset

Sets the instrument to a defined default status. The default settings are indicated in the description of commands.

Usage: Setting only

***SAV** <Number>

Save

Stores the current instrument settings under the specified number in an intermediate memory. The settings can be recalled using the command `*RCL` with the associated number.

***SRE** <Contents>

Service request enable

Sets the service request enable register to the indicated value. This command determines under which conditions a service request is triggered.

Parameters:

<Contents> Contents of the service request enable register in decimal form. Bit 6 (MSS mask bit) is always 0.

Range: 0 to 255

***STB?**

Status byte query

Reads the contents of the status byte in decimal form.

Usage: Query only

***TRG**

Trigger

Triggers all actions waiting for a trigger event. In particular, *TRG generates a manual trigger signal. This common command complements the commands of the `TRIGger` subsystem.

Usage: Event

***TST?**

Self-test query

Initiates self-tests of the instrument and returns an error code.

Return values:

<ErrorCode> **integer > 0 (in decimal format)**
An error occurred.
(For details, see the Service Manual supplied with the instrument).

0
No errors occurred.

Usage: Query only

***WAI**

Wait to continue

Prevents servicing of the subsequent commands until all preceding commands have been executed and all signals have settled (see also command synchronization and `*OPC`).

Usage: Event

20.6 General Remote Settings

This chapter describes commands that have effect on many other remote commands in different applications of the instrument.

FORMat[:DATA] <Format>, [<Length>]

Selects the data type that is used for transmission of waveform data from the instrument to the controlling computer.

Waveform data can be retrieved using the following commands:

- `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?`
- `CALCulate:MATH<m>:DATA[:VALues]?`
- `REFCurve<m>:DATA[:VALues]?`
- `DIGital<m>:DATA[:VALues]?`

The content of the data stream can be defined with `EXPort:WAVeform:INCXvalues`
.

Parameters:
<Format>,[<Length>] ASCii | REAL,32 | INT,8 | INT,16

ASCii
Data values are returned in ASCII format as a list of comma separated values in floating point format. The length can be omitted. It is 0 which means that the instrument selects the number of digits to be returned. The query returns both values (`ASC,0`).

REAL,32
The data is stored as binary data (Definite Length Block Data according to IEEE 488.2). Each waveform value is formatted in 32 Bit IEEE 754 Floating Point Format.
The schema of the result string is as follows:
`#41024<value1><value2>…<value n>` with:
`#4` = number of digits (= 4 in the example) of the following number
`1024` = number of following data bytes (= 1024 in the example)
`<value>` = 4-byte floating point values
If the data exceeds 1 GB, the result string starts with header #0 (unknown length), followed by the data values.

INT,8 | INT,16
Signed integer data with length 8 bit or 16 bit. It defines that `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?` returns the raw sample data of the ADC as integers. If format of the waveform data differs from the defined export format, the instrument converts the data to the required length.
The result string has the same schema as the REAL format.
Fot INT,16 you can set the byte order using the `FORMat:BORDer` command.
Data conversion is described in "Raw (ADC direct)" on page 439.
For digital channel data, math and histogram data, INT formats are not available.
`EXPort:WAVeform:INCXvalues` must be set `OFF`.

*RST: ASCii

Example:
```
FORMat:DATA REAL,32
FORMat:DATA?
REAL,32
```

Usage: SCPI confirmed

FORMat:BORDer <ByteOrder>

Sets the endianess.

The command is only relevant for raw data export in high definition mode (16 bit word length).

Parameters:
<ByteOrder> LSBFirst | MSBFirst

LSB first: little endian, least significant byte first
MSB first: big endian, most significant byte first

*RST: LSBFirst

FORMat:BPATtern <BitPatternFormat>

Sets the number format for all remote bit pattern queries.

Parameters:
<BitPatternFormat> DEC | HEX | OCT | BIN | ASCII | ASCii | STRG

ASCII = ASCii

*RST: HEX

Firmware/Software: V 1.25

SYSTem:DISPlay:UPDate <Enable>

Defines whether the display is updated while the instrument is in the remote state. If the display is switched off, the normal GUI is replaced by a static image while the instrument is in the remote state. Switching off the display can speed up the measurement. This is the recommended state.

See also: Chapter 19.7.2, "Using the Display during Remote Control", on page 948

Parameters:
<Enable> **ON | 1:** Display is shown and updated during remote control
OFF | 0: Display shows static image during remote control

Example:
```
SYSTem:DISPlay:UPDate 1
```
Switch on the display update.

SYSTem:KLOCk <Enable>

Locks or unlocks the local controls of the instrument. This includes the front panel keys, the keyboard, or other local interfaces. except for the "View" button on the display.

Parameters:
<Enable> **ON | 1:** Locks the local keys
OFF | 0: Keys are unlocked

Usage: SCPI confirmed

GPIB:ADDRess <Address>

Sets the GPIB address of the instrument. Changing the address has major effects on the communication to the remote computer.

Parameters:

<Address>	Range:	0 to 30
	Increment:	1
	*RST:	20

GPIB:TERMinator <Terminator>

Specifies the symbol that is used as a terminator in GPIB communication.

Parameters:

<Terminator> LFEoi | EOI

*RST: EOI

SYSTem:DISPlay:MESSage:STATe <DispMessSt>

Enables and disables the display of an additonal text in remote control.

To define the text, use `SYSTem:DISPlay:MESSage[:TEXT]`.

Parameters:

<DispMessState> ON | OFF

*RST: OFF

Firmware/Software: Version 2.70

SYSTem:DISPlay:MESSage[:TEXT] <DisplayMessage>

Defines an additional text that is displayed during remote control operation.

To enable the text display, use `SYSTem:DISPlay:MESSage:STATe` on page 980.

Parameters:

<DisplayMessage> String that contains the text.

Firmware/Software: Version 2.70

SYSTem:LANGuage <Language>

Defines the remote control behavior of the instrument and sets the remote control command set.

Parameters:

<Language> String value. Available values:
'SCPI': R&S RTP remote command set is used.
"DPO7000" or 'TDS540': Compatible remote command set of Tektronix oscilloscopes DPO7000 or TDS540 is used. If one of these emulation modes is used, you can define alternative responses to the `IDN*?` and `OPT*?` commands on the [Setup] > "Remote settings" tab.

Firmware/Software: V 1.35

Options: R&S RTP-K301

20.7 Instrument Setup

This chapter describes commands related to Setup > "System" and "File" > "Exit". For commands related to Setup > "Remote Settings", see Chapter 20.6, "General Remote Settings", on page 977.

20.7.1 System Setup

SYSTem:EXIT

Starts the shutdown of the firmware.

Usage: Event

SYSTem:SHUTdown

Starts the shutdown of the instrument (firmware and operating system).

Usage: Event

SYSTem:PRESet

Resets the instrument to the factory default settings, to the initial state. Factory settings comprise all instrument settings, including display, intensity and transparency settings. After loading factory defaults, perform a self-aligment to synchronize the signal data.

Usage: Event

SYSTem:RESet

Resets the instrument settings to defaults appropriate for remote control of the instrument. The last loaded user-defined preset is used. The command is equivalent to `*RST`.

Usage: Event

SYSTem:DATE <Year>, <Month>, <Day>

Sets the date of the internal calendar.

Parameters:

<Year>	Year, to be entered as a four-digit number (including the century and millenium information)
<Month>	Month, 1 (January) to 12 (December)
<Day>	Day, 1 to the maximum number of days in the specified month *RST: does not affect the date settings
Example:	`SYSTem:DATE?` Returned value: `2011,09,13`
Usage:	SCPI confirmed

SYSTem:TIME? <Hour>, <Minute>, <Second>

Returns the UTC (Universal Time Coordinated) of the internal clock. To define the current local time, use the time zone setting of the operating system (Setup > "Time, date")

Example:	`SYSTem:TIME?` Returned value: `15,09,20`. UTC is 15:09:20.
Usage:	Query only SCPI confirmed

SYSTem:DEVice:ID?

Returns the instrument ID - that is the material number and the serial number

Return values:

<ID>	String containing the material number and the serial number
Example:	`1316.1000K24-001122-jT`
Usage:	Query only

DIAGnostic:SERVice:FWVersion?

Returns the firmware version that is currently installed on the instrument.

Return values:

<FirmwareVersion>	Version string
Usage:	Query only

DIAGnostic:SERVice:COMPutername <ComputerName>

The query returns the computer name that is currently defined. The computer name is required when configuring a network.

The setting command changes the computer name. The change takes effect after the next reboot of the computer.

Parameters:

<ComputerName>	Name string

DIAGnostic:SERVice:PARTnumber <MaterialNumber>

Returns the material number of your instrument. This number is required to order a new option, and in case of service.

Parameters:

<MaterialNumber>	Number string

DIAGnostic:SERVice:SERialnumber?

Returns the serial number of your instrument. This number is required to order a new option, and in case of service.

Return values:

<SerialNumber>	Number string
Usage:	Query only

DIAGnostic:SERVice:CHANnelcount?

Queries the number of available channels.

Return values:

<ChannelCount>	Range:	0 to 4
	Increment:	1
	*RST:	0
Usage:	Query only	
Firmware/Software:	V 2.00	

SYSTem:VERSion?

Queries the SCPI version number to which the instrument complies. The instrument complies to the final SCPI version 1999.0.

Usage:	Query only SCPI confirmed

SYSTem:DFPRint [<Path>]

The device footprint contains the configuration of the instrument, installed modules, installed software and software licenses. This information is written in the device footprint xml file might be useful in case of maintenance or support request.

The query returns the information as block data. The setting command saves the device footprint xml file in the specified path.

It is also possible to access the device footprint xml file via the instrument's web browser. Therefore, the directory containing the xml file must be enabled for sharing.

Setting parameters:

<Path> String parameter, specifying the target path of the footprint file.

Return values:

<DeviceFootprint> Content of the device footprint xml file as block data

SYSTem:ERRor:ALL?

Queries the error/event queue for all unread items and removes them from the queue. The response is a comma separated list of error number and a short description of the error in FIFO order.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error> List of: Error/event_number,"Error/event_description>[;Device-dependent info]"
If the queue is empty, the response is 0,"No error"

Usage: Query only
SCPI confirmed

SYSTem:ERRor[:NEXT]?

Queries the error/event queue for the oldest item and removes it from the queue. The response consists of an error number and a short description of the error.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error> Error/event_number,"Error/event_description>[;Device-dependent info]"
If the queue is empty, the response is 0,"No error"

Usage: Query only
SCPI confirmed

SYSTem:ERRor:CODE:ALL?

Queries the error/event queue for all unread items and removes them from the queue. The response is a comma separated list of error numbers in FIFO order.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error> If the queue is empty, the response is 0

Usage: Query only
SCPI confirmed

SYSTem:ERRor:CODE[:NEXT]?

Queries the error/event queue for the oldest item and removes it from the queue. The response is the error number.

Positive error numbers are instrument-dependent. Negative error numbers are reserved by the SCPI standard.

Return values:

<Error> If the queue is empty, the response is 0

Usage: Query only
SCPI confirmed

SYSTem:ERRor:COUNt?

Queries the number of entries in the error queue.

Return values:

<Count> If the queue is empty, the response is 0

Usage: Query only
SCPI confirmed

20.7.2 [Quick Action] Setup

QACTion:MODE <Mode>

Sets the action that is initiated by the Quick Action key.

Parameters:

<Mode> NONE | APPL | RECA | CLS

APPL
Starts an external application. Select the path of the application executable, additional parameters, and the working directory.

RECA
Graphical recall, opens the "Load saveset" window to select and load instrument settings.

CLS
Clear all, deletes the measurement results, statistics, all wave-forms, and the history.

*RST: NONE

Example: Reset the Quick Action key to no action:
`QACTion:MODE NONE`

QACTion:EXECute

Tests the Quick Action setup.

Usage: Event

QACTion:PATH <ApplicationPath>

Sets the path to the application executable.

Parameters:
<ApplicationPath> String parameter containing path, filename, and file extension

Example:
```
QACTion:MODE APPL
QACTion:PATH 'C:\Program
Files\Wireshark\Wireshark.exe'
QACTion:EXECute
```

QACTion:PARameters <AppParameters>

Sets optional parameters for the external executable.

Parameters:
<AppParameters> String parameter

QACTion:WDIRectory <WorkDirectory>

Sets the working directory for the executable.

Parameters:
<WorkDirectory> String parameter

20.7.3 Display Settings

20.7.3.1 Signal Colors / Persistence

DISPlay:PERSistence[:STATe] <State>

If enabled, each new data point in the diagram area remains on the screen for the duration defined using `DISPlay:PERSistence:TIME`, or as long as `DISPlay:PERSistence:INFinite` is enabled.

If disabled, the signal value is only displayed as long as it actually occurs.

Parameters:

<State>	ON | OFF	
	*RST:	ON

DISPlay:PERSistence:INFinite <State>

If persistence is enabled (`DISPlay:PERSistence[:STATe]`), each new data point in the diagram area remains on the screen infinitely until this command is set to "OFF".

Parameters:

<State>	ON | OFF	
	*RST:	OFF

DISPlay:PERSistence:TIME <Time>

If persistence is enabled (`DISPlay:PERSistence[:STATe]`), each new data point in the diagram area remains on the screen for the duration defined here.

Parameters:

<Time>	Range:	0.05 to 50
	Increment:	0.05
	*RST:	0.05
	Default unit:	s

DISPlay:PERSistence:RESet

Resets the display, removing persistent values.

Usage: Event

DISPlay:INTensity <Intensity>

This value determines the strength of the waveform line in the diagram. Enter a percentage between 0 (not visible) and 100% (very strong).

The exact mapping of the cumulative value occurences according to the assigned color table is guaranteed only if the intensity is set to 50% (default). All other intensity values falsify the mapping but may improve the visibility of the signal.

See also: Chapter 3.4.3.2, "Changing Waveform Colors", on page 99.

Parameters:

<Intensity>

Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

DISPlay:DIAGram:STYLe <Style>

Select the style in which the waveform is displayed.

Parameters:

<Style> VECTors | DOTS

VECTors
The individual data points are connected by a line.

DOTS
Only the individual data points are displayed.

*RST: VECTors

DISPlay:COLor:SIGNal<m>:COLor <Value>

Suffix:

<m> 1..107
Waveform number, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Value> Decimal value of the ARGB color. Use the color dialog box on the instrument to get the hex value of the color, and convert the hex value to a decimal value.
0 is fully transparent black.
4278190080 (dec) = FF000000 (hex) is opaque black.
4294967295 (dec) = FFFFFFFF (hex) is opaque white.

DISPlay:COLor:SIGNal<m>:ASSign <ColorTable>

Assigns the color table to the specified signal.

Suffix:

<m> 1..107
Waveform number, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<ColorTable> Color table name to be assigned to the signal.

DISPlay:COLor:SIGNal<m>:USE <State>

If enabled, the selected waveform is displayed according to its assigned color table.

If this option is disabled, the default color table is used, i.e. the intensity of the specific signal color varies according to the cumulative occurance of the values.

Suffix:

<m>	1..107 Waveform number, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<State>	ON | OFF

20.7.3.2 Color Tables

DISPlay:COLor:PALette:ADD <Name>

Adds a new color table with the specified name.

Setting parameters:

<Name>	color table
Usage:	Setting only

DISPlay:COLor:PALette:REMove <Name>

Removes the specified color table.

Setting parameters:

<Name>	color table
Usage:	Setting only

DISPlay:COLor:PALette:COUNt?

Queries the number of configured color maps.

Usage:	Query only

DISPlay:COLor:PALette:POINt:ADD <PaletteName>

Appends a new row at the end of the color table.

Setting parameters:

<PaletteName> color table

Usage: Setting only

DISPlay:COLor:PALette:POINt:INSert <PaletteName>, <PointIndex>

Inserts the entry at the specified index in the color table.

Setting parameters:

<PaletteName> color table

<PointIndex> row number in the color table

Usage: Setting only

DISPlay:COLor:PALette:POINt:REMove <PaletteName>, <PointIndex>

Removes the entry with the specified index from the color table.

Setting parameters:

<PaletteName> color table

<PointIndex> row number in the color table

Usage: Setting only

DISPlay:COLor:PALette:POINt[:VALue] <ColorTableName>, <Index>,<Position>, <Color>
DISPlay:COLor:PALette:POINt[:VALue]? <ColorTableName>, <Index>

Inserts a new entry or queries the specified entry in the specified color table.

Parameters:

<Position> Cumulative occurance value

Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

<Color> ARGB value of the color to be used for the table entry. ARGB=<Opacity(alpha) value><red value><green value><blue value>, in hexadecimal or decimal format.

Range: 0 to 4294967295
Increment: 1
*RST: 0

Parameters for setting and query:

<ColorTableName> Color table to be edited

<Index> Index (row number) of the new entry in the color table

DISPlay:COLor:PALette:POINt:COUNt? <PaletteName>

Queries the number of entries in the color table.

Query parameters:
<PaletteName> color table

Usage: Query only

20.7.3.3 Diagram Layout

These settings are user-specific, they are *not* reset by [Preset] and `*RST`. You can reset them to default values using [Save Recall] > "Save/Recall > User defined preset > Factory defaults" or using the `SYSTem:PRESet` command.

DISPlay:DIAGram:GRID <Show>

If enabled, a grid is displayed in the diagram area.

Parameters:
<Show> ON | OFF

DISPlay:DIAGram:CROSshair <Crosshair>

If selected, a crosshair is displayed in the diagram area. A crosshair allows you to select a specific data point by its co-ordinates.

Parameters:
<Crosshair> ON | OFF

DISPlay:DIAGram:FINegrid <ShowFineScale>

If ON, the crosshair is displayed as a ruler with scale markers. If OFF, the crosshair is shown as dashed lines.

Parameters:
<ShowFineScale> ON | OFF

Firmware/Software: V 1.50

DISPlay:DIAGram:LABels <ShowLabels>

If enabled, labels mark values on the x- and y-axes in specified intervals in the diagram.

Parameters:
<ShowLabels> ON | OFF

DISPlay:DIAGram:TITLe <DiagTitleSt>

If enabled, the tab titles of all diagrams are displayed: "Diagram1", "Diagram2" ...

If disabled, the tab titles are not shown except for those in a tabbed diagram. In tabbed diagrams, the tab titles are required to change the tabs.

Parameters:
<DiagTitleSt> ON | OFF

DISPlay:DIAGram:YFIXed <YGridFixed>

If enabled, the horizontal grid lines remain in their position when the position of the curve is changed. Only the values at the grid lines are adapted. This reflects the behavior of traditional oscilloscopes.

Parameters:
<YGridFixed> ON | OFF

DISPlay:GATE:TRANsparency <Transparency>

Sets the transparency of the area that is defined as measurement or search gate.

Parameters:
<Transparency> Range: 0 to 100
Increment: 1
*RST: 43
Default unit: %

Firmware/Software: FW 3.20

DISPlay:RESultboxes:DEFaultpos <State>

Defines where a new result box opens.

Parameters:

<State> PREV | FLOA

PREV
Preview: The result box opens as a minimized result icon on the sidebar. It shows only two colums and a few rows of the results.

FLOA
Floating: The result box opens as a box similar to a dialog box in front of the diagrams. It can be moved and shows all results.

LAYout:ADD <NodeName>, <ParentType>, <InsertBefore>, <FirstSource>, <DiagramName>

Adds a new diagram with a waveform on the screen, in relation to an existing diagram.

Setting parameters:

<NodeName> String with the name of the existing diagram

<ParentType> HORizontal | VERTical | TAB

Position of the new diagram in relation to the existing one.

HORizontal
Besides the existing diagram

VERTical
Above or below the existing diagram

TAB
In a new tab in the existing diagram

<InsertBefore> ON | OFF

If on, the new diagram is inserted to the left (for HORizontal), above (for VERTical) or in a tab in front the existing diagram.
HOR, ON = left to the existing diagram, defined in <NodeName>
HOR, OFF = right to the existing diagram
VERT, ON = above the existing diagram
VERT, OFF = below the existing diagram

<FirstSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Waveform to be displayed in the new diagram, see Chapter 20.4.2, "Waveform Parameter", on page 970.
Spectrogram, option R&S RTP-K37: Spectrograms and timeline spectrums are automatically displayed in their own diagrams.

<DiagramName> String with the name of the new diagram.

Example: `LAYout:ADD 'Diagram2',TAB,ON,C4W1,'MyDiagram3'`
Creates a new diagram 'MyDiagram3' with waveform C4W1 in a new tab that is laid in front of 'Diagram2'.

Usage: Setting only

LAYout:REMove <DiagramName>

Closes the specified diagram. The waveforms are displayed as minimized waveforms in their signal icons on the sidebar.

Setting parameters:
<DiagramName> String with the name of the diagram

Usage: Setting only

LAYout:SHOW <DiagramName>

Selects the specified diagram.

Setting parameters:
<DiagramName> String with the name of the diagram

Usage: Setting only

LAYout:SIGNal:ASSign <DiagramName>, <Source>

Shows the specified waveform in the selected diagram.

Setting parameters:
<DiagramName> String with the diagram name

<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Waveform to be assigned, see Chapter 20.4.2, "Waveform Parameter", on page 970

Spectrogram, option R&S RTP-K37: Spectrograms and timeline spectrums are automatically displayed in their own diagrams.

Usage: Setting only

LAYout:SIGNal:UNASsign <Source>

Removes the specified waveform from the diagram.

Setting parameters:

<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

See Chapter 20.4.2, "Waveform Parameter", on page 970

Usage: Setting only

DISPlay:SIGBar[:STATe] <State>

If enabled, the sidebar is displayed.

Parameters:

<State> ON | OFF

20.7.3.4 Waveform Labels

To create a new waveform label, use `DISPlay:SIGNal:LABel:ADD`. Using the other `DISP:SIGN:LAB:...` commands, you can query the text and position of a label, and modify the initial settings. The <LabelID> and <Source> parameters identify each label uniquely. Note that it is not possible to query the <LabelID>, or to read it on the user interface.

DISPlay:SIGNal:LABel:ADD <LabelID>, <Source>, <LabelText>, <PositionMode>, <XPositon>, <YPositon>

Creates a new waveform label for the specified source waveform.

Setting parameters:

<LabelID> String with the label identifier. The <LabelID> and <Source> parameters identify each label uniquely, so the label ID must be unique for the given waveform. Note the <LabelID> because it is not possible to query it, or to read it on the user interface.

<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | QUICk | QUICK | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | SG1 | SG2 | SG3 | SG4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Waveform to that the label belongs, see Chapter 20.4.1, "Waveform Suffix", on page 968.

<LabelText> String with the label text that is shown on the display

<PositionMode> ABS | REL

ABS
Position in time and voltage values, or in other units depending on the waveform character. Absolute positions move with the waveform display when the scales, the vertical position or offset, or the reference point are changed.

REL
Fixed label position in percent of the screen counting from the upper left corner.

<XPositon>	Horizontal position of the label text. Values, range and unit depend on the position mode, the waveform position and scaling. For relative position mode, the range is 0 to 100 %.
<YPositon>	Vertical position of the label text. Values, range and unit depend on the position mode, the waveform position and scaling. For relative position mode, the range is 0 to 100 %.
Example:	`DISPlay:SIGNal:LABel:ADD 'Label1', C1W1, 'Label on C1W1', REL, 20, 20` Adds the label text 'Label on C1W1' to waveform1 of channel1 at relative position 20% from the upper left corner of the screen. The label ID is 'Label1'.
Example:	`DISPlay:SIGNal:LABel:ADD 'Label1', C2W1, 'Label on C2W1', ABS, 10e-09, 0.1` Adds the label text 'Label on C2W1' to waveform1 of channel2 at absolute position 10 ns and 0.1 V. The label ID is 'Label1'.
Usage:	Setting only

DISPlay:SIGNal:LABel:REMove <LabelID>, <Source>

Deletes the specifies waveform label.

Setting parameters:

<LabelID>	String with the label identifier.
<Source>	All waveforms that can be displayed, see `DISPlay:SIGNal:LABel:ADD`
Example:	`DISPlay:SIGNal:LABel:REMove 'Label1', C1W1`
Usage:	Setting only

DISPlay:SIGNal:LABel:TEXT <LabelID>, <Source>, <LabelText>
DISPlay:SIGNal:LABel:TEXT? <LabelID>, <Source>

Modifies or queries the text of the specified label.

Parameters:

<LabelText>	String with the label text that is shown

Parameters for setting and query:

<LabelID>	String with the label identifier.
<Source>	All waveforms that can be displayed, see `DISPlay:SIGNal:LABel:ADD`

DISPlay:SIGNal:LABel:POSMode <Source>, <PositionMode>
DISPlay:SIGNal:LABel:POSMode? <Source>

Modifies or queries the position mode: either relative to the diagram or with absolute values according to the units of the waveform. The position mode applies to all labels of the selected source. For different sources, different position modes can be selected.

Parameters:

<PositionMode> ABS | REL

ABS
Position in time and voltage values, or in other units depending on the waveform character. Absolute positions move with the waveform display when the scales, the vertical position or offset, or the reference point are changed.
Use `DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition` and `DISPlay:SIGNal:LABel:HORizontal:RELative:POSition` to set the position.

REL
Fixed label position in percent of the screen counting from the upper left corner.
Use `DISPlay:SIGNal:LABel:HORizontal:RELative:POSition` and `DISPlay:SIGNal:LABel:VERTical:RELative:POSition` to set the position.

Parameters for setting and query:

<Source> All waveforms that can be displayed, see `DISPlay:SIGNal:LABel:ADD`

DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition? <LabelID>, <Source>
DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition? <LabelID>, <Source>

Modifies or queries the absolute horizontal and vertical positiions of the specified label if `DISPlay:SIGNal:LABel:POSMode` is set to `ABS`.

Parameters:

<Position> Range: depends on waveform position and scaling
Default unit: s and V, or in other units depending on the waveform character

Parameters for setting and query:

<LabelID> String with the label identifier.

<Source> All waveforms that can be displayed, see `DISPlay:SIGNal:LABel:ADD`

Example: `DISPlay:SIGNal:LABel:HORizontal:ABSolute:POSition 'Label1', C2W1, 5e-09`
`DISPlay:SIGNal:LABel:VERTical:ABSolute:POSition 'Label1', C2W1, -0.1`
Move the label to 5 ns and -0.1 V.

DISPlay:SIGNal:LABel:HORizontal:RELative:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:HORizontal:RELative:POSition? <LabelID>, <Source>
DISPlay:SIGNal:LABel:VERTical:RELative:POSition <LabelID>, <Source>, <Position>
DISPlay:SIGNal:LABel:VERTical:RELative:POSition? <LabelID>, <Source>

Modifies or queries the relative horizontal and vertical positiions of the specified label if `DISPlay:SIGNal:LABel:POSMode` is set to `REL`.

Parameters:

<Position> Position in percent of the screen counting from the upper left corner.

Range: 0 to 100
Default unit: %

Parameters for setting and query:

<LabelID> String with the label identifier.

<Source> All waveforms that can be displayed, see `DISPlay:SIGNal:LABel:ADD`

Example: `DISPlay:SIGNal:LABel:HORizontal:RELative:POSition 'Label1', C1W1, 30`
`DISPlay:SIGNal:LABel:VERTical:RELative:POSition 'Label1', C1W1, 70`
Move the label to new relative position: horizontal at 30 % and vertical at 70 % of the screen.

20.7.4 External Application

The commands configure an external application that can be started at various events, for example, trigger event, or mask test violation.

EXECutable:NAME <ApplicationPath>

Sets the path to the application executable.

Parameters:

<ApplicationPath> String parameter containing path, filename, and file extension

Example:

```
EXECutable:NAME 'C:\Program
Files\Wireshark\Wireshark.exe'
TRIGger:EVENt:RUNexec TRIGer
```

EXECutable:PARameter <AppParameters>

Sets optional parameters for the external executable.

Parameters:
<AppParameters> String parameter

EXECutable:WDIRectory <WorkDirectory>

Sets the working directory for the executable.

Parameters:
<WorkDirectory> String parameter

<WorkDirectory>

20.8 Acquisition and Setup

20.8.1 Starting and Stopping Acquisition

RUNContinous
RUN

Starts the continuous acquisition.

Usage: Event
Asynchronous command

RUNSingle
SINGle

Starts a defined number of acquisition cycles. The number of cycles is set with `ACQuire:COUNt`.

Usage: Event
Asynchronous command

STOP

Stops the running acquistion.

Usage: Event
Asynchronous command

20.8.2 Time Base

TIMebase:SCALe <TimeScale>

Sets the horizontal scale - the time per division on the x-axis - for all channel and math waveforms.

The setting accuracy depends on the current resolution (sample rate).

- No interpolation:
  The resolution is an integer multiple of the ADC sample rate.
- With interpolation:

Any value for the horizontal scale can be set.

Parameters:

<TimeScale>	Range:	25E-12 to 10000 (RTO, RTP) | 5000 (RTE)
	Increment:	1E-12
	*RST:	10E-9
	Default unit:	s/div

TIMebase:RANGe <AcquisitionTime>

Defines the time of one acquisition, that is the time across the 10 divisions of the diagram: *TimeScale*10*.

Parameters:

<AcquisitionTime>	Range:	250E-12 to 100E+3 (RTO, RTP) | 50E+3 (RTE)
	Increment:	1E-12
	*RST:	0.5
	Default unit:	s

TIMebase:DIVisions?

Queries the number of horizontal divisions on the screen. The number cannot be changed.

Return values:

<HorizDivCnt>	Range:	4 to 20
	Increment:	2
	*RST:	10

Usage: Query only

TIMebase:HORizontal:POSition <RescaleCtrTime>

Defines the time distance between the reference point and the trigger point (the zero point of the diagram). The reference point marks the rescaling center of the time scale.

Parameters:

<RescaleCtrTime>	Range:	-100E+24 to 100E+24
	Increment:	1E-12
	*RST:	0
	Default unit:	s

Firmware/Software: V 1.50

TIMebase:REFerence <RescaleCtrPos>

Sets the position of the reference point in % of the screen. The reference point marks the rescaling center of the time scale. If you modify the time scale, the reference point remains fixed on the screen, and the scale is stretched or compresses to both sides of the reference point.

Parameters:

<RescaleCtrPos>	Range:	0 to 100
	Increment:	1
	*RST:	50
	Default unit:	%

TRIGger<m>:OFFSet:LIMited <State>

If ON, the horizontal position cannot be set outside the visible waveform diagram.

See also: `TIMebase:HORizontal:POSition` on page 1002

Suffix:
<m> 1..3
The numeric suffix is irrelevant.

Parameters:
<State> ON | OFF
*RST: OFF

AUToscale

Performs an autoset process: analyzes the enabled channel signals, and obtains appropriate horizontal, vertical, and trigger settings to display stable waveforms.

Rohde & Schwarz does not recommend using the autoset in remote control. To adjust the oscilloscope remotely, especially for automated testing applications, use the remote commands that adjust the horizontal, vertical and trigger settings.”

Usage: Event
Asynchronous command

ACQuire:POINts:AUTO <ReclgthManual>

Selection to keep constant either the resolution or the record length when you adjust the time scale (`TIMebase:SCALe`) or acquisition time (`TIMebase:RANGe`).

Parameters:
<ReclgthManual> RESolution | RECLength

RESolution
Resolution is kept constant. Set the required resolution value with `ACQuire:RESolution`.

RECLength
The record length is kept constant. Set the required record length value with `ACQuire:POINts[:VALue]`.

*RST: RESolution

ACQuire:POINts:AADJust <AutoAdjust>

Prevents undersampling and ensures a sufficient resolution to acquire the correct waveform if the time scale is changed. The setting takes effect if the changed parameter - resolution or record length - reaches a limit. The instrument automatically keeps this parameter constant at its limit, and changes the other parameter regardless of the `ACQuire:POINts:AUTO` setting.

Parameters:

<AutoAdjust>	ON | OFF	
	*RST:	ON

ACQuire:POINts:MAXimum <ReclgthLim>

Sets a limit for the record length to prevent very large records. This value only takes effect if a constant resolution is selected with `ACQuire:POINts:AUTO`. If you increase the time scale, the resolution remains constant and the record length increases until the limit is reached. Further increase of the time scale changes the resolution and keeps the record length limit.

Parameters:

<ReclgthLim>	Range:	1000 to 800 MSa. The actual maximum can be lower depending on the installed options, number of active channels, measurements and math waveforms.
	Increment:	2
	*RST:	10E+6
	Default unit:	Sa

ACQuire:POINts:ARATe?

Retrieves the sample rate of the ADC, that is the number of points that are sampled by the ADC in one second.

Return values:

<ADCSampleRate>	Range:	10E+9 and 20E+9
	*RST:	10E+9
	Default unit:	Sa/s

Usage: Query only

ACQuire:SRATe <SampleRate>

Defines the sample rate, that is the number of recorded waveform samples per second.

Parameters:

<SampleRate>	Range:	2 to 20E+12
	Increment:	1
	*RST:	10E+9
	Default unit:	Sa/s

ACQuire:SRReal <RealSampleRate>

Sets the number of captured waveform points per second. It considers the samples of the ADC, and the reduction of waveform points by decimation.

If interpolation is not active, the sample rate is the reciprocal value of the resolution and thus also depends on the acquisition time and the record length.

If interpolation is active, the sample rate is limited to the ADC sample rate.

Parameters:

<RealSampleRate>
Range: 2 to 20E+12
Increment: 1
*RST: 20E+3
Default unit: Sa/s

Firmware/Software: FW 3.40

ACQuire:RESolution <Resolution>

Indicates the time between two waveform points in the record.

Parameters:

<Resolution>
A fine resolution with low values produces a more precise waveform record.

Range: 1E-15 to 0.5
Increment: 10E-12
*RST: 100E-12
Default unit: s

ACQuire:POINts[:VALue] <RecordLength>

Indicates the record length, the number of recorded waveform points that build the waveform across the acquisition time. `[:VALue]` can be omitted.

Parameters:

<RecordLength>
Number of recorded waveform points.

Range: 1000 to 1000000000
Increment: 2
*RST: 1000
Default unit: Sa

TIMebase:ROLL:ENABle <Mode>

Activates the automatic roll mode.

Parameters:

<Mode> AUTO | OFF

AUTO: the instrument activates the roll mode under specific conditions.
See also "Roll mode" on page 124.

*RST: AUTO

TIMebase:ROLL:STATe?

Returns the status of the roll mode.

Return values:

<State> ON | OFF

*RST: OFF

Usage: Query only

TIMebase:ROLL:MTIMe <MinHorizGain>

The roll mode is enabled automatically if the acquisition time exceeds the given value, and if `TIMebase:ROLL:ENABle` is set to AUTO.

Parameters:

<MinHorizGain> Treshold value for roll mode enabling.

Range: 1 to 600
Increment: 1
*RST: 10
Default unit: s

20.8.3 Acquisition

ACQuire:INTerpolate <IntpolMd>

Selects the interpolation method.

See also: "Interpolation" on page 127.

Parameters:

<IntpolMd> LINear | SINX | SMHD

LINear
Linear interpolation between two adjacent sample points

SINX
Interpolation by means of a sin(x)/x curve.

SMHD
Sample/Hold causes a histogram-like interpolation.

*RST: SINX

ACQuire:CDTA <CoupleAcquSet>

Sets the acquisition mode and the waveform arithmetic of all channels to the last set value.

If the acquisition settings are coupled, `ACQuire:MUWaveform` is not relevant, only one waveform per channel can be used.

Parameters:

<CoupleAcquSet> ON | OFF

*RST: ON

Firmware/Software: FW 3.30
Substitutes `ACQuire:CMODode`

ACQuire:MUWaveform <MultiWaveform>

For each channel, up to three waveforms can be shown and analyzed. The decimation mode and the waveform arithmetic are specific for each waveform. So you can analyze several aspects of the signal: For example, waveform1 shows the peaks, and waveform2 shows the average of the signal.

Parameters:

<MultiWaveform> ON | OFF

*RST: OFF

Firmware/Software: FW 3.20

CHANnel<m>[:WAVeform<n>][:STATe] <State>

Activates or deactivates a waveform. `[:STATe]` can be omitted.

Up to 3 waveforms per channel can be analyzed.

Suffix:

<m> 1..4
Selects the input channel.

<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<State>	ON | OFF *RST: OFF

Example: `CHAN2:WAV2 ON`
Activates waveform 2 of channel 2 (C2W2).

CHANnel<m>[:WAVeform<n>]:TYPE <DecimationMode>

Selects the method to reduce the data stream of the ADC to a stream of waveform points with lower sample rate.

See also:"Mode" on page 127.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<DecimationMode> SAMPle | PDETect | HRESolution | RMS

SAMPle
One of n samples in a sample interval of the ADC is recorded as waveform point.

PDETect
Peak Detect: the minimum and the maximum of n samples in a sample interval are recorded as waveform points.

HRESolution
High resolution: The average of n sample points is recorded as waveform point.

RMS
The waveform point is the root mean square of n sample values.

*RST: SAMPle

CHANnel<m>[:WAVeform<n>]:ARIThmetics <Arithmetics>

Selects the method to build the resulting waveform from several consecutive acquisitions of the signal. To define the number of acquisitions, use `ACQuire:COUNt`.

See also: "Wfm Arithmetic" on page 128.

Suffix:

<m>	1..4 Selects the input channel.

<n> 1..3
Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:
<Arithmetics> OFF | ENVelope | AVERage

OFF
The data of the current acquisition is recorded according to the decimation settings.

ENVelope
Detects the minimum and maximum values in an sample interval over a number of acquisitions. To define the reset method, use ...

AVERage
Calculates the average from the data of the current acquisition and a number of acquisitions before.

*RST: OFF

ACQuire:COUNt <MaxAcqCnt>

The acquisition and average count has a double effect:

- It sets the number of waveforms acquired with `RUNSingle`.
- It defines the number of waveforms used to calculate the average waveform.

Parameters:
<MaxAcqCnt> Range: 1 to 16777215
Increment: 10
*RST: 1

ACQuire:ARESet:IMMediate

Forces the immediate restart of the envelope and average calculation for all waveforms.

Usage: Event

Firmware/Software: V 1.36

ACQuire:ARESet:MODE <ArtmRst>

Defines when the envelope and average evaluation restarts.

Parameters:
<ArtmRst> NONE | TIME | WFMS

TIME
Restarts the envelope and average calculation after the time defined with `ACQuire:ARESet:TIME`.

WFMS
Restarts the envelope and average calculation after a number of acquired waveforms defined with `ACQuire:ARESet:COUNt` on page 1010.

*RST: NONE

Firmware/Software: V 1.36

ACQuire:ARESet:TIME <EnvelopeTimeout>

Defines the time after which the envelope and average evaluation restarts.

The setting is relevant if `ACQuire:ARESet:MODE` is set to `TIME`.

Parameters:

<EnvelopeTimeout> Range: 0.1 to 10000
Increment: 0.01
*RST: 0.1
Default unit: s

Firmware/Software: V 1.36

ACQuire:ARESet:COUNt <NofWaveforms>

Defines the number of acquired waveforms after which the envelope and average evaluation restarts.

The setting is relevant if `ACQuire:ARESet:MODE` is set to `WFMS`.

Parameters:

<NofWaveforms> Range: 2 to 16777215
Increment: 10
*RST: 1000

Firmware/Software: V 2.70
Replaces the command `ACQuire:ARESet:WFMCount`

20.8.4 Fast Segmentation

ACQuire:SEGMented:STATe <State>

Switches the fast segmentation mode on and off.

See also: Chapter 4.2.3, "Fast Segmentation", on page 129.

Parameters:

<State> ON | OFF

*RST: OFF

ACQuire:SEGMented:MAX <MaxAcquisitions>

The number of acquisitions in a fast segmentation acquisition series depends on the record length.

Parameters:
<MaxAcquisitions> ON | OFF

ON
Acquires the maximum possible number of acquisitions in a series.

OFF
Acquires the number of acquisitions defined using `ACQuire:COUNt`.

*RST: OFF

ACQuire:SEGMented:AUToreplay <ReplayAfterAcq>

If enabled, the instrument starts processing and displaying the data as soon as the acquisition series is captured completely. Depending on the number of acquisitions, it may take some time until the acquisition series is displayed. If the setting is disabled, the instrument only captures the data and stores it in the sample memory.

Parameters:
<ReplayAfterAcq> ON | OFF

*RST: ON

Firmware/Software: FW 1.40

20.8.5 Vertical

CHANNel<m>:STATe <State>

Switches the channel signal on or off.

Suffix:
<m> 1..4
Selects the input channel.

Parameters:

<State> ON | OFF

*RST: OFF

CHANnel<m>:COUPling <Coupling>

Selects the connection of the indicated channel signal.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Coupling> DC

DC
Direct connection with 50 Ω termination, passes both DC and AC components.

*RST: DC

CHANnel<m>:GND <State>

Connects the signal to the ground.

Suffix:

<m> 1..4

Parameters:

<State> ON | OFF

*RST: OFF

CHANnel<m>:SCALe <Scale>

Sets the vertical scale for the indicated channel.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Scale> Scale value, given in Volts per division.

Range: Depends on attenuation factors, coupling, and instrument model, see below.
Increment: Depends on vertical and probe settings
*RST: 0.05
Default unit: V/div

With 1:1 probe and external attenuation = 1, the vertical scale (input sensitivity) is minimum 1 mV/div. If the probe and/or external attenuation is changed, multiply the values by the attenuation factors to get the actual scale range.

CHANnel<m>:RANGe <Range>

Sets the voltage range across the 10 vertical divisions of the diagram. Use the command alternativly instead of `CHANnel<m>:SCALe`.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Range> Voltage range value

Range: Dependencies see below.
Increment: Depends on vertical and probe settings
*RST: 0.5
Default unit: V/div
Depends on attenuation factors. With 1:1 probe and external attenuations, the range is 10 mV to 10 V. If the probe and/or external attenuation is changed, multiply the range values by the attenuation factors.

CHANnel<m>:POSition <Position>

Sets the vertical position of the indicated channel as a graphical value.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Position> Positive values move the waveform up, negative values move it down.

Range: -5 to 5
Increment: 0.01
*RST: 0
Default unit: div

CHANnel<m>:OFFSet <Offset>

The offset voltage is subtracted to correct an offset-affected signal. The offset of a signal is determined and set by the autoset procedure.

See also: "Offset" on page 133

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Offset> Negative values move the waveform up, positive values move it down.

Range: Depends on attenuation factors, input coupling, and the offset compensation range of active probes. The nominal offset range for 1:1 attenuation and probe offset compensation = 0 is specified in the data sheet.
Increment: Depends on vertical and probe settings
*RST: 0
Default unit: V

CHANnel<m>:INVert <InvertChannel>

Turns the inversion of the signal amplitude on or off. To invert means to reflect the voltage values of all signal components against the ground level. If the inverted channel is the trigger source, the instrument triggers on the inverted signal.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<InvertChannel> ON | OFF

*RST: OFF

Firmware/Software: FW 3.30

CHANnel<m>:BANDwidth <BandwidthLimit>

Selects the bandwidth limit for the indicated channel.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<BandwidthLimit> FULL

FULL
Use full bandwidth.

B200 | B20
Limit to 200 MHz or 20 MHz.

*RST: FULL

CHANnel<m>:IMPedance <Impedance>

Sets the impedance of the channel for power calculations and measurements.

Suffix:
<m> 1..4
Selects the input channel.

Parameters:
<Impedance> Range: 0.1 to 100E+3
Increment: 1
*RST: 50
Default unit: Ohm

CHANnel<m>:OVERload <Overload>

Retrieves the overload status of the specified channel from the status bit. When the overload problem is solved, the command resets the status bit.

Suffix:
<m> 1..4
Selects the input channel.

Parameters:
<Overload> ON | OFF
Use OFF to reset the overload status bit.
*RST: OFF

Example:
```
CHANnel2:OVERload?
```
Queries the overload status of channel 2.
```
CHANnel2:OVERload OFF
```
Resets the overload status bit.

20.8.6 Waveform Data

To set the export data format, see `FORMat[:DATA]` on page 977.

CHANnel<m>[:WAVeform<n>]:DATA:HEADer?

Returns the header of channel waveform data.

Table 20-1: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of one waveform	200000
4	Number of values per sample interval. For most waveforms the result is 1, for peak detect and envelope waveforms it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).	1

If multichannel export is enabled, the number of returned samples is *Record length* * *Number of exported waveforms*. See also EXPort:WAVeform:MULTichannel.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Example: `CHAN1:WAV1:DATA:HEAD?`
`-9.477E-008,9.477E-008,200000,1`

Usage: Query only

CHANnel<m>[:WAVeform<n>]:DATA[:VALues]? [<Offset>], [<Length>]

Returns the data of the channel waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

Without parameters, the complete waveform is retrieved. Using the offset and length parameters, data can be retrieved in smaller portions, which makes the command faster.

To set the export format, use FORMat[:DATA].

You can retrieve only Y-values (usually voltage values), or X- and Y-values. Use EXPort:WAVeform:INCXvalues to define which values are retrieved.

If multichannel export is active (EXPort:WAVeform:MULTichannel), the channel suffix is ignored. To select the channels to be exported, use CHANnel<m>:EXPortstate. The Y-values are written in interleaved order, for example, $YCh1_0$; $YCh2_0$; $YCh1_1$; $YCh2_1$... for a 2-channel instrument.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Query parameters:

[<Offset>]	Number of offset waveform points. Range: 0 to m. Limit: n + m >= record length
[<Length>]	Number of waveform points to be retrieved. Range: 1 to n. Limit: n + m >= record length

Return values:

<Data>	List of values according to the format and content settings.

Example: Retrieve the complete channel 1 waveform, only Y-values:

```
FORM ASC
EXP:WAV:INCX OFF
CHAN1:WAV1:DATA?
<-- -0.125000,-0.123016,-0.123016,-0.123016,-0.123016,-0.123016,...
```

Example: Retrieve the first 10 values of the waveform:

```
CHANnel:WAVeform:DATA:VALues? 0,10
<-- -0.10079051554203,-0.098814234137535,-0.098814234137535,
    -0.096837945282459,-0.094861663877964,-0.094861663877964,
    -0.092885382473469,-0.090909093618393,-0.090909093618393,
    -0.088932812213898
```

Example: Skip 5 samples and retrieve the next 5 samples:

```
CHANnel:WAVeform:DATA:VALues? 5,5
<-- -0.094861663877964,-0.092885382473469,-0.090909093618393,
    -0.090909093618393,-0.088932812213898
```

Usage: Query only

20.8.7 Probes

`TRPRobe:...` command are dedicated commands for the external trigger input.

20.8.7.1 Common Probe Settings

TRPRobe:SETup:STATe?
PROBe<m>:SETup:STATe?

Queries if the probe at the specified input channel is active (detected) or not active (not detected). To switch the probe on, use `CHANnel<m>:STATe`.

Suffix:

<m>	1..4

Return values:

<State>	DETected | NDETected	
	*RST:	NDETected

Usage: Query only

TRPRobe:SETup:TYPE?
PROBe<m>:SETup:TYPE?

Queries the type of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Type>	String containing one of the following values: – None (no probe detected) – Passive Probe – active single-ended

Usage: Query only

TRPRobe:SETup:NAME?
PROBe<m>:SETup:NAME?

Queries the name of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Name>	Name string

Usage: Query only

TRPRobe:SETup:BANDwidth?
PROBe<m>:SETup:BANDwidth?

Queries the bandwidth of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Bandwidth> Range: 10000 to 20E+9
*RST: 1E+9
Default unit: Hz

Usage: Query only

TRPRobe:SETup:ATTenuation[:AUTO]?
PROBe<m>:SETup:ATTenuation[:AUTO]?

Queries the attenuation of the probe.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<AutoAttenuation> Range: 1E-3 to 1000
*RST: 1
Default unit: V/V

Usage: Query only

PROBe<m>:SETup:OFFSet:AZERo

Performs an automatic correction of the zero error. If the DUT is ground-referenced, the AutoZero function can improve the measurement results.

See also: "Detect AutoZero, Use AutoZero" on page 140

Suffix:

<m> 1..4
Selects the input channel.

Usage: Event

PROBe<m>:SETup:OFFSet:USEautozero <AutoZeroOffset>

Includes the AutoZero offset in measurement results. The auto zero error is detected with `PROBe<m>:SETup:OFFSet:AZERo`.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<AutoZeroOffset> ON | OFF
*RST: OFF

Firmware/Software: Version 2.70

CHANNel<m>:EATScale <ExtAttScl>

Sets the attenuation scale for an external divider.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ExtAttScl>	LIN | LOG	
	*RST:	LIN

CHANNel<m>:EATTenuation <ExtAtt>

Sets the attenuation of an external voltage divider that is part of the DUT before the measuring point. The external attenuation is included in the measurement, and the instrument shows the results that would be measured before the divider.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ExtAtt> Values and unit depend on the selected scale (`CHANNel<m>:EATScale`).

Range:	Linear scale: 1E-3 to 1E+6, logarithmic scale: -60 dB to 120 dB
Increment:	0.01
*RST:	1

20.8.7.2 Micro Button and R&S ProbeMeter

PROBe<m>:SETup:MODE <Mode>

Select the action that is started when you press the micro button on the probe head.

See also: "Micro button action" on page 142.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Mode> RCONtinuous | RSINgle | AUToset | AZERo | SEToffsettomean | PRINt | SITFile | NOACtion | FINDtriglevel | REPort | PROBemode | PRSetup

RCONtinuous
Run continuous: The acquisition is running as long as the probe button is pressed.

RSINgle
Run single: Starts a defined number of acquisitions (same as [Single] key).

AUTOSET
Starts the autoset procedure.

AZero
AutoZero: performs an automatic correction of the zero error.

SEToffsettomean
Set offset to mean: performs an automatic compensation for a DC component of the input signal.

PRINt
Prints the current display according to the printer set with `SYSTem:COMMunicate:PRINter:SELect<1..2>`.

SITFile
Save Image To File:
Directs the display image to a file. The `MMEMory:NAME` command defines the file name. The file format is defined with `HCOPy:DEVice<m>:LANGuage`.

NOACtion
Nothing is started on pressing the micro button.

FINDtriglevel
Sets the trigger level automatically to*0.5 * (MaxPeak – MinPeak)*. The function is not available for an external trigger source.

REPort
Creates and saves a report of the current results.

PROBemode
Only available for R&S RT-ZM probes. Changes the measurement mode of the probe.

PRSetup
Opens the "Probes Setup" dialog box.

*RST: RCONtinuous

TRPRobe:SETup:DISPlaydiff <DisplayDiff>
PROBe<m>:SETup:DISPlaydiff <DisplayDiff>

Selects the input voltages to be measured by the ProbeMeter of an R&S differential active probe.

See also: "Differential Active Probes" on page 119.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<DisplayDiff> DIFFerential | SINGleended

DIFFerential
Measures differential and common mode voltages

SINGleended
Measures the voltage between the positive/negative signal socket and the ground.

*RST: DIFFerential

TRPRobe:PMETer:VISibility <Visibility>
PROBe<m>:PMETer:VISibility <Visibility>

Activates the integrated R&S ProbeMeter of active R&S probes.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Visibility> ON | OFF

*RST: OFF

Firmware/Software: FW 2.25

TRPRobe:PMETer:RESults:SINGle?
PROBe<m>:PMETer:RESults:SINGle?

Returns the ProbeMeter measurement result of single-ended active R&S probes, the voltage measured between the probe tip and the ground.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<Result> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

TRPRobe:PMETer:RESults:COMMon?
PROBe<m>:PMETer:RESults:COMMon?

Returns the ProbeMeter measurement result of differential active R&S probes: the common mode voltage, which is the mean voltage between the signal sockets and the ground socket.

Suffix:
<m> 1..4
Selects the input channel.

Return values:
<Result> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

TRPRobe:PMETer:RESults:DIFFerential?
PROBe<m>:PMETer:RESults:DIFFerential?

Returns the ProbeMeter measurement result of differential active R&S probes, the differential voltage - the voltage between the positive and negative signal sockets.

Suffix:
<m> 1..4
Selects the input channel.

Return values:
<Result> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

TRPRobe:PMETer:RESults:NEGative?
PROBe<m>:PMETer:RESults:NEGative?

Returns the ProbeMeter measurement result of differential active R&S probes, the voltage that is measured between the negative signal socket and the ground.

Suffix:
<m> 1..4
Selects the input channel.

Return values:

<Result>	Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

TRPRobe:PMETer:RESults:POSitive?
PROBe<m>:PMETer:RESults:POSitive?

Returns the ProbeMeter measurement result of differential active R&S probes, the voltage that is measured between the negative signal socket and the ground.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Result>	Range: -100E+24 to 100E+24 Increment: 1E-3 *RST: 0 Default unit: V

Usage: Query only

Firmware/Software: FW 2.25

20.8.7.3 Passive Probes

TRPRobe:SETup:ATTenuation:MODE <AttenuationMode>
PROBe<m>:SETup:ATTenuation:MODE <AttenuationMode>

Set the mode to MANual if the instrument does not detect the probe.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<AttenuationMode>	AUTO | MANual *RST: AUTO

TRPRobe:SETup:ATTenuation:UNIT <AttenuationUnit>
PROBe<m>:SETup:ATTenuation:UNIT <AttenuationUnit>

Sets the unit for the connected probe type if `PROBe<m>:SETup:ATTenuation:MODE` on page 1024 is set to `MANual`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<AttenuationUnit>	V | A | W Voltage probe (V), current probe (A), power probe (W) *RST: V

TRPRobe:SETup:ATTenuation:MANual <ManualAttenuation>
PROBe<m>:SETup:ATTenuation:MANual <ManualAttenuation>

Sets the attenuation for the connected probe if `PROBe<m>:SETup:ATTenuation:MODE` on page 1024 is set to `MANual`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ManualAttenuation>	Range: 100E-6 to 10000 Increment: 0.1 *RST: 1 Default unit: Depends on the selected unit

TRPRobe:SETup:GAIN:MANual <GainManual>
PROBe<m>:SETup:GAIN:MANual <GainManual>

Sets the gain of a current probe.

Suffix:

<m>	1..4 Selects the input channel. The number of channels depends on the instrument.

Parameters:

<GainManual>	Range: 100E-6 to 10000 Increment: 100E-6 *RST: 1 Default unit: V/A

20.8.7.4 Active Voltage Probes

TRPRobe:SETup:CMOFfset <CMOffset>
PROBe<m>:SETup:CMOFfset <CMOffset>

Sets the common-mode offset. The setting is only available for differential probes.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<CMOffset> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

TRPRobe:SETup:ZAXV <ExtAttRTZA15>
PROBe<m>:SETup:ZAXV <ExtAttRTZA15>

If you use the external attenuator R&S RT-ZA15 together with one of the differential active probes R&S RT-ZD10/20/30, enable it to include the external attenuation in the measurements.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<ExtAttRTZA15> ON | OFF
*RST: OFF

TRPRobe:SETup:ACCoupling <ProbeCouplingAC>
PROBe<m>:SETup:ACCoupling <ProbeCouplingAC>

Enables AC coupling in the R&S RT-ZPR20 probe, which removes DC and very low-frequency components. The R&S RT-ZPR20 probe requires 50 Ω input termination, for which the channel AC coupling is not available. The probe setting allows AC coupling also at 50 Ω inputs.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<ProbeCouplingAC> ON | OFF

*RST: OFF

PROBe<m>:SETup:ADVanced:PMToffset

Sets the measured ProbeMeter value as offset. Make sure that the ProbeMeter is active before you use this command.

Only available for power rail probes R&S RT-ZPR.

Suffix:

<m> 1..4

Selects the input channel.

Usage: Event

PROBe<m>:SETup:ADVanced:RANGe <ProbeRange>

Sets the voltage range of a R&S RT-ZHD probe.

Suffix:

<m> 1..4

Selects the input channel.

Parameters:

<ProbeRange> AUTO | MHIGh | MLOW

AUTO

The voltage range is set with `CHANnel<m>:SCALe`.

MHIGh

Sets the higher voltage range of the connected probe. To query the value, use `PROBe<m>:SETup:ATTenuation[:AUTO]?`.

MLOW

Sets the lower voltage range of the connected probe. To query the value, use `PROBe<m>:SETup:ATTenuation[:AUTO]?`.

*RST: AUTO

TRPRobe:SETup:ADVanced:FILTer <BwFilterSt>
PROBe<m>:SETup:ADVanced:FILTer <BwFilterSt>

Enables the lowpass filter in the probe control box.

Suffix:

<m> 1..4

Selects the input channel.

Parameters:

<BwFilterSt> ON | OFF

*RST: OFF

TRPRobe:SETup:ADVanced:AUDioverload <AudibOvrrg>
PROBe<m>:SETup:ADVanced:AUDioverload <Sound>

Activates the acustic overrange warning in the probe control box.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Sound> ON | OFF
*RST: OFF

20.8.7.5 Modular Probes

The commands of this chapter are relevant for R&S RT-ZM modular probes. The commands are available in firmware version 3.40 and higher.

The suffix <m> selects the input channel to which the probe is connected.

TRPRobe:SETup:PRMode <MeasMode>
PROBe<m>:SETup:PRMode <MeasMode>

Sets the measurement mode of the modular probe.

Suffix:

<m> 1..4

Parameters:

<MeasMode> DMODe | CMODe | PMODe | NMODe

DMODe
Differential mode input voltage (V_{dm}), the voltage between the positive and negative input terminal.

CMODe
Common mode input voltage (V_{cm}) , the mean voltage between the positive and negative input terminal vs. ground.

PMODe
Positive single-ended input voltage (V_p). the voltage between the positive input terminal and ground.

NMODe
Negative single-ended input voltage (V_N). the voltage between the negative input terminal and ground.

*RST: DMODe

PROBe<m>:SETup:DMOFfset <DMOffset>

Sets the differential offset to compensate a DC voltage applied to the positive and the negative input terminal.

Suffix:

<m> 1..4

Parameters:

<DMOffset> In "DM" probe mode (`DMODe`), this offset is used as channel offset and considered automatically for correction.

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

PROBe<m>:SETup:CMOFfset <CMOffset>

Sets the common-mode offset. The setting is only available for differential probes.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<CMOffset> Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

PROBe<m>:SETup:NOFFset <NOffset>

Sets the negative offset to compensate a DC voltage applied to the negative input terminal (Vp) referenced to ground.

Suffix:

<m> 1..4

Parameters:

<NOffset> In "N" probe mode (`NMODe`), this offset is used as channel offset and considered automatically for correction.

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

PROBe<m>:SETup:POFFset <POffset>

Sets the positive offset to compensate a DC voltage applied to the positive input terminal (Vp) referenced to ground.

Suffix:

<m>	1..4

Parameters:

<POffset> In "P" probe mode (`PMODe`), this offset is used as channel offset and considered automatically for correction.

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

PROBe<m>:SETup:TERM:STATe <VoltageState>

Activates the instrument control of the termination voltage.

Suffix:

<m>	1..4

Parameters:

<VoltageState> ON | OFF

*RST: OFF

PROBe<m>:SETup:TERM:MODE <Mode>

Setting the termination voltage is relevant if you use the R&S RT-ZMA40 SMA module.

You can set a termination voltage to correct the internal 50 Ω termination of the SMA module by the common mode voltage. To control the termination voltage by the instrument, connect the VT terminal of the R&S RT-ZM probe amplifier to the VT terminal of the SMA module using the red DC lead (see R&S RT-ZM User Manual).

Suffix:

<m>	1..4

Parameters:

<Mode> AUTO | MANual

AUTO
The instrument uses the measured common mode voltage to control the termination.

MANual
Enter the voltage to be used for termination.

*RST: AUTO

PROBe<m>:SETup:TERM:MEASure?

Returns the measured common mode voltage.

Suffix:
<m> 1..4

Return values:
<VoltageMeas> Common mode voltage

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

Usage: Query only

PROBe<m>:SETup:TERM:ADJust <VoltageAdjust>

Sets the voltage to be used for termination correction.

Suffix:
<m> 1..4

Parameters:
<VoltageAdjust> Correction voltage

Range: -100E+24 to 100E+24
Increment: 1E-3
*RST: 0
Default unit: V

20.8.7.6 Modular Probes, Deembedding

The commands of this chapter are relevant for R&S RT-ZM modular probes when used for measurements on signal frequencies of 4 GHz and higher. The commands are available in firmware version 4.00 and higher.

See also: PROBe<m>:SETup:PRMode on page 1028

PROBe<m>:DEEMbedding:TIPModule[:SELect] <ProbeTip>

Selects the tip module that is used for measurement.

Suffix:
<m> 1..4
Selects the channel to which the probe is connected.

Parameters:

<ProbeTip>	NONE | ZMA10 | ZMA12 | ZMA15 | ZMA30 | ZMA40 | ZMA50 *RST: ZMA10

PROBe<m>:DEEMbedding:TIPModule:ZMA<n>:SUBModule <Value>

Defines additional settings for some tip modules:

For the browser module R&S RT-ZMA30, measure the space between the pins, and select the appropriate value.

If R&S RT-ZMA40 is selected, choose the used submodule: semi-rigid cables or none.

Suffix:

<m>	1..4 Selects the channel to which the probe is connected.
<n>	30 (R&S RT-ZMA30) or 40 (R&S RT-ZMA40)

Parameters:

<Value>	D16 | D25 | D45 | D75 | NONE | SRCS **For R&S RT-ZMA30:** D16 = 1.6 mm D25 = 2.5 mm D45 = 4.5 mm D75 = 7.5 mm **For R&S RT-ZMA40:** NONE = no submodule SRCS = semi-rigid cables

---

PROBe<m>:DEEMbedding:BANDwidth <ProbeBandwidth>

Sets the maximum bandwidth until which the signal is corrected. This maximum value is the minimum bandwidth value of probe, probe tip and oscilloscope bandwidth, and can not be higher than the highest frequency in a used S-parameter file. Consider that most tip modules support the full bandwidth of the probe amplifier, but some tip modules have limited bandwidth.

Suffix:

<m>	1..4 Selects the channel to which the probe is connected.

Parameters:

<ProbeBandwidth>	Range: 1E+9 to 16E+9 Increment: 10 *RST: 4E+9 Default unit: Hz

---

PROBe<m>:DEEMbedding:MODE <Mode>

Sets the probing mode.

Suffix:

<m>	1..4 Selects the channel to which the probe is connected.

Parameters:

<Mode>	PROBing | TERMinating **PROBing** For measurements with a high-ohmic probe and measure on an existing line in parallel to the load. **TERMinating** For measurements if the measuring equipment is the load of the line. *RST: PROBing

PROBe<m>:DEEMbedding:REMProbeload <RemoveProbeLoad>

Removes the loading of the probe if `DEEMbedding<m>:COMPonent<n>:MODE` is set to `PROBing`.

If the probe loading is removed, you see the signal that would be at the measurement point if the probe's input impedance is ideal (infinite impedance).

Without removing the loading, you see the real signal at the measurement point, including the probe loading.

Suffix:

<m>	1..4 Selects the channel to which the probe is connected.

Parameters:

<RemoveProbeLoad>	ON | OFF *RST: ON

PROBe<m>:DEEMbedding:LOAD[:TYPE] <Value>

Sets the impedance type of the DUT.

Suffix:

<m>	1..4 Selects the channel to which the probe is connected.

Parameters:

<Value>	DEFault | CONStant | S1P | S2P **DEFault** The default value depends on the selected probing mode and the connected modular or differential probe. The impedance is a constant value over frequency. If the default value does not match to the DUT, select "Constant" or "Touchstone".

CONStant
The source impedance is a constant value over frequency. Set the value with DEEMbedding<m>:COMPonent<n>:LOAD:IMPedance on page 1842.

S1P | S2P
Touchstone file. If the complete measurement setup is a 2-port (1 input and 1 output), you need a S1P file. If the complete measurement setup is a 3-port (2 inputs and 1 output), you need a S2P file.
See also: "Impedance type" on page 154.

*RST: DEFault

PROBe<m>:DEEMbedding:LOAD:IMPedance <SourceImpedance>

Impedance of the DUT. Shows the default source impedance or sets the user-defined constant impedance value. If an R&S RT-ZM probe is connected, the value depends on the selected probe mode: common mode, differential, or single-ended measurement.

See also: PROBe<m>:DEEMbedding:LOAD[:TYPE] on page 1033.

Suffix:

<m>	1..4 Selects the channel to which the probe is connected.

Parameters:

<SourceImpedance>	Range: 100E-15 to 1E+9 Increment: 1 *RST: 50 Default unit: \x2126

PROBe<m>:DEEMbedding:LOAD:FILE <S1PFilePath>

Sets the file name, file format and path of the S-parameter file, and loads the S-parameters.

The command is relevant if:

- PROBe<m>:DEEMbedding:MODE is PROBing
- PROBe<m>:DEEMbedding:REMProbeload is ON
- PROBe<m>:DEEMbedding:LOAD[:TYPE] is S1P | S2P

Suffix:

<m>	1..4 Selects the channel to which the probe is connected.

Parameters:

<S1PFilePath>	String with path and file name with extension s1p.

20.8.7.7 Predefined Probes

TRPRobe:SETup:ATTenuation:DEFProbe <SelcPredefPrb>
PROBe<m>:SETup:ATTenuation:DEFProbe <PredefinedProbe>

Selects a predefined probe. These are probes that are not recognized automatically but the parameters of the probe are known to the instrument.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<PredefinedProbe> ZC10 | ZC20 | ZC30 | ZD01A100 | ZD01A1000 | ZZ80 | FREE | ZS10L | ZD02 | ZD08 | ZC02100 | ZC021000 | ZC03 | ZD002A10 | ZD002A100 | ZD003A20 | ZD003A200

ZC10 | ZC20 | ZC30 | ZZ80 | ZS10L | ZD02 | ZD08 | ZC03
Type of the probe

ZD01A100 | ZD01A1000 | ZD002A10 | ZD002A100 | ZD003A20 | ZD003A200
High voltage differential probes R&S RT-ZD0xx, attenuation ratio according to the setting on the probe.
A10 = 10:1
A20 = 20:1
A100 = 100:1
A200 = 200:1
A1000 = 1000:1

ZC02100 | ZC021000
Current probes 100 A or 1000 A according to the setting on the probe.

FREE
Any other probe that is not recognized by the instrument.

*RST: FREE

Firmware/Software: V 1.27

PROBe<m>:SETup:OFFSet:TOMean

Performs an automatic compensation for a DC component of the specified input signal using the result of a background mean measurement.

Suffix:

<m> 1..4
Selects the input channel.

Usage: Event

20.8.7.8 Current Probes

To set up R&S RT-ZC10 and R&S RT-ZC20, use `PROBe<m>:SETup:ATTenuation:DEFProbe`.

TRPRobe:SETup:DEGauss
PROBe<m>:SETup:DEGauss

Demagnetizes the core if it has been magnetized by switching the power on and off, or by an excessive input. Always carry out demagnetizing before measurement. The demagnetizing process takes about one second.

Suffix:

<m>	1..4 Selects the input channel.

Usage: Event

Firmware/Software: FW 2.50

PROBe<m>:SETup:OFFSet:STPRobe

Saves the zero adjust value in the probe box. If you connect the probe to another channel or to another R&S RTx oscilloscope, the value is read out again.

Suffix:

<m>	1..4 Selects the input channel.

Usage: Event

PROBe<m>:SETup:OFFSet:ZADJust <ZeroAdjustValue>

set the waveform to zero position. It corrects the effect of a voltage offset or temperature drift. To set the value by the instrument, use `PROBe<m>:SETup:OFFSet:AZERo`.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ZeroAdjustValue>	Range: -100 to 100 Increment: 0.1 *RST: 0 Default unit: %

Firmware/Software: FW 2.50

20.8.7.9 Probe Attributes

TRPRobe:ID:SWVersion?
PROBe<m>:ID:SWVersion?

Queries the version of the probe firmware.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<Softwareversion>	Version number in a string.

Usage: Query only

TRPRobe:ID:PRDate?
PROBe<m>:ID:PRDate?

Queries the production date of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<ProductionDate>	Date in a string.

Usage: Query only

TRPRobe:ID:PARTnumber?
PROBe<m>:ID:PARTnumber?

Queries the R&S part number of the probe.

Suffix:

<m>	1..4 Selects the input channel.

Return values:

<PartNumber>	Part number in a string.

Usage: Query only

TRPRobe:ID:SRNumber?
PROBe<m>:ID:SRNumber?

Queries the serial number of the probe.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<SerialNo> Serial number in a string.

Usage: Query only

TRPRobe:SETup:CAPacitance?
PROBe<m>:SETup:CAPacitance?

Queries the input capacitance of the probe.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<InputCapacity> Range: 100E-15 to 1E-9
*RST: 10E-12
Default unit: F

Usage: Query only

TRPRobe:SETup:IMPedance?
PROBe<m>:SETup:IMPedance?

Queries the termination of the probe.

Suffix:

<m> 1..4
Selects the input channel.

Return values:

<InputImpedance> Range: 100E-15 to 1E+9
*RST: 50
Default unit: Ω

Usage: Query only

20.8.8 R&S RT-ZVC Probe

20.8.8.1 Probe Setup

In the `ZVC:Z<m>:` commands, the following suffixes are used:

- `<m>` selects the multi-channel probe. The available range is `1..2`
- `<n>` selects the voltage or current channel. The available range depends on the probe characteristics and is `1..2` or `1..4`

ZVC:BANDwidth <Bandwidth>

Sets the bandwidth limit of the probe. The bandwidth specifies the maximum frequency at which a purely sinusoidal signal is still transferred at 89 % (0.1 dB) of its amplitude.

Parameters:

<Bandwidth>	Range: 5000 to 1E+6 Increment: 5000 *RST: 1E+6 Default unit: Hz

ZVC:TYPE <DecimationMode>

Sets the decimation mode for the R&S RT-ZVC probe. Decimation reduces the data stream of the ADC to a stream of waveform points with lower sample rate and a less precise time resolution.

Parameters:

<DecimationMode>	SAMPle | PDETect | HRESolution *RST: SAMPle

ZVC:Z<m>:I<n>:BANDwidth?

Queries the bandwidth of the current channel. You can set the probe bandwidth with `ZVC:BANDwidth`.

The bandwidth of some current channels is restricted to 300KHz due to their vertical settings.

Suffix:

<m>	1..2
<n>	1..4

Return values:

<Bandwidth>	Range: 5000 to 1E+6 Increment: 5000 *RST: 1E+6 Default unit: Hz

Usage: Query only

ZVC:Z<m>:I<n>:IMPedance <MeasImp>

Sets the current impedance of the probe channel for power calculations and measurements.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<MeasImp>	Range: 1 to 100E+3 Increment: 1 *RST: 50 Default unit: Ω

ZVC:Z<m>:I<n>:OFFSet <VerticalOffset>

Sets the offset current for the current channel.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<VerticalOffset>
Range: -1 to 1
Increment: 0.01
*RST: 0
Default unit: V

ZVC:Z<m>:I<n>:OVERload:RSTO <Settings>

Resets the overload indication at the probe.

In internal shunt mode (`ZVC:Z<m>:I<n>:SHUNt:MODE` is set to `INTShunt`), chooses whether to keep the operation range adjusted by the R&S RT-ZVC during overload or to restore the original settings for the given current channel.

In external shunt mode (`ZVC:Z<m>:I<n>:SHUNt:MODE` is set to `EXTShunt`), there is no adjustment of the operation range during overload.

Suffix:

<m>	1..2
<n>	1..4

Setting parameters:

<Settings> ADJusted | ORIGinal

ADJusted
The operation range that is automatically adjusted by the probe during overload is kept.
In internal shunt mode, during an overload at a current channel, the probe switches automatically to the next higher range. If the 10A range is also exceeded, the amperemeter switches to external shunt mode to protect the probe against permanent damage.

ORIGinal
The original operation range is restored as before the overload and the adjustment of the operation range.

Usage: Setting only

ZVC:Z<m>:I<n>:OVERload:VALue?

Queries if an overload of the current channel was detected.

Suffix:

<m>	1..2
<n>	1..4

Return values:

<Overload> ON | OFF

*RST: OFF

Usage: Query only

ZVC:Z<m>:I<n>:POSition <VertPosi>

Sets the vertical position of the indicated current channel as a graphical value.

Suffix:

<m> 1..2

<n> 1..4

Parameters:

<VertPosi> Range: -5 to 5
Increment: 0.02
*RST: 0
Default unit: div

ZVC:Z<m>:I<n>:SCALe <VerticalScale>

Sets the vertical scale for the current channel in Volts per division. Increasing the scale compresses the display of the signal.

Suffix:

<m> 1..2

<n> 1..4

Parameters:

<VerticalScale> Range: 1E-15 to 10E+24
Increment: 10E-6
*RST: 3
Default unit: V/div

ZVC:Z<m>:I<n>:SHUNt:EVALue <ExtShuntVal>

Defines the value of the external shunt resistor to calculate the correct current values.

Suffix:

<m> 1..2

<n> 1..4

Parameters:

<ExtShuntVal> Range: 10E-6 to 10000
Increment: 0.02
*RST: 1
Default unit: Ω

ZVC:Z<m>:I<n>:SHUNt:MODE <ShuntMode>

Sets the internal or external shunt mode.

Suffix:

<m> 1..2

<n> 1..4

Parameters:

<ShuntMode> INTShunt | EXTShunt

*RST: INTShunt

ZVC:Z<m>:I<n>:SHUNt:MAXCurrent <IntShuntMeasRg>

Sets the maximum current and the internal shunt value.

The internal shunt and maximum current parameter pairs are defined as described in the table below.

Parameter	Internal shunt	Maximum current
`A100r01`	10 A	10 mΩ
`A40R01`	4.5 A	10 mΩ
`A45M10r`	45 mA	10 Ω
`A4M510r`	4.5 mA	10 Ω
`A45u10k`	45 µA	10 KΩ
`A4U510k`	4.5 µA	10 KΩ

Suffix:

<m> 1..2

<n> 1..4

Parameters:

<IntShuntMeasRg> A100r01 | A40R01 | A45M10r | A4M510r | A45u10k | A4U510k

*RST: A100r01

ZVC:Z<m>:I<n>:SHUNt:MXCValue?

Queries the maximum current.

Suffix:

<m> 1..2

<n> 1..4

Return values:

<MaxCurrentValue> Default unit: A

Usage: Query only

ZVC:Z<m>:I<n>:SHUNt:MAXVoltage <ExtShuntMeasRg>

Sets the maximum voltage for the external shunt.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<ExtShuntMeasRg> V450m | V045m

`V450m`: 450 mV
`V045m`: 45 mV
*RST: V450m

ZVC:Z<m>:I<n>:SKEW <DeskewOffset>

Sets the skew offset value for the current probe channel. This is a delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<DeskewOffset>
Range: -6E-6 to 6E-6
Increment: 200E-9
*RST: 0
Default unit: s

ZVC:Z<m>:I<n>[:STATe] <State>

Enables the corresponding current channel of the probe.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<State> ON | OFF
*RST: OFF

ZVC:Z<m>:V<n>:BANDwidth?

Queries the bandwidth of the voltage channel. You can set the probe bandwidth with `ZVC:BANDwidth`.

Suffix:

<m>	1..2

<n> 1..4

Return values:

<Bandwidth> Range: 5000 to 1E+6
Increment: 5000
*RST: 1E+6
Default unit: Hz

Usage: Query only

ZVC:Z<m>:V<n>:IMPedance <MeasImp>

Sets the voltage impedance of the probe channel for power calculations and measurements.

Suffix:

<m> 1..2

<n> 1..4

Parameters:

<MeasImp> Range: 1 to 100E+3
Increment: 1
*RST: 50
Default unit: Ω

ZVC:Z<m>:V<n>:OFFSet <VerticalOffset>

Sets the vertical offset for the voltage channel.

Suffix:

<m> 1..2

<n> 1..4

Parameters:

<VerticalOffset> Range: -1 to 1
Increment: 0.01
*RST: 0
Default unit: V

ZVC:Z<m>:V<n>:OVERload:RSTO

Resets the overload indication at the probe.

Suffix:

<m> 1..2

<n> 1..4

Usage: Event

ZVC:Z<m>:V<n>:OVERload:VALue?

Queries if an overload of the voltage channel was detected.

Suffix:

<m>	1..2
<n>	1..4

Return values:

<Overload>	ON | OFF	
	*RST:	OFF

Usage: Query only

ZVC:Z<m>:V<n>:POSition <VertPosi>

Sets the vertical position of the indicated voltage channel as a graphical value.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<VertPosi>	Range:	-5 to 5
	Increment:	0.02
	*RST:	0
	Default unit:	div

ZVC:Z<m>:V<n>:SCALe <VerticalScale>

Sets the vertical scale for the voltage channel in Volts per division. Increasing the scale compresses the display of the signal.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<VerticalScale>	Range:	1E-15 to 10E+24
	Increment:	10E-6
	*RST:	3
	Default unit:	V/div

ZVC:Z<m>:V<n>:SKEW <DeskewOffset>

Sets the skew offset value for the voltage probe channel. This is a delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically.

Suffix:

<m>	1..2

<n>	1..4

Parameters:

<DeskewOffset> Range: -6E-6 to 6E-6
Increment: 200E-9
*RST: 0
Default unit: s

ZVC:Z<m>:V<n>[:STATe] <State>

Enables the corresponding voltage channel of the probe.

Suffix:

<m>	1..2
<n>	1..4

Parameters:

<State> ON | OFF
*RST: OFF

ZVC:Z<m>:ID:NAME?

Queries the name of the probe.

Suffix:

<m> 1..2

Return values:

<Name>

Usage: Query only

ZVC:Z<m>:ID:PARTnumber?

Queries the R&S part number of the probe.

Suffix:

<m> 1..2

Return values:

<PartNumber>

Usage: Query only

ZVC:Z<m>:ID:SRNumber?

Queries the serial number of the probe.

Suffix:

<m> 1..2

Return values:

<SerialNo>

Usage: Query only

ZVC:Z<m>:ID:SWVersion?

Queries the version of the probe firmware.

Suffix:
<m> 1..2

Return values:
<Softwareversion>

Usage: Query only

20.8.8.2 Resolution

ACQuire:POINts:ZVALue?

Returns the current record length used by the R&S RT-ZVC multi-channel power probe channel.

Return values:
<ZUIRecordLength> Range: 1000 to 200000000
Increment: 2
*RST: 1000
Default unit: Sa

Usage: Query only

ACQuire:ZRESolution?

Returns the current resolution of the R&S RT-ZVC multi-channel power probe channel.

Return values:
<ZUIResolution> Range: 1E-15 to 0.5
Increment: 10E-12
*RST: 500E-6
Default unit: s

Usage: Query only

20.8.9 Digital Filter

CHANnel<m>:DIGFilter:STATe <State>

Enables the DSP filter for input channels.

Suffix:

<m>	1..4

Parameters:

<State>	ON | OFF *RST: OFF

CHANnel<m>:DIGFilter:CUToff <CutOffLP>

Sets the limit frequency of the lowpass filter for input channels.

Suffix:

<m>	1..4 Selects the input channel. One filter is applied to a pair of channels - one filter for channels 1 and 2 and another filter for channels 3 and 4 (only 4-channel models).

Parameters:

<CutOffLP>	Range: 100E+3 to 2 GHz for R&S RTP2064, all others to 1 GHz Increment: 1000 *RST: 1E+6 Default unit: Hz

20.8.10 Skew

CHANnel<m>:SKEW:MANual <ManualCompens>

If enabled, the skew offset value (`CHANnel<m>:SKEW:TIME`) is used for compensation. This improves horizontal and trigger accuracy.

Suffix:

<m>	1..4 Selects the input channel.

Parameters:

<ManualCompens>	ON | OFF *RST: ON

CHANnel<m>:SKEW:TIME <Offset>

Sets an delay value, that is known from the circuit specifics but cannot be compensated by the instrument automatically. It affects only the selected input channel.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<Offset> Range: -100E-9 to 100E-9
Increment: 1E-12
*RST: 0
Default unit: s

20.8.11 AUX OUT

CALibration:SOURce:FREQuency <Frequency>

Frequency value and waveform type of the internal calibration source.

Parameters:

<Frequency> GHZ1

GHZ1
1 GHz sine wave generated by the mainboard.

*RST: GHZ1

Example:

```
CAL:SOUR:FREQ GHZ1
CAL:SOUR:STAT ON
```

The commands activate the 1 GHz reference frequency.

CALibration:SOURce:STATe <State>

Defines the state of the internal calibration source.

Parameters:

<State> ON | OFF

*RST: OFF

PROBe<m>:SKEState <ProbeSkew>

If enabled, the skew of all connected active probes is measured, displayed, and used for deskewing.

Suffix:

<m> 1..4
The suffix is irrelevant. The setting affects all active channels.

Parameters:

<ProbeSkew> ON | OFF

*RST: OFF

CHANnel<m>:SKEW:EXTended <ExtendSkew>

Enables a higher skew value range that can be set with `CHANnel<m>:SKEW:TIME` on page 1049. The skew extension reduces the maximum number of acquisitions in the memory.

Suffix:

<m> 1..4

The suffix is irrelevant. The setting affects all active channels.

Parameters:

<ExtendSkew> ON | OFF

*RST: OFF

20.8.12 High Definition Mode (option R&S RTP-K17)

HDEFinition:STATe <State>

Activates the high definition mode of the instrument.

Parameters:

<State> ON | OFF

ON: high definition mode, up to 16 bit digital resolution
OFF: normal oscilloscope mode

*RST: OFF

HDEFinition:BWIDth <Bandwidth>

Sets the filter bandwidth for the high definition mode.

Parameters:

<Bandwidth>

Range:	10000 to max. 2 GHz, depending on the instrument bandwidth.
Increment:	1000
*RST:	1E+6
Default unit:	Hz

See "Bandwidth" on page 136 for bandwidth limits.

HDEFinition:RESolution?

Returns the resulting digital resolution in high definition mode.

Return values:

<Resolution>	Range:	0 to 16
	Increment:	0.1
	*RST:	0

Usage: Query only

FORMat:BORDer <ByteOrder>

Sets the endianess.

The command is only relevant for raw data export in high definition mode (16 bit word length).

Parameters:

<ByteOrder> LSBFirst | MSBFirst

LSB first: little endian, least significant byte first
MSB first: big endian, most significant byte first

*RST: LSBFirst

20.8.13 Reference Clock

Commands are related to the external reference input on the rear panel, and the output of the OCXO reference signal.

SENSe[:ROSCillator]:SOURce <RefSource>

Enables the use of the external reference signal instead of the internal OCXO reference.

Parameters:

<RefSource> INTernal | EXTernal

*RST: INTernal

SENSe[:ROSCillator]:EXTernal:FREQuency <ExternalRef>

Sets the frequency of an external reference input signal that is connected to the external reference input on the rear panel.

Parameters:

<ExternalRef> *RST: 10E+6
Default unit: Hz
Range is 1E+6 to 20E+6, and the increment is 1E+6.

20.9 Trigger

20.9.1 Basic Trigger Settings

DISPlay:TRIGger:LINes <State>

Hides or shows the trigger levels in the diagrams.

Parameters:

<State> ON | OFF

*RST: OFF

TRIGger<m>:SOURce <SourceDetailed>

Selects the source of the trigger signal.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event
Available values depend on the selected trigger source. For input channels CHAN1...4, a trigger sequence can be configured.
For all other trigger sources, only suffix 1 is allowed.
See also: `TRIGger<m>:SEQuence:MODE`

Parameters:

<SourceDetailed> CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 | EXTernanalog

CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4
Input channels

EXTernanalog
External analog signal connected to the External Trigger Input.
For this source, only the analog edge trigger is available.

SBUS
Serial bus

D0...D15
Digital channels (option R&S RTP-B1)
See also: Chapter 20.18.4, "Trigger Settings for Digital Signals and Parallel Buses", on page 1795

LOGIc
Logic combination of digital channels, used as trigger source (option R&S RTP-B1)

MSOB1 | MSOB2 | MSOB3 | MSOB4
Parallel bus (option R&S RTP-B1)

*RST: CHAN1

TRIGger<m>:TYPE <Type>

Selects the trigger type to trigger on analog channels or the external trigger input.

See also: Chapter 5.3, "Trigger Types", on page 184.

To trigger on digital channels and parallel buses, use `TRIGger<m>:PARallel:TYPE`.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event
For suffix 2, only the EDGE trigger type is available.
For suffix 3, the following trigger types are availabe: GLITch, WIDTh, RUNT, WINDow, TIMeout, INTerval, SLEWrate.

Parameters:

<Type> EDGE | GLITch | WIDTh | RUNT | WINDow | TIMeout | INTerval | SLEWrate | DATatoclock | STATe | PATTern | ANEDge | TV

Most of the type values are self-explanatory.

DATatoclock
Data2Clock: analyzes the relative timimg between a data signal and the synchronous clock signal. For trigger settings, see Chapter 20.9.10, "Data2Clock Trigger", on page 1070.

ANEDge
Edge trigger for external trigger input. Only available if the trigger source is the external trigger input. This trigger type uses the analog input signal. For trigger settings, see Chapter 5.10.2, "External Trigger Setup", on page 223.

*RST: EDGE

TRIGger<m>:LEVel<n>[:VALue] <Level>

Sets the trigger level for the specified event and source.

If the trigger source is serial bus, the trigger level is set by the thresholds in the protocol configuration.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event

<n> 1..27
Indicates the trigger source:
1...4 = channel 1 to 4
5 = external trigger input
6...11 = not available
12...27 = R&S RT-ZVC input channels

Parameters:

<Level> Voltage for the trigger level.

Range: Depends on vertical scale, channel offset and other settings. The trigger level must be within the current display range.
Increment: 1E-3
*RST: 0
Default unit: V

Example:

`TRIG:LEV5 0.01`
Sets the trigger level for the external trigger signal to 10 mV.
`TRIG2:LEV3 0.2`
Sets the trigger level for the B-event and B-trigger source channel 3 to 200 mV.

TRIGger<m>:FINDlevel

Sets the trigger level automatically. The command is only relevant if the trigger source is an analog channel CHAN1...4.

Suffix:
<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event

Usage: Event
Asynchronous command

20.9.2 Edge Trigger

TRIGger<m>:EDGE:SLOPe <Slope>

Defines the edge for the edge trigger event.

Suffix:
<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event

Parameters:
<Slope> POSitive | NEGative | EITHer
See Chapter 20.4.3, "Slope Parameter", on page 970.
*RST: POSitive

TRIGger<m>:ANEDge:COUPling <Coupling>

Sets the coupling for the external trigger signal.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<Coupling> DC

DC
Direct connection with 50 Ω termination, passes both DC and AC components of the trigger signal.
*RST: DC

TRIGger<m>:ANEDge:FILTer <Filter>

Sets a filter for the external trigger signal to reject high or low frequencies.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<Filter> OFF | LFReject | RFReject

OFF
The trigger signal is not filtered.

LFReject
Frequencies higher than the "Cut-off" frequency are rejected, lower frequencies pass the filter.
You can adjust the "Cut-off" frequency using the `TRIGger<m>:ANEDge:CUToff:LOWPass` command, the default is 50 kHz.

RFReject
Frequencies below the "Cut-off" frequency are rejected, higher frequencies pass the filter.
You can adjust the "Cut-off" frequency using the `TRIGger<m>:ANEDge:CUToff:HIGHpass` command, the default is 50 kHz.

*RST: OFF

TRIGger<m>:ANEDge:CUToff:HIGHpass <AnalogCutOffHP>

Frequencies below the "Cut-off" frequency are rejected, higher frequencies pass the filter.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<AnalogCutOffHP> KHZ5 | KHZ50 | MHZ50

Cut-off frequency

KHZ5
5 kHz

KHZ50
50 kHz

MHZ50
50 MHz

*RST: KHZ50

TRIGger<m>:ANEDge:CUToff:LOWPass <AnalogCutOffLP>

Frequencies higher than the "Cut-off" frequency are rejected, lower frequencies pass the filter.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<AnalogCutOffLP> KHZ5 | KHZ50 | MHZ50

KHZ5
5 kHz

KHZ50
50 kHz

MHZ50
50 MHz

*RST: KHZ50

TRIGger<m>:ANEDge:GND <Ground>

Connects the analog signal to the ground.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<Ground> ON | OFF

*RST: OFF

TRIGger<m>:ANEDge:SLOPe <Slope>

Sets the edge for the trigger event.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<Slope> POSitive | NEGative

See Chapter 20.4.3, "Slope Parameter", on page 970.

*RST: POSitive

20.9.3 Glitch Trigger

The glitch trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:GLITch:POLarity <Polarity>

Defines the polarity of a pulse, that is the direction of the first pulse slope.

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Polarity> POSitive | NEGative | EITHer

See Chapter 20.4.4, "Polarity Parameter", on page 971.

*RST: POSitive

TRIGger<m>:GLITch:RANGe <RangeMode>

Selects which glitches are identified: shorter or longer than the width specified using `TRIGger<m>:GLITch:WIDTh`.

Suffix:

<m> 1 | 3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<RangeMode> SHORter | LONGer

SHORter
Glitches shorter than the specified width are identified.

LONGer
Glitches longer than the specified width are identified.

*RST: SHORter

TRIGger<m>:GLITch:WIDTh <Width>

Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value, depnding on the `TRIGger<m>:GLITch:RANGe` command.

You need to know the expected pulse widths of the circuit to set the glitch width correctly.

Suffix:

<m> 1 | 3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Width> Range: 100E-12 to 10000
Increment: 100E-6
*RST: 1E-9
Default unit: s

20.9.4 Width Trigger

The width trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:WIDTh:POLarity <Polarity>

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Polarity> POSitive | NEGative

See Chapter 20.4.4, "Polarity Parameter", on page 971.

*RST: POSitive

TRIGger<m>:WIDTh:RANGe <RangeMode>

Defines how the range of a pulse width is defined in relation to the width and delta specified using `TRIGger<m>:WIDTh:WIDTh` and `TRIGger<m>:WIDTh:DELTa`, respectively.

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range is defined by the width ±delta.

OUTSide
Triggers on pulses outside a given range. The range is defined by the width ±delta.

SHORter
Triggers on pulses shorter than the given width.

LONGer
Triggers on pulses longer than the given width.

*RST: WITHin

TRIGger<m>:WIDTh:WIDTh <Width>

For the ranges "Within" and "Outside" (defined using `TRIGger<m>:WIDTh:RANGe`), the width defines the center of a range which is defined by the limits "±Delta" (see `TRIGger<m>:WIDTh:DELTa` on page 1061).

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Suffix:
<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:
<Width> Range: 100E-12 to 10000
Increment: 100E-9
*RST: 5E-9
Default unit: s

TRIGger<m>:WIDTh:DELTa <WidthDelta>

Defines a range around the width value specified using `TRIGger<m>:WIDTh:WIDTh`.

Suffix:
<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:
<WidthDelta> Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

20.9.5 Runt Trigger

The runt trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:RUNT:POLarity <Polarity>

Suffix:
<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:
<Polarity> POSitive | NEGative | EITHer
See Chapter 20.4.4, "Polarity Parameter", on page 971.
*RST: POSitive

TRIGger<m>:LEVel<n>:RUNT:LOWer <Level>
TRIGger<m>:LEVel<n>:RUNT:UPPer <Level>

Set the lower and upper voltage thresholds.

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

<n> 1..27
Indicates the trigger source:
1...4 = channel 1...4
5...27 = not available

Parameters:

<Level>
Range: -10 to 10
Increment: 1E-3
*RST: Lower = -0.1, upper =0.1
Default unit: V

TRIGger<m>:RUNT:RANGe <Mode>

Defines the time limit of the runt pulse in relation to the `TRIGger<m>:RUNT:WIDTh` and `TRIGger<m>:RUNT:DELTa` settings.

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Mode> ANY | LONGer | SHORter | WITHin | OUTSide

ANY
Triggers on all runts fulfilling the level condition, without time limitation.

LONGer
Triggers on runts longer than the given "Runt width".

SHORter
Triggers on runts shorter than the given "Runt width".

WITHin
Triggers if the runt length is inside a given time range. The range is defined by "Runt width" and "±Delta".

OUTSide
Triggers if the runt length is outside a given time range. The range is defined by "Runt width" and "±Delta".

*RST: ANY

TRIGger<m>:RUNT:WIDTh <Width>

Defines the upper or lower voltage threshold. This command is not available if `TRIGger<m>:RUNT:RANGe` is set to "ANY".

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Width> Range: 100E-12 to 10000
Increment: 100E-9
*RST: 5E-9
Default unit: s

TRIGger<m>:RUNT:DELTa <WidthDelta>

Defines a range around the runt width specified using `TRIGger<m>:RUNT:WIDTh`. This command is only available if `TRIGger<m>:RUNT:RANGe` is set to "WITHin" or "OUTSide".

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<WidthDelta> Range: 100E-12 to 864
Increment: 100E-9
*RST: 100E-12
Default unit: s

20.9.6 Window Trigger

The window trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:LEVel<n>:WINDow:LOWer <Level>
TRIGger<m>:LEVel<n>:WINDow:UPPer <Level>

Set the lower and upper voltage limits for the window.

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

<n> 1..27
Indicates the trigger source:
1...4 = channel 1...4
5...27 = not available

Parameters:

<Level> Range: -10 to 10
Increment: 1E-3
*RST: Lower = -0.1, upper =0.1
Default unit: V

TRIGger<m>:WINDow:RANGe <RangeMode>

Defines the signal run in relation to the window:

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<RangeMode> ENTer | EXIT | WITHin | OUTSide

ENTer
Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.

EXIT
Triggers when the signal leaves the window.

WITHin
Triggers if the signal stays between the upper and lower level for a specified time. The time is defined using the `TRIGger<m>:WINDow:TIME` command.

OUTSide
Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is defined using the `TRIGger<m>:WINDow:TIME` command.

*RST: ENTer

TRIGger<m>:WINDow:TIME <TimeRangeMode>

Defines the limit of the window in relation to the time specified using `TRIGger<m>:WINDow:WIDTh` and `TRIGger<m>:WINDow:DELTa`. Time conditioning is available for `TRIGger<m>:WINDow:RANGe`= "WITHin" and "OUTSide".

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<TimeRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width - Delta* and for *Width + Delta* at the most.

OUTSide
"Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width - Delta* or longer than *Width + Delta*.

SHORter
Triggers if the signal crosses vertical limits before the specified "Width" time is reached.

LONGer
Triggers if the signal crosses vertical limits before the specified "Width" time is reached.

*RST: WITHin

TRIGger<m>:WINDow:WIDTh <Width>

For the ranges "Within" and "Outside" (defined using `TRIGger<m>:WINDow:RANGe`), the width defines the center of a time range which is defined by the limits "±Delta" (see `TRIGger<m>:WINDow:DELTa` on page 1065).

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger	

Parameters:

<Width>	Range:	100E-12 to 10000
	Increment:	100E-9
	*RST:	5E-9
	Default unit:	s

TRIGger<m>:WINDow:DELTa <WidthDelta>

Defines a range around the "Width" value specified using `TRIGger<m>:WINDow:WIDTh`.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger	

Parameters:

<WidthDelta>	Range:	0 to 432
	Increment:	500E-12
	*RST:	0
	Default unit:	s

20.9.7 Timeout Trigger

The timeout trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:TIMeout:RANGe <TimeoutMode>

Defines the relation of the signal level to the trigger level.

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

HIGH
The signal level stays above the trigger level.

LOW
The signal level stays below the trigger level.

EITHer
The signal level stays above or below the trigger level.

*RST: HIGH

TRIGger<m>:TIMeout:TIME <Time>

Defines the time limit for the timeout at which the instrument triggers.

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Time>
Range: 100E-12 to 10000
Increment: 100E-9
*RST: 100E-9
Default unit: s

20.9.8 Interval Trigger

The interval trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:INTerval:SLOPe <Slope>

Sets the edge for the trigger. You can analyze the interval between positive edges or between negative edges.

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Slope> POSitive | NEGative

See Chapter 20.4.3, "Slope Parameter", on page 970.

*RST: POSitive

TRIGger<m>:INTerval:RANGe <RangeMode>

Defines the range of an interval in relation to the interval width specified using `TRIGger<m>:INTerval:WIDTh` and `TRIGger<m>:INTerval:DELTa`.

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range is defined by the interval width ±delta.

OUTSide
Triggers on pulses outside a given range. The range is defined by the interval width ±delta.

SHORter
Triggers on pulses shorter than the given interval width.

LONGer
Triggers on pulses longer than the given interval width.

*RST: OUTSide

TRIGger<m>:INTerval:WIDTh <Width>

Defines the time between two pulses.

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Width>
Range: 100E-12 to 10000
Increment: 100E-9
*RST: 5E-9
Default unit: s

TRIGger<m>:INTerval:DELTa <WidthDelta>

Defines a range around the "Interval width" value specified using `TRIGger<m>:INTerval:WIDTh` on page 1067.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<WidthDelta>	Range: 0 to 10 Increment: 100E-9 *RST: 0 Default unit: s

20.9.9 Slew Rate Trigger

The slew rate trigger is not available for the B-event (Suffix = 2).

TRIGger<m>:SLEW:SLOPe <Slope>

Selects the edge type for the trigger event.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Slope>	POSitive | NEGative | EITHer See Chapter 20.4.3, "Slope Parameter", on page 970. *RST: POSitive

TRIGger<m>:LEVel<n>:SLEW:LOWer <Level>
TRIGger<m>:LEVel<n>:SLEW:UPPer <Level>

Set the lower and upper voltage thresholds. When the signal crosses a level, the slew rate measurement starts or stops depending on the selected slope.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

<n> 1..27
Indicates the trigger source:
1...4 = channel 1...4
5...27 = not available

Parameters:

<Level> Range: -10 to 10
Increment: 1E-3
*RST: Lower = -0.1, upper =0.1
Default unit: V

TRIGger<m>:SLEW:RANGe <RangeMode>

Defines the time limit for the slew rate in relation to the upper or lower trigger level (see `TRIGger<m>:SLEW:RATE` on page 1069 and `TRIGger<m>:SLEW:DELTa` on page 1070). The time measurement starts when the signal crosses the first trigger level - the upper or lower level depending on the selected slope - and stops when the signal crosses the second level.

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<RangeMode> INSRange | OUTRange | LTHan | GTHan

INSRange
Triggers on pulses inside a given range. The range is defined by the slew rate ±delta.

OUTRange
Triggers on pulses outside a given range. The range is defined by the slew rate ±delta.

LTHan
Triggers on pulses shorter than the given slew rate.

GTHan
Triggers on pulses longer than the given slew rate.

*RST: GTHan

TRIGger<m>:SLEW:RATE <Time>

For the ranges "Within" and "Outside", the slew rate defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the slew rate defines the maximum and minimum slew rate limits, respectively. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope (see `TRIGger<m>:SLEW:SLOPe` on page 1068).

Suffix:

<m> 1..3
1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<Time>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 100E-12 Default unit: s

---

TRIGger<m>:SLEW:DELTa <TimeDelta>

Defines a time range around the slew rate specified using `TRIGger<m>:SLEW:RATE`.

Suffix:

<m>	1..3 1 = A-trigger, 2 = not availabe, 3 = R-trigger

Parameters:

<TimeDelta>	Range: 0 to 10 Increment: 100E-9 *RST: 0 Default unit: s

20.9.10 Data2Clock Trigger

The Data2Clock trigger is only available for the A-event (Suffix = 1).

TRIGger<m>:DATatoclock:CSOurce[:VALue] <ClockSource>

Selects the source of the clock signal.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockSource>	CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 CHAN1 = CHANnel1, CHAN2 = CHANnel2, CHAN3 = CHANnel3, CHAN4 = CHANnel4 Input channel of the clock signal *RST: CHAN1

TRIGger<m>:DATatoclock:CSOurce:EDGE <ClockEdge>

Sets the edge of the clock signal to define the time reference point for the setup and hold time.

Suffix:

<m> 1
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockEdge> POSitive | NEGative | EITHer

See Chapter 20.4.3, "Slope Parameter", on page 970.

*RST: POSitive

TRIGger<m>:DATatoclock:CSOurce:LEVel <ClockLevel>

Sets the voltage level for the clock signal. Both this command and `TRIGger<m>:DATatoclock:CSOurce:EDGE` define the starting point for calculation of the setup and hold time.

Suffix:

<m> 1
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<ClockLevel> Range: -10 to 10
Increment: 1E-3
*RST: 0
Default unit: V

TRIGger<m>:SCOupling <LevelSourceCoupl>

Sets the trigger levels of all channels to the value of channel 1 for the indicated trigger event.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event

Parameters:

<LevelSourceCoupl> ON | OFF

*RST: OFF

TRIGger<m>:DATatoclock:HTIMe <HoldTime>

Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

The hold time can be negative. In this case, the setup time is always positive. The setup/hold interval starts before the clock edge (setup time) and ends before the clock edge (hold time). If you change the negative hold time, the setup time is adjusted by the intrument.

Suffix:

<m>	1 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<HoldTime>	Range: -99.999E-9 to 100E-9 Increment: 1E-9 *RST: 0 Default unit: s

---

TRIGger<m>:DATatoclock:STIMe <SetupTime>

Sets the minimum time **before** the clock edge while the data signal must stay steady above or below the data level.

The setup time can be negative. In this case, the hold time is always positive. The setup/hold interval starts after the clock edge (setup time) and ends after the clock edge (hold time). If you change the negative setup time, the hold time is adjusted by the instrument.

Suffix:

<m>	1 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<SetupTime>	Range: -99.999E-9 to 100E-9 Increment: 1E-9 *RST: 0 Default unit: s

20.9.11 State Trigger

The state trigger combines the edge trigger settings with trigger qualification. It is not available for the B-event (Suffix = 2).

Use the following commands:

- `TRIGger<m>:EDGE:SLOPe` on page 1056
- `TRIGger<m>:LEVel<n>[:VALue]` on page 1055
- `TRIGger<m>:SCOupling` on page 1071
- To define the state, use the `TRIG:QUAL...[ENABle]` and `TRIG:QUAL...LOGic` commands, which are described in Chapter 20.9.15, "Trigger Qualification", on page 1080.

20.9.12 Pattern Trigger

The pattern trigger is only available for the A-event (Suffix = 1).

The pattern is defined using the commands:

- TRIGger<m>:QUALify<n>:A[:ENABle] on page 1082
- TRIGger<m>:QUALify<n>:A:LOGic on page 1082
- TRIGger<m>:QUALify<n>:AB:LOGic on page 1083

These are the commands for channel 1, use the similar commands for channels 2, 3, and 4.

TRIGger<m>:PATTern:MODE <Mode>

Adds additional time limitation to the pattern definition.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Mode> OFF | TIMeout | WIDTh

OFF
No time limitation. The event occurs if the pattern condition is fulfilled.

TIMeout
Defines how long the result of the pattern condition must be true or false. The duration of the timeout is defined using TRIGger<m>:PATTern:TIMeout[:TIME].

WIDTh
Defines a time range for keeping up the true result of the pattern condition. The range is defined using TRIGger<m>:PATTern:WIDTh:RANGe.

*RST: OFF

TRIGger<m>:PATTern:TIMeout:MODE <TimeoutMode>

Defines the condition for the timeout.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<TimeoutMode> HIGH | LOW

HIGH
The result stays high.

LOW
The result stays low.

*RST: HIGH

TRIGger<m>:PATTern:TIMeout[:TIME] <Time>

Defines how long the result of the pattern condition must be true or false.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<Time> Range: 100E-12 to 10000
Increment: 100E-9
*RST: 100E-9
Default unit: s

TRIGger<m>:PATTern:WIDTh:RANGe <WidthRangeMode>

Defines how the range of a pulse width is defined for keeping up the true result of the pattern condition. The width and delta are specified using `TRIGger<m>:PATTern:WIDTh[:WIDTh]` and `TRIGger<m>:PATTern:WIDTh:DELTa`, respectively.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<WidthRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range is defined by the width ±delta.

OUTSide
Triggers on pulses outside a given range. The range is defined by the width ±delta.

SHORter
Triggers on pulses shorter than the given width.

LONGer
Triggers on pulses longer than the given width.

*RST: WITHin

TRIGger<m>:PATTern:WIDTh[:WIDTh] <Width>

For the ranges "Within" and "Outside" (defined using TRIGger<m>:PATTern:WIDTh:RANGe), the width defines the center of a range which is defined by the limits "±Delta" (see TRIGger<m>:PATTern:WIDTh:DELTa on page 1075).

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Width>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 5E-9 Default unit: s

TRIGger<m>:PATTern:WIDTh:DELTa <WidthDelta>

Defines a range around the width value specified using TRIGger<m>:PATTern:WIDTh[:WIDTh].

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<WidthDelta>	Range: 0 to 432 Increment: 500E-12 *RST: 0 Default unit: s

20.9.13 TV/Video Trigger

The TV or video trigger requires a channel input as trigger source (TRIGger<m>:SOURce). It is only available for the A-event (Suffix = 1).

Make sure to set the trigger level - the threshold of the sync pulse - with TRIGger<m>:LEVel<n>[:VALue].

TRIGger<m>:TV:STANdard <Standard>

Sets the TV standard.

Suffix:

<m> 1..3

Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Standard> CUSTom | PAL | PALM | NTSC | SECam | P480L60HZ | P720L30HZ | P720L50HZ | P720L60HZ | I1080L50HZ | I1080L60HZ | P1080L24HZ | P1080L24HZSF | P1080L25HZ | P1080L30HZ | P1080L50HZ | P1080L60HZ

CUSTom

User-defined signal. Configure the signal using:

`TRIGger<m>:TV:CUSTom:SCANmode`

`TRIGger<m>:TV:CUSTom:STYPe`

`TRIGger<m>:TV:CUSTom:LDURation`

`TRIGger<m>:TV:CUSTom:SDURation`

PAL | PALM | NTSC | SECam

SDTV standards. PALM = PAL-M

PxxxxLyyHZ

HDTV standards using progressive scanning (P). xxxx indicates the number of active lines, yy is the frame rate.

IxxxxLxxHZ

HDTV standards using interlaced scanning (I). xxxx indicates the number of active lines, yy is the field rate.

P1080L24HZSF

1080p/24sF is a HDTV standard using progressive segmented frame scanning.

*RST: PAL

Firmware/Software: FW 1.40

TRIGger<m>:TV:MODE <Mode>

Selects the lines or fields on which the instrument can trigger. Available modes depend on the scanning system.

Suffix:

<m> 1..3

Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Mode> ALL | ODD | EVEN | ALINe | LINE

ALL

All fields, triggers on the frame start (progressive scanning) or field start (interlaced and progressive segmented frame scanning)

ODD | EVEN
Only available for interlaced scanning and progressive segmented frame scanning. Triggers on the field start of the odd or even field.

ALINe
All lines, triggers on all line starts.

LINE
Triggers on a specified line. To set the line number, use `TRIGger<m>:TV:LINE`. For NTSC signals, set also the field with `TRIGger<m>:TV:LFIeld`.

*RST: ALL

Firmware/Software: FW 1.40

TRIGger<m>:TV:POLarity <Polarity>

Sets the polarity of the *signal*. Note that the sync pulse has the opposite polarity, for example, a positive signal has a negative sync pulse.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<Polarity> POSitive | NEGative
*RST: POSitive

Firmware/Software: FW 1.40

TRIGger<m>:TV:LINE <LineNumber>

Specifies the line number to trigger on. The command is relevant if `TRIGger<m>:TV:MODE` is set to `LINe`.

Usually the lines of the frame are counted beginning from the frame start. For NTSC signals, the lines are counted per field, not per frame. For these signals, set also the field with `TRIGger<m>:TV:LFIeld`.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<LineNumber> Range: Depends on the standard, see table below
Increment: 1
*RST: 1

Firmware/Software: FW 1.40

Standard	Minimum value	Maximum value
PAL	1	625
PAL-M	1	525
NTSC	1	263 in odd field 262 in even field
SECAM	1	625
480p/60 (P480L60HZ)	1	525
720p/30 (P720L30HZ) 720p/50 (P720L50HZ) 720p/60 (P720L60HZ)	1	750
1080i/50 (I1080L50HZ) 1080i/60 (I1080L60HZ) 1080p/24 (P1080L24HZ) 1080p/24sF (P1080L24HZSF) 1080p/25 (P1080L25HZ) 1080p/30 (P1080L30HZ) 1080p/50 (P1080L50HZ) 1080p/60 (P1080L60HZ)	1	1125

TRIGger<m>:TV:LFIeld <LineField>

The commands is only relevant for NTSC signals and sets the field in which the line number is counted.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<LineField> FIELD1 | FIELd1 | FIELD2 | FIELd2

FIELD1 = FIELd1 = odd field
FIELD2 = FIELd2 = even field

*RST: FIELD1

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:SCANmode <ScanMode>

Sets the scanning system. Only relevant if TRIGger<m>:TV:STANdard is set to CUSTom.

See also: "Scan" on page 205.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<ScanMode> INTerlaced | PROGressive | SEGMented

SEGMented: Progressive segmented frame uses progressive scanning to capture the frame, and interlaced scanning for transmission and display.

*RST: INTerlaced

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:LDURation <LinePeriod>

Sets the duration of a line, the time between two successive sync pulses. Only relevant if `TRIGger<m>:TV:STANdard` is set to `CUSTom`.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<LinePeriod> Range: 1E-6 to 500E-6
Increment: 100E-9
*RST: 64E-6
Default unit: s

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:STYPe <SyncPulseType>

Sets the type of the sync pulse. Only relevant if `TRIGger<m>:TV:STANdard` is set to `CUSTom`.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<SyncPulseType> BILevel | TRILevel

BILevel
Bi-level sync pulse, usually used in SDTV signals

TRILevel
Tri-level sync pulse, used in HDTV signals

*RST: BILevel

Firmware/Software: FW 1.40

TRIGger<m>:TV:CUSTom:SDURation <SyncPulseDurat>

Sets the width of the sync pulse. Only relevant if `TRIGger<m>:TV:STANdard` is set to `CUSTom`.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<SyncPulseDurat> Range: 100E-9 to 100E-6
Increment: 100E-9
*RST: 4.7E-6
Default unit: s

Firmware/Software: FW 1.40

20.9.14 Line Trigger

To select the line trigger, set `TRIGger<m>:SOURce` to `LINE`.

TRIGger<m>:POWerline:SLOPe <Slope>

Selects the rising or falling edges of the AC power input for the trigger condition.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:
<Slope> POSitive | NEGative
*RST: POSitive

20.9.15 Trigger Qualification

The A-event can have its own trigger qualification. Qualification is not available for B- and R-events (event suffix m = 2 | 3) and some trigger types.

A suffix defines the trigger type to which the qualification belongs.

Table 20-2: Trigger type suffixes

Suffix	Trigger type
1	EDGE
2	GLITch
3	WIDTh
4	RUNT
5	WINDow
6	TIMeout

Suffix	Trigger type
7	INTerval
8	Qualification is not supported (SLEWrate)
9	Qualification is not supported (DATatoclock)
10	STATe
11	PATTern
12	qualification is not supported (ANEDge, ext. trigger input)
13	Currently not used
14	Currently not used
15	Qualification is not supported (SERPattern)
16	Qualification is not supported (NFC)
17	Qualification is not supported (TV)
18	Qualification is not supported (CDR)

TRIGger<m>:QUALify<n>:STATe <AddTrigLogi>

Enables the use of the qualification definition for the selected trigger event.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> 1..18
Defines the trigger type, see Table 20-2.

Parameters:

<AddTrigLogi> ON | OFF

ON
The qualification expression is considered for the trigger event.

OFF
The qualification expression is ignored for the trigger event.

*RST: OFF

TRIGger<m>:QUALify<n>:A[:ENABle] <State>
TRIGger<m>:QUALify<n>:B[:ENABle] <State>
TRIGger<m>:QUALify<n>:C[:ENABle] <State>
TRIGger<m>:QUALify<n>:D[:ENABle] <State>

Select the channels to be considered:

- A[:ENABle]: CH1
- D[:ENABle]: CH4

The trigger source cannot be enabled.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	1..18

Parameters:

<State> ON | OFF

ON
The qualification expression is considered.

OFF
The qualification expression is ignored.

*RST: OFF

TRIGger<m>:QUALify<n>:A:LOGic <Operator>
TRIGger<m>:QUALify<n>:B:LOGic <Operator>
TRIGger<m>:QUALify<n>:C:LOGic <Operator>
TRIGger<m>:QUALify<n>:D:LOGic <Operator>

Defines the logic for the indicated channel:

- A: CH1
- B: CH2
- C: CH3
- D: CH4

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	1..18 Trigger type, see Table 20-2.

Parameters:

<Operator> DIRect | NOT

DIRect
Input value remains unchanged

NOT
Input value is inverted

*RST: DIRect

TRIGger<m>:QUALify<n>:AB:LOGic <Operator>
TRIGger<m>:QUALify<n>:CD:LOGic <Operator>
TRIGger<m>:QUALify<n>:ABCD:LOGic <Operator>

Defines the logical combination of the indicated channels after evaluating the previous logical operations:

- ABCD: result of AB and CD

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> 1..18

Parameters:

<Operator> AND | NAND | OR | NOR

AND
logical AND, conjunctive combination

NAND
logical NOT AND

OR
logical OR, disjunctive combination

NOR
logical NOT OR

*RST: AND

20.9.16 Holdoff

TRIGger<m>:HOLDoff:MODE <Mode>

Selects the method to define the holdoff condition.

The trigger holdoff defines when the next trigger after the current will be recognized. Thus, it affects the next trigger to occur after the current one. Holdoff helps to obtain stable triggering when the oscilloscope is triggering on undesired events.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Mode> TIME | EVENts | RANDom | AUTO | OFF

TIME
Defines the holdoff directly as a time period. The next trigger occurs only after the "Holdoff time" has passed (defined using `TRIGger<m>:HOLDoff:TIME`).

EVENts
Defines the holdoff as a number of trigger events. The next trigger occurs only when this number of events is reached. The number of triggers to be skipped is defined using `TRIGger<m>:HOLDoff:EVENts`.

RANDom
Defines the holdoff as a random time limited by `TRIGger<m>:HOLDoff:MIN` on page 1085 and `TRIGger<m>:HOLDoff:MAX` on page 1085. For each acquisition cycle, the instrument selects a new random holdoff time from the specified range.

AUTO
The holdoff time is calculated automatically based on the current horizontal scale.

OFF
No holdoff

*RST: OFF

TRIGger<m>:HOLDoff:TIME <Time>

Defines the holdoff time period. The next trigger occurs only after this time has passed. The setting is relevant if the holdoff mode is set to TIME.

See also:

- `TRIGger<m>:HOLDoff:MODE`

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Time> Range: 100E-9 to 10
Increment: 200E-6
*RST: 1E-3
Default unit: s

Example:

```
TRIGger1:HOLDoff:MODE TIME
TRIGger<m>:HOLDoff:TIME 1ms
```

The holdoff time is set to 1 ms.

TRIGger<m>:HOLDoff:EVENts <Events>

Defines the number of triggers to be skipped. The next trigger only occurs when this number of events is reached. The setting is relevant if the holdoff mode is set to EVENts.

See also:

- TRIGger<m>:HOLDoff:MODE

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Events>	Range: 1 to 2147483647 Increment: 1 *RST: 1

Example:
```
TRIGger1:HOLDoff:MODE EVENts
TRIGger<m>:HOLDoff:EVENts 5
```

TRIGger<m>:HOLDoff:MIN <RandomMinTime>

Defines the lower limit for the random time holdoff. The setting is relevant if the holdoff mode is set to RANDom.

See also:

- TRIGger<m>:HOLDoff:MODE
- TRIGger<m>:HOLDoff:MAX

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<RandomMinTime>	Range: 100E-9 to 5 Increment: 200E-6 *RST: 1E-3 Default unit: s

Example:
```
TRIGger1:HOLDoff:MODE RANDom
TRIGger<m>:HOLDoff:MIN 1ms
TRIGger<m>:HOLDoff:MAX 2ms
```
The holdoff time is set randomly between 1 ms and 2 ms.

TRIGger<m>:HOLDoff:MAX <RandomMaxTime>

Defines the upper limit for the random time holdoff. The setting is relevant if the holdoff mode is set to RANDom.

See also:

- TRIGger<m>:HOLDoff:MODE
- TRIGger<m>:HOLDoff:MIN

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<RandomMaxTime>	Range: 100E-9 to 10 Increment: 200E-6 *RST: 2E-3 Default unit: s

---

TRIGger<m>:HOLDoff:AUTotime?

Returns the resulting holdoff time if the holdoff mode is set to AUTO: *Auto time* = *Auto time scaling* * *Horizontal scale*. The auto time scaling factor is defined with `TRIGger<m>:HOLDoff:SCALing`.

See also: `TRIGger<m>:HOLDoff:MODE`

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Return values:

<AutoTime>	Holdoff time Range: 100E-9 to 10 *RST: 1E-3 Default unit: s

Example:
```
TRIGger1:HOLDoff:MODE AUTO
TRIGger1:HOLDoff:SCALing 0.5
TRIGger<m>:HOLDoff:AUTotime?
1ms
```
Result if the horizontal scale is 1 ns/div

Usage: Query only

TRIGger<m>:HOLDoff:SCALing <AutoTimeScaling>

Sets the auto time scaling factor the horizontal scale is multipied with: *Auto time* = *Auto time scaling* * *Horizontal scale*. The setting is relevant if the holdoff mode is set to AUTO.

See also:

- `TRIGger<m>:HOLDoff:MODE`
- `TRIGger<m>:HOLDoff:AUTotime?` on page 1086

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<AutoTimeScaling>	Range: 1E-3 to 1000 Increment: 1 *RST: 0.5

20.9.17 Noise Reject

TRIGger<m>:LEVel<n>:NOISe[:STATe] <HysteresisMode>

Selects how the hysteresis is set.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

<n> 1..27
Indicates the trigger source:
1...4 = channel 1 to 4
5 = external trigger input
6...11 = not available
12...27 = R&S RT-ZVC input channels

Parameters:

<HysteresisMode> AUTO | MANual

AUTO
This is the recommended mode. The hysteresis is set by the instrument to reject at least the internal noise of the instrument. You can define a higher minimum value using `TRIGger<m>:LEVel<n>:NOISe:ABSolute`.

MANual
The hysteresis is defined directly with `TRIGger<m>:LEVel<n>:NOISe:ABSolute`.

*RST: AUTO

TRIGger<m>:LEVel<n>:NOISe:MODE <HystMode>

Selects how the hysteresis is set.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

<n> 1..27
Indicates the trigger source:
1...4 = channel 1 to 4
5 = external trigger input

Parameters:

<HystMode> ABS | REL

ABS
The hysteresis is set in absolute values (voltage).

REL
The hysteresis is defined in relative values (div).

*RST: ABS

TRIGger<m>:LEVel<n>:NOISe:ABSolute <HystAbs>

Defines a range in absolute values around the trigger level. If the signal oscillates inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

<n> 1..27
Indicates the trigger source: see TRIGger<m>:LEVel<n>:NOISe[:STATe] on page 1087.

Parameters:

<HystAbs> Range: 0 to The value corresponding to full division range. The exact maximum value depends on the selected vertical scale.
Increment: 1E-3
*RST: 0
Default unit: V

TRIGger<m>:LEVel<n>:NOISe:PERDivision <HystInDivs>

Defines a range in divisions around the trigger level. If the signal oscillates inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

<n> 1..27
Indicates the trigger source: see TRIGger<m>:LEVel<n>:NOISe[:STATe] on page 1087.

Parameters:

<HystInDivs> Hysteresis size in divisions
Range: 0 to 5
Increment: 0.01
*RST: 0
Default unit: div

TRIGger<m>:LEVel<n>:NOISe:RELative <HystRel>

Defines a range in percent around the trigger level. If the signal oscillates inside this range and crosses the trigger level thereby, no trigger event occurs.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

<n> 1..27
Indicates the trigger source: see TRIGger<m>:LEVel<n>:NOISe[:STATe] on page 1087.

Parameters:

<HystRel> Hysteresis in %. 10% = 1 div

Range: 0 to 50
Increment: 1
*RST: 0
Default unit: %

TRIGger<m>:ANEDge:NREJect <NoiseReject>

Enables the noise reject for the external trigger input.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<NoiseReject> ON | OFF

*RST: OFF

Firmware/Software: FW 2.25

20.9.18 Trigger Sequence

TRIGger<m>:SEQuence:MODE <Type>

Selects the type of the sequence.

See also: Chapter 5.8, "Sequence", on page 214.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

Parameters:

<Type> AONLy | ABR | AZ | ABRZ | AORB | AORBZ

AONLy
Triggers only on A-events. Additionally, a holdoff condition can be set. if AONLy sequence is set, all inputs (input channels, serial and parallel buses, digital channels etc.) can be used as trigger source.

ABR
Triggers if all conditions of A- and B-events, as well as additional delay and reset timeout or R-event (reset) conditions are fulfilled. This trigger sequence requires that analog input channels CHAN1...4 are set as trigger sources for all events.

AZ
Triggers if the conditions of the A-event and the zone trigger are fulfilled. Additionally, a holdoff condition can be set. This trigger sequence requires that analog input channels CHAN1...4 are set as trigger sources for all events.
Requires option R&S RTP-K19.

ABRZ
Triggers if all conditions of A- and B-events, reset timeout or R-event (reset) conditions are fulfilled for the defined zone. This trigger sequence requires that analog input channels CHAN1...4 are set as trigger sources for all events.
Requires option R&S RTP-K19.

AORB
Triggers if the conditions of A-event or the conditions of the B-event are fulfilled. This trigger sequence requires that analog input channels CHAN1...4 are set as trigger sources for all events.

AORBZ
Triggers if the conditions of A-event or the conditions of the B-event are fulfilled for the defined zone. Additionally, a holdoff condition can be set. This trigger sequence requires that analog input channels CHAN1...4 are set as trigger sources for all events.
Requires option R&S RTP-K19.

*RST: AONLy

TRIGger<m>:ECOupling <LevelEventCoupl>

Event coupling of trigger levels: Sets the trigger levels to the values of the indicated event. Thus, channel 1 has one trigger level for all events, channel 2 has one trigger level and so on.

Suffix:
<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event

Parameters:
<LevelEventCoupl> ON | OFF
*RST: ON

TRIGger<m>:SEQuence:DELay <Delay>

Sets the time the instrument waits after an A-event until it recognizes B-events.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<Delay>	Range: 0 to 50 Increment: 1E-12 *RST: 0 Default unit: s

TRIGger<m>:SEQuence:COUNt <Events>

Sets the number of B-events to be fulfilled after an A-event. The last B-event causes the trigger.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<Events>	Range: 1 to 2147483647 Increment: 1 *RST: 1

TRIGger<m>:SEQuence:RESet:EVENt <EnabRstEvt>

If set to ON, the trigger sequence is restarted by the R-event if the specified number of B-event does not occur.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<EnabRstEvt>	ON | OFF *RST: OFF

TRIGger<m>:SEQuence:RESet:TIMeout[:ENABle] <State>

If set to ON, the instrument waits for the time defined using `TRIGger<m>:SEQuence:RESet:TIMeout:TIME` for the specified number of B-events. If no trigger occurs during that time, the sequence is restarted with the A-event.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<State> ON | OFF

*RST: OFF

TRIGger<m>:SEQuence:RESet:TIMeout:TIME <ResetTimeout>

The time the instrument waits for the number of B-events specified using `TRIGger<m>:SEQuence:COUNt` before the sequence is restarted with the A-event.

Suffix:

<m> 1..3

Irrelevant, omit the suffix.

Parameters:

<ResetTimeout> Range: 0 to 50

Increment: 1E-12

*RST: 0

Default unit: s

20.9.19 Trigger Control

TRIGger<m>:MODE <TriggerMode>

Sets the trigger mode which determines the behaviour of the instrument if no trigger occurs.

See also: "Trigger mode" on page 211

Suffix:

<m> 1..3

Irrelevant, omit the suffix.

Parameters:

<TriggerMode> AUTO | NORMal | FREerun

AUTO

The instrument triggers repeatedly after a time interval if the trigger conditions are not fulfilled. If a real trigger occurs, it takes precedence. The time interval depends on the time base.

NORMal

The instrument acquires a waveform only if a trigger occurs.

FREerun

The instrument triggers after a very short time interval - faster than in AUTO mode. Real triggers are ignored

*RST: AUTO

TRIGger<m>:FORCe

If the acquisition is running in normal mode and no valid trigger occurs, forcing the trigger provokes an immediate single acquisition. Thus you can confirm that a signal is available and use the waveform display to determine how to trigger on it.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

Usage: Event

TRIGger<m>:OUT:STATe <State>

Enables/disbales the trigger out signal that is provided to the [Trigger Out] connector on the rear panel when a trigger occurs.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

Parameters:

<State> ON | OFF

*RST: OFF

TRIGger<m>:OUT:POLarity <Polarity>

Sets the polarity of the trigger out pulse.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

Parameters:

<Polarity> POSitive | NEGative

*RST: POSitive

TRIGger<m>:OUT:PLENgth <PulseLength>

Sets the length of the trigger out pulse.

Suffix:

<m> 1..3
Irrelevant, omit the suffix.

Parameters:

<PulseLength> Range: 4E-9 to 0.06
Increment: 20E-9
*RST: 100E-9
Default unit: s

TRIGger<m>:OUT:DELay <Delay>

Sets the delay of the first pulse edge to the trigger point.

The settin gis not available if a mask test or measurement is running and the on-violation event is set to trigger out pulse.

Suffix:

<m>	1..3 Irrelevant, omit the suffix.

Parameters:

<Delay>	Range: 800E-9 to 1 Increment: 1E-9 *RST: 800E-9 Default unit: s

20.9.20 Actions on Trigger

TRIGger<m>:EVENt:BEEP <Beep>

Generates a beep sound if the command is set to `TRIGger`.

Suffix:

<m>	1..3 The suffix is irrelevant.

Parameters:

<Beep>	NOAction | TRIGger *RST: NOAction

TRIGger<m>:EVENt:PRINt <Print>

Saves a screenshot at each trigger if the command is set to `TRIGger`.

For screenshot settings, see Chapter 20.16.9, "Screenshots", on page 1291.

Suffix:

<m>	1..3 The suffix is irrelevant.

Parameters:

<Print>	NOAction | TRIGger *RST: NOAction

TRIGger<m>:EVENt:WFMSave <SaveWfm>

Saves the waveform data to file at each trigger if the command is set to `TRIGger`.

For data export settings, see Chapter 20.16.5, "Waveform Data Export to File", on page 1280.

Suffix:

<m>	1..3 The suffix is irrelevant.

Parameters:

<SaveWfm>	NOACtion | TRIGger *RST: NOACtion

TRIGger<m>:EVENt:RUNexec <RunExecutable>

Starts an external application if the command is set to `TRIGger`.

Use the following commands to set up the application:

- `EXECutable:NAME` on page 999
- `EXECutable:PARameter` on page 1000
- `EXECutable:WDIRectory` on page 1000

Suffix:

<m>	1..3 The suffix is irrelevant.

Parameters:

<RunExecutable>	NOACtion | TRIGger *RST: NOACtion

20.9.21 Zone Trigger (Option R&S RTP-K19)

TRIGger<m>:ZONE:EXPRession[:DEFine] <LogicalExpr>

Defines the zone trigger.

Suffix:

<m>	1..3 The suffix is irrelevant.

Parameters:

<LogicalExpr>	String with the logical expression

Example:

```
TRIGger:ZONE:EXPRession 'MT1 and MT2 and Zone1'
TRIGger:ZONE:EXPRession?
<-- MT1 and MT2 and Zone1
```

Firmware/Software: FW 3.20

SWTRigger:HISTory <ApplyZnTrigHistory>

Applies the zone trigger condition to the acquisitions in the history memory during history replay.

See: "Apply ZoneTrigger to history" on page 221.

Parameters:

<ApplyZnTrigHistory> ON | OFF

*RST: OFF

20.9.22 External Trigger Input

To control the external trigger signal, the TRPRobe commands are used. The required commands depend on the used probe type. They work in the same way as the PROBe commands. For details, see Chapter 20.8.7, "Probes", on page 1017

TRIGger<m>:EXTern:OVERload <Overload>

The query returns the overload status of the external trigger input.

`:TRIGger:EXTern:OVERload 0` confirms the information in the message box, it has same effect as OK.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Parameters:

<Overload> ON | OFF

ON | 1
Iindicates an overload of the probe

OFF | 0
In a query: no overlaod.
Ssetting: confirms the information in the message box

*RST: OFF

20.9.23 Acquisition Info

ACQuire:CURRent?

Shows the current number of acquisitions that have been acquired.

Return values:

<CurrAcqCnt> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

20.10 Waveform Analysis

20.10.1 Zoom

LAYout:ZOOM:ADD <NodeName>, <ParentType>, <InsertBefore>, <XStart>, <XStop>, <YStart>, <YStop>, <NewZoomName>

Adds a new zoom diagram based on the specified waveform.

Setting parameters:

<NodeName> String with the name of diagram to be zoomed

<ParentType> VERTical, OFF
The new zoom diagram is displayed below the original one.

<InsertBefore> OFF
Position of the zoom diagram, depending on `ParentType`

<XStart> Defines the x-value at the beginning of the zoom area.

<XStop>	Defines the x-value at the end of the zoom area.
<YStart>	Defines the y-value at the beginning of the zoom area.
<YStop>	Defines the y-value at the end of the zoom area.
<NewZoomName>	String with the name of the new zoom diagram.
Example:	`LAYout:ZOOM:ADD 'Diagram1', VERT, OFF, -10e-9, 20e-9, -0.1, 0.05, 'MyZoom1'` Creates the zoom diagram 'MyZoom1' for 'Diagram1'.
Example:	See Chapter 20.3.1.1, "Creating Zoom Diagrams", on page 956
Usage:	Setting only

LAYout:ZOOM:ADDCoupled <ZoomName>, <XOffset>, <YOffset>, <NewZoomName>

Creates a new zoom diagram based on the settings of an existing zoom area for the same source.

Parameters:

<NewZoomName> Defines the name of the new zoom diagram.

Setting parameters:

<ZoomName>	Defines the name of the zoom diagram to be copied.
<XOffset>	Defines an offset to the existing zoom area in x direction.
<YOffset>	Defines an offset to the existing zoom area in y direction.

LAYout:ZOOM:ONEDiagram <ShowInOne>

Shows all zooms of a diagram in one zoom window. The zoomed areas are overlaid for better comparison of the zoomed waveforms.

The command takes effect on all zoom diagrams.

Parameters:

<ShowInOne> ON | OFF
*RST: OFF

LAYout:ZOOM:POSCoupling <DiagramName>, <ZoomName>,<PositionCoupl>
LAYout:ZOOM:POSCoupling? <DiagramName>, <ZoomName>

Enables or disables the position coupling of coupled zooms. If position coupling is enabled and one zoom area is moved, the other coupled zoom areas are moved, too, and keep their distance.

Parameters:

<PositionCoupl> ON | OFF
*RST: OFF

Parameters for setting and query:

<DiagramName>	String with the name of the diagram on which the zoom is based
<ZoomName>	String with the name of the zoom diagram

LAYout:ZOOM:HORZ:MODE <DiagramName>, <ZoomName>,<Mode>
LAYout:ZOOM:HORZ:MODE? <DiagramName>, <ZoomName>

Defines whether absolute or relative values are used to specify the x-axis values. Since the zoom area refers to the active signal, relative values ensure that the zoom area remains the same.

Parameters:

<Mode> ABS | REL

Mode used to specify the x-axis values of the zoom area.

*RST: ABS

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

Example: See Chapter 20.3.1.1, "Creating Zoom Diagrams", on page 956

LAYout:ZOOM:HORZ:ABSolute:POSition <DiagramName>, <ZoomName>,<Position>
LAYout:ZOOM:HORZ:ABSolute:POSition? <DiagramName>, <ZoomName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<Position>
Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:SPAN <DiagramName>, <ZoomName>,<Span>
LAYout:ZOOM:HORZ:ABSolute:SPAN? <DiagramName>, <ZoomName>

Defines the width of the zoom area.

Parameters:

<Span>
Range: 0 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.

<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:STARt <DiagramName>, <ZoomName>,<Start>
LAYout:ZOOM:HORZ:ABSolute:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the x-axis.

Parameters:

<Start>
Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:HORZ:ABSolute:STOP <DiagramName>, <ZoomName>,<Stop>
LAYout:ZOOM:HORZ:ABSolute:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the x-axis.

Parameters:

<Stop>
Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

LAYout:ZOOM:HORZ:RELative:POSition <DiagramName>, <ZoomName>,<RelPosi>
LAYout:ZOOM:HORZ:RELative:POSition? <DiagramName>, <ZoomName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<RelPosi>
Relative position of the centerpoint (x-value)

Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<DiagramName>	Name of the diagram on which the zoom area is based.
<ZoomName>	Name of the zoom diagram

Example: See Chapter 20.3.1.1, "Creating Zoom Diagrams", on page 956

LAYout:ZOOM:HORZ:RELative:SPAN <DiagramName>, <ZoomName>,<RelativeSpan>
LAYout:ZOOM:HORZ:RELative:SPAN? <DiagramName>, <ZoomName>

Defines the width of the zoom area.

Parameters:

<RelativeSpan> Range: 1E-15 to 100
Increment: 0.1
*RST: 1
Default unit: %

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

Example: See Chapter 20.3.1.1, "Creating Zoom Diagrams", on page 956

LAYout:ZOOM:HORZ:RELative:STARt <DiagramName>, <ZoomName>,<RelativeStart>
LAYout:ZOOM:HORZ:RELative:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the x-axis.

Parameters:

<RelativeStart> Range: 0 to 100
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:HORZ:RELative:STOP <DiagramName>, <ZoomName>,<RelativeStop>
LAYout:ZOOM:HORZ:RELative:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the x-axis.

Parameters:

<RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:MODE <DiagramName>, <ZoomName>,<Mode>
LAYout:ZOOM:VERTical:MODE? <DiagramName>, <ZoomName>

Defines whether absolute or relative values are used to specify the y-axis values. Since the zoom area refers to the active signal, relative values ensure that the zoom area remains the same.

Parameters:

<Mode> ABS | REL

Mode used to specify the y-axis values of the zoom area.

*RST: ABS

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:POSition <DiagramName>, <ZoomName>,<Position>
LAYout:ZOOM:VERTical:ABSolute:POSition? <DiagramName>, <ZoomName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<Position> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:SPAN <DiagramName>, <ZoomName>,<Span>
LAYout:ZOOM:VERTical:ABSolute:SPAN? <DiagramName>, <ZoomName>

Defines the height of the zoom area.

Parameters:

<Span> Range: 0 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:STARt <DiagramName>, <ZoomName>,<Start>
LAYout:ZOOM:VERTical:ABSolute:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the y-axis.

Parameters:

<Start> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:ABSolute:STOP <DiagramName>, <ZoomName>,<Stop>
LAYout:ZOOM:VERTical:ABSolute:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the y-axis.

Parameters:

<Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:POSition <DiagramName>, <ZoomName>,<RelPosi>
LAYout:ZOOM:VERTical:RELative:POSition? <DiagramName>, <ZoomName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<RelPosi> Relative position of the centerpoint (y-value)

Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:SPAN <DiagramName>, <ZoomName>,<RelativeSpan>
LAYout:ZOOM:VERTical:RELative:SPAN? <DiagramName>, <ZoomName>

Defines the height of the zoom area.

Parameters:

<RelativeSpan>	Range:	1E-15 to 100
	Increment:	0.1
	*RST:	1
	Default unit:	%

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:STARt <DiagramName>, <ZoomName>,<RelativeStart>
LAYout:ZOOM:VERTical:RELative:STARt? <DiagramName>, <ZoomName>

Defines the lower limit of the zoom area on the y-axis.

Parameters:

<RelativeStart>	Range:	0 to 100
	Increment:	0.1
	*RST:	0
	Default unit:	%

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:VERTical:RELative:STOP <DiagramName>, <ZoomName>,<RelativeStop>
LAYout:ZOOM:VERTical:RELative:STOP? <DiagramName>, <ZoomName>

Defines the upper limit of the zoom area on the y-axis.

Parameters:

<RelativeStop>	Range:	0 to 100
	Increment:	0.1
	*RST:	100
	Default unit:	%

Parameters for setting and query:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

LAYout:ZOOM:REMove <DiagramName>, <ZoomName>

Removes the specified zoom diagram.

Setting parameters:

<DiagramName> Name of the diagram on which the zoom area is based.

<ZoomName> Name of the zoom diagram

Example: See Chapter 20.3.1.1, "Creating Zoom Diagrams", on page 956

Usage: Setting only

20.10.2 Reference Waveforms

20.10.2.1 Reference

REFCurve<m>:SOURce <Source>

Selects the source waveform to be used as a reference.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the reference waveform, see Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C1W1

REFCurve<m>:STATe <State>

If enabled, the reference waveform is displayed in the diagram.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<State> ON | OFF

*RST: OFF

REFCurve<m>:NAME <Name>

Defines the name of the reference waveform file to be loaded, saved or deleted.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<Name> Path and name of the file that contains the reference waveform or to which the reference waveform is to be stored (`.xml` or `.bin` format), enclosed in single quotes.

REFCurve<m>:OPEN

Loads the reference waveform file selected by `REFCurve<m>:NAME` on page 1106.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

REFCurve<m>:UPDate

Copies the selected source waveform (see `REFCurve<m>:SOURce` on page 1105) with all its settings to the memory of the reference waveform.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

REFCurve<m>:SAVE

Saves the reference waveform to the file selected by `REFCurve<m>:NAME` on page 1106.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

REFCurve<m>:DELete

Deletes the reference waveform file selected by `REFCurve<m>:NAME` on page 1106.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

REFCurve<m>:CLEar

The selected reference waveform is no longer displayed, its memory is deleted.

Suffix:

<m> 1..4
Reference waveform

Usage: Event

20.10.2.2 Scaling

REFCurve<m>:RESTore

Restores the settings of the source waveform, if vertical scaling is set to "Independent" (see `REFCurve<m>:VMODe` on page 1107).

Suffix:

<m> 1..4
Reference waveform

Usage: Event

REFCurve<m>:VMODe <VerticalMode>

Selects the coupling of vertical settings.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<VerticalMode> COUPled | INDependent

COUPled
Vertical position and scale of the source are used.

INDependent
Scaling and position can be set specific to the reference waveform.

*RST: INDependent

REFCurve<m>:SCALe <VerticalScale>

Sets the scale factor for the reference waveform if vertical scaling is set to "Independent" (see REFCurve<m>:VMODe on page 1107).

Suffix:

<m> 1..4
Reference waveform

Parameters:

<VerticalScale>
Range: 1E-15 to 100E+24
Increment: 10E-6
*RST: 0.5
Default unit: V/div

REFCurve<m>:POSition <VertPosi>

Moves the reference waveform and its horizontal axis up or down in the diagram, if vertical scaling is set to "Independent" (see REFCurve<m>:VMODe on page 1107).

Suffix:

<m> 1..4
Reference waveform

Parameters:

<VertPosi>
Range: -100E+24 to 100E+24
Increment: 0.02
*RST: 0
Default unit: div

REFCurve<m>:RESCale:VERTical:STATe <State>

Enables and disables the vertical stretching. Stretching changes the display of the waveform independent of the vertical scale and position.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<State> ON | OFF

*RST: OFF

REFCurve<m>:RESCale:VERTical:FACTor <ScaleFactor>

Defines the vertical stretching factor. A factor greater than 1 stretches the waveform vertically, a factor lower than 1 compresses the curve.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<ScaleFactor> Range: -1E+6 to 1E+6
Increment: 0.1
*RST: 1

REFCurve<m>:RESCale:VERTical:OFFSet <Offset>

Moves the reference waveform vertically. Like vertical offset of channel waveforms, the offset of a reference waveform is subtracted from the measured value.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<Offset> Negative values shift the waveform up, positive values shift it down.

Range: -100E+24 to 100E+24
Increment: 1E-6
*RST: 0
Default unit: V

REFCurve<m>:HMODe <HorizontalMode>

Selects the coupling of horizontal settings.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<HorizontalMode> ORIGinal | COUPled

ORIGinal
Horizontal scaling and reference point of the source waveform are used.

COUPled
The current horizontal settings of the diagram are used.

*RST: ORIGinal

REFCurve<m>:RESCale:HORizontal:STATe <State>

Enables and disables the horizontal stretching.

Stretching changes the display of the waveform independent of the horizontal settings of the source waveform and of the horizontal diagram settings.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<State> ON | OFF
*RST: OFF

REFCurve<m>:RESCale:HORizontal:FACTor <ScaleFactor>

A factor greater than 1 stretches the waveform horizontally, a factor lower than 1 compresses the curve.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<ScaleFactor> Range: 1E-6 to 1E+6
Increment: 0.1
*RST: 1

REFCurve<m>:RESCale:HORizontal:OFFSet <Offset>

Moves the waveform horizontally. Positive values shift the waveform to the right, negative values shift it to the left.

Suffix:

<m> 1..4
Reference waveform

Parameters:

<Offset> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0
Default unit: s

20.10.2.3 Waveform Data Export

Commands for saving waveform data to file are described in Chapter 20.16.5, "Waveform Data Export to File", on page 1280.Commands for reference waveforms are listed below.

REFCurve<m>:DATA:STYPe?

Returns the signal type of the source of the reference waveform.

Suffix:

<m> 1..4
Reference waveform

Return values:

<SignalType> SOUR | SPEC | CORR | NONE

SOURce = normal signal
SPECtrum = FFT spectrum, specific math signal
CORRelation = correlated signal, specific math signal
NONE = undefined

Usage: Query only

REFCurve<m>:DATA:HEADer?

Returns information on the reference waveform.

Table 20-3: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. For reference waveforms the number is always 1.	1

Suffix:

<m> 1..4
Reference waveform

Example:

```
REFC:DATA:HEAD?
-9.477E-008,9.477E-008,200000,1
```

Usage: Query only

REFCurve<m>:DATA[:VALues]?

Returns the data of the channel waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

You can retrieve only Y-values, or X- and Y-values. Use `EXPort:WAVeform:INCXvalues` to define this.

Suffix:

<m> 1..4
Reference waveform

Return values:

<Data> List of values according to the format and content settings.

Usage: Query only

20.10.2.4 Import of Multichannel Waveform Data

Commands for saving waveform data to file are described in Chapter 20.16.5, "Waveform Data Export to File", on page 1280.Commands for reference waveforms are listed below.

REFCurve<m>:MULTichannel:NAME <MultiChImportPath>

Defines the path and the file to be imported. If not path is given, the default path `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\RefWaveforms` is used.

Suffix:

<m> 1..4
The suffix is irrelevant.

Parameters:

<MultiChImportPath> String with path and filename

Example: See `REFCurve<m>:MULTichannel:IMPort` on page 1112.

REFCurve<m>:MULTichannel:IMPort <WfmSelect>

Assigns a waveform from the multichannel file to a reference waveform. To import all waveforms that are in the file, you must assign each waveform to another reference waveform.

Suffix:

<m> 1..4
Selects the reference waveform.

Parameters:

<WfmSelect> NONE | NONE | WF1 | WAFEFORM1 | WF2 | WAFEFORM2 | WF3 | WAFEFORM3 | WF4 | WAFEFORM4

WF1 = WAFEFORM1, WF2 = WAFEFORM2, WF3 = WAFEFORM3, WF4 = WAFEFORM4
Selects the waveform in the export file.

*RST: NONE

Example:
```
REFCurve:MULTichannel:NAME
RefCurve_2016-02-16_01.bin
REFCurve1:MULTichannel:IMPort WF1
REFCurve2:MULTichannel:IMPort WF3
REFCurve3:MULTichannel:IMPort WF4
REFCurve:MULTichannel:OPEN
```

Firmware/Software: FW 3.20

REFCurve<m>:MULTichannel:OPEN

Loads the waveform data to the reference waveforms.

Suffix:

<m> 1..4
The suffix is irrelevant.

Example: See `REFCurve<m>:MULTichannel:IMPort` on page 1112.

Usage: Event
Asynchronous command

20.10.3 Mathematics

CALCulate:MATH<m>[:EXPRession][:DEFine] <RemComplExpr>

Defines the math expression to be calculated for the specified math channel.

For an overview of corresponding expressions for the available keys in the formula editor, see Chapter 6.3.3, "Advanced Expressions", on page 249.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<RemComplExpr> String with regular expression for calculation

Example: `CALC:MATH 'Ch1Wfm1*Ch2Wfm1'`
Defines the multiplication of waveforms Ch1Wfm1 and Ch2Wfm1.

CALCulate:MATH<m>:STATe <State>

Enables the math waveform display.

Suffix:

<m> 1..4
math waveform

Parameters:

<State> ON | OFF
*RST: OFF

CALCulate:MATH<m>:ENVSelection <EnvelopeCurve>

Selects the upper or lower part of the waveform for mathematic calculation, or a combination of both.

The setting is relevant for waveforms with waveform arithmetic mode "Envelope" or with "Peak detect" decimation. All mathematic operations - except for derivation - can be applied to envelope waveforms and waveforms with "Peak detect" decimation.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<EnvelopeCurve> MIN | MAX | BOTH
*RST: BOTH

Firmware/Software: FW 2.25

CALCulate:MATH<m>:ARIThmetics <Arithmetics>

Selects the method to build the resulting math waveform from consecutive acquisitions. The processing is similar to the waveform arithmetics - instead of the acquired waveforms the results of the mathematic formula are used to create envelope, average and RMS.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<Arithmetics> OFF | ENVelope | AVERage | RMS | MINHold | MAXHold

waveform arithmetic mode

OFF
The math waveform is built according to the mathematic formula.

ENVelope
Detects the minimum and maximum math values in a sample interval over a number of acquisitions.

AVERage
Calculates the average from the math data of the current acquisition and a number of acquisitions before. To define the number of acquisitions, use `ACQuire:COUNt`.

RMS
The resulting math waveform is the root mean square of the current acquisition and a number of acquisitions before. The result is the average power spectrum. Number of acquisitions: `ACQuire:COUNt`

MAXHold
Determines the maximum result for each input value from the math data of the current acquisition and a number of acquisitions before. To define the number of acquisitions, use `ACQuire:COUNt`.

MINHold
Determines the minimum result for each input value from the math data of the current acquisition and a number of acquisitions before. To define the number of acquisitions, use `ACQuire:COUNt`.

*RST: OFF

CALCulate:MATH<m>:VERTical:OFFSet <VerticalOffset>

Sets a voltage offset to adjust the vertical position of the math function on the screen.

Suffix:

<m> 1..4
Math waveform

Parameters:

<VerticalOffset> Negative values move the waveform au, positive values move it down.

Range: -100E+12 to 100E+12
Increment: 0.01
*RST: 0
Default unit: div

CALCulate:MATH<m>:VERTical:RANGe <VerticalRange>

Defines the range of FFT values to be displayed.

Suffix:

<m> 1..4
Math waveform

Parameters:

<VerticalRange>	Range: 0 to 1E+15 Increment: 0.01 *RST: 0 Default unit: div

CALCulate:MATH<m>:VERTical:SCALe <VerticalScale>

Defines the scale of the y-axis in the math function diagram. The value is defined as "V per division", e.g. *50V/div*. In this case, the horizontal grid lines are displayed in intervals of 50 V.

Suffix:

<m>	1..4 Math waveform

Parameters:

<VerticalScale>	Range: 1E-12 to 100E+12 Increment: 10E-6 *RST: 0.5 Default unit: V/div

CALCulate:MATH<m>:DATA:STYPe?

Returns the signal type of the source of the math waveform.

Suffix:

<m>	1..4 Selects the math waveform.

Return values:

<SignalType>	SOUR | SPEC | CORR | MEAS | NONE SOURce = normal signal SPECtrum = FFT spectrum, specific math signal CORRelation = correlated signal, specific math signal MEAsurement = result of a measurement NONE = undefined Im GUI nicht vorhanden: XY = XY-signal SBUS = Serial bus
Usage:	Query only

CALCulate:MATH<m>:DATA:HEADer?

Returns the header of math waveform data. The header contains attributes of the waveform.

Table 20-4: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. For most waveforms the result is 1, for peak detect and envelope waveforms it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).	1

Suffix:
<m> 1..4
Selects the math waveform.

Example:
```
CALC:MATH4:DATA:HEAD
-9.477E-008,9.477E-008,200000,1
```

Usage: Query only

CALCulate:MATH<m>:DATA[:VALues]?

Returns the data of the math waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

You can retrieve only Y-values, or X- and Y-values. Use `EXPort:WAVeform:INCXvalues` to define this.

Suffix:
<m> 1..4
Selects the math waveform.

Return values:
<Data> List of values according to the format and content settings.

Usage: Query only

20.10.4 History

CHANnel<m>[:WAVeform<n>]:HISTory[:STATe] <State>

Enables or disables the history display.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<State>	ON | OFF *RST: OFF

ACQuire:AVAilable?

Returns the number of acquisitions that is saved in the memory. This number of acquisitions is available for history viewing. It is also the number of acquisitions in a fast segmentation acquisition series.

Return values:

<AcqCnt>	Range: 0 to 4294967295

Usage: Query only

Firmware/Software: V 1.25

CHANnel<m>[:WAVeform<n>]:HISTory:CURRent <CurrAcqIdx>

Accesses a particular acquisition in the memory to display it. The query returns the index of the segment that is shown.

Suffix:

<m>	1..4 Selects the input channel.
<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<CurrAcqIdx>	History index: the newest segment has the index "0", older segments have a negative index: -(n-1), ... -1 , 0 where n is the number of acquired segments. Range: 0 to -(n-1) Increment: 1

Example: `CHAN2:HIST:CURR -1`
`*OPC`
Displays the acquisition before last from the history.

CHANnel<m>[:WAVeform<n>]:HISTory:STARt <StrtAcqIdx>

Sets the index of the oldest history acquisition for the history viewing.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<StrtAcqIdx> The start index is always negative.

Range: 0 to -(n-1)
Increment: 1

CHANnel<m>[:WAVeform<n>]:HISTory:STOP <StpAcqIdx>

Sets the index of the latest segment to be displayed in the history viewer.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<StpAcqIdx> Index of the stop acquisition. The newest acquisition always has the index "0".

Range: 0 to -(n-1)
Increment: 1

CHANnel<m>[:WAVeform<n>]:HISTory:TPACq <TimePerAcq>

Sets the display time for one acquisition. The shorter the time, the faster is the replay.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<TimePerAcq> Range: 40E-6 to 10
Increment: 1
*RST: 0.05
Default unit: s

CHANnel<m>[:WAVeform<n>]:HISTory:PLAY

Starts and stops the replay of the history waveforms.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Usage: Event
Asynchronous command

CHANnel<m>[:WAVeform<n>]:HISTory:REPLay <AutoRepeat>

If ON, the replay of the history waveform sequence repeats automatically. Otherwise, the replay stops at the stop index set with `CHANnel<m>[:WAVeform<n>]:HISTory:STOP`.

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Parameters:

<AutoRepeat> ON | OFF
*RST: OFF

Usage: Asynchronous command

CHANnel<m>[:WAVeform<n>]:HISTory:TSDate?

Returns the date of the current acquisition that is shown in the history viewer (`CHANnel<m>[:WAVeform<n>]:HISTory:CURRent`).

Suffix:

<m> 1..4
Selects the input channel.

<n> 1..3
Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Return values:
<DateAbsString> String with date of the current acquisition (absolute time)

Usage: Query only

CHANnel<m>[:WAVeform<n>]:HISTory:TSABsolute?

Returns the abolsute daytime of the current acquisition that is shown in the history viewer (`CHANnel<m>[:WAVeform<n>]:HISTory:CURRent`).

Suffix:
<m> 1..4
Selects the input channel.

<n> 1..3
Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Return values:
<TimeAbsString> String containing the time and unit

Usage: Query only

CHANnel<m>[:WAVeform<n>]:HISTory:TSRelative?

Returns the relative time of the current acquisition - the time difference to the newest acquisition (index = 0).

See also: (`CHANnel<m>[:WAVeform<n>]:HISTory:CURRent`).

Suffix:
<m> 1..4
Selects the input channel.

<n> 1..3
Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Return values:
<TimeRelativ> Range: -100E+24 to 100E+24
Default unit: s

Usage: Query only

CHANnel<m>[:WAVeform<n>]:HISTory:TSRReference?

Returns the relative time of the currently selected acquisition and the internal reference time (horizontal alignment) in history view with respect to the acquisition with index 0.

Suffix:
<m> 1..4
Selects the input channel.

<n>	1..3 Selects the waveform. If [:WAVeform<n>] is omitted, waveform 1 is adressed.

Return values:

<TimeRelIntRef>	Range: -100E+24 to 100E+24 Increment: 1 *RST: 0 Default unit: s

Usage: Query only

Firmware/Software: Version 2.70

20.10.5 XY-Diagram

WAVeform<m>:XYCurve:RATio <ConstantXYRatio>

If enabled, the x- and y-axes maintain a constant ratio in the diagram.

Suffix:

<m>	1..4 XY-diagram

Parameters:

<ConstantXYRatio>	ON | OFF *RST: ON

WAVeform<m>:XYCurve:STATe <State>

Activates an XY-waveform.

Suffix:

<m>	1..4 XY-diagram

Parameters:

<State>	ON | OFF *RST: OFF

WAVeform<m>:XYCurve:SWAP

Replaces the source of the x-axis with the source of the y-axis and vice versa.

Suffix:
<m> 1..4
XY-diagram

Usage: Event

LAYout:SIGNal:AXIS <DiagramName>, <Source>, <XSource>

Creates an XY-diagram by adding a second waveform to a diagram with a channel, math or reference waveform.

Setting parameters:

<DiagramName> String with the name of the diagram where the waveform is added.

<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Waveform to be added, see Chapter 20.4.2, "Waveform Parameter", on page 970

<XSource> ON | OFF

If on, the added waveform is assigned to the x-axis.
If off, it is assigned to the y-axis.

Usage: Setting only

WAVeform<m>:XYCurve:XSOurce <XSource>

Defines the signal source that supplies the x-values of the XY-diagram.

Suffix:
<m> 1..4
XY-diagram

Parameters:

<XSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of x-values, see Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C1W1

WAVeform<m>:XYCurve:YSOurce <YSource>

Defines the signal source that supplies the y-values of the XY-diagram.

Suffix:

<m>	1..4 XY-diagram

Parameters:

<YSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of y-values, see Chapter 20.4.2, "Waveform Parameter", on page 970 *RST: C2W1

20.11 Cursor Measurements

CURSor<m>:AOFF

This command switches all cursors off.

Suffix:

<m> The numeric suffix is irrelevant.

Usage: Event

CURSor<m>:STATe <State>

Switches the indicated cursor on or off.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<State> ON | OFF

*RST: OFF

CURSor<m>:FUNCtion <Type>

Defines the type of the indicated cursor set.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<Type> HORizontal | VERTical | PAIRed

HORizontal
A pair of horizontal cursor lines.

VERTical
A pair of vertical cursor lines.

PAIRed
Both vertical and horizontal cursor line pairs.

*RST: PAIRed

CURSor<m>:TRACking[:STATe] <TrackCurve>

If set to `ON`, the horizontal cursor lines follow the waveform.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<TrackCurve> ON | OFF

*RST: OFF

CURSor<m>:SOURce <Source>

Defines the source of the cursor measurement.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | SG1 | SG2 | SG3 | SG4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the cursor measurement, see Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C1W1

CURSor<m>:SSOurce <Source2>

Selects the second cursor source.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<Source2> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | SG1 | SG2 | SG3 | SG4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the cursor measurement, see Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C2W1

Firmware/Software: FW 3.60

CURSor<m>:USSource <UseSource2>

Enables the second cursor source. To select the second source, use `CURSor<m>:SSOurce` on page 1126.

If enabled, the second corsor lines Cx.2 measure on the second source. Using a second source, you can measure differences between two channels with cursors.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<UseSource2> ON | OFF
*RST: OFF

Firmware/Software: FW 3.60

CURSor<m>:X1Position <XPosition1>

Defines the position of the left vertical cursor line.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<XPosition1> Range: 0 to 500
Increment: 0.1
*RST: 0
Default unit: s

CURSor<m>:X2Position <XPosition2>

Defines the position of the right vertical cursor line.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<XPosition2> Range: 0 to 500
Increment: 0.1
*RST: 0
Default unit: s

CURSor<m>:XCOupling <Coupling>

Defines the positioning mode of the vertical cursor.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<Coupling> ON | OFF

ON
Moving one cursor line moves the other cursor line too. The cursor lines always remain a fixed distance.

OFF
Each cursor line is positioned independently.

*RST: OFF

CURSor<m>:Y1Position <YPosition1>

Defines the position of the lower horizontal cursor line.

If `CURSor<m>:TRACking[:STATe]` is enabled, the query returns the measurement result - the lower vertical value of the waveform.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<YPosition1>
Range: -50 to 50
Increment: 0.01
*RST: 0
Default unit: The unit depends on the type of the waveform.

CURSor<m>:Y2Position <YPosition2>

Defines the position of the upper horizontal cursor line.

If `CURSor<m>:TRACking[:STATe]` is enabled, the query returns the measurement result - the upper vertical value of the waveform.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<YPosition2>
Range: -50 to 50
Increment: 0.01
*RST: 0
Default unit: The unit depends on the type of the waveform.

CURSor<m>:YCOupling <Coupling>

Defines the positioning mode of the horizontal cursor. If the horizontal cursor lines track the waveform, the y-coupling is irrelevant (`CURSor<m>:MODE TRACk`).

Suffix:
<m> 1..4
Selects the cursor set.

Parameters:
<Coupling> ON | OFF

ON
Moving one cursor line moves the other cursor line too. The cursor lines always remain a fixed distance.

OFF
Each cursor line is positioned independently.

*RST: OFF

CURSor<m>:X1ENvelope <EnvelopeCurve1>

If the waveform arithmetics are set to envelope curve (see CHANnel<m>[:WAVeform<n>]:ARIThmetics on page 1008) and CURSor<m>:TRACking[:STATe] is set to "ON", this setting defines how the first horizontal cursor is positioned.

Suffix:
<m> 1..*
Selects the cursor set. 4 cursor sets are available.

Parameters:
<EnvelopeCurve1> MIN | MAX

MIN
The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope.

MAX
The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope.

*RST: MIN

CURSor<m>:X2ENvelope <EnvelopeCurve2>

If the waveform arithmetics are set to envelope curve (see CHANnel<m>[:WAVeform<n>]:ARIThmetics on page 1008) and CURSor<m>:TRACking[:STATe] is set to "ON", this setting defines how the second horizontal cursor is positioned.

Suffix:
<m> 1..*
Selects the cursor set. 4 cursor sets are available.

Parameters:
<EnvelopeCurve2> MIN | MAX

MIN
The horizontal cursor is set to the crossing point of the vertical cursor with the minimum waveform envelope.

MAX
The horizontal cursor is set to the crossing point of the vertical cursor with the maximum waveform envelope.
*RST: MAX

CURSor<m>:XDELta[:VALue]?

Queries the delta value (distance) of two vertical cursor lines.

Suffix:
<m> 1..4
Selects the cursor set.

Return values:
<Delta> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

CURSor<m>:XDELta:INVerse?

Queries the inverse value of the delta value (distance) of the two vertical cursor lines.

Suffix:
<m> 1..4
Selects the cursor set.

Return values:
<DeltaInverse> Range: -100E+24 to 100E+24
*RST: 0
Default unit: Hz

Usage: Query only

CURSor<m>:YDELta[:VALue]?

Queries the delta value (distance) of the two horizontal cursor lines.

Suffix:
<m> 1..4
Selects the cursor set.

Return values:
<Delta> Range: -100E+24 to 100E+24
*RST: 0

Usage: Query only

CURSor<m>:YDELta:SLOPe <DeltaSlope>

Returns the inverse value of the voltage difference - the reciprocal of the vertical distance of two horizontal cursor lines: *1/ΔV*.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<DeltaSlope> Range: -100E+24 to 100E+24
Increment: 0
*RST: 0

CURSor<m>:FFT:SETCenter

Sets the center frequency to the frequency value that is measured at cursor line c1.

Suffix:

<m> The suffix is irrelevant.

Usage: Event

CURSor<m>:FFT:TOCenter

Sets the vertical cursor line c1 to the center frequency.

Suffix:

<m> The suffix is irrelevant.

Usage: Event

CURSor<m>:MAXimum[:PEAK]

Sets both cursors to the absolute peak value.

Suffix:

<m> 1..4
Selects the cursor set.

Usage: Event

CURSor<m>:MAXimum:LEFT

Sets cursor 2 to the next maximum to the left of the current position.

Suffix:

<m> 1..4
Selects the cursor set.

Usage: Event

CURSor<m>:MAXimum:RIGHt

Sets cursor 2 to the next peak to the right (from the current position).

Suffix:
<m> 1..4
Selects the cursor set.

Usage: Event

CURSor<m>:MAXimum:NEXT

Sets cursor 2 to the next smaller peak (from the current position).

Suffix:
<m> 1..4
Selects the cursor set.

Usage: Event

CURSor<m>:THReshold <Value>

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

Suffix:
<m> The suffix is irrelevant.

Parameters:
<Value> Threshold in dBm

Firmware/Software: Version 2.70

CURSor<m>:PEXCursion <Value>

Defines the minimum level by which the waveform must rise or fall so that it will be identified as a maximum or a minimum by the search functions.

Suffix:
<m> The suffix is irrelevant

Parameters:
<Value> Range: 0 to 100
Increment: 1
*RST: 5
Default unit: dB

CURSor<m>:STYLe <Style>

Defines how the cursor is displayed in the diagram.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<Style> LINes | LRHombus | VLRHombus | RHOMbus

LINes
The cursors are displayed as lines.

LRHombus
The cursors are displayed as lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

VLRHombus
The cursors are displayed only as vertical lines. The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

RHOMbus
The intersections of the cursors with the waveforms are displayed by rhombus-shaped points.

*RST: LINes

CURSor<m>:LABel <ShowLabel>

Shows the cursor labels in the diagram.

Suffix:

<m> 1..4
Selects the cursor set.

Parameters:

<ShowLabel> ON | OFF

*RST: ON

20.12 Automatic Measurements

This chapter contains all remote commands to set up automatic measurements and to analyze the measurement results.

Selection of the measurement group: MEASurement<m>

With R&S RTP you can configure up to eight simultaneous measurement groups. In manual operation, these eight measurement groups are represented by subtabs "MG1" to "MG8" in the "Measurements" dialog box. For remote operation, the measurement group is indicated by the suffix MEAS<m>, containing the number of the measurement group.

Remote control: measurement suffix <m>	Manual operation: "MG" subtab
1 to 8 correspond to	"MG1" to "MG8"
9, 10: do not use	Not available

20.12.1 General Settings

MEASurement<m>[:ENABle] <State>

Switches the indicated measurement on or off.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<State> ON | OFF
*RST: OFF

Example: See "Simple Frequency and Amplitude Measurement" on page 956.

MEASurement<m>:SOURce <SignalSource>, [<SignalSource2>]

Defines the source of the measurement.

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<SignalSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the measurement, see Chapter 20.4.2, "Waveform Parameter", on page 970

Digital channels are provided with option R&S RTP-B1.

Serial bus SBUS1 | SBUS2 | SBUS3 | SBUS4 is available as measurement source if an audio bus is configured (option R&S RTP-K5)

SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2: Spectrograms and timelines require option R&S RTP-K37.

Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4: input channels of multi-channel power probeR&S RT-ZVC.

<SignalSource2> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Digital channels are only available if <SignalSource> is a digital channel.

*RST: C1W1,C2W1

Example: See "Simple Frequency and Amplitude Measurement" on page 956.

MEASurement<m>:FSRC <Source>

Defines the first measurement source.

The command is an alternative to `MEASurement<m>:SOURce`.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | SBUS1 | SBUS2 | SBUS3 | SBUS4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the measurement, see Chapter 20.4.2, "Waveform Parameter", on page 970

SBUS1 ... SBUS4
Serial bus is available as measurement source if an audio bus is configured (option R&S RTP-K5)

D0 ... D15
Digital channels are provided with option R&S RTP-B1.

SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2
Spectrograms require option R&S RTP-K37.

Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4
Input channels of multi-channel power probeR&S RT-ZVC.

*RST: C1W1

MEASurement<m>:SSRC <Source2>

Defines the second measurement source.

The command is an alternative to `MEASurement<m>:SOURce`.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Source2>

C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Second source of the measurement, see Chapter 20.4.2, "Waveform Parameter", on page 970

Digital channels are only available if a digital channel is set as first measurement source using `MEASurement<m>:FSRC`.

*RST: C2W1

MEASurement<m>:CATegory <Category>

Defines the measurement category.

Suffix:

<m>

1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Category>

AMPTime | JITTer | EYEJitter | SPECtrum | HISTogram | PROTocol

AMPTime
Amplitude and time measurements

JITTer
Jitter measurements, only available if option R&S RTP-K12 is installed

EYEJitter
Eye diagram mesurements

SPECtrum
Spectrum measurements

HISTogram
Histogram measurements

PROTocol
Protocol measurements (track and trend)

*RST: AMPTime

Example:

See "Creating and Reading Histograms" on page 958

MEASurement<m>:MAIN <MeasType>

Defines the measurement that is used as a source for math calculations and result analysis. This measurement is mandatory in the measurement group. Further measurements are added to the measurement group with `MEASurement<m>:ADDitional`.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<MeasType>

Amplitude/time measurements
HIGH | LOW | AMPLitude | MAXimum | MINimum | PDELta | MEAN | RMS | STDDev | POVershoot | NOVershoot | AREA | RTIMe | FTIMe | PPULse | NPULse | PERiod | FREQuency | PDCYcle | NDCYcle | CYCarea | CYCMean | CYCRms | CYCStddev | PULCnt | DELay | PHASe | BWIDth | PSWitching | NSWitching | PULSetrain | EDGecount | SHT | SHR | DTOTrigger | PROBemeter | SLERising | SLEFalling
See Chapter 20.12.3, "Amplitude/Time Measurements", on page 1144.
*RST value for amplitude/time measurements: `AMPLitude`.

Jitter measurements
CCJitter | NCJitter | CCWidth | CCDutycycle | TIE | UINTerval | DRATe | SKWDelay | SKWPhase
Only available isf option R&S RTP-K12 is installed. See Chapter 20.21.1, "Jitter Measurements (Option R&S RTP-K12)", on page 1827.

Eye diagram measurements
ERPercent | ERDB | EHEight | EWIDth | ETOP | EBASe | QFACtor | RMSNoise | SNRatio | DCDistortion | ERTime | EFTime | EBRate | EAMPlitude | PPJitter | STDJitter | RMSJitter
See Chapter 20.12.4, "Eye Diagram Measurements", on page 1153
*RST value for eye/jitter measurements: `ERPercent`.

Spectrum measurements
CPOWer | OBWidth | SBWidth | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR | THDF
See Chapter 20.12.5, "Spectrum", on page 1156.
*RST value for spectrum measurements: `CPOWer`.

Histogram measurements
WCOunt | WSAMples | HSAMples | HPEak | PEAK | UPEakvalue | LPEakvalue | HMAXimum | HMINimum | MEDian | MAXMin | HMEan | HSTDdev | M1STddev | M2STddev | M3STddev | MKPositive | MKNegative
See Chapter 20.12.6.2, "Histogram Measurement", on page 1168.
*RST value for histogram measurements: `WCOunt`.

Example: See "Simple Frequency and Amplitude Measurement" on page 956.
See "Creating and Reading Histograms" on page 958

MEASurement<m>:ADDitional <MeasType>, <State>
MEASurement<m>:ADDitional? <MeasType>

Adds additional measurements to the indicated measurement group. Only one measurement can be enabled or disabled per command. The query returns the state of the specified measurement.

Note that each measurement group must contain measurements from the same category. For example, if the main measurement of measurement group 1 is amplitude, then you cannot enable an eye width measurementin the same measurement group.

Suffix:
<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:
<State> ON | OFF
Enables or disables the measurement.

Parameters for setting and query:
<MeasType> See `MEASurement<m>:MAIN` on page 1138.

MEASurement<m>:AON

Enables all additional measurements in all categories of the indicated measurement.

Suffix:
<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Usage: Event

MEASurement<m>:AOFF

Disables all additional measurements in all categories of the indicated measurement.

Suffix:
<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Usage: Event

20.12.2 Results

MEASurement<m>:ARES?

Returns the results of all active measurements for the selected measurement group. If statistics are enabled, the instrument returns also statistical results.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Return values:

<Data> Result string

Example:

```
:MEASurement:ARES?
2.351778656126e-001,1.343873517787e-001,
-1.343873517787e-001
```

Example:

```
:MEASurement:ARNames 1
:MEASurement:ARES?
Amplitude: 2.351778656126e-001,Max:
1.343873517787e-001,Min: -1.343873517787e-001
```

Example:

```
:MEASurement:ARNames 1
:MEASurement:STATistics:ENABle 1
:MEASurement:ARES?
Amplitude:
2.312252964427e-001,2.608695652174e-001,
2.292490118577e-001,2.391822576775e-001,
2.392462568683e-001,5.533663458383e-003,12447,
12447,Max: 1.343873517787e-001,
1.343873517787e-001,1.324110671937e-001,
1.340297640714e-001, 1.340319233732e-001,
7.608360495310e-004,12447,12447, Min:
-1.324110671937e-001,-1.324110671937e-001,
-1.343873517787e-001,-1.340169449387e-001,
1.340191641476e-001,7.712812700636e-004,12447,12447
Results: current, peak+, peak-, average, RMS,
standard deviation, event count, waveform count
```

Usage: Query only

MEASurement<m>:ARNames <Identifier>

Enables a prefix that indicates the measurement in the result string of the MEASurement<m>:ARES? command.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Identifier> ON | OFF

*RST: OFF

Example:

```
:MEASurement:ARNames 1
:MEASurement:ARES?
Low: -1.185770750988e-001,Amplitude:
2.371541501976e-001,Max: 1.343873517787e-001
```

MEASurement<m>:RESult[:ACTual]? [<MeasType>]
MEASurement<m>:RESult:AVG? [<MeasType>]
MEASurement<m>:RESult:EVTCount? [<MeasType>]
MEASurement<m>:RESult:NPEak? [<MeasType>]
MEASurement<m>:RESult:PPEak? [<MeasType>]
MEASurement<m>:RESult:RELiability? [<MeasType>]
MEASurement<m>:RESult:RMS? [<MeasType>]
MEASurement<m>:RESult:WFMCount? [<MeasType>]
MEASurement<m>:RESult:STDDev? [<MeasType>]

Return the statistic results of the specified measurement. If no parameter is specified, the result of the main measurement is returned. The main measurement is defined using MEASurement<m>:MAIN.

- [:ACTual]: current measurement result
- AVG: average of the long-term measurement results
- EVTCount: number of measurement results in the long-term measurement
- NPEak: negative peak value of the long-term measurement results
- PPEak: positive peak value of the long-term measurement results
- RELiability: reliability of the measurement result
- RMS: RMS value of the long-term measurement results
- STDDev: standard deviation of the long-term measurement results

For a detailed description of the results see "Selection of the measurement group: MEASurement<m>" on page 1133.

Suffix:

<m>
1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Query parameters:

<MeasType>

Amplitude/time measurements
HIGH | LOW | AMPLitude | MAXimum | MINimum | PDELta | MEAN | RMS | STDDev | POVershoot | NOVershoot | AREA | RTIMe | FTIMe | PPULse | NPULse | PERiod | FREQuency | PDCYcle | NDCYcle | CYCarea | CYCMean | CYCRms | CYCStddev | PULCnt | DELay | PHASe | BWIDth | PSWitching | NSWitching | PULSetrain | EDGecount | SETup | HOLD | SHR | DTOTrigger | PROBemeter | SLERising | SLEFalling
See Chapter 20.12.3, "Amplitude/Time Measurements", on page 1144.

Jitter measurements (option R&S RTP-K12)
CCJitter | NCJitter | CCWidth | CCDutycycle | TIE | UINTerval | DRATe | SKWDelay | SKWPhase
See Chapter 20.21.1, "Jitter Measurements (Option R&S RTP-K12)", on page 1827

Eye diagram measurements
ERPercent | ERDB | EHEight | EWIDth | ETOP | EBASe | QFACtor | RMSNoise | SNRatio | DCDistortion | ERTime | EFTime | EBRate | EAMPlitude | PPJitter | STDJitter | RMSJitter
See Chapter 20.12.4, "Eye Diagram Measurements", on page 1153.

Spectrum measurements
CPOWer | OBWidth | SBWidth | THD | THDPCT | THDA | THDU | THDR | PLISt | HAR | THDF
See Chapter 20.12.5, "Spectrum", on page 1156.

Histogram measurements
WCOunt | WSAMples | HSAMples | HPEak | PEAK | UPEak-value | LPEakvalue | HMAXimum | HMINimum | MEDian | MAX-Min | HMEan | HSTDdev | M1STddev | M2STddev | M3STddev | MKPositive | MKNegative
See Chapter 20.12.6.2, "Histogram Measurement", on page 1168.

Example: See "Simple Frequency and Amplitude Measurement" on page 956.
See "Creating and Reading Histograms" on page 958

Usage: Query only

MEASurement<m>:RESult:STARt? [<MeasType>]
MEASurement<m>:RESult:STOP? [<MeasType>]

Return the start and stop times of the specified measurement. The parameter defines the measurement. If no parameter is specified, the result of the main measurement is returned. The main measurement is defined using `MEASurement<m>:MAIN`.

Suffix:
<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Query parameters:
<MeasType> See `MEASurement<m>:RESult:STDDev?` on page 1141.

Usage: Query only

MEASurement<m>:RESult:COUNt? <MeasType>

Returns the number of result groups that are returned by `MEASurement:RESult:ACTual? HAR`.

Suffix:
<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Query parameters:
<MeasType> HAR
The command is only relevant for harmonic search.

Return values:
<Count> Number of result groups

Example:
```
:MEASurement:RESult:ACTual? HAR
99.9;-6.000139236;199.8;-80.701713562;299.7;-15.528377533;
:MEASurement:RESult:COUNt? HAR
4
```

Usage: Query only

Firmware/Software: Version 2.70

20.12.3 Amplitude/Time Measurements

The following table lists the <MeasType> parameter values with a short description.

In addition, the suffixes <n> for limit check remote commands are listed.

For a detailed description, see Chapter 7.2.5.1, "Overview of Amplitude/Time Measurements", on page 304.

Table 20-5: Amplitude and time measurements

<MeasType> parameter value (remote control)	Measurement (manual operation)	Description, result	Suffix <n>
HIGH	High	High signal level	1
LOW	Low	Low signal level	2
AMPLitude	Amplitude	Amplitude of the signal	3
MAXimum	Max	Maximum value of the waveform	4
MINimum	Min	Minimum value of the waveform	5
PDELta	Peak to peak	Peak-to-peak value of the waveform	6
MEAN	Mean	Mean value of the waveform	7
RMS	RMS	RMS (Root Mean Square) value of the voltage	8
STDDev	σ (S-dev)	Standard deviation of the waveform	9
POVershoot	Pos. overshoot	Positive overshoot of a square wave	10
NOVershoot	Neg. overshoot	Negative overshoot of a square wave	11
AREA	Area	Area beneath the waveform (integral)	12
RTIMe	Rise time	Rise time of the left-most rising edge of the waveform.	13
FTIMe	Fall time	Falling time of the left-most falling edge of the waveform.	14
PPULse	Pos. pulse	Width of a positive pulse – a rising edge followed by a falling edge. The measurement requires at least one complete period of a triggered signal.	15
NPULse	Neg. pulse	Width of a negative pulse – a falling edge followed by a rising edge. The measurement requires at least one complete period of a triggered signal.	16
PERiod	Period	Length of the left-most signal period of the waveform	17
FREQuency	Frequency	Frequency of the signal. The result is based on the period measurement.	18
PDCYcle	Pos. duty cycle	Positive duty cycle. The measurement requires at least one complete period of a triggered signal.	19
NDCYcle	Neg. duty cycle	Negative duty cycle. The measurement requires at least one complete period of a triggered signal.	20

<MeasType> parameter value (remote control)	Measurement (manual operation)	Description, result	Suffix <n>
CYCarea	Cycle area	Area (integral) beneath one cycle	21
CYCMean	Cycle mean	Mean value of one cycle	22
CYCRms	Cycle RMS	The RMS (Root Mean Square) value of one cycle	23
CYCStddev	Cycle σ (S-dev)	Standard deviation of one cycle	24
PULCnt	Pulse count	Number of positive or negative pulses of the waveform, or both	25
DELay	Delay	Time difference between the any edges of two measurement sources at any reference level. The measurement result is negative if the edge of the second source comes before the edge of the first source.	26
PHASe	Phase	Phase difference between two waveforms	27
BWIDth	Burst width	Duration of one burst, measured from the first edge to the last	28
PSWitching	Pos. switching	Settling time at rising edges	29
NSWitching	Neg. switching	Settling time at falling edges	30
PULSetrain	Pulse train	Duration of N positive pulses, measured from the rising edge of the first pulse to the falling edge of the N-th pulse. N has to be configured.	31
EDGecount	Edge count	Number of positive or negative edges of the waveform, or both	32
SETup	Setup time	Parameters to query the setup and hold times. Use these parameters only in following queries: • MEASurement<m>:ARES? • MEASurement<n>:RESult:.. commands	33
HOLD	Hold time		
SHT	Setup/Hold time	Setting parameter to enable Setup/Hold time measurements. Use this parameter only as setting in: • MEASurement<m>:MAIN on page 1138 • MEASurement<m>:ADDitional on page 1139	35
SHR	Setup/Hold ratio	Setup/Hold ratio measurement. Setup/Hold ratio is the ratio of the setup time to the sum of hold and setup time: $T_{Setup} / (T_{Setup} + T_{Hold})$ Use this parameter as setting to activate the Setup/Hold ratio measurement in: • MEASurement<m>:MAIN on page 1138 • MEASurement<m>:ADDitional on page 1139 It is also used in the following queries: • MEASurement<m>:ARES? • MEASurement<n>:RESult:.. Used also in queries with and commands.	36
Used for jitter measurements (limit checks) see Chapter 20.21.1, "Jitter Measurements (Option R&S RTP-K12)", on page 1827.			37 to 45

<MeasType> parameter value (remote control)	Measurement (manual operation)	Description, result	Suffix <n>
DTOTrigger	Delay to trigger	Time between the trigger event and a following signal slope. High accuracy even if the trigger event is outside the acquisition data.	46
PROBemeter	Trig. ProbeMeter	DC voltage measured by the connected active R&S probe	47
SLERising	Slew rate on rising edge	Steepness of the rising edge: voltage difference between the lower and higher reference level, divided by the rise time.	48
SLEFalling	Slew rate on falling edge	Steepness of the falling edge: voltage difference between the higher and lower reference level, divided by the fall time.	49

MEASurement<m>:ENVSelect <EnvelopeCurve>

The command is only relevant for measurements on envelope waveforms. It selects the envelope to be used for measurement.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<EnvelopeCurve> MIN | MAX | BOTH

MIN: measures on the lower envelope
MAX: measures on the upper envelope
BOTH: the envelope is ignored and the waveform measured as usual

*RST: BOTH

Firmware/Software: V 1.25

MEASurement<m>:DETThreshold <SignDetectThres>

Defines the value above which measurement results are displayed. Values beneath the threshold are considered to be noise and they are ignored.

Suffix:

<m> 1..10
irrelevant

Parameters:

<SignDetectThres> Range: 0 to 50
Increment: 1
*RST: 5
Default unit: %

MEASurement<m>:AMPTime:ALEVel <AreaLevel>

Defines the reference level used to integrate the waveform.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<AreaLevel> Range: -100E+24 to 100E+24
Increment: 0
*RST: 0
Default unit: V

MEASurement<m>:AMPTime:PFSLope <PeriodSlope>

Selects the slope direction for frequency and period measurements.

Suffix:

<m> 1..9
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<PeriodSlope> FIRSt | POSitive | NEGative | EITHer

POSitive | NEGative
Measures the time between rising or falling edges, respectively.

EITHer
In multiple measurements, the time is measured both between rising edges and between falling edges.
In single measurements. the first edge is taken for the measurement.

FIRSt
Time is measured either between rising edges or between falling edges. The first edge is taken for the measurement. In single measurements, it works the same way as "Either".
Only available for analog measurement sources.

*RST: FIRSt (analog source), POSitive (digital source)

MEASurement<m>:AMPTime:PSLope <PulsesSlope>

Sets the first slope of the pulses to be counted. The setting is only relevant for pulse count measurement (`MEASurement<m>:MAIN PULCnt` or `MEASurement<m>:ADDitional PULCnt,ON`).

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<PulsesSlope> POSitive | NEGative | EITHer

Count either positive or negative pulses, or both.

*RST: POSitive

MEASurement<m>:AMPTime:DELay<n>:DIRection <EdgeCntDirct>

Selects the direction for counting slopes for each source: from the beginning of the waveform, or from the end.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..2
Selects the source number.

Parameters:

<EdgeCntDirct> FRFI | FRLA

FRFI - FRom FIrst, counting starts with the first edge of the waveform.
FRLA - FRom LAst, counting starts with the last edge of the waveform.

*RST: FRFI

MEASurement<m>:AMPTime:DELay<n>:ECOunt <EdgeIndex>

Sets the number of the edge that is relevant for delay measurement for each source.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.
<n>	1..2 Selects the source number.

Parameters:

<EdgeIndex>	Edge number Range: 1 to 100000 Increment: 1 *RST: 1

MEASurement<m>:AMPTime:DELay<n>:LSELect <DelayLevelSelect>

Selects the reference level on which the time is measured for each source.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.
<n>	1..2 Selects the source number.

Parameters:

<DelayLevelSelect>	UPPer | MIDDle | LOWer *RST: MIDDle

MEASurement<m>:AMPTime:DELay<n>:SLOPe <Slope>

Sets the edge of each source, between which the delay is measured.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.
<n>	1..2 Selects the source number.

Parameters:

<Slope>	POSitive | NEGative | EITHer *RST: POSitive

MEASurement<m>:AMPTime:PTCount <PulseCount>

Sets the number of positive pulses for the pulse train measurement. It measures the duration of N positive pulses from the rising edge of the first pulse to the falling edge of the N-th pulse.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<PulseCount>	Range: 1 to 2147483647 Increment: 1 *RST: 1

MEASurement<m>:AMPTime:ESLope <EdgesSlope>

Sets the edge direction to be counted: rising edges, falling edges, or both. The setting is only relevant for edge count measurement (`MEASurement<m>:MAIN EDGecount` or `MEASurement<m>:ADDitional EDGecount,ON`).

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<EdgesSlope>	POSitive | NEGative | EITHer *RST: POSitive

MEASurement<m>:AMPTime:CSLope <SetupHoldClkSlope>

Sets the edge of the clock from which the setup and hold times are measured.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<SetupHoldClkSlope>	POSitive | NEGative | EITHer **EITHer** The clock edges next to the data edge are considered regardless of the clock slope. *RST: POSitive

MEASurement<m>:AMPTime:CLCK<n>:LSELect <ClockLevel>

Selects the reference level of the clock on which the time is measured. Reference level and clock slope define the time point for setup and hold measurements.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..2
The suffix is irrelevant, omit it.

Parameters:

<ClockLevel> UPPer | MIDDle | LOWer
*RST: MIDDle

MEASurement<m>:AMPTime:DATA<n>:LSELect <DataLevel>

Selects the reference level of the data on which the setup and hold time are measured.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..2
The suffix is irrelevant, omit it.

Parameters:

<DataLevel> UPPer | MIDDle | LOWer
*RST: MIDDle

MEASurement<m>:AMPTime:DTOTrigger<n>:SLOPe <DelaySlope>

Sets the edge direction to be used for delay measurement.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..2
The suffix is irrelevant.

Parameters:

<DelaySlope> POSitive | NEGative | EITHer
*RST: POSitive

MEASurement<m>:AMPTime:DTOTrigger<n>:LSELect <RefLevel>

Selects the reference level of the measurement source on which the delay is measured.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..2
The suffix is irrelevant.

Parameters:

<RefLevel> UPPer | MIDDle | LOWer

*RST: MIDDle

MEASurement<m>:AMPTime:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for amplitude vs. time measurements in the specified measurement channel.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..49
Number of the amplitude/time measurement, see Table 20-5.

Parameters:

<ValidRange> ILIMit | ULIMit | LLIMit | OLIMit

ILIMit
Inside (within) limit; between the upper and lower limit values

ULIMit
Upper limit; above the upper limit value

LLIMit
Lower limit; below the lower limit value

OLIMit
Outside limit; above the upper limit or below the lower limit values

*RST: ILIMit

MEASurement<m>:AMPTime:LCHeck<n>:LOWer:LIMit <Limit>
MEASurement<m>:AMPTime:LCHeck<n>:UPPer:LIMit <Limit>

Define the lower and upper limit for limit checking, respectiveley. The valid range is defined using the `MEASurement<m>:AMPTime:LCHeck<n>:VALid` command.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..49
Number of the amplitude/time measurement, see Table 20-5.

Parameters:

<Limit> Range: -100 to 100
Increment: 10E-6
*RST: 0

MEASurement<m>:AMPTime:LCHeck<n>:LOWer:MARGin <Margin>
MEASurement<m>:AMPTime:LCHeck<n>:UPPer:MARGin <Margin>

Define the lower and upper margins for the limit check, respectively. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:AMPTime:LCHeck<n>:VALid` command.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..49
Number of the amplitude/time measurement type, see Table 20-5.

Parameters:

<Margin> Range: -100 to 100
Increment: 10E-6
*RST: 0

20.12.4 Eye Diagram Measurements

The following table lists the <MeasType> parameter values with a short description.

In addition, the suffixes <n> for limit check remote commands are listed.

For a detailed description, see Chapter 7.2.6.1, "Overview of Eye Diagram Measurements", on page 316.

Table 20-6: Eye diagram measurements

<MeasType> parameter value (remote control)	Measurement (manual operation)	Description/Result	Suffix <n>
		not used	1
ERPercent	Extinction ratio (%)	Eye base / Eye top *100 Prerequisite: Eye base > 0 and Eye top > 0	2
ERDB	Extinction ratio (dB)	10*log (Eye top / Eye base)	3
EHEight	Eye height	Vertical eye opening	4
EWIDth	Eye width	Horizontal eye opening	5
ETOP	Eye top	Mean of the upper vertical histogram	6
EBASe	Eye base	Mean of the lower vertical histogram	7
		not used	8...9

<MeasType> parameter value (remote control)	Measurement (manual operation)	Description/Result	Suffix <n>
QFACtor	Q factor	(Eye top – Eye base) / (σtop + σbase)	10
		not used	11...13
RMSNoise	Noise (RMS)	Quadratic mean of the noise of eye top and eye base	14
SNRatio	S/N ratio	Signal-to-noise ratio 10 * log (Eye amplitude / Noise RMS)	15
DCDistortion	Duty cycle distortion	20 * log (Eye amplitude / Noise RMS)	16
ERTime	Eye rise time	Duration for signal to rise from 10% to 90% of the high signal level	17
EFTime	Eye fall time	Duration for signal to fall from 90% to 10% of the high signal level	18
EBRate	Eye bit rate	Frequency between two crossings	19
EAMPlitude	Eye amplitude	Eye top - Eye base	20
		not used	21...27
PPJitter	Jitter (peak to peak)	Average of the jitter for both crossing points (σcrossing1 + σcrossing2) / 2	28
STDJitter	Jitter (6*σ)	Jitter *6	29
RMSJitter	Jitter (RMS)	Quadratic mean of the jitter at both crossing points	30

MEASurement<m>:EYEJitter:AUToscale

Defines optimized settings to perform an eye diagram measurement for the selected source.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Usage: Event
Asynchronous command

MEASurement<m>:EYEJitter:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for eye/jitter measurements in the specified measurement channel.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.
<n>	1..30 Number of the eye/jitter measurement, see Table 20-6.

Parameters:

<ValidRange> ILIMit | ULIMit | LLIMit | OLIMit

ILIMit
Inside (within) limit; between the upper and lower limit values

ULIMit
Upper limit; above the upper limit value

LLIMit
Lower limit; below the lower limit value

OLIMit
Outside limit; above the upper limit or below the lower limit values

*RST: ILIMit

MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:LIMit <LowerLimit>
MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:LIMit <UpperLimit>

Define the lower and upper limit for the limit check, respectively. The valid range is defined using the `MEASurement<m>:EYEJitter:LCHeck<n>:VALid` command.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.
<n>	1..30 Number of the eye/jitter measurement, see Table 20-6.

Parameters:

<UpperLimit>
Range: -100 to 100
Increment: 10E-6
*RST: 0

MEASurement<m>:EYEJitter:LCHeck<n>:LOWer:MARGin <LowerMargin>
MEASurement<m>:EYEJitter:LCHeck<n>:UPPer:MARGin <UpperMargin>

Defines the upper margin for the limit check. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:EYEJitter:LCHeck<n>:VALid` command.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..30
Number of the eye/jitter measurement, see Table 20-6.

Parameters:

<UpperMargin> Range: -100 to 100
Increment: 10E-6
*RST: 0

20.12.5 Spectrum

The following table lists the <MeasType> parameter values with a short description.

In addition, the suffixes <n> for limit check remote commands are listed.

For a detailed description, see Chapter 7.2.7.1, "Overview of Spectrum Measurements", on page 319.

Table 20-7: Spectrum measurements

<MeasType> parameter value (remote control)	Measurement (manual operation)	Description/Result	Suffix <n>
CPOWer	Channel power	Power integrated over the sample values defined by a center frequency and a bandwidth; based on a defined impedance; the result is given in mW	1
		not used	2
OBWidth	Occupied bandwidth	From the defined center frequency, symmetric sample value pairs to the left and right are integrated until a user-defined percentage of the total power is reached	3
SBWidth	Bandwidth	n dB down bandwidth; the samples to the left and right of the peak value are analyzed until the n dB threshold is exceeded; the frequencies at which the threshold is exceeded define the limits of the requested bandwidth	4
		not used	5, 6
THD	THD[dB]	Total harmonic distortion in dB	7
THDPCT	THD[%]	Total harmonic distortion in %	8
THDA	THD_a	Is equivalent to THD. Requires option R&S RTP-K37.	9
THDU	THD_u	Requires option R&S RTP-K37.	10
THDR	THD_r	Distorsion factor. Requires option R&S RTP-K37.	11
PLISt	Peak list	List of frequency and peak power value pairs. Requires option R&S RTP-K37.	12

<MeasType> parameter value (remote control)	Measurement (manual operation)	Description/Result	Suffix <n>
HAR	Harmonic search	Returns the measured harmonics. For each harmonic, the frequency and the value is listed. To get the number of result pairs (= harmonics), use MEASurement<m>:RESult:COUNt?.	13
THDF	THD_f	Root mean square of the sum of all amplitudes of the harmonic waves in relation to the amplitude at the fundamental frequency (first harmonic). Requires option R&S RTP-K37.	14

MEASurement<m>:SPECtrum:CPOWer:BANDwidth <ChPowBw>

Defines the bandwidth over which the channel power is calculated.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<ChPowBw> Range: 0 to 4E+9
Increment: 1
*RST: 0
Default unit: Hz

MEASurement<m>:SPECtrum:OBANdwidth <OccupiedBW>

Defines the percentage of the total power used to determine the occupied bandwidth.

Suffix:
<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:
<OccupiedBW> Range: 0.1 to 99.9
Increment: 1
*RST: 20
Default unit: %

MEASurement<m>:SPECtrum:CPOWer:CFRequency <CenterFreq>

Defines the center frequency from which the channel power is calculated over the specified bandwidth.

Suffix:
<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:
<CenterFreq> Range: 0 to 6E+9
Increment: 1
*RST: 0
Default unit: Hz

MEASurement<m>:SPECtrum:NDBDown <NDbDown>

Defines the threshold until which the samples to the left and right of the peak value are analyzed in order to determine the "N dB down bandwidth".

Suffix:
<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:
<NDbDown> Range: 0 to 100
Increment: 1
*RST: 20
Default unit: dB

MEASurement<m>:SPECtrum:PEXCursion <Value>

Defines a relative threshold, the minimum level value by which the waveform must rise or fall to be considered as a peak. To avoid identifying noise peaks, enter a peak excursion value that is higher than the noise levels.

Suffix:

<m>	1..10 The suffix is irrelevant.

Parameters:

<Value>	Range: 0 to 100 Increment: 1 *RST: 5 Default unit: dB

Firmware/Software: Version 2.70

MEASurement<m>:SPECtrum:ATHReshold <Value>

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

This setting is only available for spectrum waveforms. It is valid for cursor measurements, spectrum measurements and peak search.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Value>	numeric value Default unit: dBm

MEASurement<m>:SPECtrum:RESult<n>:COUNt <MaxNoOfResults>

Sets the maximum number of measurement results that are listed in the result table. Available for peak list and harmonic search mesurements.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.
<n>	1..14

Parameters:

<MaxNoOfResults>	Range: 1 to 1000 Increment: 1 *RST: 10

MEASurement<m>:RESult:MAXCount <MeasType>,<Number>
MEASurement<m>:RESult:MAXCount? <MeasType>

Defines the maximum number of peaks that are labeled in the diagram.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Number> Maximum number of peaks

Parameters for setting and query:

<MeasType> PLISt

Only for peaklist measurements. For other measurement, this command returns an error.

MEASurement<m>:RESult:INVerse <MeasType>, <State>
MEASurement<m>:RESult:INVerse? <MeasType>

Displays labels with black font on white background using the "Full frame" label type (if `MEASurement<m>:RESult:LABorder`=`ON`).).

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<State> ON | OFF

Parameters for setting and query:

<MeasType> PLISt

Only for peaklist measurements. For other measurement, this command returns an error.

Example:

Display labels.
`MEAS:RES:SHL PLIS,ON`
Select inverted labels.
`MEAS:RES:INV PLIS,ON`
Query the type of labels for peak lists.
`MEAS:RES:INV? PLIS`
`//Result: ON`

MEASurement<m>:RESult:LABorder <MeasType>, <FrameType>
MEASurement<m>:RESult:LABorder? <MeasType>

Defines the layout of the labels.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<FrameType> NOBorder | UNDERLINE | FULL

NOBorder
Label without border or lines.

UNDERLINE
The label is underlined.

FULL
The label is surrounded by a frame.

Parameters for setting and query:

<MeasType> PLISt

Only for peaklist measurements. For other measurements, this command returns an error.

MEASurement<m>:RESult:SHFRequency <MeasType>, <State>
MEASurement<m>:RESult:SHFRequency? <MeasType>

Includes the frequency of the detected peak in the diagram labels (if `MEASurement<m>:RESult:LABorder=ON`).

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<State> ON | OFF

Parameters for setting and query:

<MeasType> PLISt

Only for peaklist measurements. For other measurements, this command returns an error.

Example:

Display labels.
`MEAS:RES:SHL PLIS,ON`
Show frequency in labels.
`MEAS:RES:SHFR PLIS,ON`
Query the type of labels for peak lists.
`MEAS:RES:SHFR? PLIS`
`//Result: ON`

MEASurement<m>:RESult:SHLabels <MeasType>, <State>
MEASurement<m>:RESult:SHLabels? <MeasType>

Defines whether a description (label) is displayed for each detected peak in the spectrum diagram.

The layout of the label is defined by `MEASurement<m>:RESult:LABorder`.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<State> ON | OFF

Parameters for setting and query:

<MeasType> PLISt

Only for peaklist measurements. For other measurements, this command returns an error.

Example: Display labels.
`MEAS:RES:SHL PLIS,ON`

MEASurement<m>:SPECtrum:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for spectrum measurements in the specified measurement channel.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..14
Number of the spectrum measurement, see Table 20-7.

Parameters:

<ValidRange> ILIMit | ULIMit | LLIMit | OLIMit

ILIMit
Inside (within) limit; between the upper and lower limit values

ULIMit
Upper limit; above the upper limit value

LLIMit
Lower limit; below the lower limit value

OLIMit
Outside limit; above the upper limit or below the lower limit values

*RST: ILIMit

MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:LIMit <LowerLimit>
MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:LIMit <UpperLimit>

Define the lower and upper limits for the limit check, respectively. The valid range is defined using the `MEASurement<m>:SPECtrum:LCHeck<n>:VALid` command.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..14
Number of the spectrum measurement, see Table 20-7.

Parameters:

<UpperLimit>	Range:	-100 to 100
	Increment:	10E-6
	*RST:	0

MEASurement<m>:SPECtrum:LCHeck<n>:LOWer:MARGin <LowerMargin>
MEASurement<m>:SPECtrum:LCHeck<n>:UPPer:MARGin <UpperMargin>

Define the lower and upper margins for the limit check, respectively. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:SPECtrum:LCHeck<n>:VALid` command.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..14
Number of the spectrummeasurement, see Table 20-7.

Parameters:

<UpperMargin>	Range:	-100 to 100
	Increment:	10E-6
	*RST:	0

20.12.6 Histograms

See also: Chapter 20.16.6, "Waveform Histogram Export to File", on page 1287

20.12.6.1 Histogram Display

LAYout:HISTogram:ADD <HistogramName>, <Source>, <XStart>, <XStop>, <YStart>, <YStop>, <Relative>, <Orientation>

Defines and displays a new histogram for the specified source.

Note: To define the mode of the histogram (vertical or horizontal), use the `LAYout:HISTogram:MODE` command.

Setting parameters:

<HistogramName> String defining the histogram name which is used to refer to the histogram by other functions.

<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Data source of the histogram, see Chapter 20.4.2, "Waveform Parameter", on page 970

<XStart> Defines the start value of the x-value range.

<XStop> Defines the stop value of the x-value range.

<YStart> Defines the start value of the y-value range.

<YStop> Defines the stop value of the y-value range.

<Relative> ON | OFF

Defines whether relative or absolute values are used for the value range definition.

<Orientation> VERTical | HORizontal

Example: See "Creating and Reading Histograms" on page 958

Usage: Setting only

LAYout:HISTogram:SOURce <HistogramName>,<Source>
LAYout:HISTogram:SOURce? <HistogramName>

Defines the source of the histogram. Any analog input signal, math or reference waveform, and measurement can be selected.

Parameters:

<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | MRESult1 | MRESult2 | MRESult3 | MRESult4 | MRESult5 | MRESult6 | MRESult7 | MRESult8 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Waveform source of the histogram, see Chapter 20.4.2, "Waveform Parameter", on page 970.
If the histogram source is a measurement, the histogram shows the density distribution of the results for the selected measurement (`MEAS<m>:MAIN`).

Parameters for setting and query:

<HistogramName> String parameter

LAYout:HISTogram:MODE <HistogramName>,<Mode>
LAYout:HISTogram:MODE? <HistogramName>

Defines or queries the type of histogram.

Parameters:

<Mode> VERTical | HORizontal

VERTical
Amplitude histogram (horizontal bars across amplitude)

HORizontal
Time or frequency histogram (vertical bars over time/frequencies)

*RST: VERTical

Parameters for setting and query:

<HistogramName> The name of the histogram as defined using `LAYout:HISTogram:ADD` on page 1164.

LAYout:HISTogram:HORZ:MODE <HistogramName>,<Mode>
LAYout:HISTogram:HORZ:MODE? <HistogramName>

Defines or queries whether the value range limits are entered as absolute or relative values.

Parameters:

<Mode> ABS | REL

*RST: ABS

Parameters for setting and query:

<HistogramName>

LAYout:HISTogram:HORZ:ABSolute:STARt <HistogramName>,<Start>
LAYout:HISTogram:HORZ:ABSolute:STARt? <HistogramName>

Defines the horizontal start value of the histogram.

Parameters:

<Start> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<HistogramName>

LAYout:HISTogram:HORZ:ABSolute:STOP <HistogramName>,<Stop>
LAYout:HISTogram:HORZ:ABSolute:STOP? <HistogramName>

Defines the horizontal stop value of the histogram.

Parameters:

<Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<HistogramName>

LAYout:HISTogram:HORZ:RELative:STARt <HistogramName>,<RelativeStart>
LAYout:HISTogram:HORZ:RELative:STARt? <HistogramName>

Defines the horizontal start value of the histogram.

Parameters:

<RelativeStart> Range: 0 to 100
Increment: 0.1
*RST: 0
Default unit: %

Parameters for setting and query:

<HistogramName>

LAYout:HISTogram:HORZ:RELative:STOP <HistogramName>,<RelativeStop>
LAYout:HISTogram:HORZ:RELative:STOP? <HistogramName>

Defines the horizontal stop value of the histogram.

Parameters:

<RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:VERTical:MODE <HistogramName>,<Mode>
LAYout:HISTogram:VERTical:MODE? <HistogramName>

Defines or queries whether the value range limits are entered as absolute or relative values.

Parameters:

<Mode>	ABS | REL	
	*RST:	ABS

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:VERTical:ABSolute:STARt <HistogramName>,<Start>
LAYout:HISTogram:VERTical:ABSolute:STARt? <HistogramName>

Defines the vertical start value of the histogram.

Parameters:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:VERTical:ABSolute:STOP <HistogramName>,<Stop>
LAYout:HISTogram:VERTical:ABSolute:STOP? <HistogramName>

Defines the vertical stop value of the histogram.

Parameters:

<Stop>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:VERTical:RELative:STARt <HistogramName>,<RelativeStart>
LAYout:HISTogram:VERTical:RELative:STARt? <HistogramName>

Defines the vertical start value of the histogram.

Parameters:

<RelativeStart>	Range:	0 to 100
	Increment:	0.1
	*RST:	0
	Default unit:	%

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:VERTical:RELative:STOP <HistogramName>,<RelativeStop>
LAYout:HISTogram:VERTical:RELative:STOP? <HistogramName>

Defines the vertical stop value of the histogram.

Parameters:

<RelativeStop>	Range:	0 to 100
	Increment:	0.1
	*RST:	100
	Default unit:	%

Parameters for setting and query:
<HistogramName>

LAYout:HISTogram:RESet <HistogramName>

Resets the values to begin a new histogram.

Setting parameters:
<HistogramName>

Usage: Setting only

LAYout:HISTogram:REMove <Name>

Removes the specified histogram.

Setting parameters:
<Name>

Usage: Setting only

20.12.6.2 Histogram Measurement

This chapter lists commands to set up measurements on histograms.

Note that the R&S RTP performs histogram measurements on the measurement that is defined with `MEASurement<m>:MAIN`. Other measurements are not considered.

See also: "Creating and Reading Histograms" on page 958.

The following table lists the <MeasType> parameter values with a short description.

In addition, the suffixes <n> for limit check remote commands are listed.

For a detailed description, see Table 7-7.

Table 20-8: Histogram measurements

<MeasType> parameter value (remote control)	Measurement (manual operation)	Description/Result	Suffix <n>
WCOunt	Waveform count	Number of acquisitions (waveforms) the histogram is based on	1
WSAMples	Waveform samples	Number of samples from the most recent acquisition included in the current histogram	2
HSAMples	Histogram samples	Number of samples from all acquisitions included in the current histogram	3
HPEak	Histogram peak	Maximum sample value in the histogram	4
PEAK	Peak value	Signal value at the histogram peak	5
UPEakvalue	Upper peak value	Signal value at the maximum sample value in the upper half of the histogram	6
LPEakvalue	Lower peak value	Signal value at the maximum sample value in the lower half of the histogram	7
HMAXimum	Maximum	Highest signal value with a probability > 0	8
HMINimum	Minimum	Lowest signal value with a probability > 0	9
MEDian	Median	Signal value for which half the samples lie above, the other half below in the histogram	10
MAXMin	Max - Min	Range of signal values with a probability > 0	11
HMEan	Mean	Weighted arithmetic average of the histogram	12
HSTDdev	σ (S-dev)	Standard deviation of the sample numbers	13
M1STddev	Mean ±σ	Range between (mean value + standard deviation) and (mean value - standard deviation)	14
M2STddev	Mean ±2*σ	Range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)	15
M3STddev	Mean ±3*σ	Range between (mean value + 3 * standard deviation) and (mean value - 2 * standard deviation)	16
MKPositive	Marker + Probability %	Marker value (according to the selected probability domain marker type) plus the defined limit. Note that the value is restricted to the histogram range.	17
MKNegative	Marker - Probability %	Marker value (according to the selected probability domain marker type) minus the defined limit. Note that the value is restricted to the histogram range.	18

MEASurement<m>:HISTogram:SELect <HistogramName>

Selects the histogram on which the measurement is based.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<HistogramName> String with the name of the histogram

Example: See "Creating and Reading Histograms" on page 958

MEASurement<m>:HISTogram:PROBability:TYPE <Marker>

Defines the marker reference in the probability domain.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Marker> PEAK | UPPK | LWPK | MAXimum | MINimum | MEDian | MEAN

PEAK
The y-value with the maximum sample value in the histogram

UPPK
The y-value at the maximum sample value in the upper half of the histogram

LWPK
The y-value at the maximum sample value in the lower half of the histogram

MAXimum
The highest y-value with a probability > 0

MINimum
The lowest y-value with a probability > 0

MEDian
The y-value for which half the samples lie above, the other half below in the histogram

MEAN
The weighted arithmetic average of the histogram

*RST: PEAK

MEASurement<m>:HISTogram:PROBability:LIMit <Limit>

Defines a range around the probability marker.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Limit>	Range: 0 to 100 Increment: 10 *RST: 10 Default unit: %

MEASurement<m>:HISTogram:LCHeck<n>:VALid <ValidRange>

Enables or disables limit checking for histogram measurements in the specified measurement channel.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.
<n>	1..18 Number of the histogram measurement, see Table 20-8.

Parameters:

<ValidRange>	ILIMit | ULIMit | LLIMit | OLIMit **ILIMit** Inside (within) limit; between the upper and lower limit values **ULIMit** Upper limit; above the upper limit value **LLIMit** Lower limit; below the lower limit value **OLIMit** Outside limit; above the upper limit or below the lower limit values *RST: ILIMit

---

MEASurement<m>:HISTogram:LCHeck<n>:LOWer:LIMit <LowerLimit>
MEASurement<m>:HISTogram:LCHeck<n>:UPPer:LIMit <UpperLimit>

Define the lower and upper limits for the limit check, respectively. The valid range is defined using the `MEASurement<m>:HISTogram:LCHeck<n>:VALid` command.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n>	1..18 Number of the histogram measurement, see Table 20-8.

Parameters:

<UpperLimit>	Range: -100 to 100 Increment: 10E-6 *RST: 0

MEASurement<m>:HISTogram:LCHeck<n>:LOWer:MARGin <LowerMargin>
MEASurement<m>:HISTogram:LCHeck<n>:UPPer:MARGin <UpperMargin>

Define the lower and upper margins for the limit check, respectively. Margins are not as strict as limits and must be within the valid value range. The valid range is defined using the `MEASurement<m>:HISTogram:LCHeck<n>:VALid` command.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.
<n>	1..18 Number of the histogram measurement, see Table 20-8.

Parameters:

<UpperMargin>	Range: -100 to 100 Increment: 10E-6 *RST: 0

20.12.7 Display

MEASurement<m>:DISPlay:LEVels <DisplayLevels>

If enabled, the reference levels used for the measurement are displayed in the diagram.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<DisplayLevels>	ON | OFF *RST: OFF

MEASurement<m>:DISPlay:RESults <DisplayResult>

If enabled, the intermediate result lines required to obtain the measurement result (e.g. signal thresholds) are displayed in the measurement diagram.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<DisplayResult> ON | OFF

*RST: OFF

MEASurement<m>:DISPlay:STYLe <DisplayStyle>

Selects the style in which the measurement waveform is displayed.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<DisplayStyle> LINE | MARKer

LINE
The individual data points are connected by a line.

MARKer
Only the individual data points are displayed as markers.

*RST: LINE

MEASurement<m>:DISPlay:HISTogram <DispHistg>

Displays a histogram for the source of the selected measurement.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<DispHistg> ON | OFF

*RST: OFF

MEASurement<m>:DISPlay:GROuping <GroupResDialogs>

If ON, all measurement results are shown in one result box. If disabled, the results of each measurement group are shown in a separate result box. The default position is ignored.

Suffix:
<m> 1..10
The suffix is irrelevant. The setting affects all measurements except for the peak list.

Parameters:
<GroupResDialogs> ON | OFF
*RST: ON

DISPlay:RESultboxes:MEPosition <Position>

Defines the position of the measurement results on the display.

Parameters:
<Position> PREV | FLOA | DOCK

PREV
Preview: result icon on the sidebar

FLOA
Floating: floating result box in front of the diagrams

DOCK
Docked: fixed tab below the diagrams

*RST: DOCK

20.12.8 Statistics and Long-term Measurements

See also: Chapter 20.16.8, "Long Term Measurement Results and Measurement Histogram Export to File", on page 1289.

MEASurement<m>:STATistics[:ENABle] <StatisticsState>

Enables statistics calculation for the measurement.

For details on the statistics results, see Chapter 7.2.10.1, "Statistics", on page 331.

Suffix:
<m>

Parameters:

<StatisticsState>	ON | OFF	
	*RST:	OFF

MEASurement<m>:CLEar

Deletes the statistic results of the indicated mesurement.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.
Usage:	Event

MEASurement<m>:MULTiple <MultiMeas>

The measurement is performed repeatedly if the measured parameter occurs several times inside the acquisition or defined gate.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<MultiMeas>	ON | OFF	
	*RST:	OFF

MEASurement<m>:MNOMeas <MaxMeasPerAcq>

Sets the maximum number of measurements per acquisition if repeated measurement is enabled (`MEASurement<m>:MULTiple` is `ON`).

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<MaxMeasPerAcq>	Range:	2 to 1000000
	Increment:	1
	*RST:	1000

MEASurement<m>:STATistics:HISTogram <ShowHistogram>

Displays a histogram of the statistical results. Enabling the histogram enables also the calculation and display of statistics for the measurement results if statistics were disabled. the histogram shows the cumulative occurence distribution of mean measurement results in a graphic.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<ShowHistogram> ON | OFF
*RST: OFF

MEASurement<m>:STATistics:HBINs <HistogramBins>

Sets the number of bins - the number of vertical bars that build the histogram.

If `MEASurement<m>:VERTical:CONT` is ON, the instrument determines the number of bins automatically based on the time base, the current measurements, and other settings.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<HistogramBins> Range: 2 to 1000
Increment: 10
*RST: 1000

Options: FW 2.50

MEASurement<m>:STATistics:MODE <ResetMode>

Defines when the statistics for long term measurements are reset.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<ResetMode> TIME | WFMS | MEAS

TIME
Sets one long term measurement point after the time defined using `MEASurement<m>:STATistics:RTIMe`.

WFMS - Waveforms
Sets one long term measurement point after a number of acquired waveforms defined using `MEASurement<m>:STATistics:RCOunt`.

MEAS
Sets one long term measurement point after a number of measurement results.

*RST: TIME

MEASurement<m>:STATistics:RCOunt <RstWfmCnt>

Defines the number of measured waveforms from which one point of the long term measurement is created (reset of statistics).

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<RstWfmCnt> Range: 1 to 65535
Increment: 10
*RST: 1000

MEASurement<m>:STATistics:RMEascount <RstMeasCnt>

Defines the number of measurement results from which one point of the long term measurement is created.

This setting is only available if `MEASurement<m>:STATistics:MODE` is set to `MEAS`.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<RstMeasCnt> Range: 1 to 65535
Increment: 10
*RST: 1000

MEASurement<m>:STATistics:RTIMe <ResetTime>

Defines the time or period after which the statistics are reset.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<ResetTime>	Range: 0.1 to 2.14748E+9 Increment: 1E-3 *RST: 0.2 Default unit: s

MEASurement<m>:STATistics:RESet

Resets the histogram, the long term measurement and the statistics.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Usage: Event

MEASurement<m>:VERTical:CONT <AutoScale>

If enabled, automatic vertical scaling is performed whenever the waveform does not fit in the diagram during the long term measurement period.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<AutoScale> ON | OFF
*RST: ON

Firmware/Software: V 1.50

MEASurement<m>:VERTical:AUTO

Performs an automatic scaling once so that the scaling is adapted to the current measurement results. Available only for long term measurement.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Usage: Event

MEASurement<m>:VERTical:OFFSet <VerticalOffset>

Defines a vertical offset for the long term measurement.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<VerticalOffset> Range: -100E+24 to 100E+24
Increment: 1E-6
*RST: 0
Default unit: div

MEASurement<m>:VERTical:SCALe <VerticalScale>

Defines the vertical scaling per division, so that the scaling can be adapted automatically during the long term measurement period.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<VerticalScale> Range: 10E-24 to 100E+24
Increment: 10E-6
*RST: 0.5
Default unit: V/div

MEASurement<m>:LTMeas[:STATe] <ShowDiagram>

Enables long term measurement for a defined number of measurement points (see `MEASurement<m>:LTMeas:COUNt` on page 1179) or a specified time (see`MEASurement<m>:LTMeas:TIME` on page 1180).

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<ShowDiagram> ON | OFF
*RST: OFF

MEASurement<m>:LTMeas:COUNt <MeasCount>

Defines the total number of points to be measured during the long term measurement.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<MeasCount>	Range:	1000 to 200000
	Increment:	10
	*RST:	1000

MEASurement<m>:LTMeas:TIME <MeasurementTime>

Defines the total duration of the long term measurement.

This setting is only available if `MEASurement<m>:STATistics:MODE` is set to "Time".

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<MeasurementTime>	Range:	0.01 to 2.14748E+9
	Increment:	1
	*RST:	200
	Default unit:	s

20.12.9 Track and Trend

MEASurement<m>:TRACk[:STATe] <State>

Enables the track functionality and displays the track.

The track functionality requires at least one option, see "Enable (Track)" on page 338.

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<State> ON | OFF

*RST: OFF

MEASurement<m>:TRACk:DATA:HEADer?

Returns the header of the track.

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Usage: Query only

MEASurement<m>:TRACk:DATA:STYPe?

Returns the data type: TRK (track).

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Usage: Query only

MEASurement<m>:TRACk:DATA[:VALues]?

Returns the data of track points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Usage: Query only

20.12.10 Gating

MEASurement<m>:GATE[:STATe] <State>

Considers the gating settings of the source waveform for the measurement.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<State> ON | OFF
*RST: OFF

MEASurement<m>:GATE:MODE <Mode>

Defines whether the gate settings are configured using absolute or relative values.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Mode> ABS | REL
*RST: ABS

MEASurement<m>:GATE:ABSolute:STARt <Start>
MEASurement<m>:GATE:ABSolute:STOP <Stop>

Define the absolute start and end values for the gate.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Start> <Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

MEASurement<m>:GATE:RELative:STARt <RelativeStart>
MEASurement<m>:GATE:RELative:STOP <RelativeStop>

Define the relative start and end values for the gate, respectively.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<RelativeStart>
<RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

MEASurement<m>:GATE:CURSor <Cursorset>

Selects the cursor set to be used for measurement gating. The gate area is defined by the cursor lines.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Cursorset>	CURSOR1 | CURSor1 | CURSOR2 | CURSor2 | CURSOR3 | CURSor3 | CURSOR4 | CURSor4 CURSOR1 = CURSor1, CURSOR2 = CURSor2, CURSOR3 = CURSor3, CURSOR4 = CURSor4 *RST: CURSOR1

MEASurement<m>:GATE:CCOupling <CursorCoupling>

Enables the cursor coupling for automatic measurements.

Select the cursor set to be used with `MEASurement<m>:GATE:CURSor`.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<CursorCoupling>	ON | OFF *RST: OFF

MEASurement<m>:GATE:ZCOupling <ZoomCoupling>

If enabled, the gate area is defined identically to the zoom area for the zoom diagram.

If enabled, define the zoom area to be used as gate with `MEASurement<m>:GATE:ZDIagram`.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<ZoomCoupling>	ON | OFF *RST: OFF

MEASurement<m>:GATE:ZDIagram <ZoomDiagram>

If `MEASurement<m>:GATE:ZCOupling` is enabled, the gate area is defined identically to the zoom area for the selected zoom diagram.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<ZoomName> String with the name of the zoom diagram

Parameters for setting and query:

<DiagramName> String with the name of the diagram on which the zoom is based

Example: `:MEASurement:GATE:ZDIagram "Diagram1","Zoom1"`

MEASurement<m>:GATE:GCOupling <GateCoupling>

If you enable the gate coupling, the gate settings of the selected measurement are copied to all other measurements. If zoom or cursor coupling is active in a measurement, the zoom size and cursor positions are adjusted.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<GateCoupling> ON | OFF
*RST: OFF

20.12.11 Limit check and Event Actions

MEASurement<m>:LCHeck <LimitCheckState>

Defines the type of the limit check that can run together with the measurement.

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<LimitCheckState> OFF | LIMit | LMARgin

OFF
No limit check.

LIMit
Only limits are checked.

LMARgin
Limits and margins are checked.

*RST: OFF

MEASurement<m>:ONViolation:BEEP <Beep>

Generates a beep sound for the specified event.

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<Beep> NOACtion | SUCCess | VIOLation

See Chapter 20.4.5, "Event Parameter", on page 971

*RST: NOACtion

MEASurement<m>:ONViolation:ACQStop <StopAcq>

Stops data acquisition for the specified event.

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<StopAcq> NOACtion | SUCCess | VIOLation

See Chapter 20.4.5, "Event Parameter", on page 971

*RST: NOACtion

MEASurement<m>:ONViolation:PRINt <Print>

Prints a screenshot including the measurement results to the printer defined using `SYSTem:COMMunicate:PRINter:SELect<1..2>` for the specified event.

Suffix:
<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:
<Print> NOACtion | SUCCess | VIOLation
See Chapter 20.4.5, "Event Parameter", on page 971
*RST: NOACtion

MEASurement<m>:ONViolation:WFMSave <SaveWfm>

Saves the waveform data.

Suffix:
<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:
<SaveWfm> NOACtion | SUCCess | VIOLation
See Chapter 20.4.5, "Event Parameter", on page 971
*RST: NOACtion

MEASurement<m>:ONViolation:REPort <Report>

Creates and saves a report of the current settings and results.

Suffix:
<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:
<Report> NOACtion | SUCCess | VIOLation
See Chapter 20.4.5, "Event Parameter", on page 971
*RST: NOACtion

MEASurement<m>:ONViolation:TRIGgerout <TriggerOutPulse>

Creates a trigger out pulse on limit or margin violation or on successful completion of themeasurement.

Suffix:
<m> 1..10

Parameters:
<TriggerOutPulse> NOACtion | SUCCess | VIOLation
*RST: NOACtion

MEASurement<m>:ONViolation:RUNexec <RunExecutable>

Starts an external application if the command is set to `VIOLation` or `SUCCess`.

Use the following commands to set up the application:

- `EXECutable:NAME` on page 999
- `EXECutable:PARameter` on page 1000
- `EXECutable:WDIRectory` on page 1000

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<RunExecutable> NOACtion | SUCCess | VIOLation
See Chapter 20.4.5, "Event Parameter", on page 971
*RST: NOACtion

20.12.12 Reference Levels

20.12.12.1 General Reference Level Settings

REFLevel<m>:LDETection <Mode>

Defines whether the reference level is configured manually or automatically.

For automatic configuration, select the signal level to be used (see `REFLevel<m>:AUTO:MODE` on page 1189).

Suffix:

<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Mode> AUTO | MANual

Example: `REFLevel2:LDETection MANual`
Sets manual level configuration for Ch1Wfm1. C1W1 corresponds to suffix number 2.

Example: See: Chapter 20.3.2.2, "Setting Reference Levels", on page 957

REFLevel<m>:LMODe <Mode>

Defines whether the reference is configured using absolute or relative values.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Mode> ABS | REL

Example: `REFLevel2:LMODe ABS`
Sets definition of reference levels to absolute values for Ch1Wfm1. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using relative values" on page 957

REFLevel<m>:RELative:MODE <Mode>

The lower, middle and upper reference levels, defined as percentages of the high signal level.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Mode> FIVE | TEN | TWENty | USER

FIVE
5/50/95

TEN
10/50/90

TWENty
20/50/80

USER
Set the reference levels to individual values with `REFLevel<m>:RELative:LOWer`, `REFLevel<m>:RELative:MIDDle`, and `REFLevel<m>:RELative:UPPer`.

Example: `REFL2:REL:MODE FIVE`
Reference levels for Ch1Wfm1: Lower reference level = 5% of high signal level, middle reference level = 50% of high signal level, upper reference level = 95% of high signal level

Example: See: "Manual reference level definition using relative values" on page 957

REFLevel<m>:USRLevel <Mode>

Defines whether the user-defined signal levels or user-defined reference levels are used for the measurements.

Suffix:

<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Mode> USIGnal | UREF

USIGnal
The high and low signal levels are defined by the user.

UREF
The reference levels are defined by the user.

Example: `REFLevel2:USRLevel UREF`
Sets user-defined reference levels to be used for Ch1Wfm1.
C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 957

20.12.12.2 Automatic Configuration

REFLevel<m>:AUTO:MODE <Mode>

Defines the high and low signal levels from which the reference levels are derived.

This setting is only available for automatic reference level mode (see `REFLevel<m>:LDETection` on page 1187).

Suffix:

<m>

1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Mode>

AUTO | PPRobability | MPRobability | ABSolutepeak | UPLM | UMLP | UALM | UMLA

AUTO
Auto select absolute probability: most suitable signal levels for the selected measurement

PPRobability
Peak probability: signal levels with the highest probability value

MPRobability
Mean probability: signal levels with mean probability

ABSolutepeak
Absolute peak: absolute peak signal levels

UPLM
Upper absolute peak, lower mean probability: high signal level is the upper absolute peak, low signal level is the level with the mean probability in the lower half of the histogram.

UMLP
Upper mean probability, lower absolute peak: high signal level is the level with mean probability in the upper half of the histogram, low signal level is the lower absolute peak.

UALM
Upper absolute peak, lower manual value: high signal level is the maximum result value of the amplitude measurement; low signal level is manually set using `REFLevel<m>:RELative:LOWer`.

UMLA
Upper manual, lower absolute peak: The upper signal level is set manually using `REFLevel<m>:RELative:UPPer`. The lower level is the minimum result value of the amplitude measurement.

Example:

`REFLevel5:AUTO:MODE PPRobability`
Sets the automatic reference level mode for Ch2Wfm1 to "Peak probability". C2W1 corresponds to suffix number 5.

Example:

See: "Automatic level detection, peak probability" on page 957

REFLevel<m>:AUTO[:STATe] <Value>

Enables averaging over several histograms to determine the reference levels. The number of histograms to consider is defined using `REFLevel<m>:AUTO:COUNt`.

This function is only available in automatic reference level mode (see `REFLevel<m>:LDETection` on page 1187).

Suffix:

<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Value> ON | OFF

REFLevel<m>:AUTO:COUNt <Value>

Defines the number of histograms from which the average is calculated.

Prerequisites:

- `REFLevel<m>:AUTO[:STATe]` is set to `ON`
- `REFLevel<m>:LDETection` on page 1187 is set to `AUTO`

Suffix:

<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Value>

20.12.12.3 Manual Configuration

REFLevel<m>:ABSolute:HIGH <Value>

The signal value that represents a high level.

Suffix:

<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Value>

Example: `REFLevel2:ABSolute:HIGH 0.015`
Sets the high signal level for Ch1Wfm1 to 15 mV. C1W1 corresponds to suffix number 2.

REFLevel<m>:ABSolute:LOW <Value>

The signal value that represents a low level.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Value>

Example: `REFLevel2:ABSolute:Low 0.0015`
Sets the low signal level forCh1Wfm1 to 1.5 mV. C1W1 corresponds to suffix number 2.

REFLevel<m>:ABSolute:TDIStance <Value>

The distance between the high signal level and the upper reference level.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Value>

Example: `REFLevel2:ABSolute:TDIStance 0.0002`
Sets the top distance for Ch1Wfm1 to 0.2 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 957

REFLevel<m>:ABSolute:BDIStance <Value>

The distance between the lower reference level and the low signal value.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Value>

Example: `REFLevel2:ABSolute:BDIStance 0.0002`
Sets the bottom distance for Ch1Wfm1 to 0.2 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 957

REFLevel<m>:ABSolute:MLEVel <Value>

For user signal level selection, the level is the middle level between high and low signal level. The value is adjusted automatically if you change the high or low signal levels. Vice versa, if you change the middle level, the high and low signal levels are adjusted.

For user reference level selection, the level is the middle level between upper and lower reference level. The value is adjusted automatically if you change the upper or lower reference levels. Vice versa, if you change the middle level, the upper and lower reference levels are adjusted.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the reference level, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Value>

Example: `REFLevel2:ABSolute:MLEVel 0.05`
Sets the middle signal level for Ch1Wfm1 to 50 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 957

REFLevel<m>:ABSolute:ULEVel <Value>

The upper reference level, required e.g. to determine a rise.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Value>

Example: `REFLevel2:ABSolute:ULEVel 0.01`
Sets the upper reference level for Ch1Wfm1 to 10 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 957

REFLevel<m>:ABSolute:LLEVel <Value>

The lower reference level, required e.g. to determine a fall.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Value>

Example: `REFLevel2:ABSolute:LLEVel 0.001`
Sets the lower reference level for Ch1Wfm1 to 1 mV. C1W1 corresponds to suffix number 2.

Example: See: "Manual reference level definition using absolute values" on page 957

REFLevel<m>:RELative:UPPer <Value>

Sets the upper relative reference level if `REFLevel<m>:RELative:MODE` is set to `USER`.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Value> Percentage of the high signal level.

Example: `REFLevel8:RELative:LOWer 85`
Sets the upper reference level for Ch3Wfm1 to 85 %. Ch3Wfm1 corresponds to suffix number 8.

Example: See: "Manual reference level definition using relative values" on page 957

REFLevel<m>:RELative:MIDDle <Value>

Sets the middle relative reference level if `REFLevel<m>:RELative:MODE` is set to `USER`.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Value> Percentage of the high signal level.

Example: `REFLevel8:RELative:MIDDle 50`
Sets the middle reference level for Ch3Wfm1 to 50 %. Ch3Wfm1 corresponds to suffix number 8.

Example: See: "Manual reference level definition using relative values" on page 957

REFLevel<m>:RELative:LOWer <Value>

Sets the lower relative reference level if `REFLevel<m>:RELative:MODE` is set to `USER`.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Value> Percentage of the high signal level.

Example: `REFLevel8:RELative:LOWer 15`
Sets the lower reference level for Ch3Wfm1 to 15 %. Ch3Wfm1 corresponds to suffix number 8.

Example: See: "Manual reference level definition using relative values" on page 957

20.12.12.4 Hysteresis

REFLevel<m>:RELative:HYSTeresis <Value>

Defines a hysteresis for the middle reference level. A rise or fall from the middle reference value that does not exceed the hysteresis is rejected as noise.

Suffix:
<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:
<Value>

20.12.12.5 Tube

REFLevel<m>:RELative:OTUBe <Value>

Defines a percentage of the signal level by which the absolute signal level may be larger than the high signal level or lower than the low signal level to be considered high or low, respectively.

Suffix:

<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Value>

REFLevel<m>:RELative:ITUBe <Value>

Defines a percentage of the signal level by which the absolute signal level may be higher than the low signal level or lower than the high signal level to be considered low or high, respectively.

Suffix:

<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Value>

REFLevel<m>:ABSolute:TOTube <Value>

Defines an area above the high signal level which is still considered to be high level.

Suffix:

<m> 1..107
Valid suffix numbers: 2...21 and 61...68
Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Value>

REFLevel<m>:ABSolute:TITube <Value>

Defines an area beneath the high signal level which is still considered to be high level.

Suffix:

<m>	1..107 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Value>

REFLevel<m>:ABSolute:BITube <Value>

Defines an area above the low signal level which is still considered to be low level.

Suffix:

<m>	1..107 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Value>

REFLevel<m>:ABSolute:BOTube <Value>

Defines an area beneath the low signal level which is still considered to be low level.

Suffix:

<m>	1..107 Valid suffix numbers: 2...21 and 61...68 Source waveform of the measurement, see Chapter 20.4.1, "Waveform Suffix", on page 968.

Parameters:

<Value>

20.12.12.6 Results

MEASurement<m>:REFLevel:RESult:LOWer?
MEASurement<m>:REFLevel:RESult:MIDDle?
MEASurement<m>:REFLevel:RESult:UPPer?

Return the lower, middle, and upper reference level, respectively.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Return values:

<Lower> <Middle> <Upper>	Range:	-100E+24 to 100E+24
	*RST:	0

Usage: Query only

MEASurement<m>:REFLevel:RESult:SIGLow?
MEASurement<m>:REFLevel:RESult:SIGHigh?

Return the signal value that represents a low or high level, respectively.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Return values:

<SignalLow>	Range:	-100E+24 to 100E+24
<SignalHigh>	*RST:	0

Usage: Query only

MEASurement<m>:REFLevel:RESult:BINNer?

Returns the area above the low signal level which is still considered to be low level.

Suffix:

<m>	1..10 See "Selection of the measurement group: MEASurement<m>" on page 1133.

Return values:

<BottomInner>	Range:	-100E+24 to 100E+24
	*RST:	0

Usage: Query only

MEASurement<m>:REFLevel:RESult:BOUTer?

Returns the area beneath the low signal level which is still considered to be low level.

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Return values:

<BottomOuter> Range: -100E+24 to 100E+24

*RST: 0

Usage: Query only

MEASurement<m>:REFLevel:RESult:TINNer?

Returns the area beneath the high signal level which is still considered to be high level.

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Return values:

<TopInner> Range: -100E+24 to 100E+24

*RST: 0

Usage: Query only

MEASurement<m>:REFLevel:RESult:TOUTer?

Returns the area above the high signal level which is still considered to be high level.

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Return values:

<TopOuter> Range: -100E+24 to 100E+24

*RST: 0

Usage: Query only

20.13 Spectrum Analysis

20.13.1 Basic FFT

CALCulate:MATH<m>:FFT:LOGScale <XAxisMode>

Defines the scaling method for the frequency (x-)axis of the spectrogram.

This command is only available if option R&S RTP-K37 is installed.

Suffix:

<m> 1..4

Parameters:

<XAxisMode> LIN | LOG

LOG
Logarithmic scaling

LIN
Linear scaling

*RST: LIN

CALCulate:MATH<m>:FFT:STARt <StartFreq>

Defines the start frequency of the displayed frequency span.

Suffix:

<m>	1..4 math waveform

Parameters:

<StartFreq>	start frequency Range: 0 to 5E+9 Increment: 1 *RST: 2E+9 Default unit: Hz

---

CALCulate:MATH<m>:FFT:STOP <StopFreq>

Defines the stop frequency of the displayed frequency span.

Suffix:

<m>	1..4 math waveform

Parameters:

<StopFreq>	stop frequency Range: 0 to 5E+9 Increment: 1 *RST: 2E+9 Default unit: Hz

---

CALCulate:MATH<m>:FFT:CFRequency <CenterFreq>

Defines the position of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The width of the range is defined using the `CALCulate:MATH<m>:FFT:SPAN` command.

Suffix:

<m>	1..4 math waveform

Parameters:

<CenterFreq>	center frequency Range: 0 to 2E+12 Increment: 1 *RST: 2.5E+9 Default unit: Hz

---

CALCulate:MATH<m>:FFT:FULLspan

Performs FFT calculation for the full frequency span.

Suffix:

<m>	1..4 math waveform

Usage: Event

CALCulate:MATH<m>:FFT:SPAN <FreqSpan>

The span is specified in Hertz and defines the width of the displayed frequency range, which is (Center - Span/2) to (Center + Span/2). The position of the span is defined using the `CALCulate:MATH<m>:FFT:CFRequency` command.

Suffix:

<m> 1..4
Math waveform

Parameters:

<FreqSpan> Frequency span

Range: 1 to 4E+12
Increment: 1
*RST: 5E+9
Default unit: Hz

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:ADJusted?

Queries the effective resolution bandwidth.

Suffix:

<m> 1..4
Math waveform

Return values:

<AdjResBW> effective resolution bandwidth

Range: 0.01 to 2E+12
*RST: 0
Default unit: Hz

Usage: Query only

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:AUTO <State>

Couples the frequency span to the RBW.

Suffix:

<m> 1..4
math waveform

Parameters:

<State> ON | OFF

*RST: ON

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution]:RATio <SpanRBWRatio>

This command defines the ratio of span (Hz) / resolution bandwidth (Hz).

Suffix:

<m> 1..4
math waveform

Parameters:

<SpanRBWRatio> ratio span / resolution bandwidth

Range: 1 to 1000
Increment: 1
*RST: 100

CALCulate:MATH<m>:FFT:BANDwidth[:RESolution][:VALue] <ResolutionBW>

This command defines the resolution bandwidth.

Suffix:

<m> 1..4
math waveform

Parameters:

<ResolutionBW> resolution bandwidth

Range: 0.01 to 2E+6
Increment: 0.01
*RST: 2E+6
Default unit: Hz

CALCulate:MATH<m>:FFT:WINDow:TYPE <WindowType>

Windowing helps minimize the discontinuities at the end of the measured signal interval and thus reduces the effect of spectral leakage, increasing the frequency resolution.

Various different window functions are provided in the R&S RTP to suit different input signals. Each of the window functions has specific characteristics, including some advantages and some trade-offs. These characteristics need to be considered carefully to find the optimum solution for the measurement task.

Suffix:

<m> 1..4
math waveform

Parameters:

<WindowType> RECTangular | HAMMing | HANN | BLACkharris | GAUSsian | FLATTOP2 | FLATtop2 | KAISerbessel

RECTangular
The rectangular window has the best frequency resolution, but a poor amplitude accuracy and is recommended for separating two tones with almost equal amplitudes and a small frequency distance.

HAMMing
The Hamming window is bell shaped and has a good frequency resolution and fair amplitude accuracy. It is recommended for frequency response measurements as well as sine waves, periodic signals and narrow-band noise

HANN
The Hann window is bell shaped and has a slightly worse frequency resolution but smaller sidelobe level than the Hamming window. The applications are the same.

BLACkharris
The Blackman window is bell shaped and has a poor frequency resolution, but very good amplitude accuracy. It is recommended mainly for signals with single frequencies to detect harmonics.

GAUSsian
Good frequiency resolution and best magnitude resolution, recommended for weak signals and short duration

FLATTOP2 = FLATtop2
The flattop window has a poor frequency resolution, but the best amplitude accuracy and the sharpest side lobe. It is recommended for accurate single-tone amplitude measurements.

KAISerbessel
The Kaiser-Bessel window has a fair frequency resolution and good amplitude accuracy, and a very high sidelobe level. It is recommended for separating two tones with differing amplitudes and a small frequency distance.

*RST: BLACkharris

Firmware/Software: Version 3.35 and higher: Use FLATTOP2 or FLATtop2 instead of FLAT2

CALCulate:MATH<m>:FFT:FRAMe:ARIThmetics <Arithmetics>

The arithmetic mode defines how the final FFT result is calculated from the individual frame results.

Suffix:

<m> 1..4
Selects the math waveform.

Parameters:

<Arithmetics> OFF | ENVelope | AVERage | RMS | MINHold | MAXHold

See "FFT Segment Arithmetics" on page 359

*RST: OFF

CALCulate:MATH<m>:FFT:FRAMe:COVerage?

Due to the restriction of the number of frames (see `CALCulate:MATH<m>:FFT:FRAMe:MAXCount` on page 1205), the waveform may only be analyzed partially. This command queries the percentage of the trace that was analyzed, i.e. which part of the trace was included in the frame calculation.

Suffix:

<m>	1..4 math waveform

Return values:

<FrameCoverage>	Range: 0 to 100 *RST: 100 Default unit: %

Usage: Query only

CALCulate:MATH<m>:FFT:FRAMe:MAXCount <MaxFrameCount>

Restricts the maximum number of frames to be calculated. Due to the other parameter settings, the required number of frames may become very high, thus slowing performance. By restricting the number of frames, you can avoid performance loss without changing the other parameters.

Suffix:

<m>	1..4 math waveform

Parameters:

<MaxFrameCount>	Range: 1 to 10000 Increment: 10 *RST: 1000

CALCulate:MATH<m>:FFT:FRAMe:OFACtor <OverlapFactor>

Defines the minimum factor by which two neighboring frames overlap. If the required number of frames to cover the input values allows for more overlap, the factor is increased.

The higher the overlap factor, the more frames are used. This leads to more individual results and improves detection of transient signal effects. However, it also extends the duration of the calculation.

Suffix:

<m>	1..4 math waveform

Parameters:

<OverlapFactor>	Range: 0 to 90 Increment: 1 *RST: 50 Default unit: %

CALCulate:MATH<m>:FFT:GATE:COUPling <GateRBWCoupling>

Defines the behaviour of the record length or RBW value in dependancy to the other FFT parameters.

See also:

- "Record Length/RBW Coupling" on page 362
- Chapter 8.1.1, "Fundamentals of FFT Analysis", on page 347

Suffix:

<m> 1..4
math waveform

Parameters:

<GateRBWCoupling> LENGth | RBW

LENGth
The record length remains constant. If not enough samples are available for the selected RBW, the RBW will be decreased.

RBW
The RBW is not adapted, i.e. remains as defined by the user. The required acquisition time for this RBW is indicated. If necessary and possible, the record length is extended to acquire the required number of samples.

*RST: RBW

TIMebase:RACTime?

Queries the required acquisition time. If FFT gating is used and the resolution BW is set to constant, record length can be extended to acquire the required number of samples. In this case, the required acquisition time differs from the adjusted acquisition time (`TIMebase:RANGe`).

Return values:

<RqrdAcqTime> Required acquisition time for FFT

Range: 125E-12 to 100E+3
*RST: 0.5
Default unit: s

Usage: Query only

CALCulate:MATH<m>:FFT:GATE:ABSolute:STARt <Start>

Defines the starting value for the gate.

Suffix:

<m> 1..4
math waveform

Parameters:

<Start> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

CALCulate:MATH<m>:FFT:GATE:ABSolute:STOP <Stop>

Defines the end value for the gate.

Suffix:

<m> 1..4
math waveform

Parameters:

<Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

CALCulate:MATH<m>:FFT:GATE:MODE <Mode>

Defines whether the gate settings are configured using absolute or relative values.

Suffix:

<m> 1..4
math waveform

Parameters:

<Mode> ABS | REL
*RST: ABS

CALCulate:MATH<m>:FFT:GATE:RELative:STARt <RelativeStart>

Defines the starting value for the gate in percent.

Suffix:

<m> 1..4
math waveform

Parameters:

<RelativeStart> Range: 0 to 100
Increment: 0.1
*RST: 0
Default unit: %

CALCulate:MATH<m>:FFT:GATE:RELative:STOP <RelativeStop>

Defines the end value for the gate in percent.

Suffix:

<m> 1..4
math waveform

Parameters:

<RelativeStop>	Range: 0 to 100 Increment: 0.1 *RST: 100 Default unit: %

CALCulate:MATH<m>:FFT:GATE:ZCOupling <ZoomCoupling>

If enabled, the gate area is defined identically to the zoom area for the zoom diagram.

Suffix:

<m>	1..4 math waveform

Parameters:

<ZoomCoupling>	ON | OFF *RST: OFF

CALCulate:MATH<m>:FFT:GATE[:STATe] <State>

Enables FFT gating.

Suffix:

<m>	1..4 math waveform

Parameters:

<State>	ON | OFF *RST: OFF

CALCulate:MATH<m>:FFT:MAGNitude:LEVel <VerticalMax>

Defines the reference level for dB scaling.

Suffix:

<m>	1..4 Math waveform

Parameters:

<VerticalMax>	Range: -100E+24 to 1E+15 Increment: 0.01 *RST: 0 Default unit: div

CALCulate:MATH<m>:FFT:MAGNitude:RANGe <Range>

Defines the vertical value range in spectrum mode.

Suffix:

<m>	1..4 math waveform

Parameters:

<Range> Range: 1 to 500
Increment: 1
*RST: 100
Default unit: dB

CALCulate:MATH<m>:FFT:MAGNitude:SCALe <MagnitudeScale>

Defines the scaling of the y-axis. The display values are valid for 50Ω termination impendance.

For details on the available scaling modes, see "Magnitude unit" on page 363.

Suffix:

<m> 1..4
math waveform

Parameters:

<MagnitudeScale> LINear | DBM | DB | DBUV | DBMV | DBV | DBPS | DBNS | DBUS | DBMS | DBS | DBHZ | DBKHZ | DBKHz | DBMHZ | DBMHz | DBGHZ | DBGHz | DBA | DBMA | DBUA

LINear
Linear scaling; displays the RMS value of the voltage

*RST: DBM

Table 20-9: Logarithmic scaling values

DBM	dBm
DB	dB (related to reference level)
DBUV	dBµV
DBMV	dBmV
DBV	dBV
DBPS	dBps
DBNS	dBns
DBUS	dBµs
DBMS	dBms
DBS	dBs
DBHZ	dBHz
DBKHZ = DBKHz	dBkHz
DBMHZ = DBMHz	dBMHz
DBGHZ = DBGHz	dBGHz
DBA	dBA
DBMA	dBmA
DBUA	dBµA

CALCulate:MATH<m>:FFT:PHASe:SCALe <PhaseScale>

Defines the scaling unit for phase display.

Suffix:

<m>	1..4 math waveform

Parameters:

<PhaseScale>	DEGRees | RADians	
	*RST:	DEGRees

CALCulate:MATH<m>:FFT:PHASe:SUPPression <Suppression>

Enables noise suppression. Phase calculation is restricted to frequencies with a minimum magnitude, the threshold value (see `CALCulate:MATH<m>:FFT:PHASe:THReshold` on page 1210).

Suffix:

<m>	1..4 math waveform

Parameters:

<Suppression>	ON | OFF	
	*RST:	OFF

CALCulate:MATH<m>:FFT:PHASe:THReshold <SupprThres>

Defines the minimum frequency magnitude for which phases are calculated. This setting is only available if `CALCulate:MATH<m>:FFT:PHASe:SUPPression` is set to "ON".

Suffix:

<m>	1..4 math waveform

Parameters:

<SupprThres>	Range:	-180 to 180
	Increment:	0.1
	*RST:	0
	Default unit:	dBm

CALCulate:MATH<m>:FFT:PHASe:UNWRap <Unwrap>

If enabled, phase shifts due to a limitation of the value range are eliminated.

Suffix:

<m>	1..4 math waveform

Parameters:

<Unwrap> ON | OFF

*RST: OFF

CALCulate:MATH<m>:FFT:COUPled:WITH<m2> <MathIndex>

Copies the current FFT settings of the selected math waveform (m) to the other selected math waveform (m2), and couples the two waveforms. This can be repeated for all math waveforms.

If any FFT setting for any of the coupled spectrums is changed, it is changed for all coupled spectrums.

Suffix:

<m>, <m2> 1..4
Math waveforms to be coupled. <m>, <m2> must be distinct

Parameters:

<MathIndex> ON | OFF

*RST: OFF

Example: `CALC:MATH1:FFT:COUP:WITH2 ON`
Couples the math waveforms m1 and m2.

20.13.2 Waveform Data

CALCulate:MATH<m>:DATA:STYPe?

Returns the signal type of the source of the math waveform.

Suffix:

<m> 1..4
Selects the math waveform.

Return values:

<SignalType> SOUR | SPEC | CORR | MEAS | NONE

SOURce = normal signal
SPECtrum = FFT spectrum, specific math signal
CORRelation = correlated signal, specific math signal
MEAsurement = result of a measurement
NONE = undefined
Im GUI nicht vorhanden:
XY = XY-signal
SBUS = Serial bus

Usage: Query only

CALCulate:MATH<m>:DATA:HEADer?

Returns the header of math waveform data. The header contains attributes of the waveform.

Table 20-10: Header data

Position	Meaning	Example
1	XStart in s	-9.477E-008 = - 94,77 ns
2	XStop in s	9.477E-008 = 94,77 ns
3	Record length of the waveform in Samples	200000
4	Number of values per sample interval. For most waveforms the result is 1, for peak detect and envelope waveforms it is 2. If the number is 2, the number of returned values is twice the number of samples (record length).	1

Suffix:
<m> 1..4
Selects the math waveform.

Example:
```
CALC:MATH4:DATA:HEAD
-9.477E-008,9.477E-008,200000,1
```

Usage: Query only

CALCulate:MATH<m>:DATA[:VALues]?

Returns the data of the math waveform points for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]`.

You can retrieve only Y-values, or X- and Y-values. Use `EXPort:WAVeform:INCXvalues` to define this.

Suffix:
<m> 1..4
Selects the math waveform.

Return values:
<Data> List of values according to the format and content settings.

Usage: Query only

20.13.3 Spectrogram (Option R&S RTP-K37)

In all `CALC:MATH<m>:FFT` commands, the suffix <m> selects the math waveform.

In all `CALC:MATH<m>:FFT:SPEC:TIM` commands, the suffix <m> selects the timeline.

CALCulate:MATH<m>:FFT:SPECtrogram:CMODe <ColorTableMode>

Selects the color table mode for the frequency analysis display.

Suffix:

<m> 1..4

Parameters:

<ColorTableMode> INCI | AMPL

INCI
("Incidence") The display color is set depending on the frequency of occurrence of a value.

AMPL
("Amplitude") In the spectrogram and the frequency analysis display, the color is used to indicate the magnitude of the FFT signal. The higher the amplitude the higher the color in the assigned color table.

*RST: INCI

CALCulate:MATH<m>:FFT:USEColtab <UseColorTable>

If enabled, the selected waveform is displayed according to its assigned color table. For information on the available color tables, see Chapter 3.4.2.2, "Color Tables", on page 92.

If this option is disabled, the preset color of the selected channel source is displayed, and the intensity of the specific signal color varies according to the cumulative occurrence of the values.

Suffix:

<m> 1..4

Parameters:

<UseColorTable> ON | OFF

*RST: OFF

CALCulate:MATH<m>:FFT:SPECtrogram:STATe <State>

Enables the spectrogram display for a math waveform.

Suffix:

<m> 1..4

Parameters:

<State> ON | OFF

*RST: OFF

CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:POSition <Position>

Defines the position of one of the two possible time lines in a spectrogram. The time line must be enabled first, using the `CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:STATe` command.

Suffix:

<m> 1..4

<n> 1..2

Parameters:

<Position> The position of the time line is defined by the index of the data acquisition in the history. How many acquisitions are available depends on the history settings.

Range: 0 to 4294967295
Increment: 1
*RST: 0

CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:STATe <State>

Enables one of two possible time lines in a spectrogram diagram. A time line marks a single waveform in the spectrogram, that is: the power vs frequency results for the data acquired at a specific time. After enabling a time line, the results for that time are displayed in the spectrum diagram.

The position of the time line is defined using the `CALCulate:MATH<m>:FFT:SPECtrogram:TIMeline<n>:POSition` command.

Suffix:

<m> 1..4

<n> 1..2

Parameters:

<State> ON | OFF

*RST: OFF

20.14 Mask Testing

20.14.1 Mask Test Definition

MTESt:ADD <MaskTestName>

Creates a new mask test definition with the specified name.

Setting parameters:

<MaskTestName> String with the name of the mask test

Example: See Chapter 20.3.3.1, "Creating a user mask", on page 959

Usage: Setting only

MTESt:REMove <MaskTestName>

Deletes the mask test definition with the specified name.

Setting parameters:

<MaskTestName> String with the name of the mask test

Usage: Setting only

MTESt[:STATe] <MaskTestName>,<State>
MTESt[:STATe]? <MaskTestName>

Activates and deactivates the mask test. If the acquisition is running, the test starts immediately. Otherwise, the test starts when acquisition is started.

The testing is stopped when acquisition is stopped, also due to the `MTESt:ONViolation:STOP` command, or if `MASK[:STATe]` is set to "OFF".

The coommand needs `*OPC` command synchronisation, see Chapter B.3, "Command Sequence and Synchronization", on page 1877.

Parameters:
<State> ON | OFF
*RST: OFF

Parameters for setting and query:
<MaskTestName> String with the name of the mask test

Example: `MTEST:STAT 'MyMask', ON; *OPC?`
See Chapter 20.3.3.1, "Creating a user mask", on page 959

MTESt:RST

Clears all totals and results in all "Mask Test" result boxes.

Usage: Event

Firmware/Software: FW 1.35

MTESt:SOURce <MaskTestName>,<Source>
MTESt:SOURce? <MaskTestName>

Selects the waveform to be tested against the mask.

Parameters:
<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | XY1 | XY2 | XY3 | XY4 | SG1TL1 | SG1TL2 | SG2TL1 | SG2TL2 | SG3TL1 | SG3TL2 | SG4TL1 | SG4TL2 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4
Waveform to be tested, see Chapter 20.4.2, "Waveform Parameter", on page 970
*RST: C1W1

Parameters for setting and query:
<MaskTestName> String containing the name of the mask test

MTESt:CONDition <MaskTestName>,<PassFailMode>
MTESt:CONDition? <MaskTestName>

Sets the first criteria for a failed test, the kind of hits to be considered for test evaluation. A test has failed if the number of sample hits or acquisition hits exceeds the limit defined by `MTESt:TOLerance`.

Parameters:
<PassFailMode> SAMPles | ACQuisitions
SAMPles
Considers the number of samples that hit the mask.

ACQuisitions
Considers the number of acquisitions that contain at least one sample hit. How many samples hit the mask in that acquisition is not relevant.

*RST: SAMPles

Parameters for setting and query:
<MaskTestName> String with the name of the mask test

MTESt:TOLerance <MaskTestName>,<ViolationCount>
MTESt:TOLerance? <MaskTestName>

Sets the second criteria for a failed test, the number of tolerable sample hits or acquisition hits. Use `MTESt:CONDition` to define which hits are considered for test evaluation.

Parameters:
<ViolationCount> Range: 0 to 4000000000
Increment: 1
*RST: 0

Parameters for setting and query:
<MaskTestName> String with the name of the mask test

MTESt:CTYPe <MaskTestName>,<DefinitionType>
MTESt:CTYPe? <MaskTestName>

Sets the method of mask definition.

Parameters:
<DefinitionType> USER | WFML | EYEMask | PROTocol

USER
The mask segments are created by entering the numerical x- and y-values of the mask points.
See: Chapter 20.14.2, "Mask Definition: User Mask", on page 1218

WFML
The mask is created from the envelope of an existing waveform.
See: Chapter 20.14.3, "Mask Definition: Waveform Mask", on page 1224

*RST: USER

Parameters for setting and query:
<MaskTestName> String with the name of the mask test

MTESt:FILE:NAME <MaskTestName>, <Path>
MTESt:FILE:NAME? <MaskTestName>

Specifies a file to save the mask test.

Parameters:
<Path> String containing path and file name, format .xml

Parameters for setting and query:
<MaskTestName> String with the name of the mask test

MTESt:FILE:SAVE <MaskTestName>

Saves the specified mask test. It contains the mask definition, defined actions and fail conditions.

Setting parameters:
<MaskTestName> String with the name of the mask test

Usage: Setting only

MTESt:FILE:OPEN <MaskTestName>

Loads the specified mask test to the instrument.

Setting parameters:
<MaskTestName> String with the name of the mask test

Usage: Setting only

MTESt:FILE:DELete <MaskTestName>

Deletes the specified mask test.

Setting parameters:
<MaskTestName> String with the name of the mask test

Usage: Setting only

20.14.2 Mask Definition: User Mask

The chapter contains commands required for the definition of user masks - `MTESt:CTYPe` is set to `USER`.

Segment and point indices

In remote control, the numbering of segments and points starts from 0. But in manual operation, the numbering starts from 1.

MTESt:SEGMent:STATe <MaskTestName>, <MaskSegmIdx>,<State>
MTESt:SEGMent:STATe? <MaskTestName>, <MaskSegmIdx>

Enables and disables the mask segment. Disabled segments are not considered by running tests.

Parameters:

<State>	ON | OFF *RST: ON

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.

MTESt:SEGMent:ADD <MaskTestName>

Creates a new segment in the mask definition.

Setting parameters:

<MaskTestName>	String with the name of the mask test
Example:	See Chapter 20.3.3.1, "Creating a user mask", on page 959
Usage:	Setting only

MTESt:SEGMent:COUNt? <MaskTestName>

Returns the number of segments in the mask definition

Query parameters:

<MaskTestName>	String with the name of the mask test

Return values:

<Count>	Number of segments
Usage:	Query only

MTESt:SEGMent:INSert <MaskTestName>, <MaskSegmIdx>

Inserts a new segment before the specified index in the mask definition.

Setting parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Usage: Setting only

MTESt:SEGMent:REMove <MaskTestName>, <MaskSegmIdx>

Removes the specified segment from the mask definition.

Setting parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Usage: Setting only

MTESt:SEGMent:REGion <MaskTestName>, <MaskSegmIdx>,<Region>
MTESt:SEGMent:REGion? <MaskTestName>, <MaskSegmIdx>

Defines the region of the segment that builds the mask.

Parameters:

<Region> UPPer | LOWer | INNer

UPPer
the segment points are connected to a line, the display area above this line is the mask segment

LOWer
the segment points are connected to a line, the display area below this line is the mask segment

INNer
the segment points form a closed geometrical shape, which is the mask segment

*RST: INNer

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Example: See Chapter 20.3.3.1, "Creating a user mask", on page 959

MTESt:SEGMent:POINt:ADD <MaskTestName>, <MaskSegmIdx>

Adds a new point to the segment definition.

Setting parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Example: See Chapter 20.3.3.1, "Creating a user mask", on page 959

Usage: Setting only

MTESt:SEGMent:POINt:INSert <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>

Inserts a new point before the specified mask segment point.

Setting parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

<MaskSegmPoint> Number of the point. Counting starts from 0.

Usage: Setting only

MTESt:SEGMent:POINt:REMove <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>

Removes the specified point from the mask segment.

Setting parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

<MaskSegmPoint> Number of the point. Counting starts from 0.

Usage: Setting only

MTESt:SEGMent:POINt:COUNt? <MaskTestName>, <MaskSegmIdx>

Returns the number of defined points for the specified mask segment.

Query parameters:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Usage: Query only

MTESt:SEGMent:POINt:X <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>,<X>
MTESt:SEGMent:POINt:X? <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>

Defines the x-value of the mask segment point.

Parameters:

<X> Range: -100E+24 to 100E+24
Increment: 1E-6
*RST: 0
Default unit: s

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
<MaskSegmPoint>	Number of the point. Counting starts from 0.
Example:	See Chapter 20.3.3.1, "Creating a user mask", on page 959

MTESt:SEGMent:POINt:Y <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>,<Y>
MTESt:SEGMent:POINt:Y? <MaskTestName>, <MaskSegmIdx>, <MaskSegmPoint>

Defines the y-value of the mask segment point.

Parameters:

<Y>
Range: -100E+24 to 100E+24
Increment: 1E-6
*RST: 0
Default unit: V

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
<MaskSegmPoint>	Number of the point. Counting starts from 0.
Example:	See Chapter 20.3.3.1, "Creating a user mask", on page 959

MTESt:SEGMent:RESCale:RECalculate <MaskTestName>, <MaskSegmIdx>

Multiplies and adds the given x- and y-factors and offsets to the coordinates of all points of the selected mask segment.

Setting parameters:

<MaskTestName>	String with the name of the mask test
<MaskSegmIdx>	Number of the segment. Counting starts from 0.
Usage:	Setting only

MTESt:SEGMent:RESCale:XFACtor <MaskTestName>, <MaskSegmIdx>,<ExpansionFactor>
MTESt:SEGMent:RESCale:XFACtor? <MaskTestName>, <MaskSegmIdx>
MTESt:SEGMent:RESCale:YFACtor <MaskTestName>, <MaskSegmIdx>,<ExpansionFactor>
MTESt:SEGMent:RESCale:YFACtor? <MaskTestName>, <MaskSegmIdx>

Stretches or compresses the selected mask segment in horizontal (XFACtor) or vertical direction (YFACtor). The x- or y-values of all points of the selected mask segment are multiplied with this factor. Factors >1 stretch the mask segment, while factors between 0 and 1 compress it. Negative values are possible and change the algebraic sign.

Only takes effect after the `MTESt:SEGMent:RESCale:RECalculate` command.

Parameters:

<ExpansionFactor>	Range:	-100 to 100
	Increment:	1
	*RST:	1

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

MTESt:SEGMent:RESCale:XOFFset <MaskTestName>, <MaskSegmIdx>,<OffsetX>
MTESt:SEGMent:RESCale:XOFFset? <MaskTestName>, <MaskSegmIdx>

Moves the mask segment horizontally. The specified offset is added to the x-values of all points of the selected mask segment.

Only takes effect after the `MTESt:SEGMent:RESCale:RECalculate` command.

Parameters:

<OffsetX>	Range:	-50 to 50
	Increment:	1E-9
	*RST:	0
	Default unit:	s

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

Firmware/Software: V 1.25

MTESt:SEGMent:RESCale:YOFFset <MaskTestName>, <MaskSegmIdx>,<OffsetY>
MTESt:SEGMent:RESCale:YOFFset? <MaskTestName>, <MaskSegmIdx>

Moves the mask segment vertically. The specified offset is added to the y-values of all points of the selected mask segment.

Only takes effect after the `MTESt:SEGMent:RESCale:RECalculate` command.

Parameters:

<OffsetY>	Range:	-1000 to 1000
	Increment:	1E-6
	*RST:	0
	Default unit:	V

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

<MaskSegmIdx> Number of the segment. Counting starts from 0.

20.14.3 Mask Definition: Waveform Mask

The chapter contains commands required for the definition of waveform masks - `MTESt:CTYPe` is set to `WFML`.

MTESt:REFWfm <MaskTestName>,<Source>
MTESt:REFWfm? <MaskTestName>

Sets the reference waveform from which the mask is created.

The reference waveform can be created before, or loaded from a file with REFCurve commands, see Chapter 20.10.2, "Reference Waveforms", on page 1105.

Parameters:

<Source> REF1 | REFerence1 | REF2 | REFerence2 | REF3 | REFerence3 | REF4 | REFerence4

REF1 = REFerence1, REF2 = REFerence2, REF3 = REFerence3, REF4 = REFerence4: reference waveforms

*RST: REF1

Parameters for setting and query:

<MaskTestName> String containing the name of the mask test

MTESt:WFMLupdate <MaskTestName>

Creates the upper and lower mask limit from the envelope of the selected reference waveform. If the reference waveform was not defined before, it is created automatically from the mask test source waveform which is set wtih `MTESt:SOURce`.

Setting parameters:

<MaskTestName> String containing the name of the mask test

Usage: Setting only

MTESt:WFMRescale:XWIDth <MaskTestName>,<HorizontalWidth>
MTESt:WFMRescale:XWIDth? <MaskTestName>

Sets the width of the mask in horizontal direction. The specified factor in divisions is added to the positive x-values and subtracted from the negative x-values of the mask limits in relation to the source waveform of the mask.

Parameters:

<HorizontalWidth> Range: 0 to 1000
Increment: 0.01
*RST: 0
Default unit: div

Parameters for setting and query:

<MaskTestName> String containing the name of the mask test

MTESt:WFMRescale:YWIDth <MaskTestName>,<VerticalWidth>
MTESt:WFMRescale:YWIDth? <MaskTestName>

Sets the width of the waveform mask in vertical direction. The specified factor in divisions is added to the y-values of the upper mask limit and subtracted from the y-values of the lower mask limit. Thus, the upper half of the mask is pulled upwards, the lower half is pulled down.

Parameters:

<VerticalWidth> Vertical mask width in divisions

Range: 0 to 1000
Increment: 0.01
*RST: 0
Default unit: div

Parameters for setting and query:

<MaskTestName> String containing the name of the mask test

MTESt:WFMRescale:YPOSition <MaskTestName>,<VertPosi>
MTESt:WFMRescale:YPOSition? <MaskTestName>

Moves the mask vertically within the display.

Parameters:

<VertPosi> Range: -1000 to 1000
Increment: 0.01
*RST: 0
Default unit: div

Parameters for setting and query:

<MaskTestName> String containing the name of the mask test

MTESt:WFMRescale:YSTRetch <MaskTestName>,<VerticalStretch>
MTESt:WFMRescale:YSTRetch? <MaskTestName>

Sets the vertical scaling to stretch the mask in y-direction. The scaling axis is the horizontal line through the lowest value of the lower mask limit.

Parameters:

<VerticalStretch>	Scale factor in % Range: 10 to 1000 Increment: 1 *RST: 100 Default unit: %

Parameters for setting and query:

<MaskTestName>	String containing the name of the mask test

20.14.4 Event Actions

MTESt:ONViolation:BEEP <MaskTestName>,<Beep>
MTESt:ONViolation:BEEP? <MaskTestName>

Generates a beep sound for the specified event.

Parameters:

<Beep>	NOACtion | SUCCess | VIOLation See Chapter 20.4.5, "Event Parameter", on page 971 *RST: NOACtion

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:ONViolation:STOP <MaskTestName>,<StopAcq>
MTESt:ONViolation:STOP? <MaskTestName>

Stops data acquisition for the specified event.

Parameters:

<StopAcq>	NOACtion | SUCCess | VIOLation See Chapter 20.4.5, "Event Parameter", on page 971 *RST: NOACtion

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:ONViolation:PRINt <MaskTestName>,<Print>
MTESt:ONViolation:PRINt? <MaskTestName>

Prints a screenshot including the measurement results to the printer defined using `SYSTem:COMMunicate:PRINter:SELect<1..2>` for the specified event.

Parameters:

<Print>	NOACtion | SUCCess | VIOLation See Event Parameter *RST: NOACtion

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:ONViolation:SAVewaveform <MaskTestName>,<SaveWfm>
MTESt:ONViolation:SAVewaveform? <MaskTestName>

Saves the waveform data.

Parameters:

<SaveWfm>	NOACtion | SUCCess | VIOLation See Chapter 20.4.5, "Event Parameter", on page 971 *RST: NOACtion

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:ONViolation:REPort <MaskTestName>,<Report>
MTESt:ONViolation:REPort? <MaskTestName>

Creates and saves a report of the current settings and results.

Parameters:

<Report>	NOACtion | SUCCess | VIOLation See Chapter 20.4.5, "Event Parameter", on page 971 *RST: NOACtion

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:ONViolation:TRIGgerout <MaskTestName>,<TriggerOutPulse>
MTESt:ONViolation:TRIGgerout? <MaskTestName>

Creates a trigger out pulse on mask violation or successful completion of the test cycle.

Parameters:

<TriggerOutPulse>	NOACtion | SUCCess | VIOLation *RST: NOACtion

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:ONViolation:RUNexec <MaskTestName>,<RunExecutable>
MTESt:ONViolation:RUNexec? <MaskTestName>

Starts an external application if the command is set to `VIOLation` or `SUCCess`.

Use the following commands to set up the application:
- `EXECutable:NAME` on page 999
- `EXECutable:PARameter` on page 1000
- `EXECutable:WDIRectory` on page 1000

Parameters:
<RunExecutable> NOACtion | SUCCess | VIOLation
See Chapter 20.4.5, "Event Parameter", on page 971
*RST: NOACtion

Parameters for setting and query:
<MaskTestName> String with the name of the mask test

20.14.5 Mask Display

MTESt:LABel <LabelState>

Switches the display of the mask test name on or off.

To change the name of the mask test, use `MTESt:REName` on page 1228.

Parameters:
<LabelState> ON | OFF
*RST: ON

MTESt:REName <MaskTestName>, <NewName>
MTESt:REName? <MaskTestName>

Changes the name of the mask test.

Parameters:
<NewName> String with the new mask test name.

Parameters for setting and query:
<MaskTestName> String with the existing mask test name.

20.14.6 Results

MTESt:RESult:STATe? <MaskTestName>

Shows if the test is running or has finished. The state is set to "Finished" if no acquisitions remain (see `MTESt:RESult:COUNt:REMaining?` on page 1229).

Query parameters:
<MaskTestName>

Return values:

<State>	RUNNing | FINished	
	*RST:	RUNNing

Usage: Query only

MTESt:RESult[:RESult]? <MaskTestName>

Returns the test result.

A test has failed if the number of sample hits or acquisition hits exceeds the limit of "Violation tolerance" hits (see `MTESt:TOLerance` on page 1217, `MTESt:RESult:COUNt:FAILures?` on page 1230 and `MTESt:RESult:COUNt:FWAVeforms?` on page 1230).

Query parameters:
<MaskTestName>

Return values:

<TestResult>	PASS | FAIL	
	*RST:	PASS

Usage: Query only

MTESt:RESult:COUNt:WAVeforms? <MaskTestName>

Returns the number of tested acquisitions.

Query parameters:
<MaskTestName>

Return values:

<AcqsCompleted>	Range:	0 to 100E+24
	*RST:	0

Usage: Query only

MTESt:RESult:COUNt:REMaining? <MaskTestName>

Remaining acquisitions until "Average count / Nx Single count" is reached.

The value is useful if you test a specified number of acquisitions with action "Stop acquisition" on violation, or if the acquisition has been stopped manually.

See also: Chapter 9.3.4, "Running a Mask Test", on page 391.

Query parameters:
<MaskTestName>

Return values:

<AcqsRemaining>	Range:	0 to 100E+24
	*RST:	0

Usage: Query only

MTESt:RESult:COUNt:FWAVeforms? <MaskTestName>

Returns the number of acquisitions that contained at least one sample hit.

Query parameters:
<MaskTestName>

Return values:

<AcquisitionHits>	Range:	0 to 100E+24
	*RST:	0

Usage: Query only

MTESt:RESult:COUNt:FAILures? <MaskTestName>

Returns the number of sample hits that violated the mask.

Query parameters:
<MaskTestName>

Return values:

<SampleHits>	Range:	0 to 100E+24
	*RST:	0

Usage: Query only

MTESt:RESult:FRATe? <MaskTestName>

Ratio of acquisition hits to the number of tested acquisitions.

Query parameters:
<MaskTestName>

Return values:

<FailRate>	Range:	-100E+24 to 100E+24
	*RST:	0
	Default unit:	%

Usage: Query only

20.14.7 Eye Mask Testing

20.14.7.1 Definition of Eye Masks

To perform mask testing on eye diagrams, the option R&S RTP-K12 adds a special mask definition type to the common mask definitions: the definition type "Eye".

MTESt:EYEMask:TYPE <MaskTestName>,<Type>
MTESt:EYEMask:TYPE? <MaskTestName>

Defines the outline of the eye mask.

Parameters:

<Type> SQUare | DIAMond | HEXagon | OCTagon

*RST: DIAMond

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:EYEMask:HEIGht<m>[:VALue] <MaskTestName>, <value>

Defines the main heigth af all eye mask shapes and the minor height for octagon mask shapes.

Suffix:

<m> 1..2
1 - main width
2 - minor width

Parameters:

<value> Default unit: s

Setting parameters:

<MaskTestName> String with the name of the mask test

MTESt:EYEMask:WIDTh<m>[:VALue] <MaskTestName>, <value>

Defines the main width af all eye mask shapes and the minor width for hexagon and octagon mask shapes.

Suffix:

<m>	1..2 1 - main width 2 - minor width

Parameters:

<value>	Default unit: s

Setting parameters:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:MSKRight <MaskTestName>,<Copy>
MTESt:EYEMask:MSKRight? <MaskTestName>
MTESt:EYEMask:MSKLeft <MaskTestName>,<Copy>
MTESt:EYEMask:MSKLeft? <MaskTestName>

Copies the eye shape to the right and left, respectively.

The distance of the copy is defined using `MTESt:EYEMask:HPERiod`.

Parameters:

<Copy>	ON | OFF *RST: OFF

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:HPERiod <MaskTestName>,<InterpattLength>
MTESt:EYEMask:HPERiod? <MaskTestName>

Defines the time distance between the shape centers if `MTESt:EYEMask:MSKLeft` and/or `MTESt:EYEMask:MSKRight` are ON.

Parameters:

<InterpattLength>	Range: 0 to 100 Increment: 0.01 *RST: 0.5 Default unit: s

Parameters for setting and query:

<MaskTestName>	String with the name of the mask test

MTESt:EYEMask:MSKTop <MaskTestName>,<Add>
MTESt:EYEMask:MSKTop? <MaskTestName>
MTESt:EYEMask:MSKBottom <MaskTestName>,<Add>
MTESt:EYEMask:MSKBottom? <MaskTestName>

Enable the upper (top) and lower (bottom) mask region, respectively.

Parameters:

<Add> ON | OFF

*RST: OFF

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:EYEMask:TOFFset <MaskTestName>,<Offset>
MTESt:EYEMask:TOFFset? <MaskTestName>
MTESt:EYEMask:BOFFset <MaskTestName>,<Offset>
MTESt:EYEMask:BOFFset? <MaskTestName>

Voltage distance from the eye shape center that limit the upper (TOFFset) and lower (BOFFset) regions.

Parameters:

<Offset> Range: 0 to 100
Increment: 0.01
*RST: 0.5
Default unit: V

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:EYEMask:TBSYmmetric <MaskTestName>,<Symmetry>
MTESt:EYEMask:TBSYmmetric? <MaskTestName>

Sets bottom and top offsets to the same value so that the outer regions are symmetric to the eye shape.

Parameters:

<Symmetry> ON | OFF

*RST: ON

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:EYEMask:TBWidth <MaskTestName>,<RectangleLength>
MTESt:EYEMask:TBWidth? <MaskTestName>

Sets the time width of the outer regions, symmetric to the eye shape center.

Parameters:

<RectangleLength>	Range:	0 to 100
	Increment:	0.01
	*RST:	0.5
	Default unit:	s

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:EYEMask:HPOSition <MaskTestName>,<PatOffsetX>
MTESt:EYEMask:HPOSition? <MaskTestName>

Sets the horizontal (time) value of the eye shape enter and thus defines the horizontal position of the eye shape on the display.

Parameters:

<PatOffsetX>	Range:	-100 to 100
	Increment:	0.01
	*RST:	0
	Default unit:	s

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

MTESt:EYEMask:VPOSition <MaskTestName>,<PatOffsetY>
MTESt:EYEMask:VPOSition? <MaskTestName>

Sets the vertical (voltage) value of the eye shape enter and thus defines the vertical position of the eye shape on the display.

Parameters:

<PatOffsetY>	Range:	-100 to 100
	Increment:	0.01
	*RST:	0
	Default unit:	V

Parameters for setting and query:

<MaskTestName> String with the name of the mask test

20.15 Search

20.15.1 General Search Settings

SEARch:ADD <SearchName>

Creates a new search definition with the specified name.

Setting parameters:

<SearchName> String with the name of the search

Example: See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 960

Usage: Setting only

SEARch:CLEar <SearchName>

Clears the search results once to start a new search.

Setting parameters:

<SearchName> Search definition

Usage: Setting only

SEARch:REMove <SearchName>

Deletes the specified search definition.

Setting parameters:

<SearchName> String with the name of the search

Usage: Setting only

SEARch:SOURce <SearchName>,<Source>
SEARch:SOURce? <SearchName>

Defines the source on which the search conditions are applied. The source can be any analog or digital channel, math or reference waveform as well as a serial bus configured for a supported protocol.

Parameters:

<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | SBUS1 | SBUS2 | SBUS3 | SBUS4

Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C1W1

Parameters for setting and query:

<SearchName> String with the name of the search

Example: See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 960

SEARch:ONLine <SearchName>,<OnlineState>
SEARch:ONLine? <SearchName>

If enabled, a search is performed repeatedly for each new data acquisition.

Parameters:

<OnlineState> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName> Search definition

SEARch:ALL <SearchName>

Performs a search for all results on the existing data from the selected source.

Setting parameters:

<SearchName> Search definition

Example: See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 960

Usage: Setting only
Asynchronous command

20.15.2 Basic Trigger Search Conditions

SEARch:TRIGger:DATatoclock[:STATe] <SearchName>,<State>
SEARch:TRIGger:DATatoclock[:STATe]? <SearchName>
SEARch:TRIGger:EDGE[:STATe] <SearchName>,<State>
SEARch:TRIGger:EDGE[:STATe]? <SearchName>
SEARch:TRIGger:GLITch[:STATe] <SearchName>,<State>
SEARch:TRIGger:GLITch[:STATe]? <SearchName>
SEARch:TRIGger:INTerval[:STATe] <SearchName>,<State>
SEARch:TRIGger:INTerval[:STATe]? <SearchName>
SEARch:TRIGger:PATTern[:STATe] <SearchName>,<State>
SEARch:TRIGger:PATTern[:STATe]? <SearchName>
SEARch:TRIGger:RUNT[:STATe] <SearchName>,<State>
SEARch:TRIGger:RUNT[:STATe]? <SearchName>
SEARch:TRIGger:SLEWrate[:STATe] <SearchName>,<State>
SEARch:TRIGger:SLEWrate[:STATe]? <SearchName>
SEARch:TRIGger:STATe[:STATe] <SearchName>,<State>
SEARch:TRIGger:STATe[:STATe]? <SearchName>
SEARch:TRIGger:TIMeout[:STATe] <SearchName>,<State>
SEARch:TRIGger:TIMeout[:STATe]? <SearchName>

SEARch:TRIGger:WIDTh[:STATe] <SearchName>,<State>
SEARch:TRIGger:WIDTh[:STATe]? <SearchName>
SEARch:TRIGger:WINDow[:STATe] <SearchName>,<State>
SEARch:TRIGger:WINDow[:STATe]? <SearchName>

Includes the search conditions for the selected trigger event type in the next search.

Parameters:

<State> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:LEVel[:VALue] <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel[:VALue]? <SearchName>, <SignalSource>

Sets the voltage of the trigger level that is used to determine other parameters.

Parameters:

<Value> Voltage value

Parameters for setting and query:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 970

SEARch:TRIGger:DATatoclock:ACOPy <SearchName>
SEARch:TRIGger:EDGE:ACOPy <SearchName>
SEARch:TRIGger:GLITch:ACOPy <SearchName>
SEARch:TRIGger:INTerval:ACOPy <SearchName>
SEARch:TRIGger:PATTern:ACOPy <SearchName>
SEARch:TRIGger:RUNT:ACOPy <SearchName>
SEARch:TRIGger:SLEWrate:ACOPy <SearchName>
SEARch:TRIGger:STATe:ACOPy <SearchName>
SEARch:TRIGger:TIMeout:ACOPy <SearchName>
SEARch:TRIGger:WIDTh:ACOPy <SearchName>
SEARch:TRIGger:WINDow:ACOPy <SearchName>

Copies the trigger event configuration from Trigger A for the selected channel source to the search condition settings.

See Chapter 5.3, "Trigger Types", on page 184.

Setting parameters:
<SearchName> Search definition

Usage: Setting only

SEARch:TRIGger:EDGE:BCOPy <SearchName>

Copies the trigger event configuration from trigger B for the selected channel source to the search condition settings.

Setting parameters:
<SearchName> String with name of the search

Usage: Setting only

20.15.3 Edge Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1238

SEARch:TRIGger:EDGE:SLOPe <SearchName>,<Slope>
SEARch:TRIGger:EDGE:SLOPe? <SearchName>

Selects the edge type.

Parameters:
<Slope> POSitive | NEGative | EITHer

See Chapter 20.4.3, "Slope Parameter", on page 970.

*RST: POSitive

Parameters for setting and query:
<SearchName> Search definition

20.15.4 Glitch Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1238

SEARch:TRIGger:GLITch:POLarity <SearchName>,<Polarity>
SEARch:TRIGger:GLITch:POLarity? <SearchName>

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

Parameters:

<Polarity> POSitive | NEGative | EITHer

See Chapter 20.4.4, "Polarity Parameter", on page 971.

*RST: POSitive

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:GLITch:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:GLITch:RANGe? <SearchName>

Selects which glitches are identified: shorter or longer than the specified width (see `SEARch:TRIGger:GLITch:WIDTh` on page 1240).

Parameters:

<RangeMode> SHORter | LONGer

*RST: SHORter

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:GLITch:WIDTh <SearchName>,<Width>
SEARch:TRIGger:GLITch:WIDTh? <SearchName>

Sets the length of a glitch. The instrument triggers on pulses shorter or longer than this value (see also `SEARch:TRIGger:GLITch:RANGe` on page 1240).

You need to know the expected pulse widths of the circuit to set the glitch width correctly.

Parameters:

<Width> Range: 100E-12 to 1E-3
Increment: 100E-6
*RST: 1E-9
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

20.15.5 Interval Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1238

SEARch:TRIGger:INTerval:SLOPe <SearchName>,<Slope>
SEARch:TRIGger:INTerval:SLOPe? <SearchName>

Sets the edge for the search.

Parameters:

<Slope> POSitive | NEGative | EITHer

See Chapter 20.4.3, "Slope Parameter", on page 970.

*RST: POSitive

Parameters for setting and query:

<SearchName> String parameter, name of the search definition

SEARch:TRIGger:INTerval:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:INTerval:DELTa? <SearchName>

Defines a range around the "Interval width" value (see `SEARch:TRIGger:INTerval:WIDTh` on page 1242).

Parameters:

<WidthDelta> Range: 0 to 10
Increment: 100E-9
*RST: 0
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:INTerval:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:INTerval:RANGe? <SearchName>

Selects how the range of an interval is defined based on the interval width and delta (see `SEARch:TRIGger:INTerval:WIDTh` on page 1242 and `SEARch:TRIGger:INTerval:DELTa` on page 1241).

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulse intervals inside a given range. The range is defined by "Interv. width" and "±Delta".

OUTSide
Triggers on intervals outside a given range. The range definition is the same as for "Within" range.

SHORter
Triggers on intervals shorter than the given "Interv. width".

LONGer
Triggers on intervals longer than the given "Interv. width".

*RST: OUTSide

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:INTerval:WIDTh <SearchName>,<Width>
SEARch:TRIGger:INTerval:WIDTh? <SearchName>

Defines the time between two pulses.

Parameters:

<Width> Range: 100E-12 to 864
Increment: 100E-9
*RST: 5E-9
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

20.15.6 Runt Search Conditions

SEARch:TRIGger:RUNT:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:RUNT:DELTa? <SearchName>

Defines a range around the given runt width.

Parameters:

<WidthDelta> Range: 100E-12 to 864
Increment: 100E-9
*RST: 100E-12
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:RUNT:POLarity <SearchName>,<Polarity>
SEARch:TRIGger:RUNT:POLarity? <SearchName>

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

Parameters:

<Polarity> POSitive | NEGative | EITHer

See Chapter 20.4.4, "Polarity Parameter", on page 971.

*RST: POSitive

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:RUNT:RANGe <SearchName>,<Mode>
SEARch:TRIGger:RUNT:RANGe? <SearchName>

Selects how the time limit of the runt pulse is defined based on the runt width and delta (see `SEARch:TRIGger:RUNT:WIDTh` on page 1243 and `SEARch:TRIGger:RUNT:DELTa` on page 1242).

Parameters:

<Mode> ANY | LONGer | SHORter | WITHin | OUTSide

ANY
Triggers on all runts fulfilling the level condition, without time limitation.

LONGer
Triggers on runts longer than the given "Runt width".

SHORter
Triggers on runts shorter than the given "Runt width".

WITHin
Triggers if the runt length is inside a given time range. The range is defined by "Runt width" and "±Delta".

OUTSide
Triggers if the runt length is outside a given time range. The range definition is the same as for "Within" range.

*RST: ANY

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:RUNT:WIDTh <SearchName>,<Width>
SEARch:TRIGger:RUNT:WIDTh? <SearchName>

For the ranges "Shorter" and "Longer", the runt width defines the maximum and minimum pulse width, respectively.

For the ranges "Within" and "Outside", the runt width defines the center of a range which is defined by "±Delta".

The range is defined using `SEARch:TRIGger:RUNT:RANGe` on page 1243.

Parameters:

<Width>
Range: 100E-12 to 864
Increment: 100E-9
*RST: 5E-9
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:LEVel:RUNT:LOWer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:RUNT:LOWer? <SearchName>, <SignalSource>
SEARch:TRIGger:LEVel:RUNT:UPPer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:RUNT:UPPer? <SearchName>, <SignalSource>

Set the lower and upper voltage threshold, respectively.

Parameters:

<Value>	Voltage value

Parameters for setting and query:

<SearchName>	String with the name of the search
<SignalSource>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4 Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 970

20.15.7 Slew Rate Search Conditions

SEARch:TRIGger:SLEWrate:DELTa <SearchName>,<TimeDelta>
SEARch:TRIGger:SLEWrate:DELTa? <SearchName>

Defines a time range around the given slew rate.

Parameters:

<TimeDelta>	Range: 0 to 10 Increment: 100E-9 *RST: 0 Default unit: s

Parameters for setting and query:

<SearchName>	String with the name of the search

SEARch:TRIGger:SLEWrate:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:SLEWrate:RANGe? <SearchName>

Selects how the time limit for the slew rate is defined. The time measurement starts when the signal crosses the first trigger level - the upper or lower level depending on the selected slope - and stops when the signal crosses the second level.

Parameters:

<RangeMode> INSRange | OUTRange | LTHan | GTHan

INSRange
Triggers on slew rates inside a given time range. The range is defined by "Slew rate" and "±Delta".

OUTRange
Triggers on slew rates outside a given time range. The range definition is the same as for "Within" range.

LTHan
Triggers on slew rates shorter than the given "Slew rate" limit.

GTHan
Triggers on slew rates longer than the given "Slew rate" limit.

*RST: GTHan

Parameters for setting and query:

<SearchName> String with the name of the search

SEARch:TRIGger:SLEWrate:SLOPe <SearchName>,<Slope>
SEARch:TRIGger:SLEWrate:SLOPe? <SearchName>

Selects the edge type.

Parameters:

<Slope> POSitive | NEGative | EITHer

See Chapter 20.4.3, "Slope Parameter", on page 970.

*RST: POSitive

Parameters for setting and query:

<SearchName> String with the name of the search

SEARch:TRIGger:SLEWrate:TIME <SearchName>,<Time>
SEARch:TRIGger:SLEWrate:TIME? <SearchName>

For the ranges "Within" and "Outside", the slew rate defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the slew rate defines the maximum and minimum slew rate limits, respectively.

The range is defined using `SEARch:TRIGger:SLEWrate:RANGe`.

Parameters:

<Time> Range: 100E-12 to 864
Increment: 100E-9
*RST: 100E-12
Default unit: s

Parameters for setting and query:

<SearchName> String with the name of the search

SEARch:TRIGger:LEVel:TRANsition:LOWer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:TRANsition:LOWer? <SearchName>, <SignalSource>
SEARch:TRIGger:LEVel:TRANsition:UPPer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:TRANsition:UPPer? <SearchName>, <SignalSource>

Set the lower and upper voltage thresholds, respectively. When the signal crosses this level, the slew rate measurement starts or stops depending on the selected slope.

Parameters:

<Value> Voltage value

Parameters for setting and query:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 970

20.15.8 Timeout Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1238

SEARch:TRIGger:TIMeout:RANGe <SearchName>,<TimeoutMode>
SEARch:TRIGger:TIMeout:RANGe? <SearchName>

Selects the relation of the signal level to the trigger level:

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

HIGH
The signal level stays above the trigger level.

LOW
The signal level stays below the trigger level.

EITHer
The signal level stays above or below the trigger level.

*RST: HIGH

Parameters for setting and query:
<SearchName> Search definition

SEARch:TRIGger:TIMeout:TIME <SearchName>,<Time>
SEARch:TRIGger:TIMeout:TIME? <SearchName>

Defines the time limit for the timeout at which the instrument triggers.

Parameters:
<Time> Range: 100E-12 to 864
Increment: 100E-9
*RST: 100E-9
Default unit: s

Parameters for setting and query:
<SearchName> Search definition

20.15.9 Width Search Conditions

Trigger level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1238

SEARch:TRIGger:WIDTh:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:WIDTh:DELTa? <SearchName>

Defines a range around the given width value (see also `SEARch:TRIGger:WIDTh:WIDTh` on page 1248).

Parameters:
<WidthDelta> Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

Parameters for setting and query:
<SearchName> Search definition

Example: See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 960

SEARch:TRIGger:WIDTh:POLarity <SearchName>,<Polarity>
SEARch:TRIGger:WIDTh:POLarity? <SearchName>

Indicates the polarity of a pulse, that is the direction of the first pulse slope.

Parameters:

<Polarity> POSitive | NEGative | EITHer

See Chapter 20.4.4, "Polarity Parameter", on page 971.

*RST: POSitive

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:WIDTh:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:WIDTh:RANGe? <SearchName>

Selects how the range of a pulse width is defined in relation to the width and delta (see `SEARch:TRIGger:WIDTh:WIDTh` on page 1248 and `SEARch:TRIGger:WIDTh:DELTa` on page 1247).

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers on pulses inside a given range. The range of the pulse width is defined by "Width" and "±Delta".

OUTSide
Triggers on pulses outside a given range. The range definition is the same as for "Within" range.

SHORter
Triggers on pulses shorter than the given "Width".

LONGer
Triggers on pulses longer than the given "Width".

*RST: WITHin

Parameters for setting and query:

<SearchName> Search definition

Example: See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 960

SEARch:TRIGger:WIDTh:WIDTh <SearchName>,<Width>
SEARch:TRIGger:WIDTh:WIDTh? <SearchName>

For the ranges "Within" and "Outside", the width defines the center of a range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", the width defines the maximum and minimum pulse width, respectively.

The range is defined using `SEARch:TRIGger:WIDTh:RANGe`.

Parameters:

<Width>
Range: 100E-12 to 864
Increment: 100E-9
*RST: 5E-9
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

Example: See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 960

20.15.10 Window Search Conditions

SEARch:TRIGger:WINDow:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:WINDow:DELTa? <SearchName>

Defines a range around the "Width" value (see `SEARch:TRIGger:WINDow:WIDTh` on page 1250).

Parameters:

<WidthDelta>
Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:WINDow:RANGe <SearchName>,<RangeMode>
SEARch:TRIGger:WINDow:RANGe? <SearchName>

Selects how the signal run is compared with the window.

Parameters:

<RangeMode> ENTer | EXIT | WITHin | OUTSide

ENTer
Triggers when the signal crosses the upper or lower level and thus enters the window made up of these two levels.

EXIT
Triggers when the signal leaves the window.

WITHin
Triggers if the signal stays between the upper and lower level for a specified time. The time is defined in various ways by the SEARch:TRIGger:WINDow:TIMerange command.

OUTSide
Triggers if the signal stays above the upper level or below the lower level for a specified time. The time is also defined by the SEARch:TRIGger:WINDow:TIMerange command.

*RST: ENTer

Parameters for setting and query:
<SearchName> Search definition

SEARch:TRIGger:WINDow:TIMerange <SearchName>,<TimeRangeMode>
SEARch:TRIGger:WINDow:TIMerange? <SearchName>

Selects how the time limit of the window is defined. Time conditioning is available for the vertical conditions "WITHin" and "OUTSide" (see SEARch:TRIGger:WINDow:RANGe on page 1249).

Parameters:
<TimeRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin
Triggers if the signal stays inside or outside the vertical window limits at least for the time *Width - Delta* and for *Width + Delta* at the most.

OUTSide
"Outside" is the opposite definition of "Within". The instrument triggers if the signal stays inside or outside the vertical window limits for a time shorter than *Width - Delta* or longer than *Width + Delta*.

SHORter
Triggers if the signal crosses vertical limits before the specified "Width" time is reached.

LONGer
Triggers if the signal crosses vertical limits before the specified "Width" time is reached.

*RST: WITHin

Parameters for setting and query:
<SearchName> Search definition

SEARch:TRIGger:WINDow:WIDTh <SearchName>,<Width>
SEARch:TRIGger:WINDow:WIDTh? <SearchName>

For the ranges "Within" and "Outside", the width defines the center of a time range which is defined by the limits "±Delta".

For the ranges "Shorter" and "Longer", it defines the maximum and minimum time lapse, respectively.

The range is defined using `SEARch:TRIGger:WINDow:RANGe`.

Parameters:

<Width> Range: 100E-12 to 864
Increment: 100E-9
*RST: 5E-9
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:LEVel:WINDow:LOWer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:WINDow:LOWer? <SearchName>, <SignalSource>
SEARch:TRIGger:LEVel:WINDow:UPPer <SearchName>, <SignalSource>, <Value>
SEARch:TRIGger:LEVel:WINDow:UPPer? <SearchName>, <SignalSource>

Set the lower and upper voltage limits for the window.

Parameters:

<Value> Voltage value

Parameters for setting and query:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 970

20.15.11 Data2Clock Search Conditions

Data level setting: `SEARch:TRIGger:LEVel[:VALue]` on page 1238

SEARch:TRIGger:DATatoclock:CEDGe <SearchName>,<ClockEdge>
SEARch:TRIGger:DATatoclock:CEDGe? <SearchName>

Sets the edge of the clock signal to define the time reference point for the setup and hold time.

Parameters:
<ClockEdge> POSitive | NEGative | EITHer

See Chapter 20.4.3, "Slope Parameter", on page 970.

*RST: POSitive

Parameters for setting and query:
<SearchName> Search definition

SEARch:TRIGger:DATatoclock:CLEVel <SearchName>,<ClockLevel>
SEARch:TRIGger:DATatoclock:CLEVel? <SearchName>

Sets the voltage level for the clock signal. Both this command and `SEARch:TRIGger:DATatoclock:CEDGe` define the starting point for calculation of the setup and hold time.

Parameters:
<ClockLevel> Range: -10 to 10
Increment: 1E-3
*RST: 0
Default unit: V

Parameters for setting and query:
<SearchName> Search definition

SEARch:TRIGger:DATatoclock:CSOurce <SearchName>,<ClockSource>
SEARch:TRIGger:DATatoclock:CSOurce? <SearchName>

Selects the waveform used for the clock signal.

Parameters:
<ClockSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

Source of the clock signal, see Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C1W1

Parameters for setting and query:
<SearchName> Search definition name

SEARch:TRIGger:DATatoclock:HTIMe <SearchName>,<HoldTime>
SEARch:TRIGger:DATatoclock:HTIMe? <SearchName>

Sets the minimum time **after** the clock edge while the data signal must stay steady above or below the data level.

The hold time can be negative. In this case, the setup time is always positive. The setup/hold interval starts before the clock edge (setup time) and ends before the clock edge (hold time). If you change the negative hold time, the setup time is adjusted by the intrument.

Parameters:

<HoldTime> Range: -99.999E-9 to 0.1
Increment: 1E-9
*RST: 0
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

SEARch:TRIGger:DATatoclock:STIMe <SearchName>,<SetupTime>
SEARch:TRIGger:DATatoclock:STIMe? <SearchName>

Sets the minimum time **before** the clock edge while the data signal must stay steady above or below the data level.

The setup time can be negative. In this case, the hold time is always positive. The setup/hold interval starts after the clock edge (setup time) and ends after the clock edge (hold time). If you change the negative setup time, the hold time is adjusted by the intrument.

Parameters:

<SetupTime> Range: -99.999E-9 to 0.1
Increment: 1E-9
*RST: 0
Default unit: s

Parameters for setting and query:

<SearchName> Search definition

20.15.12 Pattern Search Conditions

SEARch:TRIGger:PATTern:A[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:A[:ENABle]? <Searchname>
SEARch:TRIGger:PATTern:B[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:B[:ENABle]? <Searchname>
SEARch:TRIGger:PATTern:C[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:C[:ENABle]? <Searchname>
SEARch:TRIGger:PATTern:D[:ENABle] <Searchname>, <State>
SEARch:TRIGger:PATTern:D[:ENABle]? <Searchname>

Enables the channel to be considered in the pattern search. The trigger source channel is selected by default.

- A[:ENABle]: CH1
- B[:ENABle]: CH2
- C[:ENABle]: CH3
- D[:ENABle]: CH4

Digital channels are not available.

Parameters:
<State> ON | OFF

Parameters for setting and query:
<Searchname> String with name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:A:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:A:LOGic? <Searchname>
SEARch:TRIGger:PATTern:B:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:B:LOGic? <Searchname>
SEARch:TRIGger:PATTern:C:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:C:LOGic? <Searchname>
SEARch:TRIGger:PATTern:D:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:D:LOGic? <Searchname>

Defines the logic for the indicated channel:

- A: CH1
- B: CH2
- C: CH3
- D: CH4

Parameters:
<Operator> DIRect | NOT

DIRect
Input value remains unchanged

NOT
Input value is inverted

Parameters for setting and query:
<Searchname> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:AB:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:AB:LOGic? <Searchname>
SEARch:TRIGger:PATTern:CD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:CD:LOGic? <Searchname>
SEARch:TRIGger:PATTern:ABCD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:PATTern:ABCD:LOGic? <Searchname>

Defines the logical combination of the indicated channels after evaluating the previous logical operations:

- AB: CH1 and CH2
- CD: CH3 and CH4
- ABCD: result of AB and CD

Parameters:

<Operator> AND | NAND | OR | NOR

AND: logical AND, conjunctive combination
NAND:logical NOT AND
OR:logical OR, disjunctive combination
NOR: logical NOT OR

Parameters for setting and query:

<Searchname> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:MODE <SearchName>,<Mode>
SEARch:TRIGger:PATTern:MODE? <SearchName>

Adds additional time limitation to the pattern definition.

Parameters:

<Mode> OFF | TIMeout | WIDTh

OFF
No time limitation. The event is found if the pattern condition is fulfilled.

TIMeout
Defines how long the result of the pattern condition stays high or low. The duration of the timeout is defined using `SEARch:TRIGger:PATTern:TIMeout[:TIME]` The result state is defined using `SEARch:TRIGger:PATTern:TIMeout:MODE`.

WIDTh
Defines a time range for keeping up the true result of the pattern condition. The range is defined using `SEARch:TRIGger:PATTern:WIDTh:RANGe`.

*RST: OFF

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:TIMeout:MODE <SearchName>,<TimeoutMode>
SEARch:TRIGger:PATTern:TIMeout:MODE? <SearchName>

Defines the condition for the timeout.

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

EITHer
High or low, the pattern remains unchanged for the given time.

*RST: HIGH

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:TIMeout[:TIME] <SearchName>, <Time>
SEARch:TRIGger:PATTern:TIMeout[:TIME]? <SearchName>

Defines how long the result of the pattern condition must keep the given state.

Parameters:

<Time> Range: 100E-12 to 864
Increment: 100E-9
*RST: 100E-9
Default unit: s

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:WIDTh:RANGe <SearchName>, <WidthRangeMode>
SEARch:TRIGger:PATTern:WIDTh:RANGe? <SearchName>

Defines the time range of a pulse width for keeping up the true result of the pattern condition. The width and delta are specified using `SEARch:TRIGger:PATTern:WIDTh[:WIDTh]` and `SEARch:TRIGger:PATTern:WIDTh:DELTa`.

Parameters:

<WidthRangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin | OUTSide
Triggers on pulses inside or outside a given range. The range is defined by the width ±delta.

SHORter | LONGer
Triggers on pulses shorter or longer than the given width.

*RST: WITHin

Parameters for setting and query:
<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:WIDTh[:WIDTh] <SearchName>, <Width>
SEARch:TRIGger:PATTern:WIDTh[:WIDTh]? <SearchName>

For the ranges WITHin and OUTSide, the width defines the center of a range that is defined by the limits ±delta.

For the ranges SHORter and LONGer, the width defines the maximum and minimum pulse width, respectively.

To set the range mode, use `SEARch:TRIGger:PATTern:WIDTh:RANGe`. To set the delta value, use `SEARch:TRIGger:PATTern:WIDTh:DELTa`.

Parameters:
<Width> Range: 100E-12 to 864
Increment: 100E-9
*RST: 5E-9
Default unit: s

Parameters for setting and query:
<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:PATTern:WIDTh:DELTa <SearchName>,<WidthDelta>
SEARch:TRIGger:PATTern:WIDTh:DELTa? <SearchName>

Defines a range around the width value specified using `SEARch:TRIGger:PATTern:WIDTh[:WIDTh]`.

Parameters:
<WidthDelta> Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

Parameters for setting and query:
<SearchName> String with the name of the search

Firmware/Software: FW 1.40

20.15.13 State Search Conditions

SEARch:TRIGger:STATe:CSOurce <SearchName>,<Source>
SEARch:TRIGger:STATe:CSOurce? <SearchName>

Sets the source of the clock signal.

Parameters:

<Source> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:CEDGe <SearchName>,<ClockEdge>
SEARch:TRIGger:STATe:CEDGe? <SearchName>

Sets the trigger edge of the clock signal.

Parameters:

<ClockEdge> POSitive | NEGative | EITHer

*RST: POSitive

Parameters for setting and query:

<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:CLEVel <SearchName>,<ClockLevel>
SEARch:TRIGger:STATe:CLEVel? <SearchName>

Sets the trigger level of the clock signal.

The command has the same effect as with `SEARch:TRIGger:LEVel[:VALue]`.

Parameters:

<ClockLevel> Range: -10 to 10
Increment: 1E-3
*RST: 0
Default unit: V

Parameters for setting and query:
<SearchName> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:A[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:A[:ENABle]? <Searchname>
SEARch:TRIGger:STATe:B[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:B[:ENABle]? <Searchname>
SEARch:TRIGger:STATe:C[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:C[:ENABle]? <Searchname>
SEARch:TRIGger:STATe:D[:ENABle] <Searchname>, <State>
SEARch:TRIGger:STATe:D[:ENABle]? <Searchname>

Enables the channel to be considered in the state search. You can enable all channel signals except for the trigger source.

- A[:ENABle]: CH1
- B[:ENABle]: CH2
- C[:ENABle]: CH3
- D[:ENABle]: CH4

Digital channels are not available.

Parameters:
<State> ON | OFF

Parameters for setting and query:
<Searchname> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:A:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:A:LOGic? <Searchname>
SEARch:TRIGger:STATe:B:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:B:LOGic? <Searchname>
SEARch:TRIGger:STATe:C:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:C:LOGic? <Searchname>
SEARch:TRIGger:STATe:D:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:D:LOGic? <Searchname>

Defines the logic for the indicated channel:

- A: CH1
- B: CH2
- C: CH3
- D: CH4

Parameters:
<Operator> DIRect | NOT

DIRect
Input value remains unchanged

NOT
Input value is inverted

Parameters for setting and query:
<Searchname> String with the name of the search

Firmware/Software: FW 1.40

SEARch:TRIGger:STATe:AB:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:AB:LOGic? <Searchname>
SEARch:TRIGger:STATe:CD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:CD:LOGic? <Searchname>
SEARch:TRIGger:STATe:ABCD:LOGic <Searchname>, <Operator>
SEARch:TRIGger:STATe:ABCD:LOGic? <Searchname>

Defines the logical combination of the indicated channels after evaluating the previous logical operations:

- AB: CH1 and CH2
- CD: CH3 and CH4
- ABCD: result of AB and CD

Parameters:
<Operator> AND | NAND | OR | NOR

AND: logical AND, conjunctive combination
NAND:logical NOT AND
OR:logical OR, disjunctive combination
NOR: logical NOT OR

Parameters for setting and query:
<Searchname> String with the name of the search

Firmware/Software: FW 1.40

20.15.14 Search on Spectrum

CURSor<m>:PEXCursion <Value>

Defines the minimum level by which the waveform must rise or fall so that it will be identified as a maximum or a minimum by the search functions.

Suffix:
<m> The suffix is irrelevant

Parameters:
<Value> Range: 0 to 100
Increment: 1
*RST: 5
Default unit: dB

CURSor<m>:THReshold <Value>

Defines an absolute threshold as an additional condition for the peak search. Only peaks that exceed the threshold are detected.

Suffix:
<m> The suffix is irrelevant.

Parameters:
<Value> Threshold in dBm

Firmware/Software: Version 2.70

20.15.15 Search Scope Settings

SEARch:GATE[:STATe] <SearchName>,<State>
SEARch:GATE[:STATe]? <SearchName>

Performs the search only on the defined gate area of the source waveform.

Parameters:
<State> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName> Search definition

SEARch:GATE:MODE <SearchName>,<Mode>
SEARch:GATE:MODE? <SearchName>

Defines whether the gate settings are configured using absolute or relative values.

Parameters:
<Mode> ABS | REL
*RST: ABS

Parameters for setting and query:
<SearchName> Search definition

SEARch:GATE:SHOW <SearchName>,<DisplayState>
SEARch:GATE:SHOW? <SearchName>

If enabled, the gate area is indicated in the source diagram.

Parameters:

<DisplayState>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:

<SearchName>	Search definition

SEARch:GATE:ABSolute:STARt <SearchName>,<Start>
SEARch:GATE:ABSolute:STARt? <SearchName>

Defines the starting value for the gate.

Parameters:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName>	Search definition

SEARch:GATE:ABSolute:STOP <SearchName>,<Stop>
SEARch:GATE:ABSolute:STOP? <SearchName>

Defines the end value for the gate.

Parameters:

<Stop>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName>	Search definition

SEARch:GATE:RELative:STARt <SearchName>,<RelativeStart>
SEARch:GATE:RELative:STARt? <SearchName>

Defines the starting value for the gate.

Parameters:

<RelativeStart>	Range:	0 to 100
	Increment:	0.1
	*RST:	0
	Default unit:	%

Parameters for setting and query:

<SearchName>	Search definition

SEARch:GATE:RELative:STOP <SearchName>,<RelativeStop>
SEARch:GATE:RELative:STOP? <SearchName>

Defines the end value for the gate.

Parameters:

<RelativeStop>	Range:	0 to 100
	Increment:	0.1
	*RST:	100
	Default unit:	%

Parameters for setting and query:

<SearchName> Search definition

SEARch:GATE:ZCOupling <SearchName>,<ZoomCoupling>
SEARch:GATE:ZCOupling? <SearchName>

If enabled, the gate area is set to the limits of a zoom area.

The zoom diagramm is selected using `SEARch:GATE:ZDIagram`.

Parameters:

<ZoomCoupling> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName> String with the name of the search

SEARch:GATE:ZDIagram <SearchName>,<ZoomDiagram>
SEARch:GATE:ZDIagram? <SearchName>

Selects the zoom to which the gate area is set if `SEARch:GATE:ZCOupling` is set to "ON".

Parameters:

<ZoomDiagram>

Parameters for setting and query:

<SearchName> String with the name of the search

Example:

```
SEARch:GATE:ZCOupling 'Search1',ON
SEARch:GATE:ZDIagram 'Search1','Diagram1',
'Zoom2'
SEARch:GATE:ZDIagram? 'Search1'
<-- Diagram1;Zoom2
```

Enables the zoom coupling to define the gate,and selects Zoom2 as gate area. Zoom2 is based on Diagram1.

20.15.16 Noise Rejection

SEARch:TRIGger:LEVel:NOISe:ABSolute <SearchName>, <SignalSource>, <Value>

Defines the trigger hysteresis, a range in absolute values around the trigger level. If the signal jitters inside this range and crosses the trigger level, no trigger event is detected.

Parameters:

<Value> Hysteresis value

Setting parameters:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 970

SEARch:TRIGger:LEVel:NOISe:MODE <SearchName>, <SignalSource>, <Mode>
SEARch:TRIGger:LEVel:NOISe:MODE? <SearchName>, <SignalSource>

Defines whether absolute values or relative values to the vertical scaling are used as a hysteresis for noise rejection.

Parameters:

<Mode> ABS | REL

Parameters for setting and query:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the trigger waveform, see Chapter 20.4.2, "Waveform Parameter", on page 970

SEARch:TRIGger:LEVel:NOISe:RELative <SearchName>, <SignalSource>, <Value>

Defines a range around the trigger level in relative values. If the signal jitters inside this range and crosses the trigger level, no trigger event is detected.

Parameters:

<Value> Hysteresis value in %

Setting parameters:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 970

SEARch:TRIGger:LEVel:NOISe[:STATe] <SearchName>, <SignalSource>, <State>
SEARch:TRIGger:LEVel:NOISe[:STATe]? <SearchName>, <SignalSource>

If enabled, the noise reject settings for the waveform are considered for the search.

Parameters:

<State> ON | OFF

Parameters for setting and query:

<SearchName> String with the name of the search

<SignalSource> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

Source of the search, see Chapter 20.4.2, "Waveform Parameter", on page 970

20.15.17 Search Results

SEARch:RESDiagram:HORZ:ABSolute:POSition <SearchName>,<Position>
SEARch:RESDiagram:HORZ:ABSolute:POSition? <SearchName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<Position>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESDiagram:HORZ:ABSolute:SPAN <SearchName>,<Span>
SEARch:RESDiagram:HORZ:ABSolute:SPAN? <SearchName>

Defines the width of the zoom area.

Parameters:

<Span>	Range:	0 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESDiagram:HORZ:MODE <SearchName>,<Mode>
SEARch:RESDiagram:HORZ:MODE? <SearchName>

Defines whether absolute or relative values are used to specify the x-axis values.

Parameters:

<Mode>	ABS | REL	
	*RST:	ABS

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESDiagram:HORZ:RELative:POSition <SearchName>,<RelPosi>
SEARch:RESDiagram:HORZ:RELative:POSition? <SearchName>

Defines the x-value of the centerpoint of the zoom area.

Parameters:

<RelPosi>	Range:	0 to 100
	Increment:	0.1
	*RST:	100
	Default unit:	%

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:HORZ:RELative:SPAN <SearchName>,<RelativeSpan>
SEARch:RESDiagram:HORZ:RELative:SPAN? <SearchName>

Defines the width of the zoom area.

Parameters:

<RelativeSpan>	Range:	1E-15 to 100
	Increment:	0.1
	*RST:	1
	Default unit:	%

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:SHOW <SearchName>,<SearchWindow>
SEARch:RESDiagram:SHOW? <SearchName>

If enabled, a zoom window is displayed for the currently selected search result. The zoom area is indicated in the diagram that displays the source waveform of the search.

Parameters:

<SearchWindow>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:

<SearchName>	Search definition

SEARch:RESDiagram:VERT:ABSolute:POSition <SearchName>,<Position>
SEARch:RESDiagram:VERT:ABSolute:POSition? <SearchName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<Position>	Range:	-100E+24 to 100E+24
	Increment:	0.01
	*RST:	0.01

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESDiagram:VERT:ABSolute:SPAN <SearchName>,<Span>
SEARch:RESDiagram:VERT:ABSolute:SPAN? <SearchName>

Defines the height of the zoom area.

Parameters:

<Span> Range: 0 to 100E+24
Increment: 0.01
*RST: 0.01

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESDiagram:VERT:MODE <SearchName>,<Mode>
SEARch:RESDiagram:VERT:MODE? <SearchName>

Defines whether absolute or relative values are used to specify the y-axis values.

Parameters:

<Mode> ABS | REL
*RST: ABS

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESDiagram:VERT:RELative:POSition <SearchName>,<RelPosi>
SEARch:RESDiagram:VERT:RELative:POSition? <SearchName>

Defines the y-value of the centerpoint of the zoom area.

Parameters:

<RelPosi> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESDiagram:VERT:RELative:SPAN <SearchName>,<RelativeSpan>
SEARch:RESDiagram:VERT:RELative:SPAN? <SearchName>

Defines the height of the zoom area.

Parameters:

<RelativeSpan>	Range:	1E-15 to 100
	Increment:	0.1
	*RST:	1
	Default unit:	%

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESult:LIMit <SearchName>,<ResultListLimit>
SEARch:RESult:LIMit? <SearchName>

Defines the maximum number of entries in the search result table.

Parameters:

<ResultListLimit>	Range:	1 to 1000
	Increment:	1
	*RST:	100

Parameters for setting and query:

<SearchName> Search definition

Example: See Chapter 20.3.4.1, "Searching for a pulse of specified width", on page 960

SEARch:RESult:SHOW <SearchName>,<ShowResultTable>
SEARch:RESult:SHOW? <SearchName>

Displays or hides the search result table.

Parameters:

<ShowResultTable> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESult:SORT:ASCending <SearchName>,<SortAscending>
SEARch:RESult:SORT:ASCending? <SearchName>

If enabled, the results are listed in asscending order, i.e. the smallest value at the top.

Parameters:

<SortAscending> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESult:SORT[:MODE] <SearchName>,<SortMode>
SEARch:RESult:SORT[:MODE]? <SearchName>

Sorts the search result table by x-value position or value of the result.

Parameters:

<SortMode> POSition | VALue

POSition
Sorts the search result table by the x-value position.

VALue
Sorts the search result table by the value of the result.

*RST: POSition

Parameters for setting and query:

<SearchName> Search definition

SEARch:RESult[:ALL]? <SearchName>

Returns all search results.

Query parameters:

<SearchName> Search definition

Return values:

<Data> List of search results, separated by commas. For each result, six values are returned:
1. Acquisition index, currently always 0.
2. X-position of the search result
3. Y-position of the search result, currently not relevant
4. Type of the search result (Edge, Glitch, ...)
5. Slope or polarity of the search result
6. For runt, glitch, width, and window searches, the value contains the width. For timeout and interval searches, it contains the timeout. For transition searches, it contains the slew rate. For all other searches, the value is not relevant.
If a value is not relevant, 9.91E+37 is returned.

Example:

```
SEAR:RES? 'Search1'
0,1.5375e-007,-84,Edge,Positive,9.91E+37,
0,5.3e-008,-84,Edge,Positive,9.91E+37
```

The query returns two search results for edge search on rising edges at X-position 153,75 ns and 53 ns.

Usage: Query only

20.16 Data Management

20.16.1 Instrument Settings

The Mass MEMory subsystem provides commands to access the storage media and to save and reload instrument settings.

File and directory names

The <file_name> and <directory_name> parameters are strings. Some commands use a fixed directory; for others the <file_name> can contain the complete path including the drive name and all subdirectories, e.g. '`C:\TEMP\TRASH\test.txt`' for the file named test.txt in the TEMP\TRASH subdirectory of the internal hard disk drive C:\. If no complete path is specified, the file location is relative to the current directory, queried with `MMEMory:CDIRectory?`. The file name itself may contain the period as a separator for extensions.

File and directory names can be chosen according to Windows™ conventions; the restrictions placed on file names known from DOS systems do not apply. All letters and numbers are allowed, as well as the special characters "_", "^", "$", "~", "!", "#", "%", "&", "-", "{", "}", "(", ")", "@" and "`". Reserved file names are CON, AUX, COM1, ..., COM4, LPT1, ..., LPT3, NUL and PRN.

The use of wildcards ? and * is not allowed.

MMEMory:DRIVes?

Returns a list of the logical drives of the instrument as configured in the operating system.

Return values:

<Drive> List of strings, for example, `"C:\","F:\","H:\"`

Usage: Query only

MMEMory:MSIS [<msus>]

Changes the default storage device to the indicated drive or network server.

Parameters:

<msus> String parameter. Drives are indicated with their drive letter, network servers require the UNC format.

Example: `MMEM:MSIS 'C:'`

Example: `MMEM:MSIS '\\server1\share1'`

MMEMory:DCATalog? [<PathName>]

Returns the subdirectories of the current or of a specified directory.

Query parameters:

<PathName> String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be set and queried with `MMEMory:CDIRectory`.

Return values:

<FileEntry> Names of the subdirectories separated by colons. The first two strings are related to the parent directory.

Example:

```
MMEM:DCAT?
".","..","Documents and Settings","Program
Files","temp"
```

Usage: Query only

MMEMory:DCATalog:LENGth? [<PathName>]

Returns the number of subdirectories of the current or of a specified directory. The number includes the parent directory strings "." and ".." and corresponds to the number of strings returned by the `MMEMory:DCATalog?` command.

Query parameters:

<PathName> String parameter to specify the directory. If the directory is omitted, the command queries the contents of the current directory, to be set and queried with `MMEMory:CDIRectory`.

Return values:

<FileEntryCount> Number of parent and subdirectories.

Example: `MMEM:DCAT:LENG?`
`5`

Usage: Query only

MMEMory:CDIRectory [<DirectoryName>]

Changes the default directory for file access.

Parameters:

<DirectoryName> String parameter to specify the directory. If the string also contains a drive letter or network server name, the command `MMEMory:MSIS` is executed implicitely.

*RST: "\"

Example: `MMEM:CDIR 'C:\USER\DATA'`

Usage: SCPI confirmed

MMEMory:MDIRectory <DirectoryName>

Creates a new directory with the specified name.

Setting parameters:

<DirectoryName> String parameter to specify the new directory. If the path consists of several subdirectories, the complete tree will be created if necessary. If no drive letter or server name is indicated, the directory is created on the default soreage device specified with `MMEMory:MSIS`.

Example: `MMEM:MDIR 'C:\USER\DATA'`

Usage: Setting only

MMEMory:RDIRectory <DirectoryName>

Deletes the specified directory.

Setting parameters:

<DirectoryName> String parameter to specify the directory to be deleted.

Example: `MMEM:RDIR 'C:\USER\TEST'`

Usage: Setting only

MMEMory:CATalog? [<PathName>][, <Format>]

Returns the a list of files contained in the specified directory. The result corresponds to the number of files returned by the MMEMory:CATalog:LENgth command.

Query parameters:

<PathName> String parameter to specify the directory. If the directory is omitted, the command queries directory specified with `MMEMory:CDIRectory`.

<Format> ALL | WTIMe

ALL: Extended result including file, date, time and attributes
WTIMe: Extended result including file, date, time

Return values:

<UsedMemory> Total amount of storage currently used in the directory, in bytes.

<FreeMemory> Total amount of storage available in the directory, in bytes.

<FileEntry> All files and subdirectories of the directory are listed with their file name, format and size in bytes. The first two strings are related to the parent directory.

Example:

```
MMEM:CAT 'C:\USER\DATA'?
529479,1831777894400,".,DIR,0","..,DIR,0",
"Backup,DIR,0","CSS,DIR,0","DATEN,DIR,0",
"Commands.jar,BIN,529479","FAVORITES,DIR,0",
"LOG,DIR,0","DATA,DIR,0","test,DIR,0",
"TotalCMD,DIR,0"
```

Usage: Query only
SCPI confirmed

MMEMory:CATalog:LENGth? [<PathName>]

Returns the number of files and subdirectories of the current or specified directory. The number includes the parent directory strings "." and ".." and it corresponds to the number of <FileEntry> strings returned by the `MMEMory:CATalog?` command.

Query parameters:

<PathName> String parameter, directory to be queried. If the directory is omitted, the current directory is queried, specified with `MMEMory:CDIRectory`.

Return values:

<Count> Number of files and subdirectories including parent directory entries.

Example:

```
MMEM:CAT:LENG?
11
```

Usage: Query only

MMEMory:COPY <FileSource>[, <FileDestination>]

Copies an existing file to a new file.

Setting parameters:

<FileSource> String parameter, contains name and path of the file to be copied. Wildcards (* and ?) are allowed.

<FileDestination> String parameter, contains name and path of the new file. If the file already exists, it is overwritten without notice. If no file destination is specified, the source file is written to the current directory specified with MMEMory:CDIRectory.

Example:

```
MMEM:COPY 'C:\Users\Public\Documents
\Rohde-Schwarz\RTx\RefWaveforms
\RefCurve_2011-03-16*.bin','E:'
```

Copies all reference waveforms saved on March 16, 2011 to an external storage medium, mapped to drive `E:\`.

Usage: Setting only
SCPI confirmed

MMEMory:MOVE <FileSource>, <FileDestination>

Moves the specified file to a new location on the same drive and renames it.

Setting parameters:

<FileSource> String parameter, contains name and path of the file to be copied.
Wildcards (* and ?) are allowed. Therefore, specify a directory for <FileDestination>. Renaming is not possible.

<FileDestination> String parameter, contains name and path of the new file. If no path is specified, the <FileSource> directory is used - the file is renamed.

Example:

```
MMEM:MOVE 'C:\USER\DATA\SETUP.CFG','C:\STORE'
```

Moves the file "Setup.cfg" from the directory `C:\USER\DATA` to `C:\STORE`.

Usage: Setting only
SCPI confirmed

MMEMory:DELete <FileName>

Removes the specified file(s). To delete directories, use MMEMory:RDIRectory.

Setting parameters:

<FileName> String parameter to specify the name and directory of the file to be removed. Wildcards (* and ?) are allowed.
If no path is defined, the current directory is used, specified with MMEMory:CDIRectory.

Example:

```
MMEM:DEL '*.CFG’
```

Deletes all cfg files from the current directory.

Usage: Setting only
SCPI confirmed

MMEMory:DATA <FileName>, <Data>
MMEMory:DATA? <FileName>

Stores data in the specified file to the storage location specified using `MMEMory:CDIRectory`.

Parameters:

<Data> <block>

488.2 block data format. The delimiter EOI must be selected to achieve correct data transfer.
The block begins with character '#'. The next digit is the length of the length information, followed by this given number of digits providing the number of bytes in the following binary data.

Parameters for setting and query:

<FileName> String parameter, the name of the file the data is stored to.

Example: `MMEM:DATA 'abc.txt', #216This is the file`
#2: the length infomation has two digits
16: the binary data has 16 bytes

Example: `MMEM:DATA? 'abc.txt'`
Returns the data from file `abc.txt`.

MMEMory:ATTRibute <FileName>, <Attributes>
MMEMory:ATTRibute? <FileName>

Sets file attributes for the specified file(s). The command can be used for files only.

Setting parameters:

<Attributes> String with attributes and setting information.
'+' before the attribute: sets the attribute
'-' before the attribute: deletes the attribute
'R': read only
'A': archive file
'S': system file
'H': hidden file

Parameters for setting and query:

<FileName> String parameter, contains name and path of the file. Wildcards (* and ?) are allowed.

Return values:

<FileEntry> String containing: "<file_name>,<file_attributes>"

Example: `MMEM:ATTR 'C:\USER\DATA\*.LOG', '-R -A'`
Deletes the read-only and archive attributes from all LOG files in the directory`C:\USER\DATA\*.LOG`.

Example:
```
MMEM:ATTR? 'C:\USER\DATA\*.*'
"Datei1.LOG,A", "Datei2.LOG,A",
"Datei3.LOG,ASH", "Datei4.DLL,RSH",
"Datei5.INI,SH"
```

MMEMory:SAV <FileDestination>

Stores the current instrument settings to the specified file.

This command has the same effect as the combination of `*SAV` and `MMEMory:STORe:STATe`.

Parameters:

<FileDestination> String parameter specifying path and filename of the target file. Wildcards are not allowed.

Example: `MMEM:SAV 'C:\mysavefile.dfl'`
Saves the current instrument settings to the file `mysavefile.dfl` located in the directory C:\.

Usage: Event

MMEMory:RCL <FileSource>

Restores the instrument settings from the specified file.

This command has the same effect as the combination of `MMEMory:LOAD:STATe` and `*RCL`.

Parameters:

'<FileSource>' String parameter specifying the path and filename of the source file. Wildcards are not allowed.

Example: `MMEM:RCL 'C:\mysavefile.dfl'`
Loads and activates the instrument settings from the file `mysavefile.dfl` located in the directory C:\.

Usage: Event

MMEMory:STORe:STATe <MemoryNumber>, <FileName>

Stores the instrument settings from the specified internal memory to the specified file. To store the current instrument settings to the internal memory, use `*SAV` first.

Setting parameters:

<MemoryNumber> Number of the internal memory

Range: 1 to 99

<FileName> String parameter specifying the complete path and filename of the source file.

Example:
```
*SAV 4
MMEM:STORe:STATe 4,'C:
\Settings\Settings_1051.dfl'
```
Saves current instrument settings to the internal memory number 4. Then stores the settings from the internal memory number 4 to the file `C:\Settings\Settings_1051.dfl`.

Usage: Setting only

MMEMory:LOAD:STATe <MemoryNumber>, <FileName>

Loads the instrument settings from the specified file to the specified internal memory. After the file has been loaded, the settings must be activated using a `*RCL` command.

Setting parameters:

<MemoryNumber> Number of the internal memory

Range: 1 to 99

<FileName> String parameter specifying the complete path and filename of the source file.

Example:

```
MMEM:LOAD:STATe 4,'C:
\Settings\Settings_1051.dfl'
*RCL 4
```

Loads instrument settings from the file `C:\Settings\Settings_1051.dfl` to the internal memory number 4, and then activates the settings in internal memory number 4.

Usage: Setting only

20.16.2 Savesets and One File

SAVeset:CONFig:PREView <Include>

If set to OFF, the saveset is stored without the preview image to reduce the file size.

Use the command each time before you save a saveset.

Parameters:

<Include> ON | OFF

*RST: ON

SAVeset:ONEFile:NAME <Name>

Sets the path and the file name of the One File. The file format is ZIP.

Parameters:

<Name> String parameter

SAVeset:ONEFile:OPEN

Loads the One File that is specified with `SAVeset:ONEFile:NAME`.

Usage: Event

SAVeset:ONEFile:SAVE

Usage: Event

Saves the One File data to the file that is specified with SAVeset:ONEFile:NAME.

20.16.3 Autonaming

MMEMory:AUTonaming:PREFix <State>
MMEMory:AUTonaming:USERtext <State>
MMEMory:AUTonaming:DATE <State>
MMEMory:AUTonaming:INDex <State>
MMEMory:AUTonaming:TIME <State>

Includes or excludes the name part in the file name pattern for automatic file name generation. This name is used as the default file name.

The prefix indicates the type of data that is saved, for example, Histogram, RefCurve, Settings.

To define a user text, use MMEMory:AUTonaming:TEXT.

Parameters:
<State> ON | OFF
*RST: ON

MMEMory:AUTonaming:TEXT <NameString>

Defines a text, that can be included in the autonaming pattern.

Parameters:
<NameString> String parameter

MMEMory:AUTonaming:DEFaultpath <Path>

Sets the path where data and settings files will be stored. The factory default path is:

- `"C:\Users\Public\Documents\Rohde-Schwarz\RTx"` if no USB flash drive is connected

- Drive letter of the USB flash drive, for example, `"E:\"` or `"F:\"` if a USB flash drive is connected.

Parameters:

<Path> String parameter

MMEMory:AUTonaming:RESPath

Resets the path for file operations to the factory default path.

Usage: Event

MMEMory:AUTonaming:RESall

Resets all autonaming settings to the default value, including the path.

Usage: Event

20.16.4 Waveform Data Transmission

The R&S RTP provides specific data export commands for the various waveform types. The commands transmit the data of the waveform points from the instrument to the controlling computer. The data can be used in MATLAB, for example.

The commands are described in the relevant chapters:

- Analog waveforms: Chapter 20.8.6, "Waveform Data", on page 1015
- Reference waveforms: Chapter 20.10.2.3, "Waveform Data Export", on page 1110
- Math waveforms: Chapter 20.10.3, "Mathematics", on page 1113
- Spectrum waveforms: Chapter 20.13.2, "Waveform Data", on page 1211
- Logic channels: Chapter 20.18.5, "MSO Data ", on page 1803

20.16.5 Waveform Data Export to File

The resulting files of waveforms exports are described in Chapter 11.2.1, "Waveform Export Files", on page 429.

The export settings for manual operation are explained in Chapter 11.2.2, "Waveforms - Export Settings", on page 435.

EXPort:WAVeform:SOURce <Source>

Selects the waveform to be exported to file.

The commands takes effect if `EXPort:WAVeform:MULTichannel` is `OFF`.

Parameters:

<Source> C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15 | MSOB1 | MSOB2 | MSOB3 | MSOB4 | TRK1 | TRK2 | TRK3 | TRK4 | TRK5 | TRK6 | TRK7 | TRK8 | Z1V1 | Z1V2 | Z1V3 | Z1V4 | Z1I1 | Z1I2 | Z1I3 | Z1I4 | Z2V1 | Z2V2 | Z2V3 | Z2V4 | Z2I1 | Z2I2 | Z2I3 | Z2I4

*RST: C1W1

Example: See Chapter 20.3.5.2, "Exporting Waveform Data to File", on page 961

EXPort:WAVeform:MULTichannel <MltChXpt>

Enables or disables the multichannel export.

If you enable the multichannel export, all active channels are included to the export data. You can change the export state using the `CHANnel<m>:EXPortstate` command.

If multichannel export is disabled, select the waveform to be exported using the `EXPort:WAVeform:SOURce` command.

Note that `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?` returns the data of all channels that are selected for export, no matter of the channel suffix.

Parameters:

<MltChXpt> ON | OFF

*RST: OFF

CHANnel<m>:EXPortstate <ExportState>

Includes or excludes the indicated channel in waveform export. The data of channel waveform 1 is exported.

The commands takes effect if `EXPort:WAVeform:MULTichannel` is `ON`.

Suffix:

<m> 1..4
Selects the input channel.

Parameters:

<ExportState> ON | OFF

If you enable the multichannel export, the export state of all active channels is automatically set ON.

*RST: OFF

EXPort:WAVeform:NAME <FileName>

Sets the file name, file format and path to save the waveform to.

See also: Chapter 11.2.1, "Waveform Export Files", on page 429

Parameters:

<FileName> String with path and file name with extension .xml, .bin, or .csv

Example:
```
EXPort:WAVeform:NAME 'C:\temp\Export_Ch11.xml'
EXPort:WAVeform:SAVE
```
Saves the waveform data in XML format to `C:\temp\Export_Ch1.xml`.

Example:
```
EXPort:WAVeform:NAME 'C:\temp\Export_Ch2.bin'
EXPort:WAVeform:SAVE
```
Saves the waveform data in binary format to `C:\temp\Export_Ch2.bin`.

Firmware/Software: V 1.25

EXPort:WAVeform:SAVE

Saves the waveform(s) to the file specified with `EXPort:WAVeform:NAME`. The file format is also set using the `...NAME` command.

Example: See Chapter 20.3.5.2, "Exporting Waveform Data to File", on page 961

Usage: Event

Firmware/Software: V 1.25

EXPort:WAVeform:SCOPe <Scope>

Defines the part of the waveform record that has to be stored.

Parameters:

<Scope> WFM | ZOOM | CURSor | GATE | MANual

WFM
Complete waveform

ZOOM
Data included in the zoom area if a zoom is defined for the source waveform.

CURSor
Data between the cursor lines if a cursor measurement is defined for the source waveform.

GATE
data included in the measurement gate if a gated measurement is defined for the source waveform.

MANual
Saves the data between user-defined start and stop values to be set with EXPort:WAVeform:STARt and EXPort:WAVeform:STOP.

*RST: WFM

Example: See Chapter 20.3.5.2, "Exporting Waveform Data to File", on page 961

Firmware/Software: V 1.25

EXPort:WAVeform:STARt <Start>

Sets the start value of the waveform section for export, if EXPort:WAVeform:SCOPe is set to Manual.

Parameters:

<Start>
Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01
Default unit: s

Firmware/Software: V 1.25

EXPort:WAVeform:STOP <Stop>

Sets the end value of the waveform section for export, if EXPort:WAVeform:SCOPe is set to Manual.

Parameters:

<Stop>
Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01
Default unit: s

Firmware/Software: V 1.25

EXPort:WAVeform:ZOOM <ZoomDiagram>

Sets the zoom area to be used for limited data export if EXPort:WAVeform:SCOPe is set to ZOOM.

Parameters:
<ZoomName> Name of the zoom diagram

Parameters for setting and query:
<DiagramName> Name of the diagram on which the zoom area is based.

Example: See "Exporting Interleaved x/y Data of a Zoom to CSV File" on page 963

Firmware/Software: V 1.25

EXPort:WAVeform:CURSorset <Cursorset>

Sets the cursor set to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `CURSor`.

Parameters:
<Cursorset> CURSOR1 | CURSor1 | CURSOR2 | CURSor2 | CURSOR3 | CURSor3 | CURSOR4 | CURSor4

CURSOR1 = CURSor1, CURSOR2 = CURSor2, CURSOR3 = CURSor3, CURSOR4 = CURSor4

Firmware/Software: V 1.25

EXPort:WAVeform:MEAS <MeasGate>

Sets the gate to be used for limited data export if `EXPort:WAVeform:SCOPe` is set to `GATE`.

Parameters:
<MeasGate> MEAS1 | MEAS2 | MEAS3 | MEAS4 | MEAS5 | MEAS6 | MEAS7 | MEAS8

Measurement for which the gate is defined.

Example: See "Exporting Raw Data of a Measurement Gate to BIN File" on page 962

Firmware/Software: V 1.25

EXPort:WAVeform:DLOGging <DataLogging>

The command enables the export of subsequent acquisitions of the selected waveforms. The waveforms are taken from a running Nx Single acquisition (data logging, history is disabled), or from the history (multiple waveforms, history is enabled).

If the history is disabled (`CHANnel<m>[:WAVeform<n>]:HISTory[:STATe]`) and data logging is enabled, a specified number of waveforms is transferred to file directly during RUN Nx SINGLE acquisition. Enabling data logging stops a running acquisition. Set the number of acquisitions to be acquired and stored with `ACQuire:COUNt` and start export using `RUNSingle`.

If the history is enabled, the subsequent waveforms are taken from the history. Specify the range with `CHANnel<m>[:WAVeform<n>]:HISTory:STARt` and `CHANnel<m>[:WAVeform<n>]:HISTory:STOP`. Then play the history with `CHANnel<m>[:WAVeform<n>]:HISTory:PLAY`.

The commands `EXPort:WAVeform:SAVE`, `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?` and `CHANnel<m>[:WAVeform<n>]:DATA:HEADer?` are not available if data logging is enabled. The `RUNContinous` command disables data logging.

If data logging is off, and the history is enabled, one waveform out of the history is written to file. Specify the waveform using `CHANnel<m>[:WAVeform<n>]:HISTory:CURRent` and save it using `EXPort:WAVeform:SAVE`.

Parameters:

<DataLogging> ON | OFF

*RST: OFF

Example: See:
"Exporting Multiple Running Acquisitions of a Single Waveform to XML File" on page 963
"Exporting Multiple Acquisition of the History to XML File" on page 964
"Exporting a Single Acquisition of the History to BIN File" on page 964

Firmware/Software: V 1.25

EXPort:WAVeform:TIMestamps <UseTimestamps>

Exports the relative timestamps of all history waveforms to the waveform data file. The time is written at the beginning of each waveform record.

Parameters:

<UseTimestamps> ON | OFF

*RST: OFF

EXPort:WAVeform:INCXvalues <IncHorValues>

Includes horizontal values in the retrieved data (time or frequency values, depending on the waveform). X and Y-values are written alternately to the file. If disabled, only Y-values - mostly voltage values - are written. The X-values are always returned in 64 bit real format, regardless of the defined data format.

The setting is not available for the export of raw data.

The command affects the content of export files as well as data retrieved with:

- `CHANnel<m>[:WAVeform<n>]:DATA[:VALues]?`
- `CALCulate:MATH<m>:DATA[:VALues]?`
- `REFCurve<m>:DATA[:VALues]?`

Parameters:

<IncHorValues> ON | OFF

*RST: OFF

Example: See:
"Exporting Interleaved x/y Data of a Single Waveform to CSV File" on page 963
"Exporting Interleaved x/y Data of a Zoom to CSV File" on page 963

Firmware/Software: FW 1.40

EXPort:WAVeform:RAW <RawValues>

Enables the export of raw sample data, and sets the data format to integer 8 bit. In high definition acquisition mode, the data format is integer 16 bit (option R&S RTP-K17). Fot INT16, you can set the byte order using the `FORMat:BORDer` command.

The raw format reduces the file size but changes also the precision of the values.

The setting is not available for the export of digital channel data and for the export of interleaved X/Y values.

Parameters:

<RawValues> ON | OFF

*RST: OFF

Example: See:
"Exporting Raw Data of a Single Waveform to BIN File" on page 962
"Exporting Raw Data of a Measurement Gate to BIN File" on page 962

Firmware/Software: FW 1.40

EXPort:WAVeform:FASTexport <Enable>

To improve the performance of data export to file, the measurements are performed slower while the data export speeds up.

Setting parameters:

<Enable> ON | OFF

Example: See Chapter 20.3.5.2, "Exporting Waveform Data to File", on page 961

Usage: Setting only

Firmware/Software: V 1.47

20.16.6 Waveform Histogram Export to File

EXPort:HISTogram:SELect <Name>

Selects the histogram to be exported.

Parameters:
<Name> String with the histogram name.

Example: See "Exporting Histogram Data to File" on page 958

Firmware/Software: V 1.47

EXPort:HISTogram:INCidence <Incidence>

Sets the mode of exported data: relative or absolute frequency of amplitude values.

Parameters:
<Incidence> ABS | REL
*RST: REL

Example: See "Exporting Histogram Data to File" on page 958

Firmware/Software: V 1.47

EXPort:HISTogram:NAME <Path>

Sets the file name and path to save the histogram to.

Parameters:
<Path> String with path and file name. The file extension defines the file format: XML, CSV, or BIN.

Example: See "Exporting Histogram Data to File" on page 958

Firmware/Software: V 1.47

EXPort:HISTogram:SAVE

Saves the histogram to the file specified with `EXPort:HISTogram:NAME`.

Example: See "Exporting Histogram Data to File" on page 958

Usage: Event

Firmware/Software: V 1.47

EXPort:HISTogram:DATA?

Transfers the histogram data to the controlling computer. The data can be used in MATLAB, for example.

To set the export data format, use `FORMat[:DATA]`.

Return values:

<Data>	List of values according to the format settings and `EXPort:HISTogram:INCidence`. See also: Chapter 11.2.3, "Waveform Histogram", on page 440
Example:	See "Transferring Histogram Data" on page 958
Usage:	Query only
Firmware/Software:	V 1.47

20.16.7 Numeric Results

EXPort:RESult:SELect <Item>, [<STATe>]
EXPort:RESult:SELect? <Item>

Select the results that you want to save to file. All results are written into one file. To save several result boxes into one file, use the command several times, one command for each result box.

Parameters:

<STATe>	ON | OFF

Parameters for setting and query:

<Item>	String parameter, contains the name of the result box as written in the "Numeric Results" dialog box.
Example:	`EXPort:RESult:SELect 'Meas Results',1` Selects the 'Meas Results' box for export of numeric values.

EXPort:RESult:DELimiter <Delimiter>

Selects the value delimiter that is used to convert the values in columns. For MS Excel, the semicolon is recommended to be used.

Parameters:

<Delimiter>	SEMICOLON | COMMA | SPACE | TAB | COLON *RST: COMMA

EXPort:RESult:NUMeric <Numeric>

If ON, the result values are saved without unit and with more decimal places.

Parameters:
<Numeric> ON | OFF
*RST: OFF

EXPort:RESult:NAME <ExportFilename>

Sets the path, the file name, and the file format for the numeric results file. Available file formats are CSV and HTML.

Parameters:
<ExportFilename> String parameter

EXPort:RESult:SAVE

Saves the selected result boxes to the file that is specified with `EXPort:RESult:NAME`.

Usage: Event

20.16.8 Long Term Measurement Results and Measurement Histogram Export to File

EXPort:MEASurement:SELect <SelcMeas>

Selects the measurement for export of long term or measurement histogram data.

Parameters:
<SelcMeas> MEAS1 | MEAS2 | MEAS3 | MEAS4 | MEAS5 | MEAS6 | MEAS7 | MEAS8
*RST: MEAS1

Example: See "Exporting Long Term Measurement Data to File" on page 959

Firmware/Software: V 1.47

EXPort:MEASurement:TYPE <ExportType>

You can export the result data of the long term measurement, or the measurement histogram, or the track data.

To export the measurement histogram, it must be enabled using `MEASurement<m>:STATistics:HISTogram`.

To export the long term results, the long term measurement must be enabled using `MEASurement<m>:LTMeas[:STATe]`.

To export a track, the track must be enabled before. Track measurements require an option, see "Enable (Track)" on page 338.

Parameters:

<ExportType>	LONGterm | HISTogram | TRACk LONGTERM = LONGterm, HISTOGRAM = HISTogram *RST: HISTOGRAM
Example:	See "Exporting Long Term Measurement Data to File" on page 959
Firmware/Software:	V 1.47

EXPort:MEASurement:NAME <Path>

Sets the file name and path to save the long term or measurement histogram data to.

Parameters:

<Path>	String with path and file name. The file extension defines the file format: XML, CSV, or BIN.
Example:	See "Exporting Long Term Measurement Data to File" on page 959
Firmware/Software:	V 1.47

EXPort:MEASurement:SAVE

Saves the long term or measurement histogram results to the file specified using `EXPort:MEASurement:NAME`.

The measurement data can be exported as absolute or relative values, which is defined using `EXPort:HISTogram:INCidence`.

Example:	See "Exporting Long Term Measurement Data to File" on page 959
Usage:	Event
Firmware/Software:	V 1.47

EXPort:MEASurement:DATA?

Transfers the long term measurement data to the controlling computer. The data can be used in MATLAB, for example.

To set the export data format, use `FORMat[:DATA]`.

Return values:

<Data> List of values according to the format settings
Long term data:
If statistics are enabled (`MEASurement<m>:STATistics[:ENABle]`), six values for each long term point are returned: maximum, minimum, average, standard deviation, number of measured results per long term point, number of waveforms per long term point.
If statistics are disabled, the current value of each long term point is returned.
For measurement histograms, absolute values are returned.
See also: Chapter 11.2.5, "Result Analysis", on page 444

Example: See "Transferring Long Term Measurement Data" on page 959

Usage: Query only

Firmware/Software: V 1.47

20.16.9 Screenshots

The HCOPy subsystem and some other commands control the output of display information for documentation purposes on output devices (printer and clipboard) or files (also for report files). The instrument allows two independent output configurations which can be set separately with the suffix.

Note that the remote mode is intended for maximum performance. Therefore, the display does not follow the remote commmands consistantly. To get a correct screenshot, turn the display on using `SYST:DISP:UPD ON`.

HCOPy:DESTination<1..2> <Medium>

Selects the output medium: file, printer or clipboard.

Suffix:
<1..2> Selects the output configuration.

Parameters:
<Medium> MMEM | SYST:COMM:PRIN | SYST:COMM:CLIP

String parameter

MMEM
Directs the display image to a file. The `MMEMory:NAME` command defines the file name. The file format is defined with `HCOPy:DEVice<m>:LANGuage`.

SYST:COMM:PRIN
Directs the display image to the printer. The printer is selected with the `SYSTem:COMMunicate:PRINter:SELect<1..2>` command. The `HCOPy:DESTination` command should always be sent after setting the printer.

SYST:COMM:CLIP
Directs the hardcopy to the clipboard.

*RST: SYST:COMM:CLIP

Example: `HCOP:DEST 'SYST:COMM:PRIN'`
See also Chapter 20.3.5.1, "Saving a Screenshot to File", on page 961

MMEMory:NAME <FileName>

Defines the file name when an image of the display is stored to a file rather than printed to a printer using the `HCOPy:IMMediate<m>[:DUM]` command.

Setting parameters:
<FileName> String parameter specifiying path and file name of the screenshot

Example: See Chapter 20.3.5.1, "Saving a Screenshot to File", on page 961

Usage: Setting only
SCPI confirmed

HCOPy:DEVice<m>:LANGuage <FileFormat>

Defines the file format for output of the display image to file.

To set the output to file, use `HCOPy:DESTination<1..2>` with parameter `'MMEM'`.

Suffix:
<m> 1..2
Selects the output configuration.

Parameters:
<FileFormat> PNG | JPG | BMP | TIFF | PDF

*RST: PNG

Example: See Chapter 20.3.5.1, "Saving a Screenshot to File", on page 961

HCOPy:PAGE:ORIentation<1..2> <Orientation>

Defines the page orientation for output of the display image to a printer.

To set the output to printer, use `HCOPy:DESTination<1..2>` with parameter `'SYST:COMM:PRIN'`.

Suffix:
1..2 — Selects the output configuration.

Parameters:
<Orientation> — PORTrait | LANDscape
*RST: LANDscape

HCOPy:DEVice<m>:COLor <Color>

Selects between color and monochrome printing of the display image.

To set the output to printer, use `HCOPy:DESTination<1..2>` with parameter `'SYST:COMM:PRIN'`.

Suffix:
<m> — 1..2
Selects the output configuration.

Parameters:
<Color> — ON | OFF
ON: Color output
OFF: Black and white output
*RST: ON

HCOPy:DEVice<m>:INVerse <InverseColor>

Inverts the colors of the output, i.e. a dark waveform is printed on a white background.

See also:
- `HCOPy:WBKG` on page 1294
- "White background" on page 451

Suffix:
<m> — 1..2
Selects the output configuration.

Parameters:
<InverseColor> — ON | OFF
*RST: ON

Firmware/Software: V 1.27

HCOPy:WBKG <WhiteBackground>

Inverts the background color. So you can print waveforms with normal waveform colors on white background.

If both `HCOPy:WBKG` and `HCOPy:DEVice<m>:INVerse` are ON, the instrument inverts the background twice, and it appears black.

See also: "White background" on page 451.

Parameters:

<WhiteBackground>	ON | OFF	
	*RST:	OFF

HCOPy:CMAP<m>:DEFault <PrintColorSet>

Defines the default color set for printing of the display image.

To set the output to printer, use `HCOPy:DESTination<1..2>` with parameter `'SYST:COMM:PRIN'`.

Suffix:

<m> — 1..2
Selects the output configuration.

Parameters:

<PrintColorSet> — DEF1 | DEF4

DEF1
Current screen colors with white background and black grid.

DEF4
Current screen colors without any changes (black background).

*RST: DEF1

HCOPy:SSD <ShowSetupDialog>

Enables or disables the display of open dialog boxes in screenshots. Use this command if you want to document settings in screenshots.

Parameters:

<ShowSetupDialog>	ON | OFF	
	*RST:	OFF

Firmware/Software: FW 3.20

HCOPy:ISBA IncludeSignalBar

If OFF, the screenshot shows only the diagram area, without the sidebar.

Parameters:

IncludeSignalBar	ON | OFF	
	*RST:	ON

HCOPy:IMMediate<m>[:DUM]

Starts the immediate output of the display image to printer, file, or clipboard, depending on the `HCOPy:DESTination<1..2>` setting.

To get a correct screenshot of the diagrams, results, and dialog boxes, turn on the display using `SYST:DISP:UPD ON`.

Suffix:

<m> 1..2
Selects the output configuration.

Example:
```
SYST:DISP:UPD ON
HCOP:DEST 'MMEM'
MMEM:NAME 'C:\Temp\Print.bmp'
HCOP:IMMediate; *OPC?
```

Example: See Chapter 20.3.5.1, "Saving a Screenshot to File", on page 961

Usage: Event
Asynchronous command

HCOPy:IMMediate<m>:NEXT

Starts the output of the next display image to printer, file, or clipboard, depending on the `HCOPy:DESTination<1..2>` setting.

If the output is printed to a file, the file name used in the last saving process is automatically counted up to the next unused name.

Suffix:

<m> 1..2
Selects the output configuration.

Example: See Chapter 20.3.5.1, "Saving a Screenshot to File", on page 961

Usage: Event
Asynchronous command

SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?

Queries the name of the first printer in the list of printers that is configured in the Windows operating system.

To query the names of other installed printers, use the `SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]?` command.

Return values:

<PrinterName> If no printer is configured an empty string is returned.

Usage: Query only

SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]?

Queries the name of the next printer that is configured in the Windows operating system.

Before you send the ...NEXT command, send `SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?` to return to the beginning of the printer list and query the name of the first printer.

Return values:

<PrinterName> After all available printer names have been returned, an empty string enclosed by quotation marks (") is returned for the next query. Further queries are answered by a query error.

Usage: Query only

SYSTem:COMMunicate:PRINter:SELect<1..2> <PrinterName>

Selects a configured printer.

Parameters:

<PrinterName> Enter the string as it is returned with `SYSTem:COMMunicate:PRINter:ENUMerate:FIRSt?` or `SYSTem:COMMunicate:PRINter:ENUMerate[:NEXT]?`.

20.16.10 Reports

The following commands configure and save report files. To configure the screenshot that is included in the report, use the commands explained in Chapter 20.16.9, "Screenshots", on page 1291.

REPort:LANGuage <Language>

Sets the language to be used in the report. Available languages are listed in the data sheet.

Parameters:

<Language> String with the english language name, upper case.

Example: `REPort:LANGuage 'Spanish'`

REPort:PAPersize <PaperSize>

Selects the paper size: A4 or US Letter.

Parameters:

<PaperSize> A4 | USL

*RST: A4

REPort:LOGType <Logo>

By default, the Rohde & Schwarz logo is shown in the header of the report pages. You can switch the logo off, or select your logo to be shown.

Parameters:

<Logo> RS | CUST | NONE

CUST
Select the logo file using `REPort:LOGO`.

*RST: RS

REPort:LOGO <LogoFile>

Defines the logo file that is used on the report if `REPort:LOGType` is set to `CUSTom`.

Parameters:

<LogoFile> String with the path and filename of the logo image.

Example: `REPort:LOGO 'C:\Company files\logo.jpg'`

REPort:USER <User>

Enter the user name that appears in the general information section at the beginning of the report.

Parameters:

<User> String parameter

REPort:COMMent <Comment>

Enter a comment that appears in the general information section at the beginning of the report.

Parameters:

<Comment> String parameter

REPort:FILE:NAME <ReportFile>

Sets the file name and path to save the report to.

Parameters:
<ReportFile> String with path and file name. The file extension defines the file format: PDF, HTML, or DOC.

REPort:FILE:SAVE

Saves the report to the specified file.

Usage: Event
Asynchronous command

20.17 Protocols

20.17.1 Configuration Settings for all Serial Protocols

BUS<m>:TYPE <Type>

Defines the bus or protocol type for analysis.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Type> I2C | SPI | UART | CAN | CANFd | LIN | MDIO | USB | USBPD | ETHernet | CMSB | RFFE | DPHY | MPHY | EBTB | USB3 | PCIE | DDR3

CMSB: custom decode serial bus (option R&S RTP-K50)
EBTB: 8b/10b general decoding (option R&S RTP-K52)

*RST: I2C

Usage: Asynchronous command

BUS<m>[:STATe] <State>

Enables the decoding of the specified bus.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<State> ON | OFF

*RST: OFF

Usage: Asynchronous command

BUS<m>:SETReflevels

Executes the measurement of reference levels and sets the thresholds to the middle reference level of the measured amplitude.

Suffix:

<m> 1..4
Selects the serial bus.

Usage: Event
Asynchronous command

Firmware/Software: FW 1.45

BUS<m>:LABel <Label>

Defines a label to be displayed with the bus.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Label> String containing the label text.

Usage: Asynchronous command

BUS<m>:RESult <ShowResultTable>

Opens a table with decoded data of the serial signal. The function affects all protocol types and requires the option for the analyzed protocol.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ShowResultTable> ON | OFF
*RST: OFF

Usage: Asynchronous command

BUS<m>:THReshold <ShwThresLines>

If ON, the threshold levels are displayed in the diagram.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ShwThresLines> ON | OFF
*RST: OFF

Usage: Asynchronous command

BUS<m>:RESDetail <ShwResDetails>

Shows detailed information for the frames.

The command is relevant for FlexRay, D-PHY, M-PHY, Ethernet, CXPI, and Custom protocols.

Suffix:

<m> 1..4

Parameters:

<ShwResDetails> ON | OFF
*RST: OFF

Usage: Asynchronous command

Firmware/Software: FW 3.40

BUS<m>:FORMat <DataFormat>

Sets the number format for decoded data values of the indicated bus. It defines the format in the "Decode table" and in the combs of the decoded signal.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataFormat>	HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG ASCII = ASCii SYMB = Symbolic, only available for CAN and CAN FD if a DBC label list is applied. *RST: HEX

BUSFormat <DataFormat>

Sets the number format for decoded data values in the "Decode table" and on the display for all parallel and serial buses.

For serial buses, the command overwrites the the bus-specific format setting `BUS<m>:FORMat`.

For parallel buses, the command sets also the number representation for data export. In case of export to BIN file or remote data transfer, SIGN returns signed values, and all other formats return unsigned values.

Parameters:

<DataFormat>	HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG ASCII = ASCii *RST: HEX
Usage:	Asynchronous command
Firmware/Software:	FW 1.45

BUS<m>:NEWList <FileName>

Loads a label list file.

Suffix:

<m>	1..4 Selects the serial bus.

Setting parameters:

<FileName>	String parameter with path and file name.
Example:	`BUS1:NEWList 'C:\Protocols\CAN.csv'` `BUS1:SYMBols ON`
Usage:	Setting only

BUS<m>:SYMBols <UseTranslation>

Activates the lable list to be used for decoding.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<UseTranslation> ON | OFF
*RST: OFF

Usage: Asynchronous command

Firmware/Software: FW 1.36

20.17.2 Trigger Settings for all Serial Protocols

The following commands are available for all serial protocols that have a protocol trigger.

TRIGger<m>:SOURce <SourceDetailed>

Selects the source of the trigger signal.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event
Available values depend on the selected trigger source. For input channels CHAN1...4, a trigger sequence can be configured.
For all other trigger sources, only suffix 1 is allowed.
See also: `TRIGger<m>:SEQuence:MODE`

Parameters:

<SourceDetailed> CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 | EXTernanalog

CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4
Input channels

EXTernanalog
External analog signal connected to the External Trigger Input.
For this source, only the analog edge trigger is available.

SBUS
Serial bus

D0...D15
Digital channels (option R&S RTP-B1)
See also: Chapter 20.18.4, "Trigger Settings for Digital Signals and Parallel Buses", on page 1795

LOGIc
Logic combination of digital channels, used as trigger source (option R&S RTP-B1)

MSOB1 | MSOB2 | MSOB3 | MSOB4
Parallel bus (option R&S RTP-B1)

*RST: CHAN1

TRIGger<m>:SOURce:SBSelect <SerialBus>

Selects the serial bus to be triggered on.

Suffix:
<m> 1..3
Event in a trigger sequence: 1 = A-event only

Parameters:
<SerialBus> SBUS1 | SBUS2 | SBUS3 | SBUS4

Firmware/Software: Version 2.70

BUS<m>:TYPE <Type>

Defines the bus or protocol type for analysis.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<Type> I2C | SPI | UART | CAN | CANFd | LIN | MDIO | USB | USBPD | ETHernet | CMSB | RFFE | DPHY | MPHY | EBTB | USB3 | PCIE | DDR3

CMSB: custom decode serial bus (option R&S RTP-K50)
EBTB: 8b/10b general decoding (option R&S RTP-K52)

*RST: I2C

Usage: Asynchronous command

20.17.3 I²C (Option R&S RTP-K1)

20.17.3.1 Configuration

BUS<m>:I2C:SCL:SOURce <SCLSource>

Sets the waveform of the clock line.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<SCLSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15
Digital and analog channels cannot be used at the same time for data and clock lines.
See Chapter 20.4.2, "Waveform Parameter", on page 970
*RST: C2W1

Usage: Asynchronous command

BUS<m>:I2C:SDA:SOURce <SDASource>

Sets the waveform of the data line.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<SDASource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15
Digital and analog channels cannot be used at the same time for data and clock lines.
See Chapter 20.4.2, "Waveform Parameter", on page 970
*RST: C1W1

Usage: Asynchronous command

BUS<m>:I2C:SCL:THReshold <SCLThreshold>

Sets a user-defined threshold value for the clock line.

Alternatively, you can set the threshold according to the signal technology with BUS<m>:I2C:TECHnology.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SCLThreshold> User-defined clock threshold

Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:I2C:SDA:THReshold <SDAThreshold>

Sets a user-defined threshold value for the data line.

Alternatively, you can set the threshold according to the signal technology with BUS<m>:I2C:TECHnology.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SDAThreshold> User-defined data threshold

Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:I2C:TECHnology <Technology>

Sets the threshold voltage clock and data lines as defined for various signal technologies.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN

V15 | V25 | V165 | V125 | V09 | V38 | V20 | V0
1.5 V, 2.5 V, 1.65 V ... respectively

VM13
-1.3 V (negative value)

MAN
Manual setting of user-defined values with BUS<m>:I2C:SCL:THReshold and BUS<m>:I2C:SDA:THReshold.

*RST: V165

BUS<m>:I2C:RWBit <BusConfig>

Defines if the R/W bit of a 7-bit address is considered separately or as part of the address. 10-bit addresses are not affected. The setting defines which address lengths are available with TRIGger<m>:I2C:AMODe.

Suffix:

<m> 1..4

Selects the serial bus.

Parameters:

<BusConfig> SEParate | INADdress

SEParate

7-bit address and separate R/W bit.

INADdress

8-bit address with R/W bit included.

*RST: SEParate

Firmware/Software: FW 1.35

20.17.3.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- TRIGger<m>:SOURce is set to SBUS.
- The source(s) of the serial bus are channel signals: use BUS<m>:...:SOURce commands.
- Decoding is enabled: BUS<m>[:STATe] is set to ON.

TRIGger<m>:I2C:MODE <Type>

Selects the trigger type for I²C analysis.

See: "Trigger type" on page 476

Parameters:

<Type> STARt | REPStart | STOP | NACK | ADDRess | ADOR | ADAT

STARt
Start condition

REPStart
Repeated start - the start condition occurs without previous stop condition.

STOP
Stop condition, end of frame

NACK
Missing acknowledge bit. To localize specific missing acknowledge bits, use `TRIGger<m>:I2C:ADNack`, `TRIGger<m>:I2C:DWNack`, and `TRIGger<m>:I2C:DRNack`.

ADDRess
Triggers on one specific address

ADOR
Triggers on an OR combination with up to four four address conditions.

ADAT
Triggers on a combination of address and data condition.

*RST: STARt

Usage: Asynchronous command

TRIGger<m>:I2C:ACCess <RWBitAddress>

Sets the trigger condition for the R/W bit - the transfer direction of the data.

Parameters:

<RWBitAddress> READ | WRITe | EITHer

EITHer
Transfer direction is not relevant.

*RST: EITHer

Usage: Asynchronous command

TRIGger<m>:I2C:ADNack <AddressNack>

Triggers if the address acknowledge bit is missing - no slave recognizes the address.

Parameters:

<AddressNack> ON | OFF

*RST: ON

Usage: Asynchronous command

TRIGger<m>:I2C:DWNack <DataWriteNack>

Triggers if a date acknowledge bit is missing - the addressed slave does not accept the data.

Parameters:

<DataWriteNack> ON | OFF

*RST: ON

Usage: Asynchronous command

TRIGger<m>:I2C:DRNack <DataReadNack>

Triggers on the end of the read process when the master reads data from the slave. This Nack is sent according to the protocol definition, it is not an error.

Parameters:

<DataReadNack> ON | OFF

*RST: ON

Usage: Asynchronous command

TRIGger<m>:I2C:AMODe <AddressType>

Sets the address length. The setting affects the address input with `TRIGger<m>:I2C:ADDRess` and `TRIGger<m>:I2C:ADDTo`.

Parameters:

<AddressType> BIT7 | BIT7_RW | BIT10 | ANY

BIT7
Enter the 7 address bits. Only available if `BUS<m>:I2C:RWBit SEParate` is set.

BIT7_RW
Enter 7 address bits and the R/W bit. Only available if `BUS<m>:I2C:RWBitINADdress` is set.

BIT10
10-bit address

ANY
Only available for trigger type "Address + data" (`TRIGger<m>:I2C:MODE ADAT`). Used to trigger on data only, regardless of the address.

*RST: BIT7

Usage: Asynchronous command

TRIGger<m>:I2C:ACONdition <AddressOperator>

Sets the operator to set a specific address or an address range. The address values are set with TRIGger<m>:I2C:ADDRess and TRIGger<m>:I2C:ADDTo.

Parameters:

<AddressOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Firmware/Software: V 1.25

TRIGger<m>:I2C:ADDRess <Address>

Triggers on the specified slave address, or sets the the start value of an address range depending on the condition set with TRIGger<m>:I2C:ACONdition.

Parameters:

<Address> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

TRIGger<m>:I2C:ADDTo <AddressTo>

Sets the the end value of an address range if the condition is set to an address range with TRIGger<m>:I2C:ACONdition.

Parameters:

<AddressTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Usage: Asynchronous command

TRIGger<m>:I2C:ADOR<n>:ENABle <UseAddress>

Includes the indicated ADOR address in the "address OR" trigger condition.

Suffix:

<n> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:

<UseAddress> ON | OFF

*RST: OFF

TRIGger<m>:I2C:ADOR<n>:ADRType <AddressType>

Sets the address type for the indicated ADOR address in the "address OR" trigger condition.

Suffix:
<n> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:
<AddressType> BIT7 | BIT7_RW | BIT10
*RST: BIT7

TRIGger<m>:I2C:ADOR<n>[:VALue] <Address>

Defines the address pattern of the indicated ADOR address in the "address OR" trigger condition.

Suffix:
<n> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:
<Address> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

TRIGger<m>:I2C:ADOR<n>:RWBit <RWBit>

Defines the R/W bit of the indicated ADOR address in the "address OR" trigger condition.

Suffix:
<n> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:
<RWBit> UNDefined | READ | WRITe | EITHer
UNDefined
Return value only
*RST: EITHer

TRIGger<m>:I2C:DPOPerator <DataPosOperator>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:
<DataPosOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe
ANY = OFF
The position of the required pattern is not relevant.
EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:I2C:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `TRIGger<m>:I2C:DPOSition` and `TRIGger<m>:I2C:DPTO`.

*RST: ANY

TRIGger<m>:I2C:DPOSition <DataPosition>

Sets the number of data bytes before the first byte of interest. These bytes are ignored.

Parameters:

<DataPosition> The index 0 is associated with the first data byte.

Range: 0 to 4095
Increment: 1
*RST: 0

TRIGger<m>:I2C:DPTO <DataPositionTo>

Defines the last byte of interest, if `TRIGger<m>:I2C:DPOPerator` is set to `RANGe`.

Parameters:

<DataPositionTo> Range: 0 to 4095
Increment: 1
*RST: 0

TRIGger<m>:I2C:DCONdition <DataOperator>

Sets the operator to set a specific data value or a data range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

TRIGger<m>:I2C:DMIN <Data>

Specifies the data bit pattern, or sets the the start value of a data pattern range.. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Parameters:

<Data> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Usage: Asynchronous command

Firmware/Software: V 1.30

TRIGger<m>:I2C:DMAX <DataTo>

Sets the the end value of an data range if `TRIGger<m>:I2C:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Usage: Asynchronous command

Firmware/Software: V 1.30

20.17.3.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1301
- `BUS<m>:SYMBols` on page 1302

BUS<m>:I2C:FRAMe<n>:DATA?

Returns the data words of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<Data> Comma-separated list of integer values (N, D1, D2,…, DN). N is the number of bytes in the frame, and D1…DN are the values of the bytes.

Example:
```
BUS:I2C:FRAMe4:DATA?
<-- 3,74,164,18
```

Usage: Query only

BUS<m>:I2C:FCOunt?

Returns the number of decoded frames.

Suffix:
<m> 1..4
Selects the serial bus.

Return values:
<Count> Total number of decoded frames.

Usage: Query only

BUS<m>:I2C:FRAMe<n>:AACCess?

Returns the address acknowledge bit value for the indicated frame.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<AddressAckBit> INComplete | ACK | NACK | EITHer
*RST: INComplete

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ACCess?

Returns the value of the R/W bit of the indicated frame.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<RWBit> UNDefined | READ | WRITe | EITHer
*RST: UNDefined

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ACOMplete?

Returns if the address is completely contained in the acquisition.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<AddressComplete> ON | OFF
*RST: OFF

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ADBStart?

Returns the start time of the address acknowledge bit.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<AddrAckBtStrt> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ADDRess?

Returns the device address value of the indicated frame, that is, the address value that is shown in the decoded cells and in the decode results table.

If the frame has a 7-bit address, the command considers the status of `BUS<m>:I2C:RWBit`. If `BUS<m>:I2C:RWBit INADdress` is set, the returned address includes the R/W bit (8 bit). Otherwise, the pure address without the R/W bit is returned (7 bit, same result as returned with `BUS<m>:I2C:FRAMe<n>:ADEVice?`).

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<AddressValue> To set the value format, use FORMat:BPATtern.
The values below – range, increment and default – are decimal values.

Range: 0 to 1023
*RST: 0

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ADEVice?

Returns the pure device address of the indicated frame *without* the R/W bit.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<DeviceAddress> To set the value format, use FORMat:BPATtern.
The values below – range, increment and default – are decimal values.

Range: 0 to 1023
*RST: 0

Usage: Query only

BUS<m>:I2C:FRAMe<n>:AMODe?

Returns the address length.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<AddressType> BIT7 | BIT7_RW | BIT10 | AUTO | ANY

*RST: BIT7

Usage: Query only

BUS<m>:I2C:FRAMe<n>:ASTart?

Returns the start time of the address for the indicated frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<AddressStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:RWBStart?

Returns the start time of the R/W bit

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<RWBitStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:STATus?

Returns the overall state of the frame.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<FrameState> INComplete | OK | UNEXpstop | INSufficient | ADDifferent

INComplete
The stop bit is missing.

OK
The frame is valid.

UNEXpstop
A stop bit was detected but clock and data are continued.

INSufficient
The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

ADDifferent
Error in 10 bit address. In case of a read access on a 10 bit address, the first address byte is sent twice, first as write, the second as read. The first seven bits of the byte must be identical. If they are not identical, the ADDiffernt error is indicated.

*RST: OK

Usage: Query only

BUS<m>:I2C:FRAMe<n>:STARt?

Returns the start time of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:STOP?

Returns the end time of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameStop> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the number of the frame in the current acquisition, 1...n.

Return values:
<Translation> String with symbolic name of the address

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BCOunt?

Returns the number of bytes in the specified frame

Suffix:
<m> 1..4
Selects the input channel.

<n> *
Selects the frame.

Return values:
<Count> Byte count

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:ACCess?

Returns the acknowledge bit value of the specified data byte.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:
<AckBit> INComplete | ACK | NACK | EITHer
*RST: INComplete

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:ACKStart?

Returns the start time of the acknowledge bit of the specified byte.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:
<AckBitStart> To set the value format, use FORMat:BPATtern.
The values below – range, increment and reset – are decimal values.
Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:COMPlete?

Returns if the indicated byte is completely contained in the acquisition.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:
<ValueComplete> ON | OFF
*RST: OFF

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:STARt?

Returns the start time of the specified data byte.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:
<Start> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:I2C:FRAMe<n>:BYTE<o>:VALue?

Returns the data value of the specified byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte number.

Return values:

<Value> To set the value format, use FORMat:BPATtern.
The values below – range, increment and default – are decimal values.
Range: 0 to 255
*RST: 0

Usage: Query only

20.17.3.4 I²C Search Settings

In search setup commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name. The commands are similar to I²C trigger commands.

SEARch:TRIGger:I2C:SCONdition <SearchName>,<Start>
SEARch:TRIGger:I2C:SCONdition? <SearchName>

Enables the search for the start of the message.

Parameters:
<Start> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:RCONdition <SearchName>,<RepeatedStart>
SEARch:TRIGger:I2C:RCONdition? <SearchName>

Enables the search for a start condition without previous stop condition.

Parameters:
<RepeatedStart> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:STCNdition <SearchName>,<Stop>
SEARch:TRIGger:I2C:STCNdition? <SearchName>

Enables the search for the start of the message.

Parameters:
<Stop> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:NACKnowledge <SearchName>,<NoAcknowledge>
SEARch:TRIGger:I2C:NACKnowledge? <SearchName>

Searches for missing address acknowledge bits.

Parameters:
<NoAcknowledge> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:SADDress <SearchName>,<Address>
SEARch:TRIGger:I2C:SADDress? <SearchName>

Enables the search for one specific address condition or for a combination of address conditions.

To define the address condition, use the following commands:

- `SEARch:TRIGger:I2C:ACONdition` on page 1323
- `SEARch:TRIGger:I2C:ADDRess` on page 1324
- `SEARch:TRIGger:I2C:ADDTo` on page 1324
- `SEARch:TRIGger:I2C:AMODe` on page 1323
- `SEARch:TRIGger:I2C:ACCess` on page 1324

Parameters:

<Address> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:ADOR <SearchName>,<AddressOr>
SEARch:TRIGger:I2C:ADOR? <SearchName>

Enables the search for one to four address conditions.

- `SEARch:TRIGger:I2C:ADDO<m>:ENABle` on page 1324
- `SEARch:TRIGger:I2C:ADDO<m>:ADRType` on page 1325
- `SEARch:TRIGger:I2C:ADDO<m>[:VALue]` on page 1325
- `SEARch:TRIGger:I2C:ADDO<m>:RWBit` on page 1326

Parameters:

<AddressOr> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:ADData <SearchName>,<AddressData>
SEARch:TRIGger:I2C:ADData? <SearchName>

Enables the search for a combination of address and data conditions.

Parameters:

<AddressData> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:ACONdition <SearchName>,<AddressOperator>
SEARch:TRIGger:I2C:ACONdition? <SearchName>

Sets the operator to set a specific address or an address range.

Parameters:
<AddressOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with `SEARch:TRIGger:I2C:ADDRess` on page 1324.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:I2C:ADDRess` on page 1324 and `SEARch:TRIGger:I2C:ADDTo` on page 1324.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:AMODe <SearchName>,<AddressType>
SEARch:TRIGger:I2C:AMODe? <SearchName>

Sets the address length.

Parameters:
<AddressType> BIT7 | BIT7_RW | BIT10 | ANY

BIT7 | BIT10
Enter only address bits in the address pattern.

BIT7_RW
Enter seven address bits and also the R/W bit in the address pattern.

ANY
Only available for search criteria "Address and data" (`SEARch:TRIGger:I2C:ADData` is set `ON`). Used to search for data only, regardless of the address.

*RST: BIT7

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ADDRess <SearchName>,<Address>
SEARch:TRIGger:I2C:ADDRess? <SearchName>

Specifies an address pattern, or sets the the start value of an address range.

Parameters:

<Address> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.
The pattern length is defined with `SEARch:TRIGger:I2C:AMODe`.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADDTo <SearchName>,<AddressTo>
SEARch:TRIGger:I2C:ADDTo? <SearchName>

Sets the the end value of an address range if `SEARch:TRIGger:I2C:ACONdition` is set to `INRange` or `OORange`.

Parameters:

<AddressTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.
The pattern length is defined with `SEARch:TRIGger:I2C:AMODe`.

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ACCess <SearchName>,<RWBitAddress>
SEARch:TRIGger:I2C:ACCess? <SearchName>

Sets the transfer direction of the data.

Parameters:

<RWBitAddress> READ | WRITe | EITHer
*RST: EITHer

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ADDO<m>:ENABle <SearchName>,<UseAddress>
SEARch:TRIGger:I2C:ADDO<m>:ENABle? <SearchName>

Includes the indicated ADOR address in the "address OR" search condition.

Suffix:
<m> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:
<UseAddress> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADDO<m>:ADRType <SearchName>,<AddressType>
SEARch:TRIGger:I2C:ADDO<m>:ADRType? <SearchName>

Sets the address type for the indicated ADOR address in the "address OR" search condition.

Suffix:
<m> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:
<AddressType> BIT7 | BIT7_RW | BIT10

BIT7 | BIT10
Enter only address bits in the address pattern.

BIT7_RW
Enter seven address bits and also the R/W bit in the address pattern.

*RST: BIT7

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADDO<m>[:VALue] <SearchName>,<Address>
SEARch:TRIGger:I2C:ADDO<m>[:VALue]? <SearchName>

Defines the address pattern of the indicated ADOR address in the "address OR" search condition.

Suffix:
<m> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:
<Address> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.
The pattern length is defined with `SEARch:TRIGger:I2C:ADDO<m>:ADRType`.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:ADDO<m>:RWBit <SearchName>,<RWBit>
SEARch:TRIGger:I2C:ADDO<m>:RWBit? <SearchName>

Defines the R/W bit of the indicated ADOR address in the "address OR" search condition.

Suffix:

<m> 1..4
Index of the address in an "address OR" condition (OR slot)

Parameters:

<RWBit> UNDefined | READ | WRITe | EITHer

UNDefined
Only return value

*RST: EITHer

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:DPOPerator <SearchName>,<DataPosOperator>
SEARch:TRIGger:I2C:DPOPerator? <SearchName>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DataPosOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The position of the required pattern is not relevant.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with SEARch:TRIGger:I2C:DPOSition.

INRange = RANGe
In range: Set the minimum and maximum value of the range with SEARch:TRIGger:I2C:DPOSition and SEARch:TRIGger:I2C:DPTO.

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:I2C:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:I2C:DPOSition? <SearchName>

Defines the first byte of interest. All bytes before that byte are ignored.

Parameters:

<DataPosition> The index 0 is associated with the first data byte.

Range: 0 to 4095
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:DPTO <SearchName>,<DataPositionTo>
SEARch:TRIGger:I2C:DPTO? <SearchName>

Defines the last byte of interest, if `SEARch:TRIGger:I2C:DPOPerator` defines a range.

Parameters:

<DataPositionTo> Range: 0 to 4095
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:I2C:DCONdition? <SearchName>

Sets the operator to set a specific data value or a data range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:I2C:DMIN <SearchName>,<Data>
SEARch:TRIGger:I2C:DMIN? <SearchName>

Specifies the data bit pattern, or sets the the start value of a data pattern range.. Enter the bytes in msb first bit order. The maximum pattern length is 64 bit. Waveform data is compared with the pattern byte-by-byte.

Parameters:

<Data> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:DMAX <SearchName>,<DataTo>
SEARch:TRIGger:I2C:DMAX? <SearchName>

Sets the the end value of an address range if `SEARch:TRIGger:I2C:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Parameters for setting and query:

<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:ADNack <SearchName>,<AddressNack>
SEARch:TRIGger:I2C:ADNack? <SearchName>

Parameters:

<AddressNack> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:DRNack <SearchName>,<DataReadNack>
SEARch:TRIGger:I2C:DRNack? <SearchName>

Searches for the end of the read process when the master reads data from the slave. This Nack is sent according to the protocol definition, it is not an error.

Parameters:

<DataReadNack> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

Usage: Asynchronous command

SEARch:TRIGger:I2C:DWNack <SearchName>,<DataWriteNack>
SEARch:TRIGger:I2C:DWNack? <SearchName>

Searches for missing data write acknowledge bits.

Parameters:

<DataWriteNack> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

Usage: Asynchronous command

20.17.3.5 I²C Search Results

The search on decoded CAN data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.3.3, "Decode Results", on page 1312.

SEARch:RESult:I2C:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:
<Count> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:STATus? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<State> INComplete | OK | UNEXpstop | INSufficient | ADDifferent
*RST: OK

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:STARt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:STOP? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:AACCess? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<AddressAckBit> INComplete | ACK | NACK | EITHer
*RST: INComplete

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ACCess? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<RWBit> UNDefined | READ | WRITe | EITHer
*RST: UNDefined

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ACOMplete? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<AddressComplete> ON | OFF
*RST: OFF

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ADBStart? <SearchName>

Returns the start time of the address acknowledge bit.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<AddrAckBtStrt> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ADDRess? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<AddressValue>	Range:	0 to 2047
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ADEVice? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<DeviceAddress>	Range:	0 to 1023
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:AMODe? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<AddressType> BIT7 | BIT7_RW | BIT10 | AUTO | ANY

*RST: BIT7

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:ASTart? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<AddressStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:DATA? <SearchName>

Returns the data bytes of the indicated frame.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:RWBStart? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<RWBitStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:SYMBol? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Translation>

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BCOunt?

Suffix:
<m> *

Return values:
<Count>

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACCess? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<ByteAckBit> INComplete | ACK | NACK | EITHer

*RST: INComplete

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:ACKStart? <SearchName>

Returns the start time of the acknowledge bit of the indicated data byte.

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<ByteAckBitStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:COMPlete? <SearchName>

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<ByteComplete> ON | OFF

*RST: OFF

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:STARt? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<ByteStart>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:I2C:FRAMe<m>:BYTE<n>:VALue? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<Value>	Range: 0 to 255 Increment: 1 *RST: 0

Usage: Query only

20.17.4 SPI (Option R&S RTP-K1)

20.17.4.1 SPI Bus Configuration

BUS<m>:SPI:BORDer <BitOrder>

Defines if the data of the messages starts with msb (most significant bit) or lsb (least significant bit).

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<BitOrder>	LSBF | MSBF *RST: MSBF

Usage: Asynchronous command

BUS<m>:SPI:WSIZe <WordLength>

Sets the number of bits in a message.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<WordLength>	Number of bits Range: 4 to 32 Increment: 1 *RST: 8

Usage: Asynchronous command

BUS<m>:SPI:SCLK:SOURce <SCLKSource>

Sets the input channel of the clock line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<SCLKSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data, clock and slave select lines.
See Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C2W1

Usage: Asynchronous command

BUS<m>:SPI:SSELect:SOURce <SlaveSelectSource>

Sets the input channel of the slave select line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SlaveSelectSource> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data, clock and slave select lines.
See Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: None

Usage: Asynchronous command

BUS<m>:SPI:SSELect:POLarity <SSPolarity>

Selects whether transmitted slave select signal is high active (high = 1) or low active (low = 1).

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SSPolarity> ACTLow | ACTHigh

*RST: ACTLow

Usage: Asynchronous command

BUS<m>:SPI:MISO:SOURce <MISOSource>

Sets the input channel of the MISO line.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<MISOSource> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data, clock and slave select lines.
See Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: None

Usage: Asynchronous command

BUS<m>:SPI:MISO:POLarity <MISOPolarity>

Selects whether transmitted data is high active (high = 1) or low active (low = 1).

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<MISOPolarity> ACTLow | ACTHigh

*RST: ACTHigh

Usage: Asynchronous command

BUS<m>:SPI:MOSI:SOURce <MOSISource>

Sets the input channel of the MOSI line.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<MOSISource> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data, clock and slave select lines.
See Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C1W1

Usage: Asynchronous command

BUS<m>:SPI:MOSI:POLarity <MOSIPolarity>

Selects whether transmitted data is high active (high = 1) or low active (low = 1).

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<MOSIPolarity> ACTLow | ACTHigh
*RST: ACTHigh

Usage: Asynchronous command

BUS<m>:SPI:TECHnology <Technology>

Sets the threshold voltage clock, slave select and data lines as defined for various signal technologies.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN

V15 | V25 | V165 | V125 | V09 | V38 | V20 | V0
1.5 V, 2.5 V, 1.65 V ... respectively

VM13
-1.3 V (negative value)

MAN
Manual setting of user-defined values with
`BUS<m>:SPI:SCLK|SSEL|MISO|MOSI:THReshold`.

*RST: V165

BUS<m>:SPI:SCLK:THReshold <SCLKThreshold>
BUS<m>:SPI:MISO:THReshold <MISOThreshold>
BUS<m>:SPI:MOSI:THReshold <MOSIThreshold>
BUS<m>:SPI:SSELect:THReshold <SSThreshold>

Set user-defined threshold values for the clock, MISO, MOSI and slave select lines.

Alternatively, you can set the thresholds according to the signal technology with `BUS<m>:SPI:TECHnology`.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SSThreshold> User-defined value

Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:SPI:FRCondition <FrameCondition>

Defines the start of a frame. A frame contains a number of successive words, at least one word.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<FrameCondition> SS | CLKTimeout

SS
Start and end of the frame is defined by the active state of the slave select signal, see `BUS<m>:SPI:SSELect:POLarity`.

CLKTimeout
Defines a timeout on the clock line SCLK as limiter between two frames. The timeout condition is used for SPI connections without an SS line.

*RST: SS

BUS<m>:SPI:TIMeout <ClockTimeout>

Defines a timeout on the clock line SCLK as limiter between two frames. The timeout condition is used for SPI connections without an SS line.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ClockTimeout> Range: 50E-9 to 10
Increment: 1E-6
*RST: 1E-3
Default unit: s

20.17.4.2 SPI Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:SPI:MODE <Type>

Selects the trigger type for SPI analysis.

Parameters:

<Type> SSACtive | TIMeout | MOSI | MISO | MOMI

SSACtive
Start of the message: slave select signal SS changes to the active state.

TIMeout
Triggers on the next message start after the "Timeout" time.

MOSI
Triggers on a specified data pattern in that is expected on the MOSI line. Define the pattern with `TRIGger<m>:SPI:MOSipattern`.

MISO
Triggers on a specified data pattern in that is expected on the MISO line. Define the pattern with `TRIGger<m>:SPI:MISopattern`

MOMI
Triggers on a specified data patterns on the MISO and MISO lines.

*RST: SSACtive

Usage: Asynchronous command

TRIGger<m>:SPI:PALignment <DataAlignment>

Defines how the specified data pattern is searched.

Parameters:

<DataAlignment> WORD | BIT

WORD
The pattern is matched only at word boundaries.

BIT
Bit-by bit: the pattern can be at any position in the data word.

*RST: WORD

Usage: Asynchronous command

TRIGger<m>:SPI:DPOPerator <DataPosOperator>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DataPosOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The position of the required pattern is not relevant.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:SPI:DPOSition`.

INRange = RANGe
Set the minimum and maximum value of the range with `TRIGger<m>:SPI:DPOSition` and `TRIGger<m>:SPI:DPTO`.

*RST: ANY

TRIGger<m>:SPI:DPOSition <DataPosition>

Sets the number of bits or words to be ignored before the first bit or word od interest. The effect is defined by `TRIGger<m>:SPI:PALignment`.

Parameters:

<DataPosition> The index 0 is associated with the first data byte.

Range: 0 to 4095 for triggering on one line (MISO or MOSI), 2047 for triggering on both lines.
Increment: 1
*RST: 0

TRIGger<m>:SPI:DPTO <DataPositionTo>

Defines the last bit or word of interest, if `TRIGger<m>:SPI:DPOPerator` is set to `INRange`.

Parameters:

<DataPositionTo> Range: 1 to 4095 for triggering on one line (MISO or MOSI), 2047 for triggering on both lines.
Increment: 1
*RST: 1

TRIGger<m>:SPI:FCONdition <DataOperator>

Selects the operator for the MISO and MOSI pattern.

Parameters:

<DataOperator> EQUal | NEQual

*RST: EQUal

Firmware/Software: V 1.25

TRIGger<m>:SPI:MISopattern <MISOPattern>

Specifies the pattern to be triggered on the MISO line.

Parameters:

<MISOPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).
Usage:	Asynchronous command

TRIGger<m>:SPI:MOSipattern <MOSIPattern>

Specifies the pattern to be triggered on the MOSI line.

Parameters:

<MOSIPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).
Usage:	Asynchronous command

20.17.4.3 SPI Decode Results

BUS<m>:SPI:FRAMe<n>:DATA?

Returns the data words of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameData> Comma-separated sequence of integer values (N, L1, R1,…, LN, RN). N is the number of word pairs in the frame, and {L1,R1}…{LN,RN} are the value pairs. The values Lx and Rx are associated with the MOSI and the MISO channel, respectively. If a channel is disabled, an empty value is returned.

Example:
`BUS:SPI:FRAMe3:DATA?`
`<-- 2,10,108,35,70` (MOSI+MISO)
`2,10,,35,` (MOSI only)
`2,,108,,70` (MISO only)

Usage: Query only

BUS<m>:SPI:FCOunt?
BUS<m>:SPI:FRAMe<n>:COUNt?

Returns the number of decoded frames.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *

Return values:

<Count> Total number of decoded frames.

Usage: Query only

BUS<m>:SPI:FRAMe<n>:STATus?

Returns the overall state of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameState> OK | VOID | INCFirst | INCLast | INSufficient

OK: the frame is valid.
VOID: the frame is empty.
INCFirst: INComplete First word. The first word does not have the expected word length.
INCLast: INComplete Last word. The last word does not have the expected word length.
INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:SPI:FRAMe<n>:STARt?

Returns the start time of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:STOP?

Returns the end time of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameStop> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WCOunt?

Returns the number of words in the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<WordCount> Range: 0 to 4096
*RST: 0

Usage: Query only

Firmware/Software: V 1.27

BUS<m>:SPI:FRAMe<n>:WORD<o>:STARt?

Returns the start time of the specified data word.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the word number.

Return values:

<Start> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WORD<o>:STOP?

Returns the end time of the specified data word.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the word number.

Return values:

<Stop> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WORD<o>:MISO?

Returns the data value of the specified word on the MISO line.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the word number.

Return values:
<MISOValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.
Range: 0 to 4294967295
*RST: 0

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WORD<o>:FMISo?

Returns the formatted value of the specified word on the MISO line.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the word number.

Return values:
<FormattedMISOVal>

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WORD<o>:MOSI?

Returns the data value of the specified word on the MOSI line.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the word number.

Return values:
<MOSIValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.
Range: 0 to 4294967295
*RST: 0

Usage: Query only

BUS<m>:SPI:FRAMe<n>:WORD<o>:FMOSi?

Returns the formatted value of the specified word on the MOSI line.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the word number.

Return values:

<FormattedMOSIVal>

Usage: Query only

20.17.4.4 SPI Search Settings

In search setup commands, you must specify the <SearchName> parameter. It is a string parameter that contains the search definition name. All commands are similar to SPI trigger commands.

SEARch:TRIGger:SPI:MODE <SearchName>,<Type>
SEARch:TRIGger:SPI:MODE? <SearchName>

Sets the event to be searched for.

Parameters:

<Type> SSACtive | TIMeout | MOSI | MISO | MOMI

SSACtive
Searches for the start of the frame when slave select signal SS changes to the active state. This type is available if the slave select line is configured in the bus setup, and `BUS<m>:SPI:FRCondition` is `SS`.

TIMeout
Searches for the start of the frame when the clock idle time exceeds the timeout. This type is available if the slave select line is configured in the bus setup, and `BUS<m>:SPI:FRCondition` is `CLKTimeout`.

MOSI | MISO
Searches for a specified data pattern expected on the MOSI line or on the MISO line, respectively.

MOMI
Searches in parallel for specified data patterns expected on the MOSI and MISO lines.

*RST: SSACtive

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:FCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:SPI:FCONdition? <SearchName>

Selects the operator for the data pattern: equal or not equal.

Parameters:
<DataOperator> EQUal | NEQual

*RST: EQUal

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:MISopattern <SearchName>,<MISOPattern>
SEARch:TRIGger:SPI:MISopattern? <SearchName>
SEARch:TRIGger:SPI:MOSipattern <SearchName>,<MOSIPattern>
SEARch:TRIGger:SPI:MOSipattern? <SearchName>

Specifies a data pattern for the MISO or MOSI line, respectively.

Parameters:
<MISOPattern>
<MOSIPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:DPOPerator <SearchName>,<DataPosOperator>
SEARch:TRIGger:SPI:DPOPerator? <SearchName>

Operator for the data position. You can define an exact position, a position range, or let the position undefined (ANY).

Parameters:
<DataPosOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe
ANY = OFF, INRange = RANGe
*RST: ANY

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:SPI:DPOSition? <SearchName>

Sets the number of bits or words before the first word of interest, see also `SEARch:TRIGger:SPI:PALignment`. These offset bits/words are skipped. The index 0 is associated with the first data bit or word.

If the position operator defines a range, also define the last bit/word of interest using `SEARch:TRIGger:SPI:DPTO`

Parameters:
<DataPosition> Range: 0 to 32767
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:DPTO <SearchName>,<DataPositionTo>
SEARch:TRIGger:SPI:DPTO? <SearchName>

Sets the the end value of a data postion range.

Parameters:
<DataPositionTo> Range: 1 to 32767
Increment: 1
*RST: 1

Parameters for setting and query:
<SearchName>

Firmware/Software: FW 3.30

SEARch:TRIGger:SPI:PALignment <SearchName>,<DataAlignment>
SEARch:TRIGger:SPI:PALignment? <SearchName>

Defines how the specified data pattern is searched.

Parameters:
<DataAlignment> WORD | BIT

WORD
The pattern is matched only at word boundaries.

BIT
Bit-by-bit: the pattern can start at any position in the message.

*RST: WORD

Parameters for setting and query:
<SearchName>

Usage: Asynchronous command

Firmware/Software: FW 3.30

20.17.4.5 SPI Search Results

The search on decoded SPI data returns the same results as the queries for decode results.

In search result commands, you must specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

The suffix FRAMe<m> indicates the frame index. The suffix WORD<n> indicates the word index inside a frame-

For a description of the returned values, see the corresponding commands in Chapter 20.17.4.3, "SPI Decode Results", on page 1343. All SPI search commands are first implemented in firmware version 3.30.

SEARch:RESult:SPI:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:
<Count> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:COUNt?

Returns the number of frames that have matched the search criteria. In the search result table on the display, the number of rows is the number of frames that match the search criteria.

Suffix:
<m> *

Return values:
<Count>

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:DATA? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameData>

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:STARt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:STATus? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameState> OK | VOID | INCFirst | INCLast | INSufficient
*RST: OK

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:STOP? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameStop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WCOunt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameWordCount> Range: 0 to 4096
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:MISO? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<WordMISOValue> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:MOSI? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<WordMOSIValue>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:STARt? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<FrameWordStart>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:SPI:FRAMe<m>:WORD<n>:STOP? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<FrameWordStop>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

20.17.5 UART/RS-232/RS-422/RS-485 (Option R&S RTP-K2)

20.17.5.1 Configuration

BUS<m>:UART:RX:SOURce <RxSource>

Selects the input channel for the receiver signal.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<RxSource> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for RX and TX lines.
See Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: None

Usage: Asynchronous command

BUS<m>:UART:TX:SOURce <TxSource>

Selects the input channel for the transmitter signal.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<TxSource> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for RX and TX lines.

See Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C1W1

Usage: Asynchronous command

BUS<m>:UART:RX:THReshold <RxThreshold>

Sets a user-defined threshold value for the Rx line.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:UART:TECHnology`.

Suffix:

<m> 1..4

Selects the serial bus.

Parameters:

<RxThreshold> User-defined clock threshold

Range: -15 to 15
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:UART:TX:THReshold <TxThreshold>

Sets a user-defined threshold value for the Tx line.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:UART:TECHnology`.

Suffix:

<m> 1..4

Selects the serial bus.

Parameters:

<TxThreshold> User-defined clock threshold

Range: -15 to 15
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:UART:TECHnology <Technology>

Sets the threshold voltage Tx and Rx lines as defined for various signal technologies.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN

V15 | V25 | V165 | V125 | V09 | V38 | V20 | V0
1.5 V, 2.5 V, 1.65 V ... respectively

VM13
-1.3 V (negative value)

MAN
Manual setting of user-defined values with `BUS<m>:UART:RX:THReshold` and `BUS<m>:UART:TX:THReshold`.

*RST: V165

BUS<m>:UART:BITRate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:

<m> 1..4

Parameters:

<Bitrate> Range: 300 to 20000000
Increment: 1
*RST: 9600
Default unit: bps

Usage: Asynchronous command

BUS<m>:UART:BAUDrate <Bitrate>

Same as `BUS<m>:UART:BITRate`.

Suffix:

<m> 1..4

Parameters:

<Bitrate> Range: 300 to 20000000
Increment: 1
*RST: 9600
Default unit: bps

Usage: Asynchronous command

BUS<m>:UART:PARity <Parity>

Defines the optional parity bit that is used for error detection.

See also: "Parity" on page 504.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<Parity> NONE | ODD | EVEN | MARK | SPC | DC

MARK
The parity bit is always a logic 1.

SPC
SPaCe: The parity bit is always a logic 0.

DC
Don't Care: the parity is ignored.

*RST: NONE

Usage: Asynchronous command

BUS<m>:UART:POLarity <Polarity>

Defines the idle state of the bus. The idle state corresponds to a logic 1. The transmitted data on the bus is high (high = 1) or low (low = 1) active.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<Polarity> IDLLow | IDLHigh
*RST: IDLHigh

Usage: Asynchronous command

BUS<m>:UART:SBIT <StopBits>

Sets the number of stop bits: 1; 1.5 or 2 stop bits are possible.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<StopBits> B1 | B15 | B2
*RST: B1

Usage: Asynchronous command

BUS<m>:UART:SSIZe <DataBits>

Sets the number of data bits in a message.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<DataBits> Number of data bits. 9 data bits are only possible with parity = none.

Range: 5 to 9
Increment: 1
*RST: 8

Usage: Asynchronous command

BUS<m>:UART:PACKets <Packets>

Defines the method of packet separation. A packet is a number of subsequent words in a date stream.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<Packets> NONE | EWORd | TOUT

NONE
Packets are not considered.

EWORd
End word, the end condition of a packet is a pattern. To define the end word, use `BUS<m>:UART:EWORd`

TOUT
Defines a timeout between the packets. To set the timeout, use `BUS<m>:UART:TOUT`

*RST: NONE

Firmware/Software: FW 2.25

BUS<m>:UART:TOUT <InterframeTime>

Sets the timeout between packets in a UART data stream. A new packet starts with the first start bit after the timeout.

The command is relevant if `BUS<m>:UART:PACKets` is set to `TOUT`.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<InterframeTime> Range: 1E-6 to 1
Increment: 1
*RST: 1E-3
Default unit: s

Usage: Asynchronous command

Firmware/Software: FW 2.25

BUS<m>:UART:EWORd <EndOfFrame>

Sets the end pattern of the packets. A new packet starts with the first start bit after the defined end pattern.

The command is relevant if `BUS<m>:UART:PACKets` is set to `EWORd`.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<EndOfFrame> End word value in decimal format (range 0 to 255) or hexadecimal format (prefix #H). The query always returns hexadecimal values.

Example:
```
:BUS:UART:PACK EWOR
:BUS:UART:EWOR 10 // Decimal value
:BUS:UART:EWOR?
#H0A // Query returns hex
```

Example:
```
:BUS:UART:PACK EWOR
:BUS:UART:EWOR #Hff // Hexadecimal, prefix #H
:BUS:UART:EWOR?
#HFF
```

Usage: Asynchronous command

Firmware/Software: FW 2.25

20.17.5.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:UART:TYPE <Type>

Selects the trigger type for UART analysis.

See also: "Type" on page 506

Parameters:

<Type> STBT | PCKS | DATA | PRER | BRKC | STPerror

STBT: Start bit
PCKS: Packet start
DATA: Serial pattern
PRER: Parity error
BRKC: Break condition
STPerror: Stop error

*RST: STBT

Usage: Asynchronous command

TRIGger<m>:UART:SOURce <Source>

Selects the transmitter or receiver line as trigger source.

Parameters:

<Source> TX | RX

*RST: TX

Usage: Asynchronous command

TRIGger<m>:UART:DPOPerator <DataPosOperator>

Sets the operator for the data position. You can defined an exact position, or a position range.

Parameters:

<DataPosOperator> EQUal | GETHan | INRange | RANGe

INRange = RANGe

*RST: GETHan

Usage: Asynchronous command

TRIGger<m>:UART:DPOSition <DataPosition>

Sets the number of words before the first word of interest. These offset words are ignored.

Parameters:

<DataPosition> Number of words

Range: 0 to 32767
Increment: 1
*RST: 0

Usage: Asynchronous command

TRIGger<m>:UART:DPTO <DataPositionTo>

Defines the last word of interest, if `TRIGger<m>:UART:DPOPerator` defines a position range.

Parameters:

<DataPositionTo>	Range:	0 to 32767
	Increment:	1
	*RST:	0

Usage: Asynchronous command

TRIGger<m>:UART:FCONdition <DataOperator>

Selects the operator for the data pattern (`TRIGger<m>:UART:DATA`).

Parameters:

<DataOperator> EQUal | NEQual

*RST: EQUal

TRIGger<m>:UART:DATA <Data>

Specifies the data pattern to be found on the specified trigger source, in binary or hex format. Enter the words in msb first bit order.

Parameters:

<Data> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Usage: Asynchronous command

20.17.5.3 Decode Results

BUS<m>:UART:WORD<n>:RXValue?
BUS<m>:UART:WORD<n>:TXValue?

Returns the value of the specified word on the Rx line or Tx line, respectively.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<Value> To set the value format, use FORMat:BPATtern.
The stated values for range, increment and reset are decimal values.

Range: 0 to 511
*RST: 0

Usage: Query only

BUS<m>:UART:WORD<n>:COUNt?

Returns the number of words in the acquisition.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
The suffix is irrelevant.

Return values:

<Count> Number of words

Usage: Query only

BUS<m>:UART:WORD<n>:SOURce?

Returns the line on which the specified word was transferred.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<WordSource> TX | RX

*RST: TX

Usage: Query only

BUS<m>:UART:WORD<n>:STARt?

Returns the start time of the specified word.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<WordStart> Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:UART:WORD<n>:STATe?

Returns the status of the specified word.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the word.

Return values:

<WordState> OK | FRSTart | FRENd | FRME | BREak | STERror | SPERror | PRERror | INSufficient

OK: the frame is valid.
BREak:stop bit error with 0x00 word
STERror: StarT ERror, incorrect start bit
SPERror: StoP ERror, incorrect stop bit
PRERror:PaRity ERror, incorrect parity bit.
INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.

*RST: OK

Usage: Query only

20.17.6 CAN (Option R&S RTP-K3/R&S RTP-K9)

20.17.6.1 Configuration

BUS<m>:CAN:DATA:SOURce <DataSource>

Sets the source of the data line that is selected with `BUS<m>:CAN:TYPE`.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<DataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: C1W1

Usage: Asynchronous command

BUS<m>:CAN:TYPE <SignalType>

Selects the CAN-High or CAN-Low line. Both lines are required for differential signal transmission used by CAN.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<SignalType> CANH | CANL

*RST: CANL

BUS<m>:CAN:FDATa:PSTandard <ProtStd>

Only available for CAN FD buses. Selects whether the tested signal is an ISO CAN FD signal or not.

Suffix:

<m> 1..4

Parameters:

<ProtStd> ISO | NISO

ISO
Signals are decoded according to the the ISO CAN FD protocol. This protocol has an additional stuff count field before the CRC sequence.

NISO
Non-ISO. Signals are decoded according to the the Bosch CAN FD protocol.

*RST: ISO

Firmware/Software: FW 3.35

BUS<m>:CAN:DATA:THReshold <Threshold>

Sets a user-defined threshold value.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:CAN:TECHnology`.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<Threshold> Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:CAN:TECHnology <Technology>

Sets the threshold voltage as defined for various signal technologies.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<Technology> V25 | V3 | V2 | V0 | MAN

V25
2.5 Volt (CMOS 5.0 V)

V3
3.0 Volt (CAN_H HS / CAN_L LS)

V2
2.0 Volt (CAN_L HS / CAN_H LS)

V0
Ground

MAN
Manual setting of user-defined values with `BUS<m>:CAN:DATA:THReshold`.

*RST: V25

BUS<m>:CAN:BITRate <Bitrate>

For CAN buses, the "Bit rate" sets the number of transmitted bits per second.

For CAN FD buses, this parameter is called "Arbitration rate" and sets the bit rate of the arbitration phase.

The maximum bit rate for High Speed CAN is 1 Mbit/s. The bit rate is uniform and fixed for a given CAN or CAN FD bus.

Suffix:

<m>	1..4 Selects the serial bus.	

Parameters:

<Bitrate>	Range:	100 to 5E+6
	Increment:	1
	*RST:	100E+3
	Default unit:	bps

BUS<m>:CAN:FDATa:ENABle <CANFDEnabled>

Enables the CAN FD protocol configuration.

The setting is available in CAN FD option R&S RTP-K9.

Suffix:

<m>	1..4

Parameters:

<CANFDEnabled>	ON | OFF	
	*RST:	ON

BUS<m>:CAN:FDATa:DBITrate <FlexDatBitrate>

Sets the bit rate of the data phase. The data rate can be higher than the arbitration rate, but it is uniform and fixed for a given CAN FD bus.

The setting is available in CAN FD option R&S RTP-K9.

Suffix:

<m>	1..4

Parameters:

<FlexDatBitrate>	Range:	100 to 15E+6
	Increment:	1
	*RST:	1E+6
	Default unit:	bps

BUS<m>:CAN:FDATa:SAMPlepoint <FlexDatSmpPt>
BUS<m>:CAN:SAMPlepoint <SamplePoint>

Sets the position of the sample point within the bit in percent of the nominal bit time.

Alternatively, you can set the sample point with BUS<m>:CAN:T1Segment and BUS<m>:CAN:T2Segment.

For CAN FD signals, BUS<m>:CAN:SAMPlepoint defines the synchronization of the arbitration phase, and BUS<m>:CAN:FDATa:SAMPlepoint defines the synchronization of the data phase.

Suffix:

<m>	1..4 Selects the serial bus.	

Parameters:

<FlexDatSmpPt> <SamplePoint>	Range:	12 to 96 if number of segments is 24. The range reduces if the signal has fewer segments.
	Increment:	5
	*RST:	66
	Default unit:	%

BUS<m>:CAN:FDATa:T1Segment <FlexDatTimeSeg1>
BUS<m>:CAN:T1Segment <TimeSeg1>

Sets the number of time quanta before the sample point (T1Segment). T1Segment comprises the segments Synch_seg, Prop_seg, and Phase_seg1 which are specified in the CAN standard.

Make sure to set also BUS<m>:CAN:T2Segment for correct definition of the sample point. Alternatively, you can use BUS<m>:CAN:SAMPlepoint.

See also: "Synchronization: Sample point, Time segments, Jump width" on page 514

For CAN FD signals, BUS<m>:CAN:T1Segment defines the synchronization of the arbitration phase, and BUS<m>:CAN:FDATa:T1Segment defines the synchronization of the data phase.

Suffix:

<m>	1..4

Parameters:

<FlexDatTimeSeg1> <TimeSeg1>	Time quanta	
	Range:	3 to 23
	Increment:	1
	*RST:	6.6

BUS<m>:CAN:FDATa:T2Segment <FlexDatTimeSeg2>
BUS<m>:CAN:T2Segment <TimeSeg2>

Sets the number of time quanta after the sample point (T2Segment). T2Segment matches Phase_seg2 specified in the CAN standard.

Make sure to set also BUS<m>:CAN:T1Segment on page 1368 for correct definition of the sample point. Alternatively, you can use BUS<m>:CAN:SAMPlepoint.

See also: "Synchronization: Sample point, Time segments, Jump width" on page 514

For CAN FD signals, `BUS<m>:CAN:T2Segment` defines the synchronization of the arbitration phase, and `BUS<m>:CAN:FDATa:T2Segment` defines the synchronization of the data phase.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<FlexDatTimeSeg2> <TimeSeg2>	Time quanta Range: 1 to 21 Increment: 1 *RST: 3.4

BUS<m>:CAN:FDATa:JWIDth <FlexDatJumpWdt>
BUS<m>:CAN:JWIDth <JumpWidth>

Defines the maximum number of time quanta for phase correction. Time segment1 may be lengthened or Time segment2 may be shortened due to resynchronization. Resynchronization corrects the phase error of an edge caused by the drift of the oscillators.

For CAN FD signals, this setting defines the synchronization of the arbitration phase.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<JumpWidth>	Time quanta Range: 1 to 4, available maximum depends on the number of segments and the sample point Increment: 1 *RST: 1

20.17.6.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:CAN:TYPE <Type>

Selects the trigger type for CAN analysis.

See: "Trigger type" on page 516.

Parameters:

<Type> STOF | FTYP | ID | IDDT | ERRC

STOF
STart Of Frame: triggers on the first edge of the dominant SOF bit (synchronization bit).

FTYP
Frame TYPe: triggers on a specified frame type (data, remote, error, or overload) and on the identifier format.
To set the frame type, use `TRIGger<m>:CAN:FTYPe`. ´Set the identifier format with `TRIGger<m>:CAN:ITYPe`

ID
IDentifier: Sets the trigger to one specific identifier or an identifier range. To set the identifier, use `TRIGger<m>:CAN:ICONdition`, `TRIGger<m>:CAN:IMIN`, and `TRIGger<m>:CAN:IMAX`.

IDDT
IDentifier and DaTa: Combination of identifier and data conditions To set the identifier condition, use `TRIGger<m>:CAN:ICONdition`, `TRIGger<m>:CAN:IMIN`, and `TRIGger<m>:CAN:IMAX`.
To set the data condition, use `TRIGger<m>:CAN:DCONdition`, `TRIGger<m>:CAN:DMIN`, and `TRIGger<m>:CAN:DMAX`.

ERRC
ERRor Condition: Define the error types with
TRIGger<m>:CAN:ACKerror,
TRIGger<m>:CAN:BITSterror,
TRIGger<m>:CAN:CRCerror,
TRIGger<m>:CAN:FORMerror,
TRIGger<m>:CAN:FDATa:SCERror on page 1377.
*RST: STOF

TRIGger<m>:CAN:FDATa:STANdard <Standard>

Selects the CAN standard. Use ANY if the standard of the signal is unknown.

The setting is available in CAN FD option R&S RTP-K9.

Parameters:
<Standard> ANY | CAN | CANFd
*RST: CAN

TRIGger<m>:CAN:FTYPe <FrameType>

Selects the CAN frame type if TRIGger<m>:CAN:TYPE is set to FTYP (frame type) or ID (identifier).

For data and remote frames, the identifier format has to be set with TRIGger<m>:CAN:ITYPe.

See also: "Frame type" on page 517

Parameters:
<FrameType> ANY | DATA | REMote | ERRor | OVERload
Available values depend on the CAN standard and on the TRIGger<m>:CAN:TYPE setting:
Remote frames are not available in the CAN FD protocol.
If the trigger type is set to FTYP (frame type), you can set the values DATA | REMote | ERRor | OVERload.
If the trigger type is set to ID (identifier), you can set the values ANY | DATA | REMote.
*RST: ANY

TRIGger<m>:CAN:ITYPe <IdentifierType>

Selects the format of data and remote frames.

Remote frames are not available in the CAN FD protocol.

Parameters:
<IdentifierType> ANY | B11 | B29

B11
11 bit identifier (standard format). The instrument triggers on the sample point of the IDE bit.

B29
29 bit identifier (extended format). The instrument triggers on the sample point of the RTR bit.

ANY
The ID type and ID pattern are not relevant for the trigger condition.

*RST: ANY

TRIGger<m>:CAN:ICONdition <IdOperator>

Sets the operator to set a specific identifier or an identifier range.

Parameters:

<IdOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with `TRIGger<m>:CAN:IMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:CAN:IMIN` and `TRIGger<m>:CAN:IMAX` on page 1372.

*RST: EQUal

TRIGger<m>:CAN:IMIN <IdPattern>

Specifies a message identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

TRIGger<m>:CAN:IMAX <IdPatternTo>

Sets the the end value of an identifier range if `TRIGger<m>:CAN:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<IdPatternTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

TRIGger<m>:CAN:FDATa:FDF <FDFBit>

Specifies the CAN FD frame format. It corresponds to the EDL bit (extended data length), which only exists in CAN FD format.

Parameters:

<FDFBit> ONE | ZERO | DC

ONE: CAN FD.
ZERO: CAN.
DC: don't care, the format is not relevant.

*RST: DC

TRIGger<m>:CAN:FDATa:BRS <BRSBit>

Sets the bit rate switch bit.

Parameters:

<BRSBit> ONE | ZERO | DC

ONE: the bit rate switches from the bit rate of the arbitration phase to the faster data rate.

*RST: ONE

TRIGger<m>:CAN:FDATa:ESI <ESIBit>

Sets the error state indicator bit.

Parameters:

<ESIBit> ONE | ZERO | DC

DC: don't care, bit is nor relevant

*RST: DC

TRIGger<m>:CAN:DCONdition <DataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `TRIGger<m>:CAN:DMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:CAN:DMIN` and `TRIGger<m>:CAN:DMAX`.

*RST: EQUal

TRIGger<m>:CAN:DMIN <DataPattern>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:CAN:DMAX <DataPatternTo>

Sets the the end value of an data range if `TRIGger<m>:CAN:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:CAN:BORDer <Endianness>

Sets the byte order (endianness) of the data transfer. Only for CAN protocol.

Parameters:

<Endianness> BENDian | LENDian

BENDian
Big endian, data is analyzed and evaluated in the order of reception.

LENDian
Little endian, the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

*RST: BENDian

TRIGger<m>:CAN:DLCCondition <DLCOperator>

Operator to set the data length code for triggering on CAN and CAN FD data.

For details, see "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 519.

The number of data bytes to be found is set with `TRIGger<m>:CAN:DLC`.

See also: `TRIGger<m>:CAN:BORDer`.

Parameters:

<DLCOperator> EQUal | GETHan

For little endian transfer direction, EQUal must be set.

*RST: GETHan

TRIGger<m>:CAN:DLC <WordCount>

Sets the Data Length Code, the number of data bytes to be found. For complete definition, set also the operator with `TRIGger<m>:CAN:DLCCondition` on page 1374.

Parameters:

<WordCount>	Range:	CAN: 1 to 8, CAN FD: 1 to 15 (64 bytes)
	Increment:	1
	*RST:	1

TRIGger<m>:CAN:NDBYtes?

Returns the number of data bytes defined by DLC. DLC and NDB are different in CAN FD for DLCs > 8.

See also: "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 519.

Return values:

<NDBytes>	Range:	1 to 64
	Increment:	1
	*RST:	1

Usage: Query only

TRIGger<m>:CAN:FDATa:DPOPerator <DataPosOperator>

Sets the operator to define an exact position or a data range where the instrument looks for the specified data pattern.

The setting is available in CAN FD option R&S RTP-K9.

The position can be defined if the data field of the frame is longer than 8 bytes - if `TRIGger<m>:CAN:DLC`≥9.

Parameters:

<DataPosOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The data position is not relevant for the trigger condition.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `TRIGger<m>:CAN:FDATa:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `TRIGger<m>:CAN:FDATa:DPOSition` and `TRIGger<m>:CAN:FDATa:DPTO`.

*RST: ANY

TRIGger<m>:CAN:FDATa:DPOSition <DataPosition>

Defines the number of the first data byte at which the data pattern may start.

The setting is available in CAN FD option R&S RTP-K9.

Parameters:

<DataPosition>	Range:	1 to 57
	Increment:	1
	*RST:	1

TRIGger<m>:CAN:FDATa:DPTO <DataPositionTo>

Sets the number of the last byte at which the required data pattern may start.

Parameters:

<DataPositionTo>	Range:	8 to 64
	Increment:	1
	*RST:	8

TRIGger<m>:CAN:ACKerror <AckError>

Triggers when the transmitter does not receive an acknowledgment - a dominant bit during the Ack Slot.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<AckError> ON | OFF

*RST: ON

TRIGger<m>:CAN:BITSterror <BitStuffError>

Triggers if astuff error occurs - when the 6th consecutive equal bit level in the mentioned fields is detected.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<BitStuffError> ON | OFF

*RST: ON

TRIGger<m>:CAN:CRCerror <ChecksumError>

Triggers on CRC errors. A CRC error occurs when the CRC calculated by the receiver differs from the received value in the CRC sequence.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<ChecksumError> ON | OFF

*RST: ON

TRIGger<m>:CAN:FORMerror <FormError>

Triggers when a fixed-form bit field contains one or more illegal bits.

The trigger type has to be set before: `TRIGger<m>:CAN:TYPE` to `ERRC`.

Parameters:

<FormError> ON | OFF

*RST: ON

TRIGger<m>:CAN:FDATa:SCERror <StuffCountError>

Triggers on stuff count errors. A stuff count error occurs if th received stuff count value does not match the value calculated from the own stuff bit count.

The trigger type `TRIGger<m>:CAN:TYPE` must be set to `ERRC`.

Only relevant for CAN FD signals in ISO standard.

Parameters:

<StuffCountError> ON | OFF

*RST: ON

20.17.6.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1301
- `BUS<m>:SYMBols` on page 1302

BUS<m>:CAN:FCOunt?

Returns the number of decoded frames of the acquisition.

Suffix:

<m>	1..4 Selects the serial bus.

Return values:

<Count>	Total number of decoded frames. Range: 0 to 100000 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:CAN:FDATa:FRAMe<n>:STANdard?

Returns the CAN standard.

The setting is available in CAN FD option R&S RTP-K9.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* The frame suffix is irrelevant.

Return values:

<Standard>	CAN | CANFd *RST: CAN

Usage: Query only

BUS<m>:CAN:FRAMe<n>:STATus?

Returns the overall state of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameState>	OK | FORM | BTST | CRC | CRCD | NOACk | ACKD | EOFD | CAERror | FCERor | INSufficient | SERRror | SFERror | SCERror | SAERror | SCAE | SCFE

OK: the frame is valid.
FORM: Fixed-bit form error
BTST: Bit stuffing error occured.
CRC: Cyclic redundancy check failed.
CRCD: Wrong CRC delimiter occured.
NOACK: Acknowlegde is missing.
ACKD: Wrong ACK delimiter occured.
EOFD: Wrong end of frame.
CAERror: CRC error followed by an acknowledgement error (missing acknowledge)
FCERor: CRC error followed by a form error (wrong CRC delimiter or wrong ACK delimiter)
INSufficient: The frame is not completely contained in the acquisition. The acquired part of the frame is valid.
SERRror: Stuff count error (CAN-FD ISO only)
SFER: Stuff count error and FORM error (CAN-FD ISO only)
SCER: Stuff count error and CRC error (CAN-FD ISO only)
SAER: Stuff count error and ACK error (CAN-FD ISO only)
SCAE: Stuff count error and CRC error and ACK error (CAN-FD ISO only)
SCFE: Stuff count error and CRC error and FORM error (CAN-FD ISO only)

*RST: OK

Usage: Query only

BUS<m>:CAN:FRAMe<n>:NDBYtes?

REturns the number of data bytes.

Suffix:

<m> 1..4

<n> *

Return values:

<NDBytes> Range: 1 to 64
Increment: 1
*RST: 1

Usage: Query only

Firmware/Software: FW 3.35

BUS<m>:CAN:FRAMe<n>:STARt?
BUS<m>:CAN:FRAMe<n>:STOP?

Return the start time and stop time of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<Start>, <Stop> Time

Range: -100E+24 to 100E+24
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:CAN:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the number of the frame in the current acquisition, 1...n.

Return values:
<Label> String with symbolic label of the identifier

Example: `BUS:CAN:FRAMe:SYMBol?`
Response: `Temperature`

Usage: Query only

Firmware/Software: FW 1.36

BUS<m>:CAN:FRAMe<n>:TYPE?

Returns the frame type of the selected frame.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<FrameType> DATA | REMote | ERR | OVLD

Data, remote, error or overload frame.

*RST: DATA

Usage: Query only

BUS<m>:CAN:FRAMe<n>:DATA?

Returns the data of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<Data> Comma-separated list of values. The first value is the number of bytes, followed by the values of the data bytes.

Example:
```
BUS1:CAN:FRAMe2:DATA?
--> 3,208,231,32
```
Returns the data of the second frame: the number of bytes is 3 data (first value).

Usage: Query only

BUS<m>:CAN:FRAMe<n>:ACKState?
BUS<m>:CAN:FRAMe<n>:CSSTate?
BUS<m>:CAN:FRAMe<n>:DLCState?
BUS<m>:CAN:FRAMe<n>:IDSTate?

Return the states of following parts of a message

- ACKState: state of acknowledgement field
- CSSTate: state of checksum field (CRC)
- DLCState: state of data length code
- IDSTate: identifier state

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<State> OK | ERRor | UNDF

UNDF: Undefined

*RST: OK

Usage: Query only

BUS<m>:CAN:FRAMe<n>:ACKValue?

Returns the value of the acknowledge slot for the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<AckValue> To set the value format, use FORMat:BPATtern.
The values below – range, increment and reset – are decimal values.

Range: 0 to 1
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:CSValue?

Returns the CRC sequence value of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<ChecksumValue> To set the value format, use FORMat:BPATtern.
The values below – range, increment and reset – are decimal values.

Range: 0 to 2097151
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:DLCValue?

Returns the data length code of the selected frame - the number of data bytes in the frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<FrameDLCValue> Number of data bytes in decimal values.

Range: 0 to 15
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:IDTYpe?

Returns the identifier type of the selected frame, the identifier format of data and remote frames.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<IdentifierType> ANY | B11 | B29

B11: standard format, 11 bit
B29: extended format, 29 bit

*RST: B11

Usage: Query only

BUS<m>:CAN:FRAMe<n>:IDValue?

Returns the identifier value of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<IdentifierValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 536870911
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:BSEPosition?

Returns the location of a bit stuffing error.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<BitStuffErrorPos> Time when the error occured

Range: 0 to 5000
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:FERCause?

Returns information on a form error, if the frame status query returned a FORM error.

See also: BUS<m>:CAN:FRAMe<n>:STATus? on page 1378

Suffix:

<m> 1..4

<n> *

Return values:

<FormErrorCause> NONE | CRCDerror | ACKDerror | FSBE | RESerror

CRCD = CRC delimiter error
ACKD = ACK delimiter error
FSBE = Fixed stuff bit error (CAN-FD ISO only)
RESE = Reserved bit error

*RST: NONE

Usage: Query only

BUS<m>:CAN:FDATa:FRAMe<n>:SCValue?

Returns the stuff bit count modulo 8 value.

Suffix:

<m> 1..4

<n> *

Return values:

<StuffCount> Range: 0 to 7
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:CAN:FRAMe<n>:BYTE<o>:STATe?

Returns the state of the specified byte.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:

<State> OK | ERRor | UNDF

UNDF: Undefined

*RST: OK

Usage: Query only

BUS<m>:CAN:FRAMe<n>:BYTE<o>:VALue?

Returns the value of the specified byte.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:

<Value> To set the value format, use FORMat:BPATtern.
The values below – range, increment and reset – are decimal values.

Range: 0 to 255
*RST: 0

Usage: Query only

20.17.6.4 Search Settings

SEARch:TRIGger:CAN[:SSOFrame] <SearchName>,<FrameStart>
SEARch:TRIGger:CAN[:SSOFrame]? <SearchName>

Enables the search for a start of frame.

Parameters:
<FrameStart> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:SFTYpe <SearchName>,<FrameType>
SEARch:TRIGger:CAN:SFTYpe? <SearchName>

Enables the search for a specified frame type.

Parameters:
<FrameType> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:SFIDentifier <SearchName>,<Identifier>
SEARch:TRIGger:CAN:SFIDentifier? <SearchName>

Enables the search for frame indentifier.

Parameters:
<Identifier> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CAN:SIDData <SearchName>,<IdentifierData>
SEARch:TRIGger:CAN:SIDData? <SearchName>

Enables the search for identifier and data.

Parameters:

<IdentifierData> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:SERRor <SearchName>,<ErrorCondition>
SEARch:TRIGger:CAN:SERRor? <SearchName>

Enables the search for a specified error.

Parameters:

<ErrorCondition> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:FDATa:STANdard <SearchName>,<Standard>
SEARch:TRIGger:CAN:FDATa:STANdard? <SearchName>

Selects the CAN standard: CAN, CAN FD, or Any.

Use "Any" to search on either CAN or CAN-FD frame. In this case, the search configuration provides all possible settings, for CAN as well as for CAN FD.

The setting is available in CAN FD option R&S RTP-K9.

Parameters:

<Standard> ANY | CAN | CANFd

*RST: CAN

Parameters for setting and query:

<SearchName> String with the search name

SEARch:TRIGger:CAN:FTYPe <SearchName>,<FrameType>
SEARch:TRIGger:CAN:FTYPe? <SearchName>

Selects the CAN frame type to be searched for.

For data and remote frames, the identifier format has to be set with `SEARch:TRIGger:CAN:ITYPe` on page 1388.

Parameters:

<FrameType> ANY | DATA | REMote | ERRor | OVERload

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:ITYPe <SearchName>,<IdentifierType>
SEARch:TRIGger:CAN:ITYPe? <SearchName>

Selects the format of data and remote frames: 11 bit for CAN base frames, or 29 bits for CAN extended frames.

Parameters:

<IdentifierType> ANY | B11 | B29

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:ICONdition <SearchName>,<IdOperator>
SEARch:TRIGger:CAN:ICONdition? <SearchName>

Sets the operator to set a specific identifier or an identifier range.

Parameters:

<IdOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with SEARch:TRIGger:CAN:IMIN.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with SEARch:TRIGger:CAN:IMIN and SEARch:TRIGger:CAN:IMAX.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:IMAX <SearchName>,<IdPatternTo>
SEARch:TRIGger:CAN:IMAX? <SearchName>

Sets the the end value of an identifier range if SEARch:TRIGger:CAN:ICONdition is set to INRange or OORange.

Parameters:

<IdPatternTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:IMIN <SearchName>,<IdPattern>
SEARch:TRIGger:CAN:IMIN? <SearchName>

Specifies a message identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:CAN:DCONdition? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:CAN:DMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:CAN:DMIN` and `SEARch:TRIGger:CAN:DMAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:DMIN <SearchName>,<DataPattern>
SEARch:TRIGger:CAN:DMIN? <SearchName>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:DMAX <SearchName>,<DataPatternTo>
SEARch:TRIGger:CAN:DMAX? <SearchName>

Sets the the end value of an data range if `SEARch:TRIGger:CAN:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:DLCCondition <SearchName>,<DLCOperator>
SEARch:TRIGger:CAN:DLCCondition? <SearchName>

Operator to set the data length code for search.

Parameters:

<DLCOperator> EQUal | GETHan

*RST: GETHan

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:DLC <SearchName>,<WordCount>
SEARch:TRIGger:CAN:DLC? <SearchName>

Sets the Data Length Code, the number of data bytes to be found. For complete definition, set also the operator with `SEARch:TRIGger:CAN:DLCCondition`.

Parameters:

<WordCount> Range: 1 to 8
Increment: 1
*RST: 1

Parameters for setting and query:

<SearchName>

SEARch:RESult:CAN:FRAMe<m>:NDBYtes? <SearchName>

Returns the number of data bytes defined by DLC. DLC and NDB are different in CAN FD for DLCs > 8.

See also: "Data setup: DLC, NDB, Transfer, Condition, Data min, Data max" on page 519.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<NDBytes> Range: 1 to 64
Increment: 1
*RST: 1

Usage: Query only

SEARch:TRIGger:CAN:FDATa:DPOPerator <SearchName>,<DataPosOperator>
SEARch:TRIGger:CAN:FDATa:DPOPerator? <SearchName>

Sets the operator for the data position if DLC ≥ 9. You can define an exact position, or a position range.

The setting is available in CAN FD option R&S RTP-K9.

Parameters:

<DataPosOperator> ANY | OFF | EQUal | GETHan | INRange | RANGe

ANY = OFF
The data position is not relevant for the search.

EQUal | GETHan
Equal, Greater or equal than. These conditions require one data position to be set with `SEARch:TRIGger:CAN:FDATa:DPOSition`.

INRange = RANGe
In range: Set the minimum and maximum value of the range with `SEARch:TRIGger:CAN:FDATa:DPOSition` and `SEARch:TRIGger:CAN:FDATa:DPTO`.

*RST: ANY

Parameters for setting and query:

<SearchName> String with the search name

SEARch:TRIGger:CAN:FDATa:DPOSition <SearchName>,<DataPosition>
SEARch:TRIGger:CAN:FDATa:DPOSition? <SearchName>

Defines the first possible start position of the data pattern.

The setting is available in CAN FD option R&S RTP-K9.

Parameters:

<DataPosition> Range: 1 to 57
Increment: 1
*RST: 1

Parameters for setting and query:

<SearchName> String with the search name

SEARch:TRIGger:CAN:FDATa:DPTO <SearchName>,<DataPositionTo>
SEARch:TRIGger:CAN:FDATa:DPTO? <SearchName>

Defines the last possible start position of the data pattern if the position operator `SEARch:TRIGger:CAN:FDATa:DPOPerator` defines a range.

The setting is available in CAN FD option R&S RTP-K9.

Parameters:

<DataPositionTo> Range: 8 to 64
Increment: 1
*RST: 8

Parameters for setting and query:

<SearchName> String with the search name

SEARch:TRIGger:CAN:ACKerror <SearchName>,<AckError>
SEARch:TRIGger:CAN:ACKerror? <SearchName>

Searches for acknowledgement errors. An acknowledgement error occurs when the transmitter does not receive an acknowledgment - a dominant bit during the Ack Slot.

Parameters:

<AckError> ON | OFF
*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:BITSterror <SearchName>,<BitStuffError>
SEARch:TRIGger:CAN:BITSterror? <SearchName>

Searches for bit stuffing errors.

Parameters:

<BitStuffError> ON | OFF
*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:CRCerror <SearchName>,<ChecksumError>
SEARch:TRIGger:CAN:CRCerror? <SearchName>

Searches for errors in the Cyclic Redundancy Check.

Parameters:

<ChecksumError> ON | OFF
*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:FORMerror <SearchName>,<FormError>
SEARch:TRIGger:CAN:FORMerror? <SearchName>

Searches for form errors. A form error occurs when a fixed-form bit field contains one or more illegal bits.

Parameters:

<FormError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:FDATa:SCERror <SearchName>,<StuffCountError>
SEARch:TRIGger:CAN:FDATa:SCERror? <SearchName>

Triggers on stuff count errors. A stuff count error occurs if th received stuff count value does not match the value calculated from the own stuff bit count.

Only relevant for CAN FD signals in ISO standard.

Parameters:

<StuffCountError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CAN:FDATa[:FDF] <SearchName>,<FDFBit>
SEARch:TRIGger:CAN:FDATa[:FDF]? <SearchName>

Sets the EDL bit (extended data length), which determines whether a frame is CAN or CAN-FD.

The setting is available in CAN FD option R&S RTP-K9.

Parameters:

<FDFBit> ONE | ZERO | DC

ONE: CAN FD.
ZERO: CAN.
DC: don't care, the format is not relevant.

*RST: DC

Parameters for setting and query:

<SearchName> String with the search name

SEARch:TRIGger:CAN:FDATa:BRS <SearchName>,<BRSBit>
SEARch:TRIGger:CAN:FDATa:BRS? <SearchName>

Sets the bit rate switching bit for identifier and identifier + data searches.

The setting is available in CAN FD option R&S RTP-K9.

Parameters:

<BRSBit> ONE | ZERO | DC

DC: Don't care

*RST: ONE

Parameters for setting and query:

<SearchName> String with the search name

SEARch:TRIGger:CAN:FDATa:ESI <SearchName>,<ESIBit>
SEARch:TRIGger:CAN:FDATa:ESI? <SearchName>

Sets the error state indicator bit for identifier and identifier + data searches.

The setting is available in CAN FD option R&S RTP-K9.

Parameters:

<ESIBit> ONE | ZERO | DC

*RST: DC

Parameters for setting and query:

<SearchName> String with the search name

20.17.6.5 Search Results

The search on decoded CAN data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.6.3, "Decode Results", on page 1377.

SEARch:RESult:CAN:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:ACKValue? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<AckValue>	Range:	0 to 1
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:BSEPosition? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<BitStuffErrorPos>	Range:	0 to 5000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:STATe? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:

<State>	OK | ERRor | UNDF	
	*RST:	OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:BYTE<n>:VALue? <SearchName>

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<Value>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:ACKState? <SearchName>
SEARch:RESult:CAN:FRAMe<m>:CSSTate? <SearchName>
SEARch:RESult:CAN:FRAMe<m>:DLCState? <SearchName>
SEARch:RESult:CAN:FRAMe<m>:IDSTate? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<IdentifierState>	OK | ERRor | UNDF	
	*RST:	OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:CSValue? <SearchName>

Suffix:

<m>	*

Query parameters:
<SearchName>

Return values:

<ChecksumValue> Range: 0 to 2097151
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:DATA? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Data>

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:DLCValue? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameDLCValue> Range: 0 to 15
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:FERCause? <SearchName>

Returns information on a form error, if the frame status query returned a FORM error.

See also: SEARch:RESult:CAN:FRAMe<m>:STATus? on page 1399.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FormErrorCause> NONE | CRCDerror | ACKDerror | FSBE | RESerror
See BUS<m>:CAN:FRAMe<n>:FERCause? on page 1384.
*RST: NONE

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:IDTYpe? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<IdentifierType> ANY | B11 | B29
*RST: B11

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:IDValue? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<IdentifierValue> Range: 0 to 536870911
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:CAN:FDATa:FRAMe<m>:SCValue? <SearchName>

Returns the stuff bit count modulo 8.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<StuffCount> Range: 0 to 7
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:CAN:FDATa:FRAMe<m>:STANdard? <SearchName>

Returns the CAN protocol standard: CAN or CAN FD.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<Standard> CAN | CANFd

*RST: CAN

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:STARt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:STATus? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameState> OK | FORM | BTST | CRC | CRCD | NOACk | ACKD | EOFD | CAERror | FCERor | INSufficient | SERRror | SFERror | SCERror | SAERror | SCAE | SCFE

See `BUS<m>:CAN:FRAMe<n>:STATus?` on page 1378.

*RST: OK

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:STOP? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameStop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:SYMBol? <SearchName>

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m> *
Selects the number of the frame in the current acquisition, 1...n.

Query parameters:

<SearchName> String parameter that contains the search definition name

Return values:

<Label> Symbolic label (string)

Usage: Query only

SEARch:RESult:CAN:FRAMe<m>:TYPE? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameType> DATA | REMote | ERR | OVLD
*RST: DATA

Usage: Query only

20.17.6.6 Symbolic Trigger, Decode and Search

Symbolic Trigger

TRIGger<m>:CAN:SYMBolic:MSGValue <MessageName>

Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

See also: `SEARch:TRIGger:CAN:SYMBolic:MSGValue` on page 1403

Parameters:

<MessageName> String with the symbolic message name

TRIGger<m>:CAN:SYMBolic:TSIGnals <TriggerOnSignal>

Enables the trigger on a specific signal value that is part of the selected message.

Parameters:

<TriggerOnSignal> ON | OFF

*RST: OFF

TRIGger<m>:CAN:SYMBolic:SIGValue <SignalName>

Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

See also: `SEARch:TRIGger:CAN:SYMBolic:SIGValue` on page 1404

Parameters:

<SignalName> String with the signal name as defined in the DBC file.

TRIGger<m>:CAN:SYMBolic:DMAX <DataPatternTo>

Defines the maximum data value of the signal.

This value is required to specify a range if condition `INRange | OORange` is set with `TRIGger<m>:CAN:DCONdition`.

Parameters:

<DataPatternTo> Decimal representation of the data pattern

Range: -100E+24 to 100E+24
Increment: 0.5
*RST: 1

TRIGger<m>:CAN:SYMBolic:DMIN <DataPattern>

Defines the minimum data value of the signal.

To set the condition, use `TRIGger<m>:CAN:DCONdition`.

Parameters:
<DataPattern> Decimal representation of the data pattern

Range: -100E+24 to 100E+24
Increment: 0.5
*RST: 0

TRIGger<m>:CAN:SYMBolic:SGEValue <SignalEnumValue>

Sets a symbolic data value for signals with enumerated values.

Parameters:
<SignalEnumValue> Numeric value according to the value definition in the DBC file

Example: Definition line in DBC file:
```
VAL_ 2175091489 Gear 0 "Idle" 1 "Gear_1" 2 "Gear_2" 3 "Gear_3" 4 "Gear_4"
```
Search for "Gear_4"
```
TRIGger:CAN:SYMBolic:SGEValue "Search1",4
```

Symbolic Decode Results

BUS<m>:CAN:FRAMe<n>:SDATa?

Returns the complete symbolic data of the selected frame.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<SymbolicData> String with comma-separated list of symbolic data

Example:
```
BUS:CAN:FRAMe9:SDATa?
<-- [sym] 325 kW, 0x0A, 423 N, 174 l, Running, 90 degC, 0x06, 437 rpm
```
Returns the symbolic results of the 9th frame.

Usage: Query only

Symbolic Search

SEARch:RESult:CAN:FRAMe<m>:SDATa? <SearchName>

Returns the symbolic data of the selected result frame.

Suffix:
<m> *
Sets the index of the search result frame.

Query parameters:
<SearchName> String that contains the search definition name

Return values:
<SymbolicData> String with comma-separated list of symbolic data

Example:
```
SEARch:RESult:CAN:FRAMe:SDATa? 'Search1'
<-- [sym] 325 kW, 0x0A, 423 N, 174 l, Running, 90 degC, 0x06, 437 rpm
```
Returns the symbolic results of the first search result.

Usage: Query only

SEARch:TRIGger:CAN:SSYMbolic <SearchName>,<CheckSymbolic>
SEARch:TRIGger:CAN:SSYMbolic? <SearchName>

Enables the symbolic search and disables all other search criteria.

Parameters:
<CheckSymbolic> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName> String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:MSGValue <SearchName>, <MessageName>
SEARch:TRIGger:CAN:SYMBolic:MSGValue? <SearchName>

Sets the message to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same message if symbolic trigger and symbolic search is used at the same time.

See also: TRIGger<m>:CAN:SYMBolic:MSGValue on page 1401

Parameters:
<MessageName> String that contains the symbolic message name

Parameters for setting and query:
<SearchName> String that contains the search definition name

Example:
```
SEARch:TRIGger:CAN:SYMBolic:MSGValue "Search1",
"EngineData"
```

SEARch:TRIGger:CAN:SYMBolic:SSIGnals <SearchName>,<SymbolicSearch>
SEARch:TRIGger:CAN:SYMBolic:SSIGnals? <SearchName>

Enables the search for symbolic values if DBC label list file is loaded and applied. Symbolic search disables all other search criteria.

Parameters:

<SymbolicSearch> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName> String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:SIGValue <SearchName>, <SignalName>
SEARch:TRIGger:CAN:SYMBolic:SIGValue? <SearchName>

Sets the signal name to be triggered or searched for.

The setting is used by symbolic trigger and symbolic search. Thus, you always trigger on and search for the same signal if symbolic trigger and symbolic search is used at the same time.

See also: `TRIGger<m>:CAN:SYMBolic:SIGValue` on page 1401

Parameters:

<SignalName> String that contains the symbolic signal name

Parameters for setting and query:

<SearchName> String that contains the search definition name

Example:

```
SEARch:TRIGger:CAN:SYMBolic:SIGValue "Search1",
"EngForce"
```

SEARch:TRIGger:CAN:SYMBolic:DMIN <SearchName>,<DataPattern>
SEARch:TRIGger:CAN:SYMBolic:DMIN? <SearchName>

Defines the minimum data pattern in a symbolic search.

To set the condition, use `SEARch:TRIGger:CAN:DCONdition`.

Parameters:

<DataPattern> Range: -100E+24 to 100E+24
Increment: 0.5
*RST: 0

Parameters for setting and query:

<SearchName> String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:DMAX <SearchName>,<DataPatternTo>
SEARch:TRIGger:CAN:SYMBolic:DMAX? <SearchName>

Defines the maximum data pattern of the signal in a symbolic search.

This value is required to specify a range if condition `INRange | OORange` is set with `SEARch:TRIGger:CAN:DCONdition` on page 1389.

Parameters:

<DataPatternTo>	Range:	-100E+24 to 100E+24
	Increment:	0.5
	*RST:	1

Parameters for setting and query:

<SearchName> String that contains the search definition name

SEARch:TRIGger:CAN:SYMBolic:SGEValue <SearchName>, <SignalEnumValue>
SEARch:TRIGger:CAN:SYMBolic:SGEValue? <SearchName>

Sets a symbolic data value for signals with enumerated values.

Parameters:

<SignalEnumValue> Numeric value according to the value definition in the DBC file

Parameters for setting and query:

<SearchName> String that contains the search definition name

Example: Definition line in DBC file:

```
VAL_ 2175091489 Gear 0 "Idle" 1 "Gear_1" 2 "Gear_2" 3 "Gear_3" 4 "Gear_4"
```

Search for "Gear_3"

```
SEARch:TRIGger:CAN:SYMBolic:SGEValue "Search1",3
```

20.17.7 LIN (Option R&S RTP-K3)

20.17.7.1 Configuration

BUS<m>:LIN:DATA:SOURce <DataSource>

Sets the waveform of the data line.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<DataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15
See Chapter 20.4.2, "Waveform Parameter", on page 970
*RST: C1W1

Usage: Asynchronous command

BUS<m>:LIN:DATA:THReshold <Threshold>

Sets a user-defined threshold value.

Alternatively, you can set the threshold according to the signal technology with `BUS<m>:LIN:TECHnology`.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<Threshold> Range: -12 to 12
Increment: 0.1
*RST: 0
Default unit: V

BUS<m>:LIN:TECHnology <Technology>

Sets the threshold voltage as defined for various signal technologies.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<Technology> V15 | V25 | V35 | V6 | V9 | MAN

V15
1.5 Volt (TTL)

V25
2.5 Volt (CMOS 5.0 V)

V35 | V6 | V9
3.5 V (7 V supply), 6.0 V (12 V supply), 9.0 V (18 V supply) respectively

MAN
Manual setting of user-defined values with `BUS<m>:LIN:DATA:THReshold`.

*RST: V35

BUS<m>:LIN:BITRate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Bitrate>	Range: 1000 to 20000 Increment: 1 *RST: 9600 Default unit: bps

BUS<m>:LIN:POLarity <Polarity>

Defines the idle state of the bus. The idle state is the rezessive state and corresponds to a logic 1.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Polarity>	IDLLow | IDLHigh *RST: IDLHigh

BUS<m>:LIN:STANdard <Standard>

Selects the version of the LIN standard.

See also: "LIN standard" on page 551

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Standard>	V1X | V2X | J2602 | AUTO *RST: AUTO

20.17.7.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:LIN:TYPE <Type>

Selects the trigger type for LIN analysis.

See: "Trigger type" on page 552.

Parameters:

<Type> SYNC | ID | IDOR | IDDT | WKFR | ERRC

SYNC
Start of the frame, triggers on the stop bit of the sync field.

ID
Sets the trigger to one specific identifier or an identifier range.
To set the identifier, use `TRIGger<m>:LIN:ICONdition`, `TRIGger<m>:LIN:IMIN` on page 1409, and `TRIGger<m>:LIN:IMAX` on page 1409.

IDOR
Triggers on an OR combination with up to four identifier conditions. For each identifier condition, enable it with `TRIGger<m>:LIN:IDOR<n>:ENABle` and set the value with `TRIGger<m>:LIN:IDOR<n>[:VALue]`

IDDT
Combination of identifier and data conditions
To set the identifier condition, use `TRIGger<m>:LIN:ICONdition`, `TRIGger<m>:LIN:IMIN`, and `TRIGger<m>:LIN:IMAX`.
To set the data condition, use `TRIGger<m>:LIN:DCONdition`, `TRIGger<m>:LIN:DMIN`, and `TRIGger<m>:LIN:DMAX`.

WKFR
Wakeup frame

ERRC
Error condition. Define the error types with TRIGger<m>:LIN:CHKSerror on page 1412, TRIGger<m>:LIN:IPERror, and TRIGger<m>:LIN:SYERror

*RST: SYNC

TRIGger<m>:LIN:ICONdition <IdOperator>

Sets the operator to set a specific identifier or an identifier range.

Parameters:

<IdOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These condition require one identifier pattern to be set with TRIGger<m>:LIN:IMIN

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with TRIGger<m>:LIN:IMIN and TRIGger<m>:LIN:IMAX

*RST: EQUal

TRIGger<m>:LIN:IMIN <IdPattern>

Specifies a slave identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

TRIGger<m>:LIN:IMAX <IdPatternTo>

Sets the the end value of an identifier range if TRIGger<m>:LIN:ICONdition is set to INRange or OORange.

Parameters:

<IdPatternTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

TRIGger<m>:LIN:DCONdition <DataOperator>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `TRIGger<m>:LIN:DMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `TRIGger<m>:LIN:DMIN` and `TRIGger<m>:LIN:DMAX`

*RST: EQUal

TRIGger<m>:LIN:DMIN <DataPattern>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:LIN:DMAX <DataPatternTo>

Sets the the end value of an data range if `TRIGger<m>:LIN:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:LIN:BORDer <Endianness>

Sets the byte order (endianness) of the data transfer.

According to the standard, LIN data is transmitted in little endian transfer order.

Parameters:

<Endianness> BENDian | LENDian

BENDian
Big endian, data is analyzed and evaluated in the order of reception.

LENDian
Little endian, the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

*RST: BENDian

TRIGger<m>:LIN:DLECondition <DLCOperator>

Operator to set the data length for triggering on LIN data.

For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set.

Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*. With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*.

The number of data bytes to be found is set with `TRIGger<m>:LIN:DLENgth` on page 1411.

See also:`TRIGger<m>:LIN:BORDer` on page 1410 .

Parameters:

<DLCOperator>	EQUal | GETHan	
	For little endian transfer direction, EQUal must be set.	
	*RST:	GETHan

TRIGger<m>:LIN:DLENgth <WordCount>

Sets the length of the bit pattern to be found, in bytes. For "Big Endian" transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the beginning of the data pattern. For "Little Endian" transfer direction, the exact number of data bytes in the frame must be set.

For complete definition, set also the operator with `TRIGger<m>:LIN:DLECondition` on page 1411.

Parameters:

<WordCount>	Range:	1 to 8
	Increment:	1
	*RST:	1

TRIGger<m>:LIN:IDOR<n>:ENABle <UseIdentifier>

Includes the indicated IDOR address in the "identifier OR" trigger condition.

Suffix:

<n>	1..4 Index of the identifier in an "identifier OR" condition

Parameters:

<UseIdentifier>	ON | OFF	
	*RST:	OFF

Firmware/Software: V 1.25

TRIGger<m>:LIN:IDOR<n>[:VALue] <IdPattern>

Defines the pattern of the indicated IDOR identifier in the "identifier OR" trigger condition.

Suffix:

<n>	1..4 Index of the identifier in an "identifier OR" condition

Parameters:

<IdPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The parameter accepts the bit value X (don't care).

Firmware/Software: V 1.25

TRIGger<m>:LIN:SYERror <SyncError>

Triggers if a synchronization error occurs.

The trigger type has to be set before: `TRIGger<m>:LIN:TYPE` to `ERRC`.

Parameters:

<SyncError>	ON | OFF *RST: ON

TRIGger<m>:LIN:IPERror <IdParityError>

Triggers if an error occurs in the identifier parity bits. These are the bits 6 and 7 of the identifier.

The trigger type has to be set before: `TRIGger<m>:LIN:TYPE` to `ERRC`.

Parameters:

<IdParityError>	ON | OFF *RST: ON

TRIGger<m>:LIN:CHKSerror <ChecksumError>

Triggers on checksum errors according to the LIN standard set with `BUS<m>:LIN:STANdard`.

The trigger type has to be set before: `TRIGger<m>:LIN:TYPE` to `ERRC`.

The frame identifier must be set with `TRIGger<m>:LIN:ERRPattern` on page 1413 and the data length with `TRIGger<m>:LIN:CRCDatalen` on page 1413.

Parameters:

<ChecksumError>	ON | OFF *RST: ON

TRIGger<m>:LIN:ERRPattern <ErrorPattern>

Sets the frame identifier to trigger on a checksum error with `TRIGger<m>:LIN:CHKSerror` on page 1412.

Parameters:

<ErrorPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.
Possible values depend on `TRIGger<m>:LIN:CRCDatalen`.
Defining don't care bits 'X' in the ERRP bit string resets CRCDatalen to 0. When CRCDatalen is different than 0, then all the bits in ERRP must be 1 or 0, and X bits are set to 0.

Example:

```
FORM:BPAT STRG
TRIG1:LIN:ERRP '1X0'
TRIG1:LIN:ERRP?
<-- 1X0XXX
TRIGger:LIN:CRCDatalen?
<-- 0
TRIGger:LIN:CRCDatalen 4
TRIG1:LIN:ERRP?
<-- 100000
TRIG1:LIN:ERRP '00x11'
TRIG1:LIN:ERRP?
<-- 00X11X
TRIGger:LIN:CRCDatalen?
<-- 0
```

Firmware/Software: V 1.25

TRIGger<m>:LIN:CRCDatalen <CRCDataLength>

Sets the number of data bytes to trigger on CRC errors (`TRIGger<m>:LIN:TYPE` is set to ERRC and `TRIGger<m>:LIN:CHKSerror` is set ON.)

Parameters:

<CRCDataLength> Values ≠0 restrict allowed bit values in `TRIGger<m>:LIN:ERRPattern` to 0 and 1.

Range: 0 to 8
Increment: 1
*RST: 0

TRIGger<m>:LIN:STANdard <LINStandard>

Sets the LIN standard to trigger on CRC errors (`TRIGger<m>:LIN:TYPE` is set to ERRC and `TRIGger<m>:LIN:CHKSerror` is set ON.)

See also: "LIN standard" on page 551.

Parameters:

<LINStandard> V1X | V2X | J2602 | AUTO

*RST: AUTO

20.17.7.3 Decode Results

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1301
- `BUS<m>:SYMBols` on page 1302

BUS<m>:LIN:FCOunt?

Returns the number of decoded frames.

Suffix:

<m> 1..4
Selects the serial bus.

Return values:

<Count> Total number of decoded frames.

Usage: Query only

BUS<m>:LIN:FRAMe<n>:STATus?

Returns the overall state of the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n>	* Selects the frame.

Return values:

<FrameState>	OK | UART | CHCKsum | VERS | LENer | SPERror | PRERror | SYERror | WAKeup | CPERror | INSufficient | INComplete UART: at least one UART error occured. LIN uses UART words without parity bit. CHCKsum: checksum error VERS: the version of the LIN standard is not valid LENer: unexpected length SPERror: stop error PRERror: parity error in identifier SYERror: synchronization error WAKeup: the frame is a wakeup frame CPERror: parity error and checksum error INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid. INComplete: the frame is missing some parts *RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:STARt?
BUS<m>:LIN:FRAMe<n>:STOP?

Returns the start time and stop time of the selected frame, respectively.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Start>, <Stop>	Range: -100E+24 to 100E+24 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:LIN:FRAMe<n>:SYMBol?

Returns the symbolic label of the specified frame if the label list is enabled.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the number of the frame in the current acquisition, 1...n.

Return values:
<Translation> String with symbolic name of the identifier

Example: `BUS:LIN:FRAMe2:SYMBol?`
Response: `Temperature`

Usage: Query only

Firmware/Software: FW 1.36

BUS<m>:LIN:FRAMe<n>:VERSion?

Returns the version of the LIN standard for the specified frame.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<FrameVersion> V1X | V2X | UNK
UNK: Unknown
*RST: UNK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:DATA?

Returns the data bytes of the specified frame.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<Data> Comma-separated list of integer values (N, D1, D2,…, DN). N is the number of bytes in the frame, and D1…DN are the values of the bytes.

Example:
```
BUS:LIN:FRAMe4:DATA?
<-- 4,118,39,71,123
```

Usage: Query only

BUS<m>:LIN:FRAMe<n>:IDSTate?

Returns the identifier state of the selected frame.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<IdentifierState> OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient

STERror: start error
SPERror: stop error
PRERror: parity error
UVAL: unexpected value
NOEXists: byte does not exist
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:IDValue?

Returns the identifier value of the selected frame.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:
<IdentifierValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 63
*RST: 0

Usage: Query only

BUS<m>:LIN:FRAMe<n>:IDPValue?

Returns the value of the identifier parity bits of the selected frame.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<IdtfParityValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 3
*RST: 0

Usage: Query only

BUS<m>:LIN:FRAMe<n>:SYSTate?

Returns the state of the sync field for the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<SyncState> OK | STERror | SPERror | UVAL | NOEXists | INSufficient

STERror: start error
SPERror: stop error
UVAL: unexpected value
NOEXists: byte does not exist
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:CSSTate?

Returns the checksum state of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<ChecksumState> OK | STERror | SPERror | UVAL | NOEXists | INSufficient

STERror: start error
SPERror: stop error
UVAL: unexpected value
NOEXists: byte does not exist
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:CSValue?

Returns the checksum value of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<ChecksumValue> To set the value format, use `FORMat:BPATtern`.
The values below – range, increment and reset – are decimal values.

Range: 0 to 255
*RST: 0

Usage: Query only

BUS<m>:LIN:FRAMe<n>:BYTE<o>:STATe?

Returns the state of the specified byte.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the byte number.

Return values:

<ByteState> OK | STERror | SPERror | UVAL | NOEXists | INSufficient

STERror: start error
SPERror: stop error
UVAL: unexpected value
NOEXists: byte does not exist
INSufficient: the frame is not completely contained in the acquisition. The decoded part of the frame is valid.

*RST: OK

Usage: Query only

BUS<m>:LIN:FRAMe<n>:BYTE<o>:VALue?

Returns the value of the specified byte.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the byte.

Return values:

<ByteValue> To set the value format, use `FORMat:BPATtern`.

The values below – range, increment and reset – are decimal values.

Range: 0 to 255

*RST: 0

Usage: Query only

20.17.7.4 LIN Search Settings

In search setup commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name. The commands are similar to LIN trigger commands.

SEARch:TRIGger:LIN:SSOFrame <SearchName>,<FrameStart>
SEARch:TRIGger:LIN:SSOFrame? <SearchName>

Enables the search for the stop bit of the sync field, which marks the frame start.

Parameters:
<FrameStart> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:SFIDentifier <SearchName>,<Identifier>
SEARch:TRIGger:LIN:SFIDentifier? <SearchName>

Enables the search for one specific identifier or an identifier range.

Parameters:
<Identifier> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:IDENtifieror <SearchName>,<IdentifierOr>
SEARch:TRIGger:LIN:IDENtifieror? <SearchName>

Enables the search for one to four address conditions.

Parameters:
<IdentifierOr> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:SIDData <SearchName>,<IdentifierData>
SEARch:TRIGger:LIN:SIDData? <SearchName>

Enables the search for a combination of identifier and data conditions.

Parameters:
<IdentifierData> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:SERRor <SearchName>,<ErrorCondition>
SEARch:TRIGger:LIN:SERRor? <SearchName>

Enables the search for various errors in the frame.

Parameters:

<ErrorCondition> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:WUFRame <SearchName>,<WakeUpFrame>
SEARch:TRIGger:LIN:WUFRame? <SearchName>

Enables the search for wakeup frames.

Parameters:

<WakeUpFrame> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:ICONdition <SearchName>,<IdOperator>
SEARch:TRIGger:LIN:ICONdition? <SearchName>

Sets the operator to define a specific identifier or an identifier range.

Parameters:

<IdOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These operators require one identifier pattern to be set with `SEARch:TRIGger:LIN:IMIN`

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:LIN:IMIN` and `SEARch:TRIGger:LIN:IMAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:IMIN <SearchName>,<IdPattern>
SEARch:TRIGger:LIN:IMIN? <SearchName>

Specifies a slave identifier pattern, or sets the the start value of an identifier range.

Parameters:

<IdPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:IMAX <SearchName>,<IdPatternTo>
SEARch:TRIGger:LIN:IMAX? <SearchName>

Sets the the end value of an identifier range if `SEARch:TRIGger:LIN:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<IdPatternTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:IDOR<m>:ENABle <SearchName>,<UseIdentifier>
SEARch:TRIGger:LIN:IDOR<m>:ENABle? <SearchName>

Includes the indicated IDOR address in the "identifier OR" search.

Suffix:

<m> 1..4
Index of the identifier in an "identifier OR" condition

Parameters:

<UseIdentifier> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:IDOR<m>[:VALue] <SearchName>,<IdPattern>
SEARch:TRIGger:LIN:IDOR<m>[:VALue]? <SearchName>

Defines the pattern of the indicated IDOR identifier in the "identifier OR" trigger condition.

Suffix:

<m> 1..4
Index of the identifier in an "identifier OR" condition

Parameters:

<IdPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:LIN:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:LIN:DCONdition? <SearchName>

Sets the operator to set a specific data pattern or a data pattern range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with `SEARch:TRIGger:LIN:DMIN`.

INRange | OORange
In range / Out of range: Set the minimum and maximum value of the range with `SEARch:TRIGger:LIN:DMIN` and `SEARch:TRIGger:LIN:DMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:DMIN <SearchName>,<DataPattern>
SEARch:TRIGger:LIN:DMIN? <SearchName>

Specifies a data pattern, or sets the the start value of a data pattern range.

Parameters:

<DataPattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:DMAX <SearchName>,<DataPatternTo>
SEARch:TRIGger:LIN:DMAX? <SearchName>

Sets the the end value of an identifier range if `SEARch:TRIGger:LIN:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataPatternTo> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:BORDer <SearchName>,<Endianness>
SEARch:TRIGger:LIN:BORDer? <SearchName>

Sets the byte order (endianness) of the data transfer.

Parameters:

<Endianness> BENDian | LENDian

BENDian
Big endian, data is analyzed and evaluated in the order of reception.

LENDian
Little endian, the instrument reads the complete data, reverses the byte order of the data, and compares it with the specified data word.

*RST: BENDian

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:DLECondition <SearchName>,<DLCOperator>
SEARch:TRIGger:LIN:DLECondition? <SearchName>

Operator to set the data length for search on LIN data.

For Big Endian transfer direction, you can trigger on a number of bytes less than the data length of the frame, that means, on the first bytes that are transmitted. For Little Endian transfer direction, the exact number of data bytes in the frame must be set.

Example: The data word to be sent is *12 34 56*, and it is sent little endian by the LIN node. With Data length ≥ 2 and Transfer = Big endian, you trigger on the data of the first two bytes, that is *56 34*. With Data length = 3 and Transfer = Little endian, you trigger on the required data word *12 34 56*.

The number of data bytes to be found is set with `SEARch:TRIGger:LIN:DLENgth`.

See also: `SEARch:TRIGger:LIN:BORDer` on page 1425.

Parameters:

<DLCOperator> EQUal | GETHan

For little endian transfer direction, EQUal must be set.

*RST: GETHan

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:DLENgth <SearchName>,<WordCount>
SEARch:TRIGger:LIN:DLENgth? <SearchName>

Sets the length of the bit pattern to be found, in bytes.

For complete definition, set the operator using `SEARch:TRIGger:LIN:DLECondition`, and the transfer direction with `SEARch:TRIGger:LIN:BORDer`.

Parameters:

<WordCount>	Range:	1 to 8
	Increment:	1
	*RST:	1

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:IPERror <SearchName>,<IdParityError>
SEARch:TRIGger:LIN:IPERror? <SearchName>

Searches for errors in the identifier parity bits. These are the bits 6 and 7 of the identifier.

Parameters:

<IdParityError>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:SYERror <SearchName>,<SyncError>
SEARch:TRIGger:LIN:SYERror? <SearchName>

Searches for synchronization errors.

Parameters:

<SyncError>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:CHKSerror <SearchName>,<ChecksumError>
SEARch:TRIGger:LIN:CHKSerror? <SearchName>

Searches for checksum errors according to the LIN standard.

Use the following commands to configure the checksum error search:

- `SEARch:TRIGger:LIN:ERRPattern` on page 1427
- `SEARch:TRIGger:LIN:CRCDatalen` on page 1427
- `SEARch:TRIGger:LIN:STANdard` on page 1427

Parameters:

<ChecksumError>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:ERRPattern <SearchName>,<ErrorPattern>
SEARch:TRIGger:LIN:ERRPattern? <SearchName>

Sets the frame identifier to search for a checksum error.

Parameters:

<ErrorPattern>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:CRCDatalen <SearchName>,<CRCDataLength>
SEARch:TRIGger:LIN:CRCDatalen? <SearchName>

Sets the number of data bytes search for CRC errors.

Parameters:

<CRCDataLength>	Range:	0 to 8
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:LIN:STANdard <SearchName>,<LINStandard>
SEARch:TRIGger:LIN:STANdard? <SearchName>

Sets the LIN standard to search for CRC errors.

Parameters:

<LINStandard>	V1X | V2X | J2602 | AUTO	
	*RST:	AUTO

Parameters for setting and query:
<SearchName>

20.17.7.5 LIN Search Results

The search on decoded LIN data returns the same results as the queries for decode results.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.7.3, "Decode Results", on page 1414.

SEARch:RESult:LIN:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:STATus? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<State> OK | UART | CHCKsum | VERS | LENer | SPERror | PRERror | SYERror | WAKeup | CPERror | INSufficient | INComplete

*RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:STARt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:STOP? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:DATA? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data> Data bytes in the Frame

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:CSSTate? <SearchName>

Returns the status of the frame checksum.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<ChecksumState> OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient

STERror: StarT ERror, incorrect start bit
SPERror: StoP ERror, incorrect stop bit
PRERror:PaRity ERror, incorrect parity bit.
UVAL: unexpected value
NOEXists: byte does not exist

*RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:CSValue? <SearchName>

Returns the checksum value.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<ChecksumValue> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:IDSTate? <SearchName>

Returns the status of the identifier.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<IdentifierState> OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient

STERror: StarT ERror, incorrect start bit
SPERror: StoP ERror, incorrect stop bit
PRERror:PaRity ERror, incorrect parity bit.
UVAL: unexpected value
NOEXists: byte does not exist

*RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:IDValue? <SearchName>

Returns the value of the identifier.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<IdentifierValue> Range: 0 to 63
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:IDPValue? <SearchName>

Returns the value of the identifier parity bit.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<IdParityValue> Range: 0 to 3
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:SYMBol? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Label>

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:SYSTate? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<SyncState> OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient
*RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:VERSion? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Version> V1X | V2X | UNK
*RST: UNK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:STATe? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<ByteState> OK | STERror | SPERror | PRERror | UVAL | NOEXists | INSufficient
*RST: OK

Usage: Query only

SEARch:RESult:LIN:FRAMe<m>:BYTE<n>:VALue? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<ByteValue> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

20.17.8 Ethernet 10BASE-T and 100BASE-TX (Option R&S RTP-K8)

20.17.8.1 Configuration

In all `BUS<m>:ETHernet` commands, the suffix <m> selects the serial bus.

BUS<m>:ETHernet:VARiant <Variant>

Selects the Ethernet protocol variant and transmission speed.

Suffix:

<m> 1..4

Parameters:

<Variant> B10T | B100TX | B100tx

B10T
Ethernet protocol variant 10BASE-T (10 Mbit/s)

B100TX = B100tx
Ethernet protocol variant 100BASE-TX (100 Mbit/s)

*RST: B10T

BUS<m>:ETHernet:SOURce <SourceData>

Selects the source channel for the data signal. For triggering on a serial bus, analog channels "C1"–"C4" are required. Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:

<m> 1..4

Parameters:

<SourceData> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

See Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C1W1

BUS<m>:ETHernet:POLarity <Polarity>

Defines the polarity of the data signal. This setting is only available in 10BASE-T.

Suffix:
<m> 1..4

Parameters:
<Polarity> NORMal | INVert

NORMal
Normal (non-inverted) data signal polarity

INVert
Inverted data signal polarity

*RST: NORMal

BUS<m>:ETHernet:THReshold:HIGH <ThresholdUpper>

Sets the upper threshold value for the signal digitization. If the signal value is higher than the this threshold, the signal state is considered high.

Suffix:
<m> 1..4

Parameters:
<ThresholdUpper> Range: 0 to 10
Increment: 0.01
*RST: 0.5
Default unit: V

BUS<m>:ETHernet:THReshold:LOW <ThresholdLower>

Sets the lower threshold value for the signal digitization. If the signal value is below this threshold, the signal state is considered low.

Suffix:
<m> 1..4

Parameters:
<ThresholdLower> Range: -10 to 0
Increment: 0.01
*RST: -0.5
Default unit: V

BUS<m>:ETHernet:PRESet <ThresholdPreset>

Sets the thresholds to predefined or individually definable voltage levels.

Suffix:
<m> 1..4

Parameters:
<ThresholdPreset> T0 | T100 | TX0 | TX100 | MAN

T0
Sets the thresholds to the default values for 10BASE-T (0 meters): upper threshold to 1.25 V, lower threshold to -1.25 V

T100
Sets the thresholds to the default values for 10BASE-T (100 meters): upper threshold to 0.75 V, lower threshold to -0.75 V

TX0
Sets the thresholds to the default values for 100BASE-TX (0 meters): upper threshold to 0.5 V, lower threshold to -0.5 V

TX100
Sets the thresholds to the default values for 100BASE-TX (100 meters): upper threshold to 0.35 V, lower threshold to -0.35 V

MAN
Allows to set individual threshold voltage levels

*RST: T0

BUS<m>:ETHernet:BITRate <BitRateValue>

Sets the bit rate value that defines the transmission speed in bits per second.

Suffix:
<m> 1..4

Parameters:
<BitRateValue> Range: 10000 to 150000000
Increment: 1000
*RST: 10000000
Default unit: bps

20.17.8.2 Trigger (10BASE-T)

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:ETHernet:TYPE <Type>

Sets the trigger type for Ethernet variant 10BASE-T to either "Frame Start" or "Pattern".

Suffix:
<m> 1..3

Parameters:
<Type> STARt | PATTern

STARt
Selects to trigger for the start of frame: search for the preamble and set the trigger instant thereafter.

PATTern
Selects to trigger for a bit pattern (data) to be specified in `TRIGger<m>:ETHernet:PATTern` on page 1436.

*RST: STARt

TRIGger<m>:ETHernet:PATTern <DataPattern>

Specifies the bit pattern (or data) that is to be triggered.

Suffix:
<m> 1..3

Parameters:
<DataPattern>

20.17.8.3 Decode Results

In all `BUS<m>:ETHernet:WORD<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the word number in the decode table.

As an example, with reference to Table 12-8, a set of query commands for bus #1 and word #1 is shown in the following, together with examples for results of these queries:

- `BUS1:ETH:WCOunt?` !2
- `BUS1:ETH:WORD1:STATe?` !OK
- `BUS1:ETH:WORD1:STARt?` !-0.000135
- `BUS1:ETH:WORD1:STOP?` !-6.62e-5
- `BUS1:ETH:WORD1:DEST?` !FF:FF:FF:FF:FF:FF
- `BUS1:ETH:WORD1:SRC?` !0F:0E:0D:0C:0B:0A
- `BUS1:ETH:WORD1:DATA?` ![60]45003c3e6210...
- `BUS1:ETH:WORD1:TYPE?` !2048
- `BUS1:ETH:WORD1:CRC?` !-1821935433
- `BUS1:ETH:WORD1:SSYM?` !
- `BUS1:ETH:WORD1:DSYM?` !BroadCast
- `BUS1:ETH:WORD1:BYTE1:VAL?` !69
- `BUS1:ETH:WORD1:BYTE2:VAL?` !0

BUS<m>:ETHernet:WCOunt?

Returns the frame count for the selected serial bus, i.e. the number of frames in the current acquisition. The result corresponds to the number of rows in the result table.

Suffix:
<m> 1..4

Return values:
<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:ETHernet:WORD<n>:FTYPe?

Returns the frame type of the selected word in the current acquisition.

Suffix:
<m> 1..4

<n> *

Return values:
<FrameType> MAC | IDLE | SLEep | EOS | UNKNown
*RST: MAC

Usage: Query only

BUS<m>:ETHernet:WORD<n>:STATe?

Returns the frame state of the selected word in the current acquisition.

Suffix:
<m> 1..4

<n> *

Return values:
<State> OK | ERR_PREAMBLE | ERR_LENGTH | UNCorrelated | INComplete

OK
No error detected

ERR_PREAMBLE
Error in the preamble of the selected word

ERR_SFD
Error in the start frame delimiter (SFD). The value of a correct SFD byte is 171. The SFD is transmitted LSB first.

ERR_LENGTH
Error in the number of bits in the selected word

*RST: OK

Usage: Query only

BUS<m>:ETHernet:WORD<n>:STARt?

Returns the frame start time of the selected word in the current acquisition.

Suffix:

<m>	1..4
<n>	*

Return values:

<Start>
Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

BUS<m>:ETHernet:WORD<n>:STOP?

Returns the frame stop time of the selected word in the current acquisition.

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop>
Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

BUS<m>:ETHernet:WORD<n>:DESTaddress?

Returns the destination address of the specified word.

Suffix:

<m>	1..4
<n>	*

Return values:

<DestAddress> String parameter

Usage: Query only

BUS<m>:ETHernet:WORD<n>:SRCaddress?

Returns the source address of the specified word.

Suffix:

<m> 1..4

<n> *

Return values:

<SrcAddress> String parameter

Usage: Query only

BUS<m>:ETHernet:WORD<n>:TYPE?

The sub-protocol (e.g. HTML, video, etc.) determines what meaning this field has. Since the content of this data area is not decoded, the interpretation of the TYPE field is ambivalent.

Suffix:

<m> 1..4

<n> *

Return values:

<Type> Returns the word type (specific for the sub-protocol), or the length of the selected word.

Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:ETHernet:WORD<n>:DATA?

Returns the number of word bytes in brackets [.] followed by the first six word bytes of data in hexadecimal format.

Use `BUS<m>:ETHernet:WORD<n>:BYTE<o>:VALue?` to access the word bytes.

Suffix:

<m> 1..4

<n> *

Return values:

<Data> String parameter

Example:
```
BUS:ETHernet:WORD3:DATA?
<-- '[60]FF00FFFF1234'
```

Usage: Query only

BUS<m>:ETHernet:WORD<n>:CRC?

Returns the Cyclic Redundancy Code (CRC, or frame check) checksum of the selected word.

Suffix:

<m> 1..4

<n> *

Return values:

<CRC> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:ETHernet:WORD<n>:DSYMbol?

Returns the symbolic label (or translation) of the destination address of the specified word, if the label list is enabled.

Suffix:

<m> 1..4

<n> *

Return values:

<DestTranslation> String parameter

Usage: Query only

BUS<m>:ETHernet:WORD<n>:SSYMbol?

Returns the symbolic label (or translation) of the source address of the specified word, if the label list is enabled.

Suffix:

<m> 1..4

<n> *

Return values:

<SrcTranslation> String parameter

Usage: Query only

BUS<m>:ETHernet:WORD<n>:BYTE<o>:VALue?

BYTE returns all data of up to 1982 bytes (not just the first 5 or 6 bytes). This is also visible in the data table under "Show details".

Suffix:

<m>	1..4
<n>	*
<o>	* Selects the byte number.

Return values:

<FrameByteValue>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:ETHernet:WORD<n>:NUMWords?

Returns the number of words in the selected frame. The result corresponds to the "Number of Words" column in the results table.

Suffix:

<m>	1..4
<n>	* Frame index

Return values:

<NumWords>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

20.17.8.4 Search Settings

SEARch:TRIGger:ETHernet:FRAMe:SELect <SearchName>,<CheckFrame>
SEARch:TRIGger:ETHernet:FRAMe:SELect? <SearchName>

Defines, whether a search within a frame shall be activated or not.

Parameters:

<CheckFrame> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:DCONdition <SearchName>,<DestAddrOptor>
SEARch:TRIGger:ETHernet:FRAMe:DCONdition? <SearchName>

Defines the operator to search a specific destination address within a frame.

Parameters:

<DestAddrOptor> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a destination address to be set with `SEARch:TRIGger:ETHernet:FRAMe:DMIN`.

INRange | OORange
In range, Out of range. Set the minimum and maximum value of the range with `SEARch:TRIGger:ETHernet:FRAMe:DMIN` and `SEARch:TRIGger:ETHernet:FRAMe:DMAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:DMIN <SearchName>,<DestAddrPattMin>
SEARch:TRIGger:ETHernet:FRAMe:DMIN? <SearchName>

Defines a destination address, or sets the start value of a destination address range.

Parameters:

<DestAddrPattMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:DMAX <SearchName>,<DestAddrPattMax>
SEARch:TRIGger:ETHernet:FRAMe:DMAX? <SearchName>

Sets the end value of a destination address range, if `SEARch:TRIGger:ETHernet:FRAMe:DCONdition` is set to `INRange` or `OORange`.

Parameters:
<DestAddrPattMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:SCONdition <SearchName>,<SrcAddrOperator>
SEARch:TRIGger:ETHernet:FRAMe:SCONdition? <SearchName>

Defines the operator to search a specific source address within a frame.

Parameters:
<SrcAddrOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a destination address to be set with `SEARch:TRIGger:ETHernet:FRAMe:SMIN`.

INRange | OORange
In range, Out of range. Set the minimum and maximum value of the range with `SEARch:TRIGger:ETHernet:FRAMe:SMIN` and `SEARch:TRIGger:ETHernet:FRAMe:SMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:SMIN <SearchName>,<SrcAddrPattMin>
SEARch:TRIGger:ETHernet:FRAMe:SMIN? <SearchName>

Defines a source address, or sets the start value of a source address range.

Parameters:
<SrcAddrPattMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:SMAX <SearchName>,<SrcAddrPattMax>
SEARch:TRIGger:ETHernet:FRAMe:SMAX? <SearchName>

Sets the end value of a source address range, if `SEARch:TRIGger:ETHernet:FRAMe:SCONdition` is set to `INRange` or `OORange`.

Parameters:

<SrcAddrPattMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:TCONdition <SearchName>,<TypeOperator>
SEARch:TRIGger:ETHernet:FRAMe:TCONdition? <SearchName>

Defines the operator to search for a specific frame length or type.

Parameters:

<TypeOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a pattern to be set with `SEARch:TRIGger:ETHernet:FRAMe:TMIN`.

INRange | OORange
In range, Out of range. Set the minimum and maximum value of the range with `SEARch:TRIGger:ETHernet:FRAMe:TMIN` and `SEARch:TRIGger:ETHernet:FRAMe:TMAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:TMIN <SearchName>,<TypePatternMin>
SEARch:TRIGger:ETHernet:FRAMe:TMIN? <SearchName>

Defines a frame length/type, or sets the start value for a range of frame lengths/types.

Parameters:

<TypePatternMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:TMAX <SearchName>,<TypePatternMax>
SEARch:TRIGger:ETHernet:FRAMe:TMAX? <SearchName>

Sets the end value of a range of frame lengths/types, if `SEARch:TRIGger:ETHernet:FRAMe:TCONdition` is set to `INRange` or `OORange`.

Parameters:

<TypePatternMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:CCONdition <SearchName>,<CRCOperator>
SEARch:TRIGger:ETHernet:FRAMe:CCONdition? <SearchName>

Defines the operator to search for a Cyclic Redundancy Code (CRC, or frame check) error condition within a frame.

Parameters:

<CRCOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater Than, Greater than or equal. These conditions require a CRC pattern to be set with `SEARch:TRIGger:ETHernet:FRAMe:CMIN`.

INRange | OORange
In range, Out of range. Set the minimum and maximum value of the range with `SEARch:TRIGger:ETHernet:FRAMe:CMIN` and `SEARch:TRIGger:ETHernet:FRAMe:CMAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:CMIN <SearchName>,<CRCPatternMin>
SEARch:TRIGger:ETHernet:FRAMe:CMIN? <SearchName>

Defines a CRC error condition pattern, or sets the start value of such a pattern.

Parameters:

<CRCPatternMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:ETHernet:FRAMe:CMAX <SearchName>,<CRCPatternMax>
SEARch:TRIGger:ETHernet:FRAMe:CMAX? <SearchName>

Sets the end value of a CRC error condition pattern, if `SEARch:TRIGger:ETHernet:FRAMe:CCONdition` is set to `INRange` or `OORange`.

Parameters:
<CRCPatternMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName> String parameter

SEARch:TRIGger:ETHernet:ERRor:SELect <SearchName>,<ErrorCondition>
SEARch:TRIGger:ETHernet:ERRor:SELect? <SearchName>

Defines, whether a search for an error condition shall be activated or not.

Parameters:
<ErrorCondition> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName> String parameter

SEARch:TRIGger:ETHernet:ERRor:PREamble <SearchName>,<ErrorPreamble>
SEARch:TRIGger:ETHernet:ERRor:PREamble? <SearchName>

Defines, whether a search for any preamble error shall be activated or not.

Parameters:
<ErrorPreamble> ON | OFF
*RST: ON

Parameters for setting and query:
<SearchName> String parameter

SEARch:TRIGger:ETHernet:ERRor:LENGth <SearchName>,<ErrorLength>
SEARch:TRIGger:ETHernet:ERRor:LENGth? <SearchName>

Defines, whether a search for any word length error (too few or too many bits per word) shall be activated or not.

Parameters:
<ErrorLength> ON | OFF
*RST: ON

Parameters for setting and query:
<SearchName> String parameter

20.17.8.5 Search Results

To show the results on the screen, use the following commands:

- `BUS<m>:RESult` on page 1300
- `BUS<m>:RESDetail` on page 1300

In all `SEARch:RESult:ETHernet:WORD<m>` commands, the suffix <m> selects the word number in the list of search results.

SEARch:RESult:ETHernet:WCOunt? <SearchName>

Returns the number of decoded words within the search result.

Query parameters:
<SearchName> String parameter

Return values:
<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:STATe? <SearchName>

Returns the frame state of the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName> String parameter

Return values:
<State> OK | ERR_PREAMBLE | ERR_LENGTH

OK
No error detected

ERR_PREAMBLE
Error in the preamble of the selected word

ERR_SFD
Error in the start frame delimiter (SFD). The value of a correct SFD byte is 171. The SFD is transmitted LSB first.

ERR_LENGTH
Error in the number of bits in the selected word

*RST: OK

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:STARt? <SearchName>

Returns the frame start time of the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName> String parameter

Return values:
<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:STOP? <SearchName>

Returns the frame stop time of the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName> String parameter

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:DESTaddress? <SearchName>

Returns the destination address of the specified word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName> String parameter

Return values:
<DestAddress> String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:SRCaddress? <SearchName>

Returns the source address of the specified word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName> String parameter

Return values:
<SourceAddress> String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:TYPE? <SearchName>

The sub-protocol (e.g. HTML, video, etc.) determines what meaning this field has. Since the content of this data area is not decoded, the interpretation of the TYPE field is ambivalent. The query either returns the word type (specific for the sub-protocol), or the length of the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName> String parameter

Return values:
<Type> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:FTYPe? <SearchName>

Returns the frame type of the specified frame.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameType> MAC | IDLE | SLEep | EOS | UNKNown

*RST: MAC

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:DATA? <SearchName>

Returns the data bytes of the specified word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<Data> String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:CRC? <SearchName>

Returns the Cyclic Redundancy Code (CRC, or frame check) checksum of the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<CRC> Range: 0 to 4294967295

Increment: 1

*RST: 0

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:DSYMbol? <SearchName>

Returns the symbolic label (or translation) of the destination address of the specified word within the search result, if the label list is enabled.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<DestTranslation> String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:SSYMbol? <SearchName>

Returns the symbolic label (or translation) of the source address of the specified word within the search result, if the label list is enabled.

Suffix:

<m> *

Query parameters:

<SearchName> String parameter

Return values:

<SrcTranslation> String parameter

Usage: Query only

SEARch:RESult:ETHernet:WORD<m>:BYTE<n>:VALue? <SearchName>

BYTE returns all data of up to 1982 bytes (not just the first 5 or 6 bytes). This is also visible in the data table under "Show details".

Suffix:

<m> *

<n> *
Selects the byte number.

Query parameters:

<SearchName> String parameter

Return values:

<FrameByteValue> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

20.17.9 Ethernet 100BASE-T1 (Option R&S RTP-K57)

20.17.9.1 Configuration

In all `BUS<m>:HBTO` commands, the suffix <m> selects the serial bus.

BUS<m>:HBTO:ATTN <Attenuation>

Sets the attenuation factor. It is used to de-amplify the reverse signal before subtracting it from the forward signal.

Suffix:
<m> 1..4

Parameters:
<Attenuation> Range: -100 to 0
Increment: 0.1
*RST: -26
Default unit: dB

BUS<m>:HBTO:FDAM <SourceDAminus>

Selects the DA- source of the provided forward single ended signal, if `BUS<m>:HBTO:FTYP` is set to `SINGle`.

Suffix:
<m> 1..4

Parameters:
<SourceDAminus> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
*RST: C2W1

BUS<m>:HBTO:FDAP <SourceDAplus>

Selects the DA+ source of the provided forward single ended signal, if `BUS<m>:HBTO:FTYP` is set to `SINGle`.

Suffix:
<m> 1..4

Parameters:
<SourceDAplus> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
*RST: C1W1

BUS<m>:HBTO:FDIF <SrcDiff>

Sets the source of the provided forward differential signal, if `BUS<m>:HBTO:FTYP` is set to `DIFFerential`.

Suffix:

<m>	1..4

Parameters:

<SrcDiff>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
	*RST: C1W1

BUS<m>:HBTO:FTYP <SignalType>

Sets the type of forward signal measurement.

Suffix:

<m>	1..4

Parameters:

<SignalType>	DIFFerential | SINGle
	*RST: DIFFerential

BUS<m>:HBTO:RDAM <SrcRevDAminus>

Selects the DA- source of the provided reversed single ended signal, if `BUS<m>:HBTO:RTYP` is set to `SINGle`.

Suffix:

<m>	1..4

Parameters:

<SrcRevDAminus>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

BUS<m>:HBTO:RDAP <SourceRevDAplus>

Selects the DA+ source of the provided reversed single ended signal, if `BUS<m>:HBTO:RTYP` is set to `SINGle`.

Suffix:

<m>	1..4

Parameters:

<SourceRevDAplus>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

BUS<m>:HBTO:RDIF <SrcRevDiff>

Sets the source of the provided reversed differential signal, if `BUS<m>:HBTO:RTYP` is set to `DIFFerential`.

Suffix:

<m>	1..4

Parameters:

<SrcRevDiff>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

BUS<m>:HBTO:RTYP <SignalRevType>

Sets the type of reverse signal measurement.

Suffix:

<m>	1..4

Parameters:

<SignalRevType>	DISabled | DIFFerential | SINGle
	*RST: DISabled

BUS<m>:HBTO:THReshold <ThresholdUpper>

Sets an user-defined threshold value.

Suffix:

<m>	1..4

Parameters:

<ThresholdUpper>	Range:	0 to 2
	Increment:	1E-3
	*RST:	0.4
	Default unit:	V

BUS<m>:HBTO:POLarity <Polarity>

Selects the polarity of the data signal.

Suffix:

<m>	1..4

Parameters:

<Polarity>	NORMal | INVert
	*RST: NORMal

BUS<m>:HBTO:MODE <Mode>

Selects the direction of the full-duplex signal you want to look at.

Suffix:

<m>	1..4

Parameters:

<Mode>	MASTer | SLAVe
	*RST: MASTer

BUS<m>:HBTO:SYMRate <SymbolRate>

Defines the rate of ternary symbols.

Suffix:

<m>	1..4

Parameters:

<SymbolRate>	Range: 10 to 150 Increment: 1E-3 *RST: 66.6667 Default unit: MSymb/s

20.17.9.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:HBTO:TYPE <Type>

Selects the type of frame to be triggered on.

Suffix:

<m> 1..3

Parameters:

<Type> STARt | MAC | IDLE | ERRor

STARt
Start of frame.

MAC
MAC frame. This frame contains information that define how to go about transmitting and receiving frames.

IDLE
IDLE frame. This frame is used for clock synchronization.

ERRor
Error frame. Thi frame contains erroneous bits.

*RST: STARt

TRIGger<m>:HBTO:DADDress:CONDition <DestAddrOptor>

Sets the condition for the destination address. You can define an exact value or a value range.

Suffix:

<m> 1..3

Parameters:

<DestAddrOptor> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:HBTO:DADDress:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:HBTO:DADDress:MIN` and `TRIGger<m>:HBTO:DADDress:MAX`.

*RST: EQUal

TRIGger<m>:HBTO:DADDress:MIN <DestAddrPattMin>

Specifies the destination address bit pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<DestAddrPattMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:HBTO:DADDress:MAX <DestAddrPattMax>

Sets the end value of the destination address range if `TRIGger<m>:HBTO:DADDress:CONDition` is set to `INRange` or `OORange`.

Suffix:
<m> 1..3

Parameters:
<DestAddrPattMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:HBTO:SADDress:CONDition <SrcAddrOperator>

Sets the condition for the source address. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<SrcAddrOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:HBTO:SADDress:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:HBTO:SADDress:MIN` and `TRIGger<m>:HBTO:SADDress:MAX`.

*RST: EQUal

TRIGger<m>:HBTO:SADDress:MIN <SrcAddrPattMin>

Specifies the source address bit pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:

<SrcAddrPattMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:HBTO:SADDress:MAX <SrcAddrPattMax>

Sets the end value of the source address range if `TRIGger<m>:HBTO:SADDress:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m> 1..3

Parameters:

<SrcAddrPattMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:HBTO:LENGth:CONDition <TypeOperator>

Sets the condition for the length / type. You can define an exact value or a value range.

Suffix:

<m> 1..3

Parameters:

<TypeOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:HBTO:LENGth:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:HBTO:LENGth:MIN` and `TRIGger<m>:HBTO:LENGth:MAX`.

*RST: EQUal

TRIGger<m>:HBTO:LENGth:MIN <TypePatternMin>

Specifies the length / type bit pattern, or sets the start value of a pattern range.

Suffix:

<m> 1..3

Parameters:

<TypePatternMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:HBTO:LENGth:MAX <TypePatternMax>

Sets the end value of the length / type range if TRIGger<m>:HBTO:LENGth:CONDition is set to INRange or OORange.

Suffix:
<m> 1..3

Parameters:
<TypePatternMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:HBTO:CRC:CONDition <CRCOperator>

Sets the condition for the frame check. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<CRCOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding TRIGger<m>:HBTO:CRC:MIN command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with TRIGger<m>:HBTO:CRC:MIN and TRIGger<m>:HBTO:CRC:MAX.

*RST: EQUal

TRIGger<m>:HBTO:CRC:MIN <CRCPatternMin>

Specifies the frame check bit pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<CRCPatternMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:HBTO:CRC:MAX <CRCPatternMax>

Sets the end value of the frame check range if TRIGger<m>:HBTO:CRC:CONDition is set to INRange or OORange.

Suffix:
<m> 1..3

Parameters:
<CRCPatternMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:HBTO:DATA:DCONdition <DataOperator>

Sets the condition for the data. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:HBTO:DATA:DMIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:HBTO:DATA:DMIN` and `TRIGger<m>:HBTO:DATA:DMAX`.

*RST: EQUal

TRIGger<m>:HBTO:DATA:DMIN <DataMin>

Specifies the data bit pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<DataMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:HBTO:DATA:DMAX <DataMax>

Sets the end value of the data range if `TRIGger<m>:HBTO:DATA:DCONdition` is set to `INRange` or `OORange`.

Suffix:
<m> 1..3

Parameters:

<DataMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:HBTO:DATA:ICONdition <DataIdxOperator>

Sets the condition for the index. You can define an exact value or a value range.

Suffix:

<m> 1..3

Parameters:

<DataIdxOperator> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:HBTO:DATA:IMIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:HBTO:DATA:IMIN` and `TRIGger<m>:HBTO:DATA:IMAX`.

*RST: INRange

TRIGger<m>:HBTO:DATA:IMIN <DataIndexMin>

Specifies the index bit pattern, or sets the start value of a pattern range.

Suffix:

<m> 1..3

Parameters:

<DataIndexMin>
Range: 1 to 65535
Increment: 1
*RST: 1

TRIGger<m>:HBTO:DATA:IMAX <DataIndexMax>

Sets the end value of the index range if `TRIGger<m>:HBTO:DATA:ICONdition` is set to `INRange` or `OORange`.

Suffix:

<m> 1..3

Parameters:

<DataIndexMax>
Range: 1 to 65535
Increment: 1
*RST: 0

TRIGger<m>:HBTO:ERRor:PREamble <ErrorPreamble>

Enables / disables trigger on preamble error.

Suffix:

<m> 1..3

Parameters:

<ErrorPreamble> ON | OFF

*RST: ON

TRIGger<m>:HBTO:ERRor:CRC <ErrorCRC>

Enables / disables trigger on Cyclic Redundancy Check (CRC) error.

Suffix:

<m> 1..3

Parameters:

<ErrorCRC> ON | OFF

*RST: ON

TRIGger<m>:HBTO:ERRor:SFD <ErrorSFD>

Enables / disables trigger on start frame delimiter (SFD) error.

Suffix:

<m> 1..3

Parameters:

<ErrorSFD> ON | OFF

*RST: ON

20.17.9.3 Decode Results

To show the results on the screen, use the following commands:

- `BUS<m>:RESult` on page 1300
- `BUS<m>:RESDetail` on page 1300

In all `BUS<m>:HBTO:RESult:FRAMe<n>:WORD<o>` commands, the suffix <m> selects the serial bus, suffix <n> selects the frame in the decode table and suffix <o> selects the word in the selected frame.

BUS<m>:HBTO:RESult:FCOunt?

Returns the number of decoded frames.

Suffix:

<m>	1..4

Return values:

<FrameCount>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:FTYPe?

Returns the type of frame for the selected frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameType> IDLE | MAC | FILLer | UNKNown

IDLE
IDLE frame. This frame is used for clock synchronization.

MAC
MAC frame. This frame contains information that define how to go about transmitting and receiving frames.

FILLer
Filler frame. The frame is used to maintain transmission activity.

UNKNown
No meaningful frame can be determined.

*RST: MAC

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:STATe?

Returns the state of the frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<State> OK | ERR_PREAMBLE | ERR_SFD | ERR_LENGTH | ERR_CRC | UNCorrelated | INComplete

OK
Valid frame.

ERR_PREAMBLE
Erroneous frame due to preamble error.

ERR_SFD
Erroneous frame due to SFD error.

ERR_LENGTH
Erroneous frame due to length / type error.

ERR_CRC
Erroneous frame due to CRC error.

*RST: OK

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:STARt?

Returns the start time of the selected frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:STOP?

Returns the end time of the selected frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:DESTaddress?

Returns the destination address of the selected frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<DestAddress>

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:SRCaddress?

Returns the source address of the selected frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<SrcAddress>

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:TYPE?

Returns the value of length / type field of the selected frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<TypeLen>	Range: 0 to 65535 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:DATA?

Returns the data for the selected frame, corresponds to the Data column in the decode results table.

Suffix:

<m>	1..4
<n>	*

Return values:

<Data>

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:CRC?

Returns the CRC (frame check) checksum of the selected frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<CRC> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:NUMWords?

Returns the number of decoded words for the selected frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<NumWords> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:DSYMbol?

Returns the destination symbols of the selected frame.

Suffix:

<m>	1..4
<n>	*

Return values:
<DestTranslation>

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:SSYMbol?

Returns the source symbols of the selected frame.

Suffix:

<m>	1..4
<n>	*

Return values:
<SrcTranslation>

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:WORD<o>:TYPE?

Returns the data type for the selected word.

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:
<WordType>

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:WORD<o>:VALue?

Returns the data value for the selected word.

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:
<WordValue> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:HBTO:RESult:FRAMe<n>:WORD<o>:VSTR?

Returns the string equivalent of data value for the selected cell.

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:

<WordValueString>	String parameter
Usage:	Query only

20.17.9.4 Search Settings

SEARch:TRIGger:HBTO:TYPE <SearchName>,<Type>
SEARch:TRIGger:HBTO:TYPE? <SearchName>

Selects the type of frame to be searched for.

Parameters:

<Type> STARt | MAC | IDLE | ERRor

STARt
Start of frame.

MAC
MAC frame. This frame contains information that define how to go about transmitting and receiving frames.

IDLE
IDLE frame. This frame is used for clock synchronization.

ERRor
Error frame. Thi frame contains erroneous bits.

*RST: STARt

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:DADDress:CONDition <SearchName>,<DestAddrOptor>
SEARch:TRIGger:HBTO:DADDress:CONDition? <SearchName>

Sets the condition for the destination address. You can define an exact value or a value range.

Parameters:
<DestAddrOptor> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:HBTO:DADDress:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:HBTO:DADDress:MIN` and `SEARch:TRIGger:HBTO:DADDress:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:DADDress:MIN <SearchName>,<DestAddrPattMin>
SEARch:TRIGger:HBTO:DADDress:MIN? <SearchName>

Specifies the destination address bit pattern, or sets the start value of a pattern range.

Parameters:
<DestAddrPattMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:DADDress:MAX <SearchName>,<DestAddrPattMax>
SEARch:TRIGger:HBTO:DADDress:MAX? <SearchName>

Sets the end value of the destination address range if `SEARch:TRIGger:HBTO:DADDress:CONDition` is set to `INRange` or `OORange`.

Parameters:

<DestAddrPattMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:HBTO:SADDress:CONDition <SearchName>,<SrcAddrOperator>
SEARch:TRIGger:HBTO:SADDress:CONDition? <SearchName>

Sets the condition for the source address. You can define an exact value or a value range.

Parameters:

<SrcAddrOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:HBTO:SADDress:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:HBTO:SADDress:MIN` and `SEARch:TRIGger:HBTO:SADDress:MAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:HBTO:SADDress:MIN <SearchName>,<SrcAddrPattMin>
SEARch:TRIGger:HBTO:SADDress:MIN? <SearchName>

Specifies the source address bit pattern, or sets the start value of a pattern range.

Parameters:

<SrcAddrPattMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:HBTO:SADDress:MAX <SearchName>,<SrcAddrPattMax>
SEARch:TRIGger:HBTO:SADDress:MAX? <SearchName>

Sets the end value of the source address range if `SEARch:TRIGger:HBTO:SADDress:CONDition` is set to `INRange` or `OORange`.

Parameters:
<SrcAddrPattMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:LENGth:CONDition <SearchName>,<TypeOperator>
SEARch:TRIGger:HBTO:LENGth:CONDition? <SearchName>

Sets the condition for the length / type. You can define an exact value or a value range.

Parameters:
<TypeOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:HBTO:LENGth:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:HBTO:LENGth:MIN` and `SEARch:TRIGger:HBTO:LENGth:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:LENGth:MIN <SearchName>,<TypePatternMin>
SEARch:TRIGger:HBTO:LENGth:MIN? <SearchName>

Specifies the length / type bit pattern, or sets the start value of a pattern range.

Parameters:
<TypePatternMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:LENGth:MAX <SearchName>,<TypePatternMax>
SEARch:TRIGger:HBTO:LENGth:MAX? <SearchName>

Sets the end value of the length / type range if `SEARch:TRIGger:HBTO:LENGth:CONDition` is set to `INRange` or `OORange`.

Parameters:

<TypePatternMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:HBTO:CRC:CONDition <SearchName>,<CRCOperator>
SEARch:TRIGger:HBTO:CRC:CONDition? <SearchName>

Sets the condition for the frame check. You can define an exact value or a value range.

Parameters:

<CRCOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:HBTO:CRC:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:HBTO:CRC:MIN` and `SEARch:TRIGger:HBTO:CRC:MAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:HBTO:CRC:MIN <SearchName>,<CRCPatternMin>
SEARch:TRIGger:HBTO:CRC:MIN? <SearchName>

Specifies the frame check bit pattern, or sets the start value of a pattern range.

Parameters:

<CRCPatternMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:HBTO:CRC:MAX <SearchName>,<CRCPatternMax>
SEARch:TRIGger:HBTO:CRC:MAX? <SearchName>

Sets the end value of the frame check range if `SEARch:TRIGger:HBTO:CRC:CONDition` is set to `INRange` or `OORange`.

Parameters:

<CRCPatternMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:DATA:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:HBTO:DATA:DCONdition? <SearchName>

Sets the condition for the data. You can define an exact value or a value range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:HBTO:DATA:DMIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:HBTO:DATA:DMIN` and `SEARch:TRIGger:HBTO:DATA:DMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:DATA:DMIN <SearchName>,<DataMin>
SEARch:TRIGger:HBTO:DATA:DMIN? <SearchName>

Specifies the data bit pattern, or sets the start value of a pattern range.

Parameters:

<DataMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:DATA:DMAX <SearchName>,<DataMax>
SEARch:TRIGger:HBTO:DATA:DMAX? <SearchName>

Sets the end value of the data range if `SEARch:TRIGger:HBTO:DATA:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:DATA:ICONdition <SearchName>,<DataIdxOperator>
SEARch:TRIGger:HBTO:DATA:ICONdition? <SearchName>

Sets the condition for the index. You can define an exact value or a value range.

Parameters:

<DataIdxOperator> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:HBTO:DATA:IMIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:HBTO:DATA:IMIN` and `SEARch:TRIGger:HBTO:DATA:IMAX`.

*RST: INRange

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:DATA:IMIN <SearchName>,<DataIndexMin>
SEARch:TRIGger:HBTO:DATA:IMIN? <SearchName>

Specifies the index bit pattern, or sets the start value of a pattern range.

Parameters:

<DataIndexMin> Range: 1 to 0
Increment: 1
*RST: 1

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:DATA:IMAX <SearchName>,<DataIndexMax>
SEARch:TRIGger:HBTO:DATA:IMAX? <SearchName>

Sets the end value of the index range if `SEARch:TRIGger:HBTO:DATA:ICONdition` is set to `INRange` or `OORange`.

Parameters:

<DataIndexMax>	Range:	1 to 0
	Increment:	1
	*RST:	0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:ERRor:PREamble <SearchName>,<ErrorPreamble>
SEARch:TRIGger:HBTO:ERRor:PREamble? <SearchName>

Enables / disables search for preamble error.

Parameters:

<ErrorPreamble>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:ERRor:CRC <SearchName>,<ErrorCRC>
SEARch:TRIGger:HBTO:ERRor:CRC? <SearchName>

Enables / disables trigger on Cyclic Redundancy Check (CRC) error.

Parameters:

<ErrorCRC>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:HBTO:ERRor:SFD <SearchName>,<ErrorSFD>
SEARch:TRIGger:HBTO:ERRor:SFD? <SearchName>

Enables / disables search for start frame delimiter (SFD) error.

Parameters:

<ErrorSFD>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

20.17.9.5 Search Results

In all `SEARch:RESult:HBTO:FRAMe<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:HBTO:FCOunt? <SearchName>

Returns the number of decoded frames within the search result.

Query parameters:
<SearchName>

Return values:
<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:TYPE? <SearchName>

Returns the value of length / type field of the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<TypeLen> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:STATe? <SearchName>

Returns the state of the frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<State> OK | ERR_PREAMBLE | ERR_SFD | ERR_LENGTH | ERR_CRC | UNCorrelated | INComplete

OK
Valid frame.

ERR_PREAMBLE
Erroneous frame due to preamble error.

ERR_SFD
Erroneous frame due to SFD error.

ERR_LENGTH
Erroneous frame due to length / type error.

ERR_CRC
Erroneous frame due to CRC error.

*RST: OK

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:STARt? <SearchName>

Returns the start time of the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:STOP? <SearchName>

Returns the end time of the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:DESTaddress? <SearchName>

Returns the destination address of the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<DestAddress>

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:SRCaddress? <SearchName>

Returns the source address of the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<SourceAddress>

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:DATA? <SearchName>

Returns the data for the selected frame, corresponds to the Data column in the decode results table.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:CRC? <SearchName>

Returns the CRC checksum of the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<CRC> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:NUMWords? <SearchName>

Returns the number of decoded words for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<NumWords> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:FTYPe? <SearchName>

Returns the type of frame for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameType> IDLE | MAC | FILLer | UNKNown

IDLE
IDLE frame. This frame is used for clock synchronization.

MAC
MAC frame. This frame contains information that define how to go about transmitting and receiving frames.

FILLer
Filler frame. The frame is used to maintain transmission activity.

UNKNown
No meaningful frame can be determined.

*RST: MAC

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:DSYMbol? <SearchName>

Returns the destination symbols of the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<DestTranslation>

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:SSYMbol? <SearchName>

Returns the source symbols of the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<SrcTranslation>

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:WORD<n>:TYPE? <SearchName>

Returns the data type of the selected word within the search result.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<WordType> String parameter

Usage: Query only

SEARch:RESult:HBTO:FRAMe<m>:WORD<n>:VALue? <SearchName>

Returns the data value of the selected word within the search result.

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<WordValue>	Range:	0 to 65535
	Increment:	1
	*RST:	0

Usage: Query only

20.17.10 RFFE (Option R&S RTP-K40)

For programming examples, see Chapter 20.3.6.1, "RFFE (Option R&S RTP-K40)", on page 966.

20.17.10.1 Configuration

In all BUS<m>:RFFE commands, the suffix <m> selects the serial bus.

For programming examples, see "Configuring RFFE Bus" on page 966.

BUS<m>:RFFE:CLOCk:SOURce <SourceClock>

Sets the source of the RFFE clock line.

For triggering on a serial bus, analog or digital input channels are required.

Suffix:

<m>	1..4

Parameters:

<SourceClock> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: C2W1

BUS<m>:RFFE:DATA:SOURce <SourceData>

Sets the source of the RFFE data line. For triggering on a serial bus, analog or digital input channels are required.

Suffix:

<m> 1..4

Parameters:

<SourceData> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: C1W1

BUS<m>:RFFE:PRESet <ThresholdPreset>

Sets default threshold voltages for 1.2 V or 1.8 V bus. Set the value to MAN if you want to define individual thresholds.

Suffix:

<m> 1..4

Parameters:

<ThresholdPreset> V12 | V18 | MAN

*RST: V12

BUS<m>:RFFE:COUPling <ThresCpl>

If enabled, the SDATA thresholds are set to the SCLK threshold values.

Suffix:

<m> 1..4

Parameters:

<ThresCpl> ON | OFF

*RST: ON

BUS<m>:RFFE:DATA:THReshold:HIGH <ThresDatPos>

Set the positive going threshold (V_{TP}) for the data signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m> 1..4

Parameters:

<ThresDatPos> Range: 0 to 2.5
Increment: 0.1
*RST: 0.72
Default unit: V

BUS<m>:RFFE:DATA:THReshold:LOW <ThresDatNeg>

Set the negative going threshold (V_{TN}) for the data signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m> 1..4

Parameters:

<ThresDatNeg> Range: 0 to 2.5
Increment: 0.1
*RST: 0.48
Default unit: V

BUS<m>:RFFE:DATA:THReshold:HYSTeresis <ThresDatHyst>

Set the hysteresises between V_{TP} and V_{TN} for the data signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m> 1..4

Parameters:

<ThresDatHyst> Range: 0 to 1
Increment: 0.1
*RST: 0.2
Default unit: V

BUS<m>:RFFE:CLOCk:THReshold:HIGH <ThresClkPos>

Set the positive going threshold (V_{TP}) for the clock signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m> 1..4

Parameters:

<ThresClkPos>	Range: 0 to 2.5 Increment: 0.1 *RST: 0.72 Default unit: V

BUS<m>:RFFE:CLOCk:THReshold:LOW <ThresClkNeg>

Set the negative going threshold (V_{TN}) for the clock signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m>	1..4

Parameters:

<ThresClkNeg>	Range: 0 to 2.5 Increment: 0.1 *RST: 0.48 Default unit: V

BUS<m>:RFFE:CLOCk:THReshold:HYSTeresis <ThresClkHyst>

Set the hysteresis between V_{TP} and V_{TN} for the clock signal.

Note that the high and low thresholds and the hysteresis values are dependent, so it is sufficient to define two values for each line.

Suffix:

<m>	1..4

Parameters:

<ThresClkHyst>	Range: 0 to 1 Increment: 0.1 *RST: 0.2 Default unit: V

BUS<m>:RFFE:GFILter <GlitchFilter>

Enables the glitch filter on the SCLK and SDATA lines to improve decode accuracy.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<GlitchFilter>	ON | OFF *RST: OFF

BUS<m>:RFFE:GFWidth <GlitchFilterWdt>

Sets the maximum glitch width to be ignored.

Suffix:

<m>	1..4

Parameters:

<GlitchFilterWdt>
Range: 10E-12 to 10E-9
Increment: 10E-12
*RST: 1E-9
Default unit: s

BUS<m>:RFFE:MINGap:SELect <MinGapSelect>

If the minimum gap is enabled, the instrument detects the specified gap.

Set the minimum gap time using `BUS<m>:RFFE:MINGap:TIME`.

Suffix:

<m>	1..4

Parameters:

<MinGapSelect>
ON | OFF
*RST: OFF

BUS<m>:RFFE:MINGap:TIME <MinGapTime>

Sets the minimum idle time between the Bus Park Cycle (BP) and Sequence Start Condition (SSC).

The setting is only relevant if `BUS<m>:RFFE:MINGap:SELect` is enabled.

Suffix:

<m>	1..4

Parameters:

<MinGapTime>
Range: 10E-9 to 10E-6
Increment: 10E-9
*RST: 1E-6
Default unit: s

20.17.10.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

For programming examples, see "Triggering on RFFE Bus" on page 967.

TRIGger<m>:RFFE:TYPE <Type>

Selects the trigger type for RFFE analysis.

Parameters:

<Type> STARt | STOP | RZWR | RWR | RRD | ERWR | ERRD | ERWL | ERRL | ERRor

STARt
Triggers on the beginning of a command sequence, exactly after the slave address. Optionally, you can specify a slave address condition.

STOP
Triggers on the end of a command sequence, exactly at the start of the bus park cycle. Optionally, you can specify a slave address condition.

RZWR
Triggers on "Register 0 Write" command sequences. Optionally, you can specify a slave address condition and a data pattern condition.

RWR
Triggers on "Register Write" command sequences. Optionally, you can specify a slave address condition, a register address condition, and a data pattern condition.

RRD
Triggers on "Register Read" command sequences. Optionally, you can specify a slave address condition, a register address condition, and a data pattern condition.

ERWR
Triggers on "Extended Register Write" command sequences. Optionally, you can specify a slave address condition, a register address condition, a byte count condition, a data index condition, and a data pattern condition.

ERRD
Triggers on "Extended Register Read" command sequences. Optional trigger conditions are the same as for ERWR.

ERWL
Triggers on "Extended Register Write Long" command sequences. Optional trigger conditions are the same as for ERWR.

ERRL
Triggers on "Extended Register Read Long" command sequences. Optional trigger conditions are the same as for ERWR.

ERRor
Triggers if one of the enabled errors occurs in a frame.
To enable the error types, use `TRIGger<m>:RFFE:ERRor:BP`, `TRIGger<m>:RFFE:ERRor:LENGth`, `TRIGger<m>:RFFE:ERRor:NOResponse`, `TRIGger<m>:RFFE:ERRor:PARity`, `TRIGger<m>:RFFE:ERRor:SSC`, and `TRIGger<m>:RFFE:ERRor:USEQuence`.

*RST: STARt

To specify additional trigger conditions for command sequences, use the following commands:

Slave address	`TRIGger<m>:RFFE:SADD:CONDition`
	`TRIGger<m>:RFFE:SADD:MIN`
	`TRIGger<m>:RFFE:SADD:MAX`

Register address	`TRIGger<m>:RFFE:ADDRess:CONDition`
	`TRIGger<m>:RFFE:ADDRess:MIN`
	`TRIGger<m>:RFFE:ADDRess:MAX`

Data pattern	`TRIGger<m>:RFFE:DATA:DCON`
	`TRIGger<m>:RFFE:DATA:DMIN`
	`TRIGger<m>:RFFE:DATA:DMAX`

Byte count	`TRIGger<m>:RFFE:BCOunt:CONDition`
	`TRIGger<m>:RFFE:BCOunt:MIN`
	`TRIGger<m>:RFFE:BCOunt:MAX`

Data index	`TRIGger<m>:RFFE:DATA:ICONdition`
	`TRIGger<m>:RFFE:DATA:IMIN`
	`TRIGger<m>:RFFE:DATA:IMAX`

TRIGger<m>:RFFE:SADD:CONDition <SIDOperator>
TRIGger<m>:RFFE:ADDRess:CONDition <AddressOperator>
TRIGger<m>:RFFE:BCOunt:CONDition <ByteCntOperator>
TRIGger<m>:RFFE:DATA:DCON <DatPattOptor>

Sets the operator to trigger on a specific pattern or a range.

Parameters:

<DatPattOptor> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set using the corresponding `TRIGger<m>:RFFE:...:MIN` command.

INRange | OORange
In range / Out of range: Set the minimum and maximum value using the corresponding `TRIGger<m>:RFFE:...:MIN` and `TRIGger<m>:RFFE:...:MAX`

*RST: EQUal

Example: See "Triggering on RFFE Bus" on page 967.

TRIGger<m>:RFFE:DATA:ICONdition <DataIdxOperator>

Sets the operator to define the data frames in which the data pattern is expected.

Parameters:

<DataIdxOperator> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal | LTHan | LETHan | GTHan | GETHan
Equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set using `TRIGger<m>:RFFE:DATA:IMIN`.

INRange = RANGe
In range: Set the minimum and maximum value using `TRIGger<m>:RFFE:DATA:IMIN` and `TRIGger<m>:RFFE:DATA:IMAX`.

*RST: INRange

TRIGger<m>:RFFE:SADD:MIN <SIDMin>
TRIGger<m>:RFFE:ADDRess:MIN <AddressMin>
TRIGger<m>:RFFE:BCOunt:MIN <ByteCountMin>
TRIGger<m>:RFFE:DATA:IMIN <DataIndexMin>
TRIGger<m>:RFFE:DATA:DMIN <DataPatternMin>

Specifies a pattern, or sets the the start value of a pattern range.

Parameters:

<DataPatternMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Example: See "Triggering on RFFE Bus" on page 967.

TRIGger<m>:RFFE:SADD:MAX <SIDMax>
TRIGger<m>:RFFE:ADDRess:MAX <AddressMax>
TRIGger<m>:RFFE:BCOunt:MAX <ByteCountMax>
TRIGger<m>:RFFE:DATA:IMAX <DataIndexMax>
TRIGger<m>:RFFE:DATA:DMAX <DataPatternMax>

Sets the the end value of an range if the corresponding condition is set to `INRange` or `OORange`. See `TRIGger<m>:RFFE:...:CON`

Parameters:

<DataPatternMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Example: See "Triggering on RFFE Bus" on page 967.

TRIGger<m>:RFFE:ERRor:BP <BusParkError>

Enables the trigger on a bus park error - when an incorrect bus parlk cycle has been found.

Parameters:

<BusParkError> ON | OFF

*RST: ON

TRIGger<m>:RFFE:ERRor:LENGth <LengthError>

Enables the trigger on a length error - when an incorrect length of the command sequence has been found.

Parameters:

<LengthError> ON | OFF

*RST: ON

TRIGger<m>:RFFE:ERRor:NOResponse <NoResponse>

Enables the trigger on any No Response Frame.

Parameters:

<NoResponse> ON | OFF

*RST: ON

TRIGger<m>:RFFE:ERRor:PARity <ParityError>

Enables the trigger on incorrect parity bits.

Parameters:

<ParityError>	ON | OFF *RST: ON

TRIGger<m>:RFFE:ERRor:SSC <SSCError>

Enables the trigger on an SSC error - when no valid SSC sequence has been found after the idle time.

Parameters:

<SSCError>	ON | OFF *RST: ON

TRIGger<m>:RFFE:ERRor:USEQuence <UnknownSequence>

Enables the trigger on an unknown sequence - when the instrument cannot detect any supported command sequence.

Parameters:

<UnknownSequence>	ON | OFF *RST: ON

20.17.10.3 Decode Results

In all BUS<m>:RFFE commands, the suffix <m> selects the serial bus. Suffix <n> selects index of the command sequence.

To load and acivate a label list, use:

- `BUS<m>:NEWList` on page 1301
- `BUS<m>:SYMBols` on page 1302

BUS<m>:RFFE:FCOunt?

Returns the number of command sequences in the current acquisition.

Suffix:

<m>	1..4

Return values:

<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:STATe?

Returns the overall state of the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameState> OK | SSC | GAP | PARity | LENGth | BP | USEQuence | INComplete

OK: the sequence is valid.
SSC: SSC error
GAP: Timing error
PARity: parity error
LENGth: length error
BP: bus park error
USEQuence: Unknown sequence
INComplete: The sequence is not completely contained in the acquisition. The acquired part of the sequence is valid.

*RST: OK

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:STARt?
BUS<m>:RFFE:SEQuence<n>:STOP?

Return the start time (SSC) and stop time (BP) of the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<Start>, <Stop>	Time Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:TYPE?

Returns the type of the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameType>	UNDESC | RZWR | RWR | RRD | ERWR | ERRD | ERWL | ERRL | MASR | MASW | MASOHO | IRSUM | UNDEF | ERRor RZWR: Register 0 Write RWR: Register Write RRD: Register Read ERWR: Extended Register Write ERRD: Extended Register Read ERWL: Extended Register Write Long ERRL: Extended Register Read Long MASR: Master Read MASW: Master Write MASOHO: Master Ownership Handover IRSUM: Interrupt Summary and Notification ERRor: the bits defining the command sequence are not valid, no supported command sequence *RST: RZWR

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:SADD?

Returns the slave address of the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameSID>	Range: 0 to 15 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:ADDRess?

Returns the register address of the selected command sequence.

Suffix:

<m> 1..4

<n> *

Return values:

<FrameAddress> Range: Depends on the sequence type, address can have 0, 5, 8, or 16 bits

Increment: 1

*RST: 0

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:BCOunt?

Returns the byte count of the selected command sequence.

Suffix:

<m> 1..4

<n> *

Return values:

<ByteCount> Decimal value

Range: 15

Increment: 1

*RST: 0

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:DATA?

Returns the data bytes of the specified command sequence.

Use `BUS<m>:RFFE:SEQuence<n>:BYTE<o>:VALue?` to access the sequence bytes.

Suffix:

<m> 1..4

<n> *

Return values:

<Data> Bit pattern (B1, B2, B3, B4…) in variable length up to eight bytes.

Example:
```
BUS:RFFE:SEQuence3:DATA?
<-- #H08,#H49,#H54,#H33,#HFF
```

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:SYMBol?

Returns the symbolic label that belongs to the address of the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<Translation>	String containing the label name

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:PADone?

Returns the address-one parity for the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameState>	OK | PARity `PARity`: PArrity error *RST: OK

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:PADZero?

Returns the address-zero parity for the selected command sequence.

Suffix:

<m>	1..4
<n>	*

Return values:

<FrameState>	OK | PARity `PARity`: PArrity error *RST: OK

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:PCTRl?

Returns the control parity for the selected command sequence.

Suffix:

<m>	1..4

<n> *

Return values:
<FrameState> OK | PARity

PARity: PArrity error

*RST: OK

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:BYTE<o>:STATe?

Returns the state of the specified data byte.

Suffix:
<m> 1..4

<n> *

<o> *
Selects the number of the data byte (1...n).

Return values:
<ByteState> OK | PARity

OK: the byte is valid.
PARity: parity error

*RST: OK

Usage: Query only

BUS<m>:RFFE:SEQuence<n>:BYTE<o>:VALue?

Returns the value of the specified byte in the specified command sequence.

Suffix:
<m> 1..4

<n> *

<o> *
Selects the number of the data byte (1...n).

Return values:
<ByteValue> To set the value format, use FORMat:BPATtern.
The values below – range, increment and reset – are decimal values.

Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

20.17.10.4 Search Settings

For programming example, see "Searching RFFE Data " on page 967.

SEARch:TRIGger:RFFE:TYPE <SearchName>,<SearchType>
SEARch:TRIGger:RFFE:TYPE? <SearchName>

Sets the event to be searched for.

See also: "Type" on page 623

Parameters:

<SearchType> STARt | STOP | RZWR | RWR | RRD | ERWR | ERRD | ERWL | ERRL | MASR | MASW | MASOHO | IRSUM | ERRor

STARt
Start of a command sequence (SSC). Optional: slave address.

STOP
End of a command sequence (start of the bus park cycle). Optional: slave address condition.

RZWR
"Register 0 Write" command sequence. Optional: slave address condition and data pattern condition.

RWR
"Register Write" command sequence. Optional: slave address condition, register address condition, and data pattern condition.

RRD
"Register Read" command sequence. Optional: slave address condition, register address condition, and data pattern condition.

ERWR
"Extended Register Write" command sequences. Optional: slave address condition, register address condition, byte count condition, data index condition, and data pattern condition.

ERRD
"Extended Register Read" command sequence. Optional search conditions are the same as for ERWR.

ERWL
"Extended Register Write Long" command sequence. Optional search conditions are the same as for ERWR.

ERRL
"Extended Register Read Long" command sequence. Optional search conditions are the same as for ERWR.

MASR
Master Read. Optional: slave address condition, register address condition, and data pattern condition.

MASW
Master Write. Optional: slave address condition, register address condition, and data pattern condition.

MASOHO
Master Ownership Handover. Optional: slave address condition, and data pattern condition.

IRSUM
Interrupt Summary and Notification. Optional: slave address condition, byte count condition, and data pattern condition.

ERRor
Searches for enabled errors. To enable the error types, use:
`SEARch:TRIGger:RFFE:ERRor:BP`
`SEARch:TRIGger:RFFE:ERRor:LENGth`
`SEARch:TRIGger:RFFE:ERRor:NOResponse`
`SEARch:TRIGger:RFFE:ERRor:PARity`
`SEARch:TRIGger:RFFE:ERRor:SSC`
`SEARch:TRIGger:RFFE:ERRor:USEQuence`.

*RST: STARt

Parameters for setting and query:

<SearchName> String parameter

Example: See "Searching RFFE Data " on page 967

To specify additional search conditions for command sequences, use the following commands:

Slave address	SEARch:TRIGger:RFFE:SADD:CONDition SEARch:TRIGger:RFFE:SADD:MIN SEARch:TRIGger:RFFE:SADD:MAX
Register address	SEARch:TRIGger:RFFE:ADDRess:CONDition SEARch:TRIGger:RFFE:ADDRess:MIN SEARch:TRIGger:RFFE:ADDRess:MAX
Data pattern	SEARch:TRIGger:RFFE:DATA:DCON SEARch:TRIGger:RFFE:DATA:DMIN SEARch:TRIGger:RFFE:DATA:DMAX
Byte count	SEARch:TRIGger:RFFE:BCOunt:CONDition SEARch:TRIGger:RFFE:BCOunt:MIN SEARch:TRIGger:RFFE:BCOunt:MAX
Data index	SEARch:TRIGger:RFFE:DATA:ICONdition SEARch:TRIGger:RFFE:DATA:IMIN SEARch:TRIGger:RFFE:DATA:IMAX

SEARch:TRIGger:RFFE:SADD:CONDition <SearchName>,<SIDOperator>
SEARch:TRIGger:RFFE:SADD:CONDition? <SearchName>
SEARch:TRIGger:RFFE:ADDRess:CONDition <SearchName>,<AddressOperator>
SEARch:TRIGger:RFFE:ADDRess:CONDition? <SearchName>
SEARch:TRIGger:RFFE:BCOunt:CONDition <SearchName>,<ByteCntOperator>
SEARch:TRIGger:RFFE:BCOunt:CONDition? <SearchName>
SEARch:TRIGger:RFFE:DATA:DCON <SearchName>,<DatPattOptor>
SEARch:TRIGger:RFFE:DATA:DCON? <SearchName>

Sets the operator to search for a specific pattern or a range

Parameters:

<DatPattOptor> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set using the corresponding SEARch:TRIGger:RFFE:...:MIN command.

INRange | OORange
In range / Out of range: Set the minimum and maximum value using the corresponding SEARch:TRIGger:RFFE:...:MIN and SEARch:TRIGger:RFFE:...:MAX

*RST: EQUal

Parameters for setting and query:

<SearchName> String parameter

Example: See "Searching RFFE Data " on page 967

SEARch:TRIGger:RFFE:DATA:ICONdition <SearchName>,<DataIdxOperator>
SEARch:TRIGger:RFFE:DATA:ICONdition? <SearchName>

Sets the operator to define the data frames in which the data pattern is searched

Parameters:

<DataIdxOperator> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal | LTHan | LETHan | GTHan | GETHan
Equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set using `SEARch:TRIGger:RFFE:DATA:IMIN`.

INRange = RANGe
In range: Set the minimum and maximum value using `SEARch:TRIGger:RFFE:DATA:IMIN` and `SEARch:TRIGger:RFFE:DATA:IMAX`.

*RST: INRange

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:RFFE:SADD:MIN <SearchName>,<SIDMin>
SEARch:TRIGger:RFFE:SADD:MIN? <SearchName>
SEARch:TRIGger:RFFE:ADDRess:MIN <SearchName>,<AddressMin>
SEARch:TRIGger:RFFE:ADDRess:MIN? <SearchName>
SEARch:TRIGger:RFFE:BCOunt:MIN <SearchName>,<ByteCountMin>
SEARch:TRIGger:RFFE:BCOunt:MIN? <SearchName>
SEARch:TRIGger:RFFE:DATA:IMIN <SearchName>,<DataIndexMin>
SEARch:TRIGger:RFFE:DATA:IMIN? <SearchName>
SEARch:TRIGger:RFFE:DATA:DMIN <SearchName>,<DataPatternMin>
SEARch:TRIGger:RFFE:DATA:DMIN? <SearchName>

Specifies a pattern, or sets the the start value of a pattern range.

Parameters:

<DataPatternMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

Example: See "Searching RFFE Data " on page 967

SEARch:TRIGger:RFFE:SADD:MAX <SearchName>,<SIDMax>
SEARch:TRIGger:RFFE:SADD:MAX? <SearchName>
SEARch:TRIGger:RFFE:ADDRess:MAX <SearchName>,<AddressMax>
SEARch:TRIGger:RFFE:ADDRess:MAX? <SearchName>
SEARch:TRIGger:RFFE:BCOunt:MAX <SearchName>,<ByteCountMax>
SEARch:TRIGger:RFFE:BCOunt:MAX? <SearchName>

SEARch:TRIGger:RFFE:DATA:IMAX <SearchName>,<DataIndexMax>
SEARch:TRIGger:RFFE:DATA:IMAX? <SearchName>
SEARch:TRIGger:RFFE:DATA:DMAX <SearchName>,<DataPatternMax>
SEARch:TRIGger:RFFE:DATA:DMAX? <SearchName>

Sets the the end value of an range if the corresponding condition is set to `INRange` or `OORange`. See `SEARch:TRIGger:RFFE:...:CON`

Parameters:

<DataPatternMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:RFFE:INTerrupt <SearchName>,<Interrupt>
SEARch:TRIGger:RFFE:INTerrupt? <SearchName>

Defines the pattern of the interrrupt identification sequence, which consists of interrupt slots 15 to 0.

Parameters:

<Interrupt> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName> String parameter

Firmware/Software: FW 3.30

SEARch:TRIGger:RFFE:ERRor:BP <SearchName>,<BusParkError>
SEARch:TRIGger:RFFE:ERRor:BP? <SearchName>

Enables the search for bus park errors - when an incorrect bus parlk cycle has been found.

Parameters:

<BusParkError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:RFFE:ERRor:LENGth <SearchName>,<LengthError>
SEARch:TRIGger:RFFE:ERRor:LENGth? <SearchName>

Enables the search for length errors - when an incorrect length of the command sequence has been found.

Parameters:

<LengthError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:RFFE:ERRor:NOResponse <SearchName>,<NoResponse>
SEARch:TRIGger:RFFE:ERRor:NOResponse? <SearchName>

Enables the search for No Response Frames.

Parameters:

<NoResponse> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:RFFE:ERRor:PARity <SearchName>,<ParityError>
SEARch:TRIGger:RFFE:ERRor:PARity? <SearchName>

Enables the search for incorrect parity bits.

Parameters:

<ParityError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:RFFE:ERRor:SSC <SearchName>,<SSCError>
SEARch:TRIGger:RFFE:ERRor:SSC? <SearchName>

Enables the search for SSC errors - when no valid SSC sequence has been found after the idle time.

Parameters:

<SSCError> ON | OFF

*RST: ON

Parameters for setting and query:

<SearchName> String parameter

SEARch:TRIGger:RFFE:ERRor:USEQuence <SearchName>,<UnknownSequence>
SEARch:TRIGger:RFFE:ERRor:USEQuence? <SearchName>

Enables the search for unknown sequences - when the instrument cannot detect any supported command sequence.

Parameters:
<UnknownSequence> ON | OFF
*RST: ON

Parameters for setting and query:
<SearchName> String parameter

20.17.10.5 Search Results

The search on decoded RFFE data returns the same results as the queries for decode results.

In all SEARch:RESult:RFFE commands, the suffix <m> selects the command sequence. Suffix <n> selects index of byte inside a command sequence.

In search result commands, you have to specify the <SearchName> parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.10.3, "Decode Results", on page 1490.

For programming example, see "Searching RFFE Data " on page 967.

SEARch:RESult:RFFE:FCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:
<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:TYPE? <SearchName>

Returns the type of the specified command sequence.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameType> UNDESC | RZWR | RWR | RRD | ERWR | ERRD | ERWL | ERRL | MASR | MASW | MASOHO | IRSUM | UNDEF | ERRor

See `SEARch:TRIGger:RFFE:TYPE`.

*RST: RZWR

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:STATe? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameState> OK | SSC | GAP | PARity | LENGth | BP | USEQuence | INComplete

*RST: OK

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:STARt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameStart> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:SADD? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameSID> Range: 0 to 15
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameStop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:ADDRess? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<FrameAddress> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:BCOunt? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<ByteCount> Range: 0 to 16
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:DATA? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:SYMBol? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Translation>

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:BYTE<n>:STATe? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<ByteState> OK | PARity

OK: the byte is valid.
PARity: parity error

*RST: OK

Usage: Query only

SEARch:RESult:RFFE:SEQuence<m>:BYTE<n>:VALue? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:

<ByteValue>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

20.17.11 D-PHY (Option R&S RTP-K42)

20.17.11.1 D-PHY Configuration

BUS<m>:DPHY:CONFig <Configuration>

Sets the number of data lanes and if the clock lane and low power are available.

Suffix:

<m> 1..4

Parameters:

<Configuration> D1CN | D1CL | D2CN | D2CL | D3CN | D3NL | D4NN

`D1CN`: 1 data lane, clock lane
`D1CL`: 1 data lane, clock lane, low power
`D2CN`: 2 data lane, clock lane
`D2CL`: 2 data lanes, clock lane, low power
`D3CN`: 3 data lane, clock lane
`D3CL`: 3 data lanes, no clock lane, low power
`D4NN`: 4 data lanes and no clock

*RST: D4NN

BUS<m>:DPHY:CP:PROBe <ProbeCP>

Selects the type of probe used for the clock lane.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ProbeCP> DIFFerential | SINGle

*RST: SINGle

BUS<m>:DPHY:CP:SOURce <ClockSource>

Selects the source of the clock lane.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ClockSource> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

*RST: NONE

BUS<m>:DPHY:DRATe <DataRate>

Sets a data rate.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<DataRate> Range: 1000000 to 2500000000
Increment: 1000000
*RST: 800000000
Default unit: bps

BUS<m>:DPHY:DSPData <DispDatVect>

Enables the display of the data vector, which means that the whole frame will be decoded.

When the display vector is disabled only the packet header will be decoded and not the actual data payload of the frame. This will speed up the decoding.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<DispDatVect> ON | OFF
*RST: OFF

BUS<m>:DPHY:THCoupling <ThresCpl>

Enables coupling, i.e. the same threshold and hysteresis value is used for all lanes.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ThresCpl> ON | OFF
*RST: ON

BUS<m>:DPHY:THPReset <ThresholdPreset>

Prests the threshold and hysteresis values of the high speed data lanes. A preset sets the low power threshold to 1.20V and high speed threshold to 200 mV.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<ThresholdPreset> LPHS | MANual
*RST: LPHS

BUS<m>:DPHY:VARiant <ProtSel>

Selects the protocol running on the interface.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<ProtSel> DSI | CSI2
*RST: CSI2

BUS<m>:DPHY:DNZero:LPOWer:THUPper <ThresLPDN0High>
BUS<m>:DPHY:DPZero:LPOWer:THUPper <ThresLPDP0High>

Sets the upper threshold value for the respective lane used for the low power mode.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<ThresLPDP0High> Range: -1.5 to 1.5
Increment: 0.01
*RST: 0.88
Default unit: V

BUS<m>:DPHY:DNZero:LPOWer:THLower <ThresLPDN0Low>
BUS<m>:DPHY:DPZero:LPOWer:THLower <ThresLPDP0Low>

Sets the lower threshold value for the respective lane used for the low power mode.

Suffix:
<m> 1..4
Selects the serial bus.

Parameters:
<ThresLPDP0Low> Range: -1.5 to 1.5
Increment: 0.01
*RST: 0.55
Default unit: V

BUS<m>:DPHY:DPZero:SOURce <DataSource>

Selects the source of the DP0 data line.

Suffix:
<m> 1..4

Parameters:
<DataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
*RST: C1W1

BUS<m>:DPHY:DNZero:SOURce <DataSource>
BUS<m>:DPHY:DPONe:SOURce <DataSource>
BUS<m>:DPHY:DPTWo:SOURce <DataSource>
BUS<m>:DPHY:DPTHree:SOURce <DataSource>

Selects the source of the corresponding data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataSource>	NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4	
	*RST:	DNZero: NONE, DPONe: C2W1, DPTWo: C3W1, DPTHree: C4W1

BUS<m>:DPHY:DNZero:PROBe <ProbeDN0>
BUS<m>:DPHY:DPZero:PROBe <ProbeDP0>
BUS<m>:DPHY:DPONe:PROBe <ProbeDP1>
BUS<m>:DPHY:DPTWo:PROBe <ProbeDP2>
BUS<m>:DPHY:DPTHree:PROBe <ProbeDP3>

Selects the type of probe used for the corresponding data lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ProbeDP3>	DIFFerential | SINGle	
	*RST:	SINGle

BUS<m>:DPHY:CP:HSPeed:HYSTeresis <HysteresisHSCP>
BUS<m>:DPHY:DPZero:HSPeed:HYSTeresis <HysteresisHSDP0>
BUS<m>:DPHY:DPONe:HSPeed:HYSTeresis <HysteresisHSDP1>
BUS<m>:DPHY:DPTWo:HSPeed:HYSTeresis <HysteresisHSDP2>
BUS<m>:DPHY:DPTHree:HSPeed:HYSTeresis <HysteresisHSDP3>

Sets a value for the hysteresis of the respective lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<HysteresisHSDP3>	Range:	0 to 0.5
	Increment:	0.01
	*RST:	0.2
	Default unit:	V

BUS<m>:DPHY:CP:HSPeed:THReshold <ThresholdHSCP>
BUS<m>:DPHY:DPZero:HSPeed:THReshold <ThresholdHSDP0>
BUS<m>:DPHY:DPONe:HSPeed:THReshold <ThresholdHSDP1>
BUS<m>:DPHY:DPTWo:HSPeed:THReshold <ThresholdHSDP2>
BUS<m>:DPHY:DPTHree:HSPeed:THReshold <ThresholdHSDP3>

Sets the threshold value for the digitization of the respective high speed data line.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresholdHSDP3>	Range: -1 to 1 Increment: 0.01 *RST: 0.2 Default unit: V

20.17.11.2 D-PHY Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:DPHY:TYPE <Type>

Sets the type of frame to be triggered on.

Parameters:

<Type> HS_SOP | HS_EOP | HS_PH | HS_DATA | LP_ESC | LP_TURN | LP_HSRQ

HS_SOP
High speed start of packet

HS_EOP
High speed end of packet

HS_PH
High speed packet header

HS_DATA
High speed data

LP_ESC
Low power escape mode frame

LP_TURN
Low power lane turnaround

LP_HSRQ
Low power high speed request

*RST: HS_SOP

TRIGger<m>:DPHY:DATA:CONDition <Format>

Set the condition for the data value. You can define an exact value or a value range.

Parameters:

<Format> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:DPHY:DATA:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:DPHY:DATA:MIN` and `TRIGger<m>:DPHY:DATA:MAX`.

*RST: EQUal

TRIGger<m>:DPHY:DATA:MAX <DataMax>

Sets the the end value of a data type range if TRIGger<m>:DPHY:DATA:CONDition is set to INRange or OORange.

Parameters:

<DataMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:DATA:MIN <DataMin>

Specifies a data bit pattern, or sets the the start value of a pattern range.

Parameters:

<DataMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:DIDX:CONDition <Format>

Sets the condition for the data index. You can define an exact value or a value range.

Parameters:

<Format> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding TRIGger<m>:DPHY:DIDX:MIN command.

INRange = RANGe
In range: Set the minimum and maximum value using TRIGger<m>:DPHY:DIDX:MIN and TRIGger<m>:DPHY:DIDX:MAX.

*RST: INRange

TRIGger<m>:DPHY:DIDX:MAX <DXSymbol>

Sets the the end value of a data index range if TRIGger<m>:DPHY:DIDX:CONDition is set to INRange or RANGe.

Parameters:

<DXSymbol> Range: 0 to 65535
Increment: 1
*RST: 0

TRIGger<m>:DPHY:DIDX:MIN <SymbolType>

Specifies a data index minimum, or sets the the start value of a range.

Parameters:

<SymbolType> Range: 0 to 65535
Increment: 1
*RST: 0

TRIGger<m>:DPHY:DTYPe:CONDition <Format>

Set the condition for the data type. You can define an exact value or a value range

Parameters:

<Format> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:DPHY:DTYPe:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:DPHY:DTYPe:MIN` and `TRIGger<m>:DPHY:DTYPe:MAX`.

*RST: EQUal

TRIGger<m>:DPHY:DTYPe:MAX <HSDataTypeMax>

Sets the the end value of a data type range if `TRIGger<m>:DPHY:DTYPe:CONDition` is set to `INRange` or `OORange`.

Parameters:

<HSDataTypeMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:DTYPe:MIN <HSDataTypeMin>

Specifies a data type pattern, or sets the the start value of a pattern range.

Parameters:

<HSDataTypeMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:ESCMode:CONDition <Format>

Set the condition for the escape mode. You can define an exact value or a value range

Parameters:

<Format> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:DPHY:ESCMode:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:DPHY:ESCMode:MIN` and `TRIGger<m>:DPHY:ESCMode:MAX`.

*RST: EQUal

TRIGger<m>:DPHY:ESCMode:MAX <LPEscapeModeMax>

Sets the the end value of an escape mode range if `TRIGger<m>:DPHY:ESCMode:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LPEscapeModeMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:ESCMode:MIN <LPEscapeModeMin>

Specifies a escape mode bit pattern, or sets the the start value of a pattern range.

Parameters:

<LPEscapeModeMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:ESDTa:CONDition <Format>

Set the condition for the escape mode data value. You can define an exact value or a value range.

Parameters:

<Format> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding TRIGger<m>:DPHY:ESDTa:MIN command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with TRIGger<m>:DPHY:ESDTa:MIN and TRIGger<m>:DPHY:ESDTa:MAX.

OFF | ANY
Any pattern is detected.

*RST: EQUal

TRIGger<m>:DPHY:ESDTa:MAX <LPEscapeDataMax>

Sets the the end value of a escape mode data type range if TRIGger<m>:DPHY:ESDTa:CONDition is set to INRange or OORange.

Parameters:
<LPEscapeDataMax>

TRIGger<m>:DPHY:ESDTa:MIN <LPEscapeDataMin>

Specifies an escape mode data bit pattern, or sets the the start value of a pattern range.

Parameters:
<LPEscpMdDatMin>

TRIGger<m>:DPHY:ESINdex:CONDition <Format>

Sets the condition for the escape mode data index. You can define an exact value or a value range.

Parameters:
<Format> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding TRIGger<m>:DPHY:ESINdex:MIN command.

INRange = RANGe
In range: Set the minimum and maximum value using TRIGger<m>:DPHY:ESINdex:MIN and TRIGger<m>:DPHY:ESINdex:MAX.

*RST: INRange

TRIGger<m>:DPHY:ESINdex:MAX <DXSymbol>

Sets the the end value of a data index range if `TRIGger<m>:DPHY:ESINdex:CONDition` is set to `INRange` or `RANge`.

Parameters:

<DXSymbol>	Range:	0 to 255
	Increment:	1
	*RST:	0

TRIGger<m>:DPHY:ESINdex:MIN <SymbolType>

Specifies an escape mode data index minimum, or sets the the start value of a range.

Parameters:

<SymbolType>	Range:	0 to 255
	Increment:	1
	*RST:	0

TRIGger<m>:DPHY:HSVC <HSVC>

Sets the virtual channel to be triggered on.

Parameters:

<HSVC>

TRIGger<m>:DPHY:WCOunt:CONDition <Format>

Set the condition for the word count. You can define an exact value or a value range.

Parameters:

<Format> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:DPHY:WCOunt:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:DPHY:WCOunt:MIN` and `TRIGger<m>:DPHY:WCOunt:MAX`.

*RST: EQUal

TRIGger<m>:DPHY:WCOunt:MAX <HSWordCountMax>

Sets the the end value of a data type range if `TRIGger<m>:DPHY:WCOunt:CONDition` is set to `INRange` or `OORange`.

Parameters:
<HSWordCountMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:DPHY:WCOunt:MIN <HSWordCountMin>

Specifies a word bit pattern, or sets the the start value of a pattern range.

Parameters:
<HSWordCountMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

20.17.11.3 D-PHY Decode Results

To show the results on the screen, use the following commands:

- `BUS<m>:RESult` on page 1300
- `BUS<m>:RESDetail` on page 1300

BUS<m>:DPHY:RESult:FCOunt?

Returns the number of decoded frames for the selected serial bus.

Suffix:
<m> 1..4

Return values:
<Count> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:CS?

Returns the checksum of the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<CS> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:DATA?

Returns the data or word count value.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<WordCountOrData> 16 bit integer value
Range: 0 to 65535
Increment: 1
*RST: 0

Example:

```
BUS:DPHY:RESult:FRAMe2:DATA?
<-- 13245
```

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:DTName?

Returns the data type name for the specified frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<DataTypeName>

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:DTYPe?

Returns the data type for the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<DataType>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:ECC?

Returns the error correction code (ECC) of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<ECC>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:PACKet<o>:IDX?

Returns the index of the data payload.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the packet number.

Return values:

<PacketIndex>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:PACKet<o>:VALue?

Returns the byte value of the data payload.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the packet number.

Return values:

<PacketValue> Range: 0 to 9223372036854775808
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:STARt?

Returns the start time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:STATe?

Returns the overall state of the frame.

Suffix:

<m>	1..4 Selects the serial bus.

<n>	* Selects the frame.

Return values:

<State>	OK | CS | ECC | ECCWarning | LENGth | FORMat | UNKNOWN_FRAME | INComplete **OK** The frame is valid. **LENGth** Length error. **UNKNOWN_FRAME** Unknown frame type **INComplete** The sequence is not completely contained in the acquisition *RST: OK

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:STOP?

Returns the end time of the specified frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:TYPE?

Returns the type of frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameType>	HS_SP | HS_LP | HS_INCOMPLETE | LP_HSREQ | LP_TA | LP_ESC

HS_SP
High speed short packet frame

HS_LP
High speed long packet frame

HS_INCOMPLETE
Incomplete high speed frame

LP_HSREQ
High speed request frame

LP_TA
Low power lane turnaround frame

LP_ESC
Low power escape mode frame

*RST: HS_SP

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:NUMPackets?

Returns the number of packets in the indicated frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<NumPackets> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:DPHY:RESult:FRAMe<n>:VCHannel?

Returns the number of virtual channels.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<VirtualChannel> Range: 0 to 3
Increment: 1
*RST: 0

Usage: Query only

20.17.11.4 D-PHY Search Settings

SEARch:TRIGger:DPHY:TYPE <SearchName>,<Type>
SEARch:TRIGger:DPHY:TYPE? <SearchName>

Sets the type of frame to be searched for.

Parameters:

<Type> HS_SOP | HS_EOP | HS_PH | HS_DATA | LP_ESC | LP_TURN | LP_HSRQ

HS_SOP
High speed start of packet

HS_EOP
High speed end of packet

HS_PH
High speed packet header

HS_DATA
High speed data

LP_ESC
Low power escape mode frame

LP_TURN
Low power lane turnaround

LP_HSRQ
Low power high speed request

*RST: HS_SOP

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DATA:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:DATA:CONDition? <SearchName>

Set the condition for the data value. You can define an exact value or a value range.

Parameters:

<Format> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:DPHY:DATA:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:DPHY:DATA:MIN` and `SEARch:TRIGger:DPHY:DATA:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DATA:MAX <SearchName>,<DataMax>
SEARch:TRIGger:DPHY:DATA:MAX? <SearchName>

Sets the the end value of a data type range if `SEARch:TRIGger:DPHY:DATA:CONDition` is set to `INRange` or `OORange`.

Parameters:

<DataMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DATA:MIN <SearchName>,<DataMin>
SEARch:TRIGger:DPHY:DATA:MIN? <SearchName>

Specifies a data bit pattern, or sets the the start value of a pattern range.

Parameters:

<DataMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DIDX:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:DIDX:CONDition? <SearchName>

Sets the condition for the data index. You can define an exact value or a value range.

Parameters:

<Format> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:DPHY:DIDX:MIN` command.

INRange = RANGe
In range: Set the minimum and maximum value using `SEARch:TRIGger:DPHY:DIDX:MIN` and `SEARch:TRIGger:DPHY:DIDX:MAX`.

*RST: INRange

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DIDX:MAX <SearchName>,<DXSymbol>
SEARch:TRIGger:DPHY:DIDX:MAX? <SearchName>

Sets the the end value of a data index range if `SEARch:TRIGger:DPHY:DIDX:CONDition` is set to `INRange` or `RANGe`.

Parameters:

<DXSymbol>
Range: 0 to 65535
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DIDX:MIN <SearchName>,<SymbolType>
SEARch:TRIGger:DPHY:DIDX:MIN? <SearchName>

Specifies a data index minimum, or sets the the start value of a range.

Parameters:

<SymbolType>
Range: 0 to 65535
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DTYPe:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:DTYPe:CONDition? <SearchName>

Set the condition for the data type. You can define an exact value or a value range

Parameters:

<Format> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:DPHY:DTYPe:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:DPHY:DATA:MIN` and `SEARch:TRIGger:DPHY:DATA:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DTYPe:MAX <SearchName>,<HSDataTypeMax>
SEARch:TRIGger:DPHY:DTYPe:MAX? <SearchName>

Sets the the end value of a data type range if `SEARch:TRIGger:DPHY:DTYPe:CONDition` is set to `INRange` or `OORange`.

Parameters:

<HSDataTypeMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:DTYPe:MIN <SearchName>,<HSDataTypeMin>
SEARch:TRIGger:DPHY:DTYPe:MIN? <SearchName>

Specifies a data type pattern, or sets the the start value of a pattern range.

Parameters:

<HSDataTypeMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESCMode:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:ESCMode:CONDition? <SearchName>

Set the condition for the escape mode. You can define an exact value or a value range

Parameters:

<Format> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:DPHY:ESCMode:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:DPHY:ESCMode:MIN` and `SEARch:TRIGger:DPHY:ESCMode:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESCMode:MAX <SearchName>,<LPEscapeModeMax>
SEARch:TRIGger:DPHY:ESCMode:MAX? <SearchName>

Sets the the end value of an escape mode range if `SEARch:TRIGger:DPHY:ESCMode:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LPEscapeModeMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESCMode:MIN <SearchName>,<LPEscapeModeMin>
SEARch:TRIGger:DPHY:ESCMode:MIN? <SearchName>

Specifies a escape mode bit pattern, or sets the the start value of a pattern range.

Parameters:

<LPEscapeModeMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESDTa:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:ESDTa:CONDition? <SearchName>

Set the condition for the escape mode data value. You can define an exact value or a value range.

Parameters:

<Format> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:DPHY:ESDTa:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:DPHY:ESDTa:MIN` and `SEARch:TRIGger:DPHY:ESDTa:MAX`.

OFF | ANY
Any pattern is detected.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESDTa:MAX <SearchName>,<LPEscapeDataMax>
SEARch:TRIGger:DPHY:ESDTa:MAX? <SearchName>

Sets the the end value of a escape mode data type range if `SEARch:TRIGger:DPHY:ESDTa:CONDition` is set to `INRange` or `OORange`.

Parameters:
<LPEscapeDataMax>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESDTa:MIN <SearchName>,<LPEscapeDataMin>
SEARch:TRIGger:DPHY:ESDTa:MIN? <SearchName>

Specifies an escape mode data bit pattern, or sets the the start value of a pattern range.

Parameters:
<LPEscapeDataMin>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESINdex:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:ESINdex:CONDition? <SearchName>

Sets the condition for the escape mode data index. You can define an exact value or a value range.

Parameters:

<Format> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:DPHY:ESINdex:MIN` command.

INRange = RANGe
In range: Set the minimum and maximum value using `SEARch:TRIGger:DPHY:ESINdex:MIN` and `SEARch:TRIGger:DPHY:ESINdex:MAX`.

*RST: INRange

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESINdex:MAX <SearchName>,<DXSymbol>
SEARch:TRIGger:DPHY:ESINdex:MAX? <SearchName>

Sets the the end value of a data index range if `SEARch:TRIGger:DPHY:ESINdex:CONDition` is set to `INRange` or `RANGe`.

Parameters:

<DXSymbol> Range: 0 to 255
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:ESINdex:MIN <SearchName>,<SymbolType>
SEARch:TRIGger:DPHY:ESINdex:MIN? <SearchName>

Specifies an escape mode data index minimum, or sets the the start value of a range.

Parameters:

<SymbolType> Range: 0 to 255
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:HSVC <SearchName>,<HSVC>
SEARch:TRIGger:DPHY:HSVC? <SearchName>

Sets the virtual channel to be searched for.

Parameters:
<HSVC>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:WCOunt:CONDition <SearchName>,<Format>
SEARch:TRIGger:DPHY:WCOunt:CONDition? <SearchName>

Set the condition for the word count. You can define an exact value or a value range.

Parameters:

<Format> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:DPHY:WCOunt:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:DPHY:WCOunt:MIN` and `SEARch:TRIGger:DPHY:WCOunt:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:WCOunt:MAX <SearchName>,<HSWordCountMax>
SEARch:TRIGger:DPHY:WCOunt:MAX? <SearchName>

Sets the the end value of a data type range if `SEARch:TRIGger:DPHY:WCOunt:CONDition` is set to `INRange` or `OORange`.

Parameters:

<HSWordCountMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DPHY:WCOunt:MIN <SearchName>,<HSWordCountMin>
SEARch:TRIGger:DPHY:WCOunt:MIN? <SearchName>

Specifies a word bit pattern, or sets the the start value of a pattern range.

Parameters:

<HSWordCountMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

20.17.11.5 D-PHY Search Results

In all `SEARch:RESult:DPHY:FRAMe<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:DPHY:FCOunt? <SearchName>

Returns the number of frames within the search result for the selected serial bus.

Query parameters:

<SearchName>

Return values:

<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:CS? <SearchName>

Returns the checksum for the selected frame within the search result.

Suffix:

<m> *

Query parameters:
<SearchName>

Return values:

<CS>	Range:	0 to 65535
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:DATA? <SearchName>

Returns the data or word count value for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<WordCountOrData>	Range:	0 to 65535
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:DTName? <SearchName>

Returns the data type name for the specified frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<DataTypeName>

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:DTYPe? <SearchName>

Returns the data type for the specified frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<DataType>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:ECC? <SearchName>

Returns the error correction code (ECC) of the specified frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<ECC>	Range:	0 to 255
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:PACKet<n>:IDX? <SearchName>

Returns the index of the data payload for the selected frame within the search result.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:

<PacketIndex>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:PACKet<n>:VALue? <SearchName>

Returns the byte value of the data payload for the selected frame within the search result.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:

<PacketValue> Range: 0 to 9223372036854775808
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:STARt? <SearchName>

Returns the start time of the specified frame within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:STATe? <SearchName>

Returns the overall state of the selected frame within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<State> OK | CS | ECC | ECCWarning | LENGth | FORMat | UNKNOWN_FRAME | INComplete

OK
The frame is valid.

LENGth
Length error.

UNKNOWN_FRAME
Unknown frame type

*RST: OK

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:STOP? <SearchName>

Returns the end time for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:TYPE? <SearchName>

Returns the type of frame for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameType> HS_SP | HS_LP | HS_INCOMPLETE | LP_HSREQ | LP_TA | LP_ESC

HS_SP
High speed short packet frame

HS_LP
High speed long packet frame

HS_INCOMPLETE
Incomplete high speed frame

LP_HSREQ
High speed request frame

LP_TA
Low power lane turnaround frame

LP_ESC
Low power escape mode frame

*RST: HS_SP

Usage: Query only

SEARch:RESult:DPHY:FRAMe<m>:VCHannel? <SearchName>

Returns the number of virtual channels for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<VirtualChannel> Range: 0 to 3
Increment: 1
*RST: 0

Usage: Query only

20.17.12 M-PHY (Option R&S RTP-K44)

20.17.12.1 Configuration

BUS<m>:MPHY:VARiant <Protocol>

Selects the protocol running on the interface.

Suffix:

<m> 1..4
Selects the serial bus.

Parameters:

<Protocol> MPHY | UNIPRO | SSIC
*RST: MPHY

BUS<m>:MPHY:DLANes <DataLaneCount>

Sets the number of data lanes.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataLaneCount>	Range: 1 to 4 Increment: 1 *RST: 4

BUS<m>:MPHY:DZERo:SOURce <DataSource>

Sets the source for Lane 0.

Suffix:

<m>	1..4

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 *RST: C1W1

BUS<m>:MPHY:DONE:SOURce <DataSource>
BUS<m>:MPHY:DTWO:SOURce <DataSource>
BUS<m>:MPHY:DTHRee:SOURce <DataSource>

Selects the source of the corresponding data lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<DataSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | NONE *RST: DONe: C2W1, DTWo: C3W1, DTHree: C4W1

BUS<m>:MPHY:DZERo:THReshold <ThresholdD0>
BUS<m>:MPHY:DONE:THReshold <ThresholdD1>
BUS<m>:MPHY:DTWO:THReshold <ThresholdD2>
BUS<m>:MPHY:DTHRee:THReshold <ThresholdD3>

Sets the threshold value for the respective lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresholdD1> <ThresholdD2> <ThresholdD3>	Range: 0 to 1 Increment: 0.01 *RST: 0.1 Default unit: V

BUS<m>:MPHY:THCoupling <Coupling>

Enables the same threshold value to be used for all lanes.

When the threshold coupling is disabled, changes to the threshold value only affect the respective lane.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<Coupling>	ON | OFF *RST: ON

BUS<m>:MPHY:THPReset <ThresholdPreset>

Selects the predefined value to preset the threshold value of the data lanes.

Suffix:

<m>	1..4 Selects the serial bus.

Parameters:

<ThresholdPreset>	THRES_60MV | THRES_120MV | THRES_240MV | MANual **THRES_60MV | THRES_120MV | THRES_240MV** Sets the threshold value of the data lane to the selected predefined value. **MANual** Automatically switches to this option if you edit the threshold text box manually. *RST: MANual

BUS<m>:MPHY:SCRMode <SSICScrambleMd>

Sets if the SSIC data is scrambled or unscrambled.

Suffix:

<m>	1..4

Parameters:

<SSICScrambleMd>	SCRM | NSCR `SCRM`: scrambled `NSCR`: unscrambled *RST: SCRM

20.17.12.2 Trigger M-PHY

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:MPHY:TYPE <Type>

Selects the type of frame to be triggered on.

Suffix:
<m> 1..3

Parameters:
<Type> START | BURST | ADAPT | LCC | DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC | PACP | TRIGUPR0 | TRIGUPR1 | TRIGUPR2 | ERRor

START
M-PHY or UniPro start of frame.

BURST
M-PHY burst frame.

ADAPT
M-PHY Adapt frame. This control frame is used for clock/bit synchronization.

LCC
M-PHY LCC frame. This control frame is used for line configuration depending on the `LCC Type`.

DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC
UniPro DL PDU frame.

PACP
UniPro PACP frame. This control frame is used mainly for power mode change and L1.5 link management.

TRIGUPR0 | TRIGUPR1 | TRIGUPR2
UniPro Trigger Upper frame. This control frame is used for link startup sequence.

ERRor
M-PHY or UniPro error frame.

*RST: START

TRIGger<m>:MPHY:LCCType <LCCType>

Selects the type of LCC frame to be triggered on.

Suffix:
<m> 1..3

Parameters:
<LCCType> ANY | SLEEP | STALL | READCAP | READMFG | READVEND | WRITEATTR | PWMG0 | PWMG1 | PWMG2 | PWMG3 | PWMG4 | PWMG5 | PWMG6 | PWMG7 | HSG1A | HSG2A | HSG3A | HSG4A | HSG1B | HSG2B | HSG3B | HSG4B | RESERVED

ANY
All the available LCC commands.

SLEEP
Switches the power-saving state to ultra-low power. In this state, up to 90% power saving is achieved.

STALL
Switches the power-saving state to ultra-low power. In this state, up to 75% power saving is achieved.

READCAP
Recovers data about the OMC's capabilities.

READMFG
Retrieves manufacturing ID and vendor-specific information.

READVEND
Retrieves the additional four delimited bytes containing vendor-specific information.

WRITEATTR
Sets the configuration parameters required for lane operation.

PWMG0 | PWMG1 | PWMG2 | PWMG3 | PWMG4 | PWMG5 | PWMG6 | PWMG7
Switches the transmission mode to the selected low-power gear.

HSG1A | HSG2A | HSG3A | HSG4A | HSG1B | HSG2B | HSG3B | HSG4B
Switches the transmission mode to the selected high-speed gear.

RESERVED
Reserved bit command. These bits are reserved for future use.

*RST: ANY

TRIGger<m>:MPHY:LWONe:CONDition <CondOperator>

Sets the condition for WORD 1. You can define an exact value or a value range.

Suffix:

<m> 1..3

Parameters:

<CondOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:MPHY:LWONe:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:LWONe:MIN` and `TRIGger<m>:MPHY:LWONe:MAX`.

*RST: EQUal

TRIGger<m>:MPHY:LWONe:MIN <LCCWORD1Min>

Specifies the WORD 1 pattern, or sets the start value of a pattern range.

Suffix:

<m> 1..3

Parameters:

<LCCWORD1Min> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWONe:MAX <LCCWORD1Max>

Sets the end value of the WORD 1 range if `TRIGger<m>:MPHY:LWONe:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m> 1..3

Parameters:

<LCCWORD1Max> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWTWo:CONDition <CondOperator>

Sets the condition for WORD 2. You can define an exact value or a value range.

Suffix:

<m> 1..3

Parameters:

<CondOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:MPHY:LWTWo:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:LWTWo:MIN` and `TRIGger<m>:MPHY:LWTWo:MAX`.

*RST: EQUal

TRIGger<m>:MPHY:LWTWo:MIN <LCCWORD2Min>

Specifies the WORD 2 pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<LCCWORD2Min> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWTWo:MAX <LCCWORD2Max>

Sets the end value of the WORD 2 range if `TRIGger<m>:MPHY:LWTWo:CONDition` is set to `INRange` or `OORange`.

Suffix:
<m> 1..3

Parameters:
<LCCWORD2Max> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWTHree:CONDition <CondOperator>

Sets the condition for WORD 3. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<CondOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:MPHY:LWTHree:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:LWTHree:MIN` and `TRIGger<m>:MPHY:LWTHree:MAX`.

*RST: EQUal

TRIGger<m>:MPHY:LWTHree:MIN <LCCWORD3Min>

Specifies the WORD 3 pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<LCCWORD3Min> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWTHree:MAX <LCCWORD3Max>

Sets the end value of the WORD 3 range if `TRIGger<m>:MPHY:LWTHree:CONDition` is set to `INRange` or `OORange`.

Suffix:
<m> 1..3

Parameters:
<LCCWORD3Max> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWFour:CONDition <CondOperator>

Sets the condition for WORD 4. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<CondOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:MPHY:LWFour:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:LWFour:MIN` and `TRIGger<m>:MPHY:LWFour:MAX`.

*RST: EQUal

TRIGger<m>:MPHY:LWFour:MIN <LCCWORD4Min>

Specifies the WORD 4 pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<LCCWORD4Min> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:LWFour:MAX <LCCWORD4Max>

Sets the end value of the WORD 4 range if `TRIGger<m>:MPHY:LWFour:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m> 1..3

Parameters:

<LCCWORD4Max> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:TC <TC>

Specifies the TC bit pattern.

Suffix:

<m> 1..3

Parameters:

<TC> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:DATA:DCON <DataOperator>

Sets the condition for the data. You can define an exact value or a value range.

Suffix:

<m> 1..3

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:MPHY:DATA:DMIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:DATA:DMIN` and `TRIGger<m>:MPHY:DATA:DMAX`.

*RST: EQUal

TRIGger<m>:MPHY:DATA:DMIN <DataMin>

Specifies the data bit pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<DataMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:DATA:DMAX <DataMax>

Sets the end value of the data range if `TRIGger<m>:MPHY:DATA:DCON` is set to `INRange` or `OORange`.

Suffix:
<m> 1..3

Parameters:
<DataMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:DATA:ICONdition <DataIdxOperator>

Sets the condition for the index. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<DataIdxOperator> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal | LTHan | LETHan | GTHan | GETHan
Equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `TRIGger<m>:MPHY:DATA:IMIN` command.

INRange = RANGe
In range: Set the minimum and maximum value using `TRIGger<m>:MPHY:DATA:IMIN` and `TRIGger<m>:MPHY:DATA:IMAX`.

*RST: INRange

TRIGger<m>:MPHY:DATA:IMIN <DataIndexMin>

Specifies the index minimum, or sets the start value of a range.

Suffix:
<m> 1..3

Parameters:

<DataIndexMin> Range: 1 to 0
Increment: 1
*RST: 1

TRIGger<m>:MPHY:DATA:IMAX <DataIndexMax>

Sets the end value of the index range if TRIGger<m>:MPHY:DATA:ICONdition is set to INRange or RANge.

Suffix:

<m> 1..3

Parameters:

<DataIndexMax> Range: 1 to 0
Increment: 1
*RST: 0

TRIGger<m>:MPHY:FSNumber:CONDition <FSNOperator>

Sets the condition for FSN. You can define an exact value or a value range.

Suffix:

<m> 1..3

Parameters:

<FSNOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding TRIGger<m>:MPHY:FSNumber:MIN command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with TRIGger<m>:MPHY:FSNumber:MIN and TRIGger<m>:MPHY:FSNumber:MAX.

*RST: EQUal

TRIGger<m>:MPHY:FSNumber:MIN <FSNMin>

Specifies the FSN bit pattern, or sets the start value of a pattern range.

Suffix:

<m> 1..3

Parameters:

<FSNMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:FSNumber:MAX <FSNMax>

Sets the end value of the FSN range if `TRIGger<m>:MPHY:FSNumber:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3

Parameters:

<FSNMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:CRC:CONDition <CRCOperator>

Sets the condition for CRC. You can define an exact value or a value range.

Suffix:

<m>	1..3

Parameters:

<CRCOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:MPHY:CRC:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:CRC:MIN` and `TRIGger<m>:MPHY:CRC:MAX`.

*RST: EQUal

TRIGger<m>:MPHY:CRC:MIN <CRCMin>

Specifies the CRC bit pattern, or sets the start value of a pattern range.

Suffix:

<m>	1..3

Parameters:

<CRCMin>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:CRC:MAX <CRCMax>

Sets the end value of the CRC range if `TRIGger<m>:MPHY:CRC:CONDition` is set to `INRange` or `OORange`.

Suffix:

<m> 1..3

Parameters:

<CRCMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:CREQ <REQ>

Specifies the CREQ bit pattern.

Suffix:

<m> 1..3

Parameters:

<REQ> ONE | ZERO | DC

ONE
Sets the trigger condition to binary 1.

ZERO
Sets the trigger condition to binary 0.

DC
Sets the trigger condition to any CREQ value (don't care).

*RST: DC

TRIGger<m>:MPHY:RREQ <REQ>

Specifies the RREQ bit pattern.

Suffix:

<m> 1..3

Parameters:

<REQ> ONE | ZERO | DC

ONE
Sets the trigger condition to binary 1.

ZERO
Sets the trigger condition to binary 0.

DC
Sets the trigger condition to any RREQ value (don't care).

*RST: DC

TRIGger<m>:MPHY:CREDit:CONDition <CreditOperator>

Sets the condition for Credit. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<CreditOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:MPHY:CREDit:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:CREDit:MIN` and `TRIGger<m>:MPHY:CREDit:MAX`.

*RST: EQUal

TRIGger<m>:MPHY:CREDit:MIN <CreditMin>

Specifies the Credit bit pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<CreditMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:CREDit:MAX <CreditMax>

Sets the end value of the Credit range if `TRIGger<m>:MPHY:CREDit:CONDition` is set to `INRange` or `OORange`.

Suffix:
<m> 1..3

Parameters:
<CreditMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:PBEGin:CONDition <CondPACPBegin>

Sets the condition for PACP Begin. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<CondPACPBegin> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:MPHY:PBEGin:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:PBEGin:MIN` and `TRIGger<m>:MPHY:PBEGin:MAX`.

*RST: EQUal

TRIGger<m>:MPHY:PBEGin:MIN <PACPBEGINMin>

Specifies the PACP Begin bit pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<PACPBEGINMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:PBEGin:MAX <PACPBEGINMax>

Sets the end value of the PACP Begin range if `TRIGger<m>:MPHY:PBEGin:CONDition` is set to `INRange` or `OORange`.

Suffix:
<m> 1..3

Parameters:
<PACPBEGINMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:PFID:CONDition <CondPACPFunc>

Sets the condition for PACP Function ID. You can define an exact value or a value range.

Suffix:
<m> 1..3

Parameters:
<CondPACPFunc> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `TRIGger<m>:MPHY:PFID:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `TRIGger<m>:MPHY:PFID:MIN` and `TRIGger<m>:MPHY:PFID:MAX`.

*RST: EQUal

TRIGger<m>:MPHY:PFID:MIN <PACPFunIDMin>

Specifies the PACP Function ID bit pattern, or sets the start value of a pattern range.

Suffix:
<m> 1..3

Parameters:
<PACPFunIDMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:PFID:MAX <PACPFunIDMax>

Sets the end value of the PACP Function ID range if `TRIGger<m>:MPHY:PFID:CONDition` is set to `INRange` or `OORange`.

Suffix:
<m> 1..3

Parameters:
<PACPFunIDMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:MPHY:PRPLength <Width>

Sets the width for the width trigger based upon the data rate.

Suffix:
<m> 1..3

Parameters:

<Width>	Range: 100E-12 to 10000 Increment: 100E-9 *RST: 5E-9 Default unit: s

TRIGger<m>:MPHY:ERRor:LCMD <LCCError>

Enables/disables trigger on LCC error.

Suffix:

<m> 1..3

Parameters:

<LCCError> ON | OFF

*RST: ON

TRIGger<m>:MPHY:ERRor:LENGth <ErrorLength>

Enables/disables trigger on length error.

Suffix:

<m> 1..3

Parameters:

<ErrorLength> ON | OFF

*RST: ON

TRIGger<m>:MPHY:ERRor:REServed <ErrorReserved>

Enables/disables trigger on reserved bit error.

Suffix:

<m> 1..3

Parameters:

<ErrorReserved> ON | OFF

*RST: ON

TRIGger<m>:MPHY:ERRor:SYMBol <ErrorSymbol>

Enables/disables trigger on 8b10b symbol error.

Suffix:

<m> 1..3

Parameters:

<ErrorSymbol> ON | OFF

*RST: ON

TRIGger<m>:MPHY:ERRor:UNKNown <ErrorUnknown>

Enables/disables trigger on unidentified UniPro frame error.

Suffix:

<m>	1..3

Parameters:

<ErrorUnknown>	ON | OFF
	*RST: ON

20.17.12.3 Decode Results M-PHY

To show the results on the screen, use the following commands:

- BUS<m>:RESult on page 1300
- BUS<m>:RESDetail on page 1300

BUS<m>:MPHY:RESult:FRAMe<n>:FTYPe?

Returns the type of frame for the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<FrameType>	BURST | ADAPT | LCC | DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC | PACP | TRIGUPR0 | TRIGUPR1 | TRIGUPR2 | SKIP | FILLER | SPACER | UNKNOWN **BURST** M-PHY burst frame.

ADAPT
M-PHY Adapt frame. This control frame is used for clock/bit synchronization.

LCC
M-PHY LCC frame. This control frame is used for line configuration depending on the `LCC Type`.

DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC
UniPro DL PDU frame.

PACP
UniPro frame. This control frame is used mainly for power mode change and L1.5 link management.

TRIGUPR0 | TRIGUPR1 | TRIGUPR2
UniPro frame. This control frame is used for link startup sequence.

SKIP
UniPro frame with Skip symbols for reducing protocol payload bandwidth.

FILLER
M-PHY or UniPro frame with filler words to maintain transmission activity.

SPACER
Scrambled UniPro frame with filler words.

UNKNOWN
No meaningful frame can be determined.

*RST: UNKNOWN

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:STATe?

Returns the state of the frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<State> OK | RSVDERROR | CMDERROR | SYMBOLERROR | UNKNOWNERROR | INVALID | INCOMPLETE | UNCorrelated | CRCERROR | VOOR | LENGTHERROR

OK
Valid frame.

RSVDERROR
Erroneous frame due to reserved bit error.

CMDERROR
Erroneous frame due to LCC error.

SYMBOLERROR
Erroneous frame due to 8b10b symbol error.

UNKNOWNERROR
Erroneous frame due to unidentified UniPro frame error.

INVALID
Invalid frame.

INCOMPLETE
The frame is not complete.

LENGTHERROR
Erroneous frame due to length error.

*RST: OK

Usage: Query only

BUS<m>:MPHY:RESult:FCOunt?

Returns the number of decoded frames.

Suffix:

<m> 1..4
Selects the serial bus.

Return values:

<Count> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:CCOunt?

Returns the number of decoded cells for the selected frame.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

Return values:

<NumWords> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:CELL<o>:DATA?

Returns the data value for the selected cell.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the cell.

Return values:

<WordValue>	Range: 0 to 4294967295 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:CELL<o>:STARt?

Returns the start time for the selected cell.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.
<o>	* Selects the cell.

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:CELL<o>:STOP?

Returns the stop time for the selected cell.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

<o> *
Selects the cell.

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:CELL<o>:STATe?

Returns the state for the selected cell.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the cell.

Return values:
<State> OK | RSVDERROR | CMDERROR | SYMBOLERROR | UNKNOWNERROR | INVALID | INCOMPLETE | UNCorrelated | CRCERROR | VOOR | LENGTHERROR
*RST: OK

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:CELL<o>:TYPE?

Returns the data type for the selected cell.

Suffix:
<m> 1..4
Selects the serial bus.

<n> *
Selects the frame.

<o> *
Selects the cell.

Return values:
<WordType>

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:DATA?

Returns the data for the selected frame, corresponds to the Data column in the decode results table.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:
<Data>

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:INFO?

Returns the selected frame label. This label is on top of the frame as seen in the honeycomb display, also corresponds to the Info column in the decode results table.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:
<Info>

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:SSFT?

Returns the type of frame for the selected SSIC frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<SSICFrameType>	TSEQ | TS1 | TS1A | TS1B | TS2 | SLF | U2IT | VDT | PCAP | PCNF | PCNR | LDM | ACK | NRDY | ERDY | STATus | STALl | FWAKe | LTM | BIAM | HRR | SSPD | PING | PNGR | DPH | DPHN | DPP | DPPA | ITP | LC | SKIP | BRST | BDAT | BERC | BCNT | IDLE | UHP | ULMP | UTP | UDVN | UDEF | ERRor | CTLB | DATB | SYNC | SDS *RST: UDEF

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:STARt?

Returns the start time of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:MPHY:RESult:FRAMe<n>:STOP?

Returns the end time of the selected frame.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	* Selects the frame.

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

20.17.12.4 Search Settings M-PHY

SEARch:TRIGger:MPHY:TYPE <SearchName>,<Type>
SEARch:TRIGger:MPHY:TYPE? <SearchName>

Selects the type of frame to be searched for.

Parameters:

<Type> START | BURST | ADAPT | LCC | DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC | PACP | TRIGUPR0 | TRIGUPR1 | TRIGUPR2 | ERRor

START
M-PHY or UniPro start of frame.

BURST
M-PHY burst frame.

ADAPT
M-PHY Adapt frame. This control frame is used for clock/bit synchronization.

LCC
M-PHY LCC frame. This control frame is used for line configuration depending on the `LCC Type`.

DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC
UniPro DL PDU frame.

PACP
UniPro PACP frame. This control frame is used mainly for power mode change and L1.5 link management.

TRIGUPR0 | TRIGUPR1 | TRIGUPR2
UniPro Trigger Upper frame. This control frame is used for link startup sequence.

ERRor
M-PHY or UniPro error frame.

*RST: START

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:LCCType <SearchName>,<LCCType>
SEARch:TRIGger:MPHY:LCCType? <SearchName>

Selects the type of LCC frame to be searched for.

Parameters:
<LCCType> ANY | SLEEP | STALL | READCAP | READMFG | READVEND | WRITEATTR | PWMG0 | PWMG1 | PWMG2 | PWMG3 | PWMG4 | PWMG5 | PWMG6 | PWMG7 | HSG1A | HSG2A | HSG3A | HSG4A | HSG1B | HSG2B | HSG3B | HSG4B | RESERVED

ANY
All the available LCC commands.

SLEEP
Switches the power-saving state to ultra-low power. In this state, up to 90% power saving is achieved.

STALL
Switches the power-saving state to ultra-low power. In this state, up to 75% power saving is achieved.

READCAP
Recovers data about the OMC's capabilities.

READMFG
Retrieves manufacturing ID and vendor-specific information.

READVEND
Retrieves the additional four delimited bytes containing vendor-specific information.

WRITEATTR
Sets the configuration parameters required for lane operation.

PWMG0 | PWMG1 | PWMG2 | PWMG3 | PWMG4 | PWMG5 | PWMG6 | PWMG7
Switches the transmission mode to the selected low-power gear.

HSG1A | HSG2A | HSG3A | HSG4A | HSG1B | HSG2B | HSG3B | HSG4B
Switches the transmission mode to the selected high-speed gear.

RESERVED
Reserved bit command. These bits are reserved for future use.

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:LWONe:CONDition <SearchName>,<CondOperator>
SEARch:TRIGger:MPHY:LWONe:CONDition? <SearchName>

Sets the condition for WORD 1. You can define an exact value or a value range.

Parameters:

<CondOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:MPHY:LWONe:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:LWONe:MIN` and `SEARch:TRIGger:MPHY:LWONe:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:LWONe:MIN <SearchName>,<LCCWORD1Min>
SEARch:TRIGger:MPHY:LWONe:MIN? <SearchName>

Specifies the WORD 1 pattern, or sets the the start value of a pattern range.

Parameters:

<LCCWORD1Min> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:LWONe:MAX <SearchName>,<LCCWORD1Max>
SEARch:TRIGger:MPHY:LWONe:MAX? <SearchName>

Sets the end value of the WORD 1 range if `SEARch:TRIGger:MPHY:LWONe:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LCCWORD1Max> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWTWo:CONDition <SearchName>,<CondOperator>
SEARch:TRIGger:MPHY:LWTWo:CONDition? <SearchName>

Sets the condition for WORD 2. You can define an exact value or a value range.

Parameters:

<CondOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:MPHY:LWTWo:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:LWTWo:MIN` and `SEARch:TRIGger:MPHY:LWTWo:MAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWTWo:MIN <SearchName>,<LCCWORD2Min>
SEARch:TRIGger:MPHY:LWTWo:MIN? <SearchName>

Specifies the WORD 2 pattern, or sets the the start value of a pattern range.

Parameters:

<LCCWORD2Min> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWTWo:MAX <SearchName>,<LCCWORD2Max>
SEARch:TRIGger:MPHY:LWTWo:MAX? <SearchName>

Sets the end value of the WORD 2 range if `SEARch:TRIGger:MPHY:LWTWo:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LCCWORD2Max> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWTHree:CONDition <SearchName>,<CondOperator>
SEARch:TRIGger:MPHY:LWTHree:CONDition? <SearchName>

Sets the condition for WORD 3. You can define an exact value or a value range.

Parameters:

<CondOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:MPHY:LWTHree:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:LWTHree:MIN` and `SEARch:TRIGger:MPHY:LWTHree:MAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWTHree:MIN <SearchName>,<LCCWORD3Min>
SEARch:TRIGger:MPHY:LWTHree:MIN? <SearchName>

Specifies the WORD 3 pattern, or sets the the start value of a pattern range.

Parameters:

<LCCWORD3Min> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWTHree:MAX <SearchName>,<LCCWORD3Max>
SEARch:TRIGger:MPHY:LWTHree:MAX? <SearchName>

Sets the end value of the WORD 3 range if `SEARch:TRIGger:MPHY:LWTHree:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LCCWORD3Max> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWFour:CONDition <SearchName>,<CondOperator>
SEARch:TRIGger:MPHY:LWFour:CONDition? <SearchName>

Sets the condition for WORD 4. You can define an exact value or a value range.

Parameters:

<CondOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:MPHY:LWFour:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:LWFour:MIN` and `SEARch:TRIGger:MPHY:LWFour:MAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWFour:MIN <SearchName>,<LCCWORD4Min>
SEARch:TRIGger:MPHY:LWFour:MIN? <SearchName>

Specifies the WORD 4 pattern, or sets the the start value of a pattern range.

Parameters:

<LCCWORD4Min> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:LWFour:MAX <SearchName>,<LCCWORD4Max>
SEARch:TRIGger:MPHY:LWFour:MAX? <SearchName>

Sets the end value of the WORD 4 range if `SEARch:TRIGger:MPHY:LWFour:CONDition` is set to `INRange` or `OORange`.

Parameters:

<LCCWORD4Max> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:TC <SearchName>,<TC>
SEARch:TRIGger:MPHY:TC? <SearchName>

Specifies the TC bit pattern.

Parameters:

<TC> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:DATA:DCONdition <SearchName>,<DataOperator>
SEARch:TRIGger:MPHY:DATA:DCONdition? <SearchName>

Sets the condition for the data. You can define an exact value or a value range.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:DATA:DMIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:DATA:DMIN` and `SEARch:TRIGger:MPHY:DATA:DMAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:DATA:DMIN <SearchName>,<DataMin>
SEARch:TRIGger:MPHY:DATA:DMIN? <SearchName>

Specifies the data bit pattern, or sets the the start value of a pattern range.

Parameters:

<DataMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:DATA:DMAX <SearchName>,<DataMax>
SEARch:TRIGger:MPHY:DATA:DMAX? <SearchName>

Sets the end value of the data range if `SEARch:TRIGger:MPHY:DATA:DCONdition` is set to `INRange` or `OORange`.

Parameters:

<DataMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:DATA:ICONdition <SearchName>,<DataIdxOperator>
SEARch:TRIGger:MPHY:DATA:ICONdition? <SearchName>

Sets the condition for the index. You can define an exact value or a value range.

Parameters:

<DataIdxOperator> EQUal | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

EQUal | LTHan | LETHan | GTHan | GETHan
Equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one pattern to be set with the corresponding `SEARch:TRIGger:MPHY:DATA:IMIN` command.

INRange = RANGe
In range: Set the minimum and maximum value using `SEARch:TRIGger:MPHY:DATA:IMIN` and `SEARch:TRIGger:MPHY:DATA:IMAX`.

*RST: INRange

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:DATA:IMIN <SearchName>,<DataIndexMin>
SEARch:TRIGger:MPHY:DATA:IMIN? <SearchName>

Specifies the index minimum, or sets the start value of a range.

Parameters:

<DataIndexMin> Range: 1 to 0
Increment: 1
*RST: 1

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:DATA:IMAX <SearchName>,<DataIndexMax>
SEARch:TRIGger:MPHY:DATA:IMAX? <SearchName>

Sets the end value of the index range if `SEARch:TRIGger:MPHY:DATA:ICONdition` is set to `INRange` or `RANge`.

Parameters:

<DataIndexMax> Range: 1 to 0
Increment: 1
*RST: 0

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:FSNumber:CONDition <SearchName>,<FSNOperator>
SEARch:TRIGger:MPHY:FSNumber:CONDition? <SearchName>

Sets the condition for FSN. You can define an exact value or a value range.

Parameters:

<FSNOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:FSNumber:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:FSNumber:MIN` and `SEARch:TRIGger:MPHY:FSNumber:MAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:FSNumber:MIN <SearchName>,<FSNMin>
SEARch:TRIGger:MPHY:FSNumber:MIN? <SearchName>

Specifies the FSN bit pattern, or sets the start value of a pattern range.

Parameters:

<FSNMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:FSNumber:MAX <SearchName>,<FSNMax>
SEARch:TRIGger:MPHY:FSNumber:MAX? <SearchName>

Sets the end value of the FSN range if `SEARch:TRIGger:MPHY:FSNumber:CONDition` is set to `INRange` or `OORange`.

Parameters:

<FSNMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:CRC:CONDition <SearchName>,<CRCOperator>
SEARch:TRIGger:MPHY:CRC:CONDition? <SearchName>

Sets the condition for CRC. You can define an exact value or a value range.

Parameters:

<CRCOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:CRC:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:CRC:MIN` and `SEARch:TRIGger:MPHY:CRC:MAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:CRC:MIN <SearchName>,<CRCMin>
SEARch:TRIGger:MPHY:CRC:MIN? <SearchName>

Specifies the CRC bit pattern, or sets the start value of a pattern range.

Parameters:

<CRCMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:CRC:MAX <SearchName>,<CRCMax>
SEARch:TRIGger:MPHY:CRC:MAX? <SearchName>

Sets the end value of the CRC range if `SEARch:TRIGger:MPHY:CRC:CONDition` is set to `INRange` or `OORange`.

Parameters:

<CRCMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:CREQ <SearchName>,<REQ>
SEARch:TRIGger:MPHY:CREQ? <SearchName>

Specifies the CREQ bit pattern.

Parameters:

<REQ> ONE | ZERO | DC

ONE
Sets the trigger condition to binary 1.

ZERO
Sets the trigger condition to binary 0.

DC
Sets the trigger condition to any CREQ value (don't care).

*RST: DC

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:RREQ <SearchName>,<REQ>
SEARch:TRIGger:MPHY:RREQ? <SearchName>

Specifies the RREQ bit pattern.

Parameters:

<REQ> ONE | ZERO | DC

ONE
Sets the trigger condition to binary 1.

ZERO
Sets the trigger condition to binary 0.

DC
Sets the trigger condition to any RREQ value (don't care).

*RST: DC

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:CREDit:CONDition <SearchName>,<CreditOperator>
SEARch:TRIGger:MPHY:CREDit:CONDition? <SearchName>

Sets the condition for Credit. You can define an exact value or a value range.

Parameters:

<CreditOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:CREDit:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:CREDit:MIN` and `SEARch:TRIGger:MPHY:CREDit:MAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:CREDit:MIN <SearchName>,<CreditMin>
SEARch:TRIGger:MPHY:CREDit:MIN? <SearchName>

Specifies the Credit bit pattern, or sets the start value of a pattern range.

Parameters:

<CreditMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:CREDit:MAX <SearchName>,<CreditMax>
SEARch:TRIGger:MPHY:CREDit:MAX? <SearchName>

Sets the end value of the Credit range if `SEARch:TRIGger:MPHY:CREDit:CONDition` is set to `INRange` or `OORange`.

Parameters:
<CreditMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:PBEGin:CONDition <SearchName>,<CondPACPBegin>
SEARch:TRIGger:MPHY:PBEGin:CONDition? <SearchName>

Sets the condition for PACP Begin. You can define an exact value or a value range.

Parameters:
<CondPACPBegin> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:PBEGin:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:PBEGin:MIN` and `SEARch:TRIGger:MPHY:PBEGin:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:PBEGin:MIN <SearchName>,<PACPBEGINMin>
SEARch:TRIGger:MPHY:PBEGin:MIN? <SearchName>

Specifies the PACP Begin bit pattern, or sets the start value of a pattern range.

Parameters:
<PACPBEGINMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:PBEGin:MAX <SearchName>,<PACPBEGINMax>
SEARch:TRIGger:MPHY:PBEGin:MAX? <SearchName>

Sets the end value of the PACP Begin range if `SEARch:TRIGger:MPHY:PBEGin:CONDition` is set to `INRange` or `OORange`.

Parameters:

<PACPBEGINMax> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:PFID:CONDition <SearchName>,<CondPACPFunc>
SEARch:TRIGger:MPHY:PFID:CONDition? <SearchName>

Sets the condition for PACP Function ID. You can define an exact value or a value range.

Parameters:

<CondPACPFunc> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less or equal than, Greater Than, Greater or equal than. These conditions require one data pattern to be set with the corresponding `SEARch:TRIGger:MPHY:PFID:MIN` command.

INRange | OORange
In range/Out of range: set the minimum and maximum value of the range with `SEARch:TRIGger:MPHY:PFID:MIN` and `SEARch:TRIGger:MPHY:PFID:MAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:PFID:MIN <SearchName>,<PACPFunIDMin>
SEARch:TRIGger:MPHY:PFID:MIN? <SearchName>

Specifies the PACP Function ID bit pattern, or sets the start value of a pattern range.

Parameters:

<PACPFunIDMin> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:PFID:MAX <SearchName>,<PACPFunIDMax>
SEARch:TRIGger:MPHY:PFID:MAX? <SearchName>

Sets the end value of the PACP Function ID range if `SEARch:TRIGger:MPHY:PFID:CONDition` is set to `INRange` or `OORange`.

Parameters:

<PACPFunIDMax>	Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:ERRor:REServed <SearchName>,<ErrorReserved>
SEARch:TRIGger:MPHY:ERRor:REServed? <SearchName>

Enables/disables search for reserved bit error.

Parameters:

<ErrorReserved>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:ERRor:LCMD <SearchName>,<LCCError>
SEARch:TRIGger:MPHY:ERRor:LCMD? <SearchName>

Enables/disables search for LCC error.

Parameters:

<LCCError>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:ERRor:SYMBol <SearchName>,<ErrorSymbol>
SEARch:TRIGger:MPHY:ERRor:SYMBol? <SearchName>

Enables/disables search for 8b10b symbol error.

Parameters:

<ErrorSymbol>	ON | OFF *RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:ERRor:UNKNown <SearchName>,<ErrorUnknown>
SEARch:TRIGger:MPHY:ERRor:UNKNown? <SearchName>

Enables/disables search for unidentified UniPro frame error.

Parameters:

<ErrorUnknown>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:ERRor:LENGth <SearchName>,<ErrorLength>
SEARch:TRIGger:MPHY:ERRor:LENGth? <SearchName>

Enables/disables search for length error.

Parameters:

<ErrorLength>	ON | OFF	
	*RST:	ON

Parameters for setting and query:
<SearchName>

20.17.12.5 Search Results M-PHY

In all `SEARch:RESult:MPHY:FRAMe<m>` commands, the suffix <m> selects the frame number and suffix <n> selects the cell number in the list of search results.

SEARch:RESult:MPHY:FCOunt? <SearchName>

Returns the number of frames within the search result.

Query parameters:
<SearchName>

Return values:

<Count>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:CCOunt? <SearchName>

Returns the number of cells within the search result for the selected frame.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<NumWords>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:DATA? <SearchName>

Returns the data value within the search result for the selected cell.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:

<WordValue>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:TYPE? <SearchName>

Returns the data type within the search result for the selected cell.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<WordType>

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:STARt? <SearchName>

Returns the start time of the cell with the selected field number within the frame with the selected frame number within the search result.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:STOP? <SearchName>

Returns the stop time of the cell with the selected field number within the frame with the selected frame number within the search result.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:CELL<n>:STATe? <SearchName>

Returns the state type within the search result for the selected cell.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:

<State> OK | RSVDERROR | CMDERROR | SYMBOLERROR | UNKNOWNERROR | INVALID | INCOMPLETE | UNCorrelated | CRCERROR | VOOR | LENGTHERROR

*RST: OK

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:DATA? <SearchName>

Returns the data for the selected frame within the search result, corresponds to the Data column in the search results table.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:FTYPe? <SearchName>

Returns the type of frame for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameType> BURST | ADAPT | LCC | DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC | PACP | TRIGUPR0 | TRIGUPR1 | TRIGUPR2 | SKIP | FILLER | SPACER | UNKNOWN

BURST
M-PHY burst frame.

ADAPT
M-PHY Adapt frame. This control frame is used for clock/bit synchronization.

LCC
M-PHY LCC frame. This control frame is used for line configuration depending on the `LCC Type`.

DLPDUSOF | DLPDUCOF | DLPDUEOF | DLPDUNAC | DLPDUAFC
UniPro DL PDU frame.

PACP
UniPro frame. This control frame is used mainly for power mode change and L1.5 link management.

TRIGUPR0 | TRIGUPR1 | TRIGUPR2
UniPro frame. This control frame is used for link startup sequence.

SKIP
UniPro frame with Skip symbols for reducing protocol payload bandwidth.

FILLER
M-PHY or UniPro frame with filler words to maintain transmission activity.

SPACER
Scrambled UniPro frame with filler words.

UNKNOWN
No meaningful frame can be determined.

*RST: UNKNOWN

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:STATe? <SearchName>

Returns the state of the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<State> OK | RSVDERROR | CMDERROR | SYMBOLERROR | UNKNOWNERROR | INVALID | INCOMPLETE | UNCorrelated | CRCERROR | VOOR | LENGTHERROR

OK
Valid frame.

RSVDERROR
Erroneous frame due to reserved bit error.

CMDERROR
Erroneous frame due to LCC error.

LENGTHERROR
Erroneous frame due to length error.

SYMBOLERROR
Erroneous frame due to 8b10b symbol error.

UNKNOWNERROR
Erroneous frame due to unidentified UniPro frame error.

INVALID
Invalid frame.

INCOMPLETE
The frame is not complete.

*RST: OK

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:STARt? <SearchName>

Returns the start time of the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Start>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:MPHY:FRAMe<m>:STOP? <SearchName>

Returns the end time for the selected frame within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Stop>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

20.17.12.6 Trigger USB SSIC (Option R&S RTP-K64)

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

There are two commands for each parameter, that you can use for defining the SSIC trigger settings.

For example, to set the *Frame type =ACK > Field =Route String >Data* value you can use one of the following commands:

- `TRIGger:MPHY:SSIC:FRAMe13:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `TRIGger:MPHY:SSIC:DMIN "ACK", "Route String", 01100`
  Defines the parameter by using the frame and field name.

TRIGger<m>:MPHY:SSIC:ERENable <ErrorName>, <Enabler>
TRIGger<m>:MPHY:SSIC:ERRor<n>:ENABle <Enable>

Enables or disables the trigger on an error condition.

Suffix:

<m>	1..3
<n>	*

Parameters:

<Enable>	ON | OFF	
	*RST:	ON

Example: Trigger on CRC and length errors:
`TRIGger:MPHY:SSIC:ERRor1:ENABle ON`
Enables CRC Error.
`TRIGger:MPHY:SSIC:ERENable "Length Error",ON`
Enables Length Error.

TRIGger<m>:MPHY:SSIC:FRENable <Frame>, <Enabler>
TRIGger<m>:MPHY:SSIC:FRAMe<n>:ENABle <Enable>

Enables or disables the checking condition for the selected frame.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the field number within the frame.

Parameters:

<Enable> ON | OFF
*RST: OFF

Example: `TRIGger:MPHY:SSIC:FRAMe1:ENABle ON`
Enables the checking condition for the TSEQ frame.
`TRIGger:MPHY:SSIC:FRENable "TS1" ON`
Enables the checking condition for the TS1 frame.

TRIGger<m>:MPHY:SSIC:FIENable <Frame>, <Field>, <Enabler>
TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the field number within the frame.

<o> *
Specifies the field number within the frame.

Parameters:

<CondEnabler> ON | OFF
*RST: OFF

Example: `TRIGger:MPHY:SSIC:FRAMe1:FLD1:ENABle ON`
Enables the checking condition for the Symbol field of the TSEQ frame.
`TRIGger:MPHY:SSIC:FRENable "TS1", "Loop" ON`
Enables the checking condition for the Loop field of the TS1 frame.

TRIGger<m>:MPHY:SSIC:BIT <Frame>, <Field>, <Bit>
TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	* Specifies the frame number.
<o>	* Specifies the field number within the frame.

Parameters:

<BitState>	ONE | ZERO | DC *RST: DC

TRIGger<m>:MPHY:SSIC:DMAX <Frame>, <Field>, <Data>
TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:DMAX <DataMax>

Sets the end value of a data pattern range if `TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:DOPerator` is set to `INRange` or `OORange`.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	* Specifies the frame number.
<o>	* Specifies the field number within the frame.

Parameters:

<DataMax>

TRIGger<m>:MPHY:SSIC:DMIN <Frame>, <Field>, <Data>
TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:DMIN <DataMin>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	* Specifies the frame number.
<o>	* Specifies the field number within the frame.

Parameters:

<DataMin>

TRIGger<m>:MPHY:SSIC:DOPerator <Frame>, <Field>, <Operator>
TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:DOPerator <DataOperator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the field number within the frame.

<o> *

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:DMIN`.

INRange | OORange
In range, out of range. These conditions require a range of endpoint values to be set using `TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:DMIN` and `TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:DMAX`.

*RST: EQUal

TRIGger<m>:MPHY:SSIC:IMAX <Frame>, <Field>, <Data>
TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:IMAX <IndexMax>

Sets the end value of an index range if `TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:IOPerator` is set to `INRange` or `RANGe`.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the field number within the frame.

<o> *

Parameters:

<IndexMax> Specifies the end value for the index range within the field. The index range, increment and *RST values depend on the field type.

TRIGger<m>:MPHY:SSIC:IMIN <Frame>, <Field>, <Data>
TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:IMIN <IndexMin>

Specifies the index, or sets the start value of an index range.

Suffix:

<m> 1..3

<n> *
Specifies the field number within the frame.

<o> *

Parameters:

<IndexMin> Specifies the index value or index start value within the field. The index range, increment and *RST values depend on the field type.

Range: 1 to 65534
Increment: 1
*RST: 1

TRIGger<m>:MPHY:SSIC:IOPerator <Frame>, <Field>, <Operator>
TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:IOPerator <IndexOperator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the field number within the frame.

<o> *

Parameters:

<IndexOperator> EQUal | INRange | RANGe

EQUal
This condition requires one endpoint value to be set using `TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:IMIN`.

INRange | RANGe
This condition requires a range of endpoint values to be set using `TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:IMIN` and `TRIGger<m>:MPHY:SSIC:FRAMe<n>:FLD<o>:IMAX`.

*RST: INRange

20.17.12.7 Search Settings USB SSIC (Option R&S RTP-K64)

There are two commands for each parameter, that you can use for defining the SSIC search settings.

For example, to set the *Frame type =ACK > Field =Route String >Data* value you can use one of the following commands:

- `SEARch:TRIGger:MPHY:SSIC:FRAMe13:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SEARch:TRIGger:MPHY:SSIC:DMIN "ACK", "Route String", 01100`
  Defines the parameter by using the frame and field name.

SEARch:TRIGger:MPHY:SSIC:ERENable <SearchName>,<ErrorName>, <Enabler>
SEARch:TRIGger:MPHY:SSIC:ERRor<m>:ENABle <SearchName>,<Enable>
SEARch:TRIGger:MPHY:SSIC:ERRor<m>:ENABle? <SearchName>

Enables or disables the searching for an error condition.

Suffix:

<m>	*

Parameters:

<Enable>	ON | OFF *RST: ON

Parameters for setting and query:

<SearchName>

Example:

Searches for CRC and length errors:
`SEARch:TRIGger:MPHY:SSIC:ERRor1:ENABle ON`
Enables searching for CRC Error.
`SEARch:TRIGger:MPHY:SSIC:ERENable "Length Error",ON`
Enables searching for Length Error.

SEARch:TRIGger:MPHY:SSIC:FRENable <SearchName>,<Frame>, <Enabler>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:ENABle <SearchName>,<Enable>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:ENABle? <SearchName>

Defines the frame type to be searched for.

Suffix:

<m>	* Specifies the frame number.

Parameters:

<Enable>	ON | OFF *RST: OFF

Parameters for setting and query:

<SearchName>	String with the name of the search.

Example:

`SEARch:TRIGger:MPHY:SSIC:FRAMe1:ENABle ON`
Enables searching for the TSEQ frame.
`SEARch:TRIGger:MPHY:SSIC:FRENable "TS1" ON`
Enables searching for the TS1 frame.

SEARch:TRIGger:MPHY:SSIC:FIENable <SearchName>,<Frame>, <Field>, <Enabler>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:ENABle <SearchName>,<CondEnabler>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:ENABle? <SearchName>

Enables or disables the checking condition for searching a specific data pattern in the selected field of the selected frame.

Suffix:

<m> *
Specifies the frame number.

<n> *
Specifies the field number within the frame.

Parameters:

<CondEnabler> ON | OFF

ON
Checking condition enabled

OFF
Checking condition disabled

*RST: OFF

Parameters for setting and query:

<SearchName>

Example:

```
SEARch:TRIGger:MPHY:SSIC:FRAMe1:FLD1:ENABle ON
```
Enables searching for the Symbol field of the TSEQ frame.
```
SEARch:TRIGger:MPHY:SSIC:FRENable "TS1", "Loop"
ON
```
Enables searching for the Loop field of the TS1 frame.

SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:ENABle <SearchName>,<CondEnabler>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:ENABle? <SearchName>

Enables or disables the checking condition for searching a specific data pattern in the selected field of the selected frame.

Suffix:

<m> *
Specifies the frame number.

<n> *
Specifies the field number within the frame.

Parameters:

<CondEnabler> ON | OFF

ON
Checking condition enabled

OFF
Checking condition disabled

*RST: OFF

Parameters for setting and query:
<SearchName>

Example:
`SEARch:TRIGger:MPHY:SSIC:FRAMe1:FLD1:ENABle ON`
Enables searching for the Symbol field of the TSEQ frame.
`SEARch:TRIGger:MPHY:SSIC:FRENable "TS1", "Loop" ON`
Enables searching for the Loop field of the TS1 frame.

SEARch:TRIGger:MPHY:SSIC:BIT <SearchName>,<Frame>, <Field>, <Bit>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:BIT <SearchName>,<BitState>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:BIT? <SearchName>

Sets the bit state of a field to be searched that only consists of one bit.

Suffix:
<m> *
Specifies the frame number.

<n> *
Specifies the field number within the frame.

Parameters:
<BitState> ONE | ZERO | DC

ONE
1

ZERO
0

DC
"Don't care" (DC) = X

*RST: DC

Parameters for setting and query:
<SearchName> String with the name of the search.

SEARch:TRIGger:MPHY:SSIC:DMAX <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DMAX <SearchName>,<DataMax>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DMAX? <SearchName>

Sets the end value of a data pattern range if `SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DOPerator` is set to `INRange` or `OORange`.

Suffix:
<m> *
Specifies the frame number.

<n> *
Specifies the field number within the frame.

Parameters:

<DataMax> Specifies the name of the generic trigger setting frame.

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:MPHY:SSIC:DMIN <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DMIN <SearchName>,<DataMin>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DMIN? <SearchName>

Specifies the data pattern to be searched, or sets the start value of a data pattern range to be searched.

Suffix:

<m> *
Specifies the frame number.

<n> *
Specifies the field number within the frame.

Parameters:

<DataMin> Specifies the name of the generic trigger setting frame.

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:MPHY:SSIC:DOPerator <SearchName>,<Frame>, <Field>, <Operator>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DOPerator <SearchName>,<DataOperator>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DOPerator? <SearchName>

Sets the operator to set a specific data pattern to be searched in the selected field of the selected frame.

Suffix:

<m> *
Specifies the frame number.

<n> *
Specifies the field number within the frame.

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DMIN`.

INRange | OORange
In range, out of range. These conditions require a range of end-point values to be set using SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DMIN and SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:DMAX.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:SSIC:FRENable <SearchName>,<Frame>, <Enabler>

Setting parameters:
<SearchName>

<Frame>

<Enabler> ON | OFF

Usage: Setting only

SEARch:TRIGger:MPHY:SSIC:IMAX <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IMAX <SearchName>,<IndexMax>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IMAX? <SearchName>

Sets the end value of an index range if SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IOPerator is set to INRange or RANGe.

Suffix:
<m> *
Specifies the frame number.

<n> *
Specifies the field number within the frame.

Parameters:
<IndexMax> Specifies the end value for the index range within the field.
The index range, increment and *RST values depend on the field type.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MPHY:SSIC:IMIN <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IMIN <SearchName>,<IndexMin>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IMIN? <SearchName>

Specifies the index at which the data is to be searched, or sets the start value of an index range in which the data is to be searched.

Suffix:

<m> *

Specifies the field number within the frame.

<n> *

Parameters:

<IndexMin> Specifies the index value or the start value of an index range within the field.
The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:MPHY:SSIC:IOPerator <SearchName>,<Frame>, <Field>, <Operator>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IOPerator <SearchName>,<IndexOperator>
SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IOPerator? <SearchName>

Sets the operator for the index for searching in the selected field of the selected frame.

Suffix:

<m> *

Specifies the field number within the frame.

<n> *

Parameters:

<IndexOperator> EQUal | INRange | RANGe

EQUal
This condition requires one endpoint value to be set using `SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IMIN`.

INRange | RANGe
This condition requires a range of endpoint values to be set using `SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IMIN` and `SEARch:TRIGger:MPHY:SSIC:FRAMe<m>:FLD<n>:IMAX`.

*RST: INRange

Parameters for setting and query:

<SearchName>

20.17.13 Custom: Manchester / NRZ (Option R&S RTP-K50)

20.17.13.1 Configuration

In all `BUS<m>:CMSB` commands, the suffix <m> selects the serial bus.

In all `BUS<m>:CMSB:FRAMe<n>` commands, the suffix <n> selects a frame number, and the suffix <o> selects a cell number.

BUS<m>:CMSB:CODing <CodingStandard>

Selects the custom serial bus coding standard.

Suffix:

<m>	1..4

Parameters:

<CodingStandard> MANC | MANT | NRZ | NRZU

MANC
Manchester (normal polarity)

MANT
Manchester II (inverted polarity).
Note that some additional subtle differences between MANC and MANT require separate protocols.

NRZ
NRZ (non-return-to-zero), clocked

NRZU
NRZ (non-return-to-zero), unclocked

*RST: MANC

BUS<m>:CMSB:MANChester:DATA <SourceMANData>

Selects the source channel for the data signal. For triggering on a serial bus, analog channels "C1"–"C4" are required. Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:

<m>	1..4

Parameters:

<SourceMANData> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

*RST: C1W1

BUS<m>:CMSB:MANChester:POLarity <PolarityData>

Selects the polarity of the custom serial bus data signal in Manchester coding standards.

Suffix:

<m>	1..4

Parameters:

<PolarityData> NORMal | INVert

NORMal
Manchester or Manchester II polarity remains unchanged

INVert
Manchester polarity is inverted and becomes Manchester II polarity, Manchester II polarity is inverted and becomes Manchester polarity

*RST: NORMal

BUS<m>:CMSB:MANChester:THReshold:HIGH <ThresholdUpper>

Sets the upper threshold for data signal digitization in Manchester coding standards.

Suffix:

<m>	1..4

Parameters:

<ThresholdUpper>
Range: -25 to 25
Increment: 0.1
*RST: 5
Default unit: V

BUS<m>:CMSB:MANChester:THReshold:LOW <ThresholdLower>

Sets the lower threshold for data signal digitization in Manchester coding standards.

Suffix:

<m>	1..4

Parameters:

<ThresholdLower>
Range: -25 to 25
Increment: 0.1
*RST: -5
Default unit: V

BUS<m>:CMSB:MANChester:THReshold:PRESet <ThresholdPreset>

Sets the Manchester thresholds to predefined or individually definable voltage levels.

Suffix:

<m>	1..4

Parameters:

<ThresholdPreset> V05 | V2 | V5 | V7 | MAN

V05
Sets the upper threshold to +0.5 V and the lower threshold to -0.5 V

V2
Sets the upper threshold to +2.0 V and the lower threshold to -2.0 V

V5
Sets the upper threshold to +5.0 V and the lower threshold to -5.0 V

V7
Sets the upper threshold to +7.0 V and the lower threshold to -7.0 V

MAN
Allows to set individual threshold voltage levels

*RST: V5

BUS<m>:CMSB:MANChester:THReshold:COUPling <ThresholdCoupling>

Couples the upper and lower threshold values for the Manchester and Manchester II coding standards. The values are coupled to voltages with the same magnitude but opposite sign (positive for the upper threshold and negative for the lower threshold). However, if the upper threshold is set to a negative voltage or the lower threshold is set to a positive voltage, coupling is disabled, and the other voltage (the one that was not actively set) is automatically adjusted, to avoid an upper threshold below the lower one, or a lower threshold above the upper one.

Suffix:
<m> 1..4

Parameters:
<ThresholdCoupling> ON | OFF

ON
Activates coupling of the upper and lower threshold values.

OFF
Disables coupling of the upper and lower threshold values.

*RST: ON

BUS<m>:CMSB:MANChester:CPHase <ClockPhase>

Selects the phase of the custom serial bus clock signal for the "Manchester" coding standards. For details, see "Clock Phase (Manchester)" on page 692.

Suffix:
<m> 1..4

Parameters:
<ClockPhase> FEDGe | SEDGe

FEDGe
Sets the sampling edge to be on the first edge.

SEDGe
Sets the sampling edge to be on the second edge.

AUTO
Lets the decoder automatically select the method ("First Edge" or "Second Edge") for detecting the sampling edge.

*RST: SEDGe

BUS<m>:CMSB:NRZ:CLCK <SourceNRZClock>

Selects the source channel for the clock signal in the NRZ Clocked coding standard.

For triggering on the serial bus when the NRZ clocked coding standard is selected, analog or digital channel sources are required.

Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:
<m> 1..4

Parameters:
<SourceNRZClock> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: C2W1

BUS<m>:CMSB:NRZ:DATA <SourceNRZData>

Selects the source channel for the data signal in NRZ coding standards.

For triggering on the serial bus when the NRZ clocked coding standard is selected, analog or digital channel sources are required.

For triggering on the serial bus when the NRZ unclocked coding standard is selected, analog channel sources are required.

Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:
<m> 1..4

Parameters:
<SourceNRZData> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: C1W1

BUS<m>:CMSB:NRZ:IDLPolarity <PolarityIdle>

Selects the idle polarity of the custom serial bus data signal (only available for the coding standard "NRZ Unclocked").

Suffix:
<m> 1..4

Parameters:
<PolarityIdle> IDLLow | IDLHigh

IDLLow
Sets the base value of the data bus to be "0". After an idle period, the data signal starts with a low-to-high transition

IDLHigh
Sets the base value of the data bus to be "1". After an idle period, the data signal starts with a high-to-low transition

*RST: IDLLow

BUS<m>:CMSB:NRZ:CPOLarity <PolarityClock>

Selects the polarity of the clock signal for the coding standard NRZ Clocked.

Suffix:
<m> 1..4

Parameters:
<PolarityClock> IDLLow | IDLHigh

IDLLow
Sets the base value of the clock to be "0", the clock signal starts with a low-to-high transition

IDLHigh
Sets the base value of the clock to be "1", the clock signal starts with a high-to-low transition.

*RST: IDLLow

BUS<m>:CMSB:NRZ:CPHase <ClockPhase>

Selects the phase of the custom serial bus clock signal for the coding standard "NRZ Clocked", depending on `BUS<m>:CMSB:NRZ:IDLPolarity` on page 1598.

Suffix:
<m> 1..4

Parameters:
<ClockPhase> FEDGe | SEDGe

FEDGe
Sets the clocking transaction to be on the first edge:
If Clock Polarity = "IDLLow", data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge
If Clock Polarity = "IDLHigh", data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge

SEDGe
Sets the clocking transaction to be on the second edge:
If Clock Polarity = "IDLLow", data are captured on the clock's falling edge (high-to-low transition) and propagated on a rising edge
If Clock Polarity = "IDLHigh", data are captured on the clock's rising edge (low-to-high transition) and propagated on a falling edge
*RST: FEDGe

BUS<m>:CMSB:NRZ:ENBLe <SourceNRZEnable>

Selects the input source for the custom serial bus enable signal.

If an input is chosen, signals will be only decoded while this channel is in the enabled state. This allows you to mark a time when the signal on the selected source is active and when not.

For triggering on a serial bus, analog channels "C1"–"C4" are required. Otherwise, if no serial bus trigger has been selected, permitted source selections include the mathematical channels "Math1"–"Math4" and the reference channels "Ref1"–"Ref4".

Suffix:
<m> 1..4

Parameters:
<SourceNRZEnable> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

BUS<m>:CMSB:NRZ:ENAPolarity <PolarityEnable>

Sets whether the transmitted enable signal is active when the voltage is below the threshold (`ENALow`) or higher than it (`ENAHIgh`).

Suffix:
<m> 1..4

Parameters:
<PolarityEnable> ENALow | ENAHigh
*RST: ENAHigh

BUS<m>:CMSB:NRZ:POLarity <PolarityData>

Selects the polarity of the custom serial bus data signal in NRZ coding standards.

Suffix:
<m> 1..4

Parameters:
<PolarityData> ACTLow | ACTHigh

ACTLow
Active low: the value "1" is represented by a voltage below the threshold

ACTHigh
Active high: the value "1" is represented by a voltage above the threshold

*RST: ACTHigh

BUS<m>:CMSB:NRZ:THReshold:CLCK <ThresholdClock>

Sets the threshold for the clock signal digitization in the NRZ Clocked coding standard.

Suffix:

<m>	1..4

Parameters:

<ThresholdClock>	Range: -25 to 25 Increment: 0.1 *RST: 2 Default unit: V

BUS<m>:CMSB:NRZ:HYSTeresis:CLCK <HystClock>

Sets the hysteresis size on the clock channel.

Suffix:

<m>	1..4

Parameters:

<HystClock>	Range: -25 to 25 Increment: 0.1 *RST: 0.1 Default unit: V

BUS<m>:CMSB:NRZ:THReshold:DATA <ThresholdData>

Sets the threshold for the data signal digitization in NRZ coding standards.

Suffix:

<m>	1..4

Parameters:

<ThresholdData>	Range: -25 to 25 Increment: 0.1 *RST: 2 Default unit: V

BUS<m>:CMSB:NRZ:HYSTeresis:DATA <HystData>

Sets the hysteresis size on the data line channel.

Suffix:

<m>	1..4

Parameters:

<HystData> Range: -25 to 25
Increment: 0.1
*RST: 0.1
Default unit: V

BUS<m>:CMSB:NRZ:THReshold:ENBLe <ThresholdEnable>

Sets the threshold for the enable signal digitization in NRZ coding standards.

Suffix:

<m>	1..4

Parameters:

<ThresholdEnable> Range: -25 to 25
Increment: 0.1
*RST: 2
Default unit: V

BUS<m>:CMSB:NRZ:HYSTeresis:ENBLe <HystEnable>

Sets the hysteresis size on the enable line channel.

Suffix:

<m>	1..4

Parameters:

<HystEnable> Range: -25 to 25
Increment: 0.1
*RST: 0.1
Default unit: V

BUS<m>:CMSB:NRZ:THReshold:PRESet <ThresholdPreset>

Sets the NRZ thresholds to predefined or individually definable voltage levels.

Suffix:

<m>	1..4

Parameters:

<ThresholdPreset> V05 | V2 | V5 | V7 | MAN

V05
Sets the clock and data threshold to +0.5 V (in case of NRZ Unclocked: data threshold, only)

V2
Sets the clock and data threshold to +2.0 V (in case of NRZ Unclocked: data threshold, only)

V5
Sets the clock and data threshold to +5.0 V (in case of NRZ Unclocked: data threshold, only)

V7
Sets the clock and data threshold to +7.0 V (in case of NRZ Unclocked: data threshold, only)

MAN
Allows to set individual threshold voltage levels

*RST: V5

BUS<m>:CMSB:NRZ:THReshold:COUPling <ThresholdCoupling>

Couples the clock and data threshold values for the NRZ Clocked coding standard. The values are coupled to the same number.

Suffix:

<m> 1..4

Parameters:

<ThresholdCoupling> ON | OFF

ON
Activates coupling of the NRZ clock and data threshold values.

OFF
Disables coupling of the NRZ clock and data threshold values.

*RST: ON

BUS<m>:CMSB:BITRate:ENABle <BitrateEnable>

Enables the bit rate settings (must always be enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard).

Suffix:

<m> 1..4

Parameters:

<BitrateEnable> ON | OFF

ON
Bit rate settings enabled

OFF
Bit rate settings disabled

*RST: OFF

BUS<m>:CMSB:BITRate:VALue <Bitrate>

Sets the transmission speed setting for the custom serial bus data signal.

Suffix:

<m> 1..4

Parameters:

<Bitrate>	Range: 300 to 2E9 Increment: 100E3 *RST: 10E6 Default unit: bps

BUS<m>:CMSB:GAPTime:ENABle <GapTimeEnable>

Enables the gap time settings (must always be enabled for the coding standard "NRZ Unclocked", and also for triggering on signals in any coding standard).

Suffix:

<m> 1..4

Parameters:

<GapTimeEnable> ON | OFF

ON
Gap time settings enabled

OFF
Gap time settings disabled

*RST: OFF

BUS<m>:CMSB:GAPTime:VALue <MinGapTime>

Sets a minimum gap time for synchronization.

Suffix:

<m> 1..4

Parameters:

<MinGapTime>	Range: 1E-9 to 1 Increment: 1E-9 *RST: 10E-6 Default unit: s

BUS<m>:CMSB:ADDFrame

Creates an empty frame format description and adds it to the end of the frame description list.

Suffix:

<m> 1..4

Usage: Event

BUS<m>:CMSB:FCOunt?

Returns the number of frames.

Suffix:

<m> 1..4

Return values:
<Count>

Usage: Query only

BUS<m>:CMSB:CLR

Erases all cells and frames that have been created for a specific custom protocol.

Suffix:
<m> 1..4

Usage: Event

BUS<m>:CMSB:FRAMe<n>:TYPE <FrameType>

Enables the user to set a string to describe the frame type, typically according to the applicable protocol standard specifications. (For example, MDIO (Option R&S RTP-K55) defines the frames READ, WRITE, ADDRESS, etc.)

Suffix:
<m> 1..4

<n> *

Parameters:
<FrameType>

BUS<m>:CMSB:FRAMe<n>:APPend

Creates an empty cell description and adds it to the end of the active frame description.

Suffix:
<m> 1..4

<n> *

Usage: Event

BUS<m>:CMSB:FRAMe<n>:CCOunt?

Returns the number of cells in the specified frame.

Suffix:
<m> 1..4

<n> *

Return values:
<Count>

Usage: Query only

BUS<m>:CMSB:FRAMe<n>:CELL<o>:NAME <CellName>

Enables the user to set a cell name within a frame. Names do not have to be unique, they are just for user support.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:
<CellName>

BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITCount <BitCount>

Sets the bit count of a cell, hence its length. Based upon the lengths of the previous cells, this also defines the position of the cell start and end within a frame.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<BitCount>	Range:	1 to 64
	Increment:	1
	*RST:	1

BUS<m>:CMSB:FRAMe<n>:CELL<o>:CONDition <Condition>

Sets various operators for a cell, to identify, e.g., mandatory values such as a CRC checksum or an ID, that help to identify a frame.

The implemented conditions and functionalities are the "equal" and "array" operators. For details, see "Condition" on page 700.

The numeric format of the condition needs to be set according to `BUS<m>:CMSB:FRAMe<n>:CELL<o>:FORMat` on page 1607.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:
<Condition>

BUS<m>:CMSB:FRAMe<n>:CELL<o>:FORMat <CellFormat>

Selects the numeric data format for the command `BUS<m>:CMSB:FRAMe<n>:CELL<o>:CONDition` on page 1606, as well as for the result and honeycomb display.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<CellFormat> DEC | HEX | OCT | BIN

DEC
Decimal

HEX
Hexadecimal

OCT
Octal

BIN
Binary

*RST: BIN

BUS<m>:CMSB:FRAMe<n>:CELL<o>:BITorder <BitOrder>

Selects in which order the bits of a cell are evaluated, as well as presented in the results table and honeycomb display.

Suffix:

<m>	1..4
<n>	*
<o>	*

Parameters:

<BitOrder> LSBF | MSBF

LSBF
Least significant bit first, evaluation starts at the LSB

MSBF
Most significant bit first, evaluation starts at the MSB

*RST: MSBF

BUS<m>:CMSB:FRAMe<n>:CELL<o>:CRGB <Color>

Selects a cell's color representation in the honeycomb display.

Suffix:

<m>	1..4
<n>	*

<o> *

Parameters:

<Color> ARGB value of the color to be used for the table entry. ARGB=<Opacity(alpha) value><red value><green value><blue value>, in hexadecimal or decimal format.

Range: 0 to 4294967295

Increment: 1

*RST: 0

BUS<m>:CMSB:EXRBits

Exports the decoded frames as raw bits.

Suffix:

<m> 1..4

Usage: Event

BUS<m>:CMSB:FRAMe<n>:CELL<o>:CLMN <Column>

Selects which cell shall be displayed in which result column of the decode table.

The decode table supports three result columns, which have to be unique for each frame type. For different frame types, though, different result columns can be defined to display unrelated information.

Suffix:

<m> 1..4

<n> *

<o> *

Parameters:

<Column> NONE | COL1 | COL2 | COL3

NONE
The result is not displayed in the decode table.

COL1
The result is displayed in column 1 of the decode table.

COL2
The result is displayed in column 2 of the decode table.

COL3
The result is displayed in column 3 of the decode table.

*RST: NONE

BUS<m>:CMSB:LOAD <FileName>

Opens an existing frame description file in xml format. The default path is `\\Public\Documents\Rohde-Schwarz\RTx\SaveXML`

Suffix:
<m> 1..4

Setting parameters:
<FileName>

Usage: Setting only

BUS<m>:CMSB:SAVE <FileName>

Saves a created frame description into an xml file ("Save As..."). The default path is `\\Public\Documents\Rohde-Schwarz\RTx\SaveXML`

Suffix:
<m> 1..4

Setting parameters:
<FileName>

Usage: Setting only

20.17.13.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:CMSB:TYPE <Type>

Selects the trigger type for custom serial bus analysis.

Suffix:
<m> 1..3

Parameters:
<Type> STARt | PATTern | ADVanced

STARt
Triggers on the frame start, which is the end of the gap time as specified in `BUS<m>:CMSB:GAPTime:VALue` on page 1604

ADVanced
Advanced trigger with `TRIGger:CMSB:ADVanced` commands.
Only available if frames are defined.

PATTern
Triggers on a data pattern to be specified in `TRIGger<m>:CMSB:PATTern` on page 1610

*RST: STARt

TRIGger<m>:CMSB:PATTern <DataPattern>

Sets the pattern match conditions for a payload data check. The trigger is set to the first occurrence of a matching data bit pattern (which can be freely specified), starting after the minimum gap time (`BUS<m>:CMSB:GAPTime:VALue` on page 1604), and after the detected start of the data frame.

Suffix:
<m> 1..3

Parameters:
<DataPattern>

TRIGger<m>:CMSB:ICONdition <DataIdxOperator>

Sets the operator to set a specific bit index (data position).

Suffix:
<m> 1..3

Parameters:
<DataIdxOperator> EQUal | GETHan | INRange

EQUal
Equal

GETHan
Greater than or equal

INRange
In range

*RST: INRange

TRIGger<m>:CMSB:IMIN <DataPosition>

Sets the bit index (data position). If `TRIGger<m>:CMSB:ICONdition` on page 1610 is set to "INRange", "IMIN" sets the start value of the bit index range.

Suffix:

<m>	1..3

Parameters:

<DataPosition>	Range:	0 to 65535
	Increment:	1
	*RST:	0

TRIGger<m>:CMSB:IMAX <DataPositionTo>

Sets the end value of the bit index range (data position range), if `TRIGger<m>:CMSB:ICONdition` on page 1610 is set to "INRange".

Suffix:

<m>	1..3

Parameters:

<DataPositionTo>	Range:	0 to 65535
	Increment:	1
	*RST:	65535

TRIGger<m>:CMSB:NRZ:WRDLength <NRZWordLength>

Sets the number of bits in an NRZ Unclocked word.

Suffix:

<m>	1..3

Parameters:

<NRZWordLength>	Range:	0 to 31
	Increment:	1
	*RST:	8

TRIGger<m>:CMSB:ADVanced:FRAMe<n>:ENABle <Enable>
TRIGger<m>:CMSB:ADVanced:FRENable <Frame>, <Enabler>

Enables or disables the specific frame to be triggered on.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Setting parameters:
<Frame>

<Enabler> ON | OFF

Example: `:TRIGger:CMSB:ADVanced:FRENable "Master" 1`
Enables the Master frame.
`:TRIGger:CMSB:ADVanced:FRAMe1:ENABle 1`
Enables the 1st frame that you have defined.

Usage: Setting only

TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:ENABle <CondEnabler>
TRIGger<m>:CMSB:ADVanced:FIENable <Frame>, <Field>, <Enabler>

Enables or disables the specific field within the defined frame to be triggered on.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Setting parameters:
<Frame>

<Field>

<Enabler> ON | OFF

Example: `:TRIGger:CMSB:ADVanced:FIEN "Master", "CRC", 1`
Enables the CRC field of the Master frame.
`:TRIGger:CMSB:ADVanced:FRAMe1:FLD3:ENABle 1`
Enables the 3rd field of the 1st frame that you have defined.

Usage: Setting only

TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:BIT <BitState>
TRIGger<m>:CMSB:ADVanced:BIT <Frame>, <Field>, <Bit>

Sets the bit state of a field to be triggered on that only consists of one bit.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Setting parameters:
<Frame>

<Field>

<Bit> ONE | ZERO | DC

ONE
1

ZERO
0

DC
"Do not care" (DC) = X

Usage: Setting only

TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:DMAX <DataMax>
TRIGger<m>:CMSB:ADVanced:DMAX <Frame>, <Field>, <Data>

Sets the end value of a data pattern range if `TRIGger<m>:CMSB:ADVanced:DOPerator` is set to `INRange` or `OORange`.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Setting parameters:
<Frame>

<Field>

<Data>

Usage: Setting only

TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:DMIN <DataMin>
TRIGger<m>:CMSB:ADVanced:DMIN <Frame>, <Field>, <Data>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Setting parameters:
<Frame>

<Field>

<Data>

Usage: Setting only

TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:DOPerator <DataOperator>
TRIGger<m>:CMSB:ADVanced:DOPerator <Frame>, <Field>, <Operator>

Sets the operator for the data pattern.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Setting parameters:
<Frame>

<Field>

<Operator> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

ANY = OFF
The data of the required pattern is not relevant.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
This condition requires one endpoint value to be set using `TRIGger<m>:CMSB:ADVanced:DMIN`.

INRange | RANGe
This condition requires a range of endpoint values to be set using `TRIGger<m>:CMSB:ADVanced:DMAX` and `TRIGger<m>:CMSB:ADVanced:DMIN`.

Usage: Setting only

TRIGger<m>:CMSB:ADVanced:ERRor<n>:ENABle <Enable>
TRIGger<m>:CMSB:ADVanced:ERENable <ErrorName>, <Enabler>

Enables triggering on errors. You can search for all error types in parallel.

Suffix:
<m> 1..3

Setting parameters:
<ErrorName>

<Enabler> ON | OFF

Usage: Setting only

TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:IMAX <IndexMax>
TRIGger<m>:CMSB:ADVanced:IMAX <Frame>, <Field>, <Data>

Sets the end value of an index range if `TRIGger<m>:CMSB:ADVanced:IMAX` is set to `INRange` or `RANGe`.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Setting parameters:
<Frame>

<Field>

<Data>

Usage: Setting only

TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:IMIN <IndexMin>
TRIGger<m>:CMSB:ADVanced:IMIN <Frame>, <Field>, <Data>

Specifies the index, or sets the start value of an index range.

Suffix:
<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Setting parameters:
<Frame>

<Field>

<Data>

Usage: Setting only

TRIGger<m>:CMSB:ADVanced:FRAMe<n>:FLD<o>:IOPerator <IndexOperator>
TRIGger<m>:CMSB:ADVanced:IOPerator <Frame>, <Field>, <Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:
<m> Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

Setting parameters:
<Frame>

<Field>

<Operator> ANY | OFF | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

ANY = OFF
The index of the required pattern is not relevant.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
This condition requires one endpoint value to be set using `TRIGger<m>:CMSB:ADVanced:IMIN`.

INRange | RANGe
This condition requires a range of endpoint values to be set using `TRIGger<m>:CMSB:ADVanced:IMAX` and `TRIGger<m>:CMSB:ADVanced:IMIN`.

Usage: Setting only

20.17.13.3 Filter

BUS<m>:CMSB:FILTer:BIT <Frame>, <Field>, <Bit>

Sets the bit state of a field to be filtered on that only consists of one bit.

Suffix:
<m> 1..4

Setting parameters:
<Frame>

<Field>

<Bit> ONE | ZERO | DC

Usage: Setting only

BUS<m>:CMSB:FILTer:DMAX <Frame>, <Field>, <Data>

Sets the end value of a data pattern range if `BUS<m>:CMSB:FILTer:DOPerator` is set to `INRange` or `OORange`.

Suffix:
<m> 1..4

Setting parameters:
<Frame>

<Field>

<Data>

Usage: Setting only

BUS<m>:CMSB:FILTer:DMIN <Frame>, <Field>, <Data>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:
<m> 1..4

Setting parameters:
<Frame>

<Field>

<Data>

Usage: Setting only

BUS<m>:CMSB:FILTer:DOPerator <Frame>, <Field>, <Operator>

Sets the operator for the data pattern.

Suffix:
<m> 1..4

Setting parameters:
<Frame>

<Field>

<Operator> OFF | ANY | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

ANY = OFF
The data of the required pattern is not relevant.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
This condition requires one endpoint value to be set using `BUS<m>:CMSB:FILTer:DMIN`.

INRange | RANGe
This condition requires a range of endpoint values to be set using `BUS<m>:CMSB:FILTer:DMAX` and `BUS<m>:CMSB:FILTer:DMIN`.

Usage: Setting only

BUS<m>:CMSB:FILTer:ENABle <Enable>

Enables filtering for the custom serial bus.

Suffix:
<m> 1..4

Parameters:
<Enable> ON | OFF

*RST: OFF

BUS<m>:CMSB:FILTer:ERENable <ErrorName>, <Enabler>

Enables filtering on error.

Suffix:
<m> 1..4

Setting parameters:
<ErrorName>

<Enabler> ON | OFF

Usage: Setting only

BUS<m>:CMSB:FILTer:ERRor<n>:ENABle <Enable>

Enables filtering on error. You can filter all error types in parallel.

Suffix:

<m>	1..4
<n>	*

Parameters:

<Enable>	ON | OFF *RST: ON

BUS<m>:CMSB:FILTer:FIENable <Frame>, <Field>, <Enabler>

Enables or disables the specific field within the defined frame to be filtered.

Suffix:

<m>	1..4

Setting parameters:

<Frame>	
<Field>	
<Enabler>	ON | OFF
Usage:	Setting only

BUS<m>:CMSB:FILTer:FRAMe<n>:ENABle <Enable>

Enables or disables the specific frame to be filtered.

Suffix:

<m>	1..4
<n>	*

Parameters:

<Enable>	ON | OFF *RST: OFF

BUS<m>:CMSB:FILTer:FRENable <Frame>, <Enabler>

Enables or disables the specific frame to be filtered.

Suffix:

<m>	1..4

Setting parameters:

<Frame>	
<Enabler>	ON | OFF
Usage:	Setting only

BUS<m>:CMSB:FILTer:IMAX <Frame>, <Field>, <Data>

Sets the end value of an index range if BUS<m>:CMSB:FILTer:IOPerator is set to INRange or RANGe.

Suffix:
<m> 1..4

Setting parameters:
<Frame>

<Field>

<Data>

Usage: Setting only

BUS<m>:CMSB:FILTer:IMIN <Frame>, <Field>, <Data>

Specifies the index, or sets the start value of an index range.

Suffix:
<m> 1..4

Setting parameters:
<Frame>

<Field>

<Data>

Usage: Setting only

BUS<m>:CMSB:FILTer:IOPerator <Frame>, <Field>, <Operator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:
<m> 1..4

Setting parameters:
<Frame>

<Field>

<Operator> ANY | OFF | EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | RANGe

ANY = OFF
The index of the required pattern is not relevant.

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
This condition requires one endpoint value to be set using BUS<m>:CMSB:FILTer:IMIN.

INRange | RANGe
This condition requires a range of endpoint values to be set using BUS<m>:CMSB:FILTer:IMAX and BUS<m>:CMSB:FILTer:IMIN.

Usage: Setting only

20.17.13.4 Decode Results

In all BUS<m>:CSMB:RESult<n> commands, the suffix <m> selects the serial bus, the suffix <n> selects the result number in the decode table, and the suffix <o> selects the cell number.

As an example, with reference to Figure 12-72, Table 12-13 and Table 12-14, a set of query commands for bus #1 and result #1 is shown in the following, together with examples for outcomes of these queries:

- :BUS1:CMSB:RCOunt? !5

- :BUS1:CMSB:RESult1:STATe? !OK
- :BUS1:CMSB:RESult1:STARt? ! -0.0024964177
- :BUS1:CMSB:RESult1:STOP? ! -0.0024030384
- :BUS1:CMSB:RESult1:TYPE? !ff
- :BUS1:CMSB:RESult1:CONE? !0b11111111
- :BUS1:CMSB:RESult1:CTWO? !0xAA
- :BUS1:CMSB:RESult1:CTHR? !0xF590

- :BUS1:CMSB:RESult1:CCOunt? !5

- :BUS1:CMSB:RESult1:CELL1:STAT? !OK
- :BUS1:CMSB:RESult1:CELL1:NAME? !Start Delim
- :BUS1:CMSB:RESult1:CELL1:VALue? !101010101HL10HL0

- :BUS1:CMSB:RESult1:CELL2:STAT? !OK
- :BUS1:CMSB:RESult1:CELL2:NAME? !OP-FF
- :BUS1:CMSB:RESult1:CELL2:VALue? !0b11111111

- :BUS1:CMSB:RESult1:CELL3:STAT? !OK
- :BUS1:CMSB:RESult1:CELL3:NAME? !data
- :BUS1:CMSB:RESult1:CELL3:VALue? !0xAA

- :BUS1:CMSB:RESult1:CELL4:STAT? !OK
- :BUS1:CMSB:RESult1:CELL4:NAME? !CRC
- :BUS1:CMSB:RESult1:CELL4:VALue? !0xF590

- `:BUS1:CMSB:RESult1:CELL5:STAT?` !OK
- `:BUS1:CMSB:RESult1:CELL5:NAME?` !End Delim
- `:BUS1:CMSB:RESult1:CELL5:VALue?` !1HLHL101

To show the results on the screen, use the following commands:

- `BUS<m>:RESult` on page 1300
- `BUS<m>:RESDetail` on page 1300

BUS<m>:CMSB:RCOunt?

Returns the count number of decoded result frames in a custom serial bus waveform. Basically, this is the maximum result index <n> when querying results by using `BUS<m>:CMSB:RESult<n>:XXX`.

Suffix:
<m> 1..4

Return values:
<Count>

Usage: Query only

BUS<m>:CMSB:RESult<n>:STATe?

Returns the overall state of the frame: either OK or the relevant error condition. R&S RTP-K50 marks each frame with a status that indicates whether the decode succeeded or not.

Suffix:
<m> 1..4

<n> *

Return values:
<State> OK | LENGth | UNKNown | INComplete | CRC | PARity

OK
The frame was decoded normally and conforms to the frame description.

LENGth
The length error indicates that the frame ended prematurely, or an array in the frame had too few elements. The amount of bits that the software expected (based upon the user's frame description) was not found before the frame was terminated. This might occur because a new frame synchronized, or a gap appeared between the bits.

UNKNown
Unknown error

INComplete
The frame ended prematurely because it extends past the end of the record.

CRC
Checksum error in cyclic redundancy check (error in data)

PARity
Parity bit error, indicating a transmission error (only available if a parity is configured)

*RST: OK

Usage: Query only

BUS<m>:CMSB:RESult<n>:STARt?

Returns the start time of the frame.

Suffix:

<m> 1..4

<n> *

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:CMSB:RESult<n>:STOP?

Returns the stop time of the frame.

Suffix:

<m> 1..4

<n> *

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:CMSB:RESult<n>:TYPE?

Returns the name of the selected frame (n) from the user defined frame format description, labeled according to `BUS<m>:CMSB:FRAMe<n>:TYPE` on page 1605.

Suffix:

<m> 1..4

<n> *

Return values:

<Type>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CONE?

Returns the 1st cell content as specified in the Result Column of the "Frame Format" specification table.

Suffix:

<m> 1..4

<n> *

Return values:

<Custom1>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CTWO?

Returns the 2nd cell content as specified in the Result Column of the "Frame Format" specification table.

Suffix:

<m> 1..4

<n> *

Return values:

<Custom2>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CTHRee?

Returns the 3rd cell content as specified in the Result Column of the "Frame Format" specification table.

Suffix:

<m>	1..4
<n>	*

Return values:
<Custom3>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CCOunt?

Returns the number of decoded cells in the specified result frame.

Suffix:

<m>	1..4
<n>	*

Return values:

<NumWords>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:CMSB:RESult<n>:CELL<o>:NAME?

Returns the name of the specified cell. Cell names are not necessarily unique.

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:
<Name>

Usage: Query only

BUS<m>:CMSB:RESult<n>:CELL<o>:STARt?

Returns the start time of the selected cell.

Suffix:

<m>	1..4 Selects the serial bus.
<n>	*

<o> *
Selects the cell.

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:CMSB:RESult<n>:CELL<o>:STOP?

Returns the end time of the selected cell.

Suffix:

<m> 1..4
Selects the serial bus.

<n> *

<o> *
Selects the cell.

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:CMSB:RESult<n>:CELL<o>:STATe?

Returns the state of the cell.

Suffix:

<m> 1..4

<n> *

<o> *

Return values:

<State> OK | LENGth | UNKNown | INComplete | CRC | PARity

OK
No error detected

LENGth
The length error indicates that the cell ended prematurely. The amount of bits that the software expected (based upon the user's frame description) was not found before the cell was terminated. This might occur because a new frame synchronized, or a gap appeared between the bits.

UNKNown
Unknown error

INComplete
The cell ended prematurely because it extends past the end of the record.

CRC
Checksum error in cyclic redundancy check (error in data)

PARity
Parity bit error, indicating a transmission error (only available if a parity is configured)

Usage: Query only

BUS<m>:CMSB:RESult<n>:CELL<o>:VALue?

Data content of the specified cell.

Suffix:

<m> 1..4

<n> *

<o> *

Return values:
<Value>

Usage: Query only

20.17.13.5 Search Settings

SEARch:TRIGger:CMSB:ERENable <SearchName>,<ErrorName>, <Enabler>
SEARch:TRIGger:CMSB:ERRor<m>:ENABle <SearchName>,<Enable>
SEARch:TRIGger:CMSB:ERRor<m>:ENABle? <SearchName>

Defines the error type to be searched for. You can search for all error types in parallel.

Suffix:
<m> *

Parameters:
<Enable> ON | OFF
*RST: ON

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CMSB:FIENable <SearchName>,<Frame>, <Field>, <Enabler>

Enables or disables the specific field within the defined frame to be searched for.

Setting parameters:
<SearchName>

<Frame>

<Field>

<Enabler> ON | OFF

Usage: Setting only

SEARch:TRIGger:CMSB:FRENable <SearchName>,<Frame>, <Enabler>

Enables or disables the specific frame to be searched for.

Setting parameters:
<SearchName>

<Frame>

<Enabler> ON | OFF

Usage: Setting only

SEARch:TRIGger:CMSB:BIT <SearchName>,<Frame>, <Field>, <Bit>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:BIT <SearchName>,<BitState>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:BIT? <SearchName>

Sets the bit state of a field to be searched that only consists of one bit.

Suffix:
<m> *

<n> *

Parameters:
<BitState> ONE | ZERO | DC

ONE
1

ZERO
0

DC
"Do not care" (DC) = X

*RST: DC

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CMSB:DMAX <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DMAX <SearchName>,<DataMax>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DMAX? <SearchName>

Sets the end value of a data pattern range if `SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DOPerator` is set to `INRange` or `OORange`.

Suffix:
<m> *

<n> *

Parameters:
<DataMax> Specifies the name of the generic trigger setting frame.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CMSB:DMIN <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DMIN <SearchName>,<DataMin>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DMIN? <SearchName>

Specifies the data pattern to be searched, or sets the start value of a data pattern range to be searched.

Suffix:
<m> *

<n> *

Parameters:
<DataMin> Specifies the name of the generic trigger setting frame.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CMSB:DOPerator <SearchName>,<Frame>, <Field>, <Operator>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DOPerator <SearchName>,<DataOperator>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DOPerator? <SearchName>

Sets the operator to set a specific data pattern to be searched in the selected field of the selected frame.

Suffix:

<m> *

<n> *

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DMIN`.

INRange | OORange
In range, out of range. These conditions require a range of endpoint values to be set using `SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DMIN` and `SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:DMAX`.

*RST: EQUal

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:CMSB:FRAMe<m>:ENABle <SearchName>,<Enable>
SEARch:TRIGger:CMSB:FRAMe<m>:ENABle? <SearchName>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:ENABle <SearchName>,<CondEnabler>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:ENABle? <SearchName>

Enables or disables the checking condition for searching a specific data pattern in the selected field of the selected frame.

Suffix:

<m> *

<n> *

Parameters:

<CondEnabler> ON | OFF

ON
Checking condition enabled

OFF
Checking condition disabled

*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IMAX <SearchName>,<IndexMax>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IMAX? <SearchName>
SEARch:TRIGger:CMSB:IMAX <SearchName>,<Frame>, <Field>, <Data>

Sets the end value of the bit index range (data position range), if `SEARch:TRIGger:CMSB:IOPerator` is set to `INRange`.

Setting parameters:
<SearchName>

<Frame>

<Field>

<Data>

Usage: Setting only

SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IMIN <SearchName>,<IndexMin>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IMIN? <SearchName>
SEARch:TRIGger:CMSB:IMIN <SearchName>,<Frame>, <Field>, <Data>

Sets the bit index (data position).

Setting parameters:
<SearchName>

<Frame>

<Field>

<Data>

Usage: Setting only

SEARch:TRIGger:CMSB:IOPerator <SearchName>,<Frame>, <Field>, <Operator>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IOPerator <SearchName>,<IndexOperator>
SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IOPerator? <SearchName>

Sets the operator for the index for searching in the selected field of the selected frame.

Suffix:
<m> *

<n> *

Parameters:
<IndexOperator> EQUal | INRange | RANGe

EQUal
This condition requires one endpoint value to be set using `SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IMIN`.

INRange | RANGe
This condition requires a range of endpoint values to be set using `SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IMIN` and `SEARch:TRIGger:CMSB:FRAMe<m>:FLD<n>:IMAX`.
*RST: INRange

Parameters for setting and query:
<SearchName>

20.17.13.6 Search Results

SEARch:RESult:CMSB<m>:FCOunt? <SearchName>

Returns the count number of decoded result frames in a custom serial bus waveform. Basically, this is the maximum result index <n> when querying results by using `SEARch:RESult:CMSB<m>:FRAMe<n>:XXX`.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:CCOunt? <SearchName>

Returns the count number of cell in the frames, within the search result, in a custom serial bus waveform.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:

<NumWords> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:CELL<o>:NAME? <SearchName>

Returns the name of the specified cell within the search result. Cell names are not necessarily unique.

Suffix:
<m> *

<n> *

<o> *

Query parameters:
<SearchName>

Return values:
<Name>

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:CELL<o>:STARt? <SearchName>

Returns the start time of the cell within the search result.

Suffix:
<m> *

<n> *

<o> *

Query parameters:
<SearchName>

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:CELL<o>:STATe? <SearchName>

Returns the state of the cell within the search result.

Suffix:

<m>	*
<n>	*
<o>	*

Query parameters:
<SearchName>

Return values:
<State> OK | LENGth | UNKNown | INComplete | CRC | PARity

OK
No error detected

LENGth
The length error indicates that the cell ended prematurely. The amount of bits that the software expected (based upon the user's frame description) was not found before the cell was terminated. This might occur because a new frame synchronized, or a gap appeared between the bits.

UNKNown
Unknown error

INComplete
The cell ended prematurely because it extends past the end of the record.

CRC
Checksum error in cyclic redundancy check (error in data)

PARity
Parity bit error, indicating a transmission error (only available if a parity is configured)

*RST: OK

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:CELL<o>:STOP? <SearchName>

Returns the stop time of the cell within the search result.

Suffix:

<m>	*
<n>	*
<o>	*

Query parameters:
<SearchName>

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:CELL<o>:VALue? <SearchName>

Data content of the specified cell within the search result.

Suffix:

<m> *

<n> *

<o> *

Query parameters:

<SearchName>

Return values:

<Value>

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:CONE? <SearchName>

Returns the 1st cell content within the search result, as specified in the Result Column of the "Frame Format" specification table.

Suffix:

<m> *

<n> *

Query parameters:

<SearchName>

Return values:

<Custom1>

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:CTHRee? <SearchName>

Returns the 3rd cell content, within the search result as specified in the Result Column of the "Frame Format" specification table.

Suffix:

<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<Custom3>

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:CTWO? <SearchName>

Returns the 2nd cell content within the search result, as specified in the Result Column of the "Frame Format" specification table.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<Custom2>

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:STARt? <SearchName>

Returns the start time of the frame within the search result.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<Start>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:STATe? <SearchName>

Returns the overall state of the frame within the search result: either OK or the relevant error condition. R&S RTP-K50 marks each frame with a status that indicates whether the decode succeeded or not.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<State> OK | LENGth | UNKNown | INComplete | CRC | PARity

OK
The frame was decoded normally and conforms to the frame description.

LENGth
The length error indicates that the frame ended prematurely, or an array in the frame had too few elements. The amount of bits that the software expected (based upon the user's frame description) was not found before the frame was terminated. This might occur because a new frame synchronized, or a gap appeared between the bits.

UNKNown
Unknown error

INComplete
The frame ended prematurely because it extends past the end of the record.

CRC
Checksum error in cyclic redundancy check (error in data)

*RST: OK

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:STOP? <SearchName>

Returns the stop time of the frame within the search result.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:CMSB<m>:FRAMe<n>:TYPE? <SearchName>

Returns the name of the selected frame (n) from the user defined frame format description, labeled according to BUS<m>:CMSB:FRAMe<n>:TYPE on page 1605.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<Type>

Usage: Query only

20.17.14 8B/10B (Option R&S RTP-K52)

20.17.14.1 Configuration

In all BUS<m>:EBTB commands, the suffix <m> selects the serial bus.

BUS<m>:EBTB:BITRate <Bitrate>

Sets the number of transmitted bits per second.

Suffix:
<m> 1..4

Parameters:

<Bitrate> Range: 100 to 12.5E+9
Increment: 10
*RST: 1.25E+9
Default unit: bps

BUS<m>:EBTB:EBTRate?

Queries the estimated bitrate value.

Suffix:

<m> 1..4

Return values:

<EstimatedBitrate> Range: 100 to 100E+9
Increment: 10
*RST: 1.25E+9
Default unit: bps

Usage: Query only

BUS<m>:EBTB:DIFFerential:SOURce <SrcDiff>

Selects the source of the provided differential signal, if `BUS<m>:EBTB:TYPE DIFFerential` is set.

Suffix:

<m> 1..4

Parameters:

<SrcDiff> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
*RST: C1W1

Usage: Asynchronous command

BUS<m>:EBTB:DIFFerential:THRHigh <ThresholdHigh>

Sets the high threshold of the signal, if `BUS<m>:EBTB:TYPE DIFFerential`.

Suffix:

<m> 1..4

Parameters:

<ThresholdHigh> Range: -10 to 10
Increment: 1E-3
*RST: 0.15
Default unit: V

BUS<m>:EBTB:DIFFerential:THRLow <ThresholdLow>

Sets the low threshold of the signal, if `BUS<m>:EBTB:TYPE DIFFerential`.

Suffix:
<m> 1..4

Parameters:
<ThresholdLow> Range: -10 to 10
Increment: 1E-3
*RST: -0.15
Default unit: V

BUS<m>:EBTB:DISF <DisplayFormat>

Selects the display format for the results in the decode table and for the results of `BUS<m>:EBTB:SYMBol<n>:DATA?`.

Suffix:
<m> 1..4

Parameters:
<DisplayFormat> KD | EB | TB
KD: K/D codes
EB: 8-bit pattern
TB: 10-bit pattern
*RST: KD

BUS<m>:EBTB:DMINus:SOURce <SourceDminus>

Selects the D- source of the provided single ended signal, if `BUS<m>:EBTB:TYPE SINGle` is set.

Suffix:
<m> 1..4

Parameters:
<SourceDminus> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
Default unit: NONE

Usage: Asynchronous command

BUS<m>:EBTB:DMINus:THReshold <ThresholdDminus>

Sets the low threshold (D-) of the signal, if `BUS<m>:EBTB:TYPE SINGle`.

Suffix:
<m> 1..4

Parameters:
<ThresholdDminus> Range: -10 to 10
Increment: 1E-3
*RST: 0
Default unit: V

BUS<m>:EBTB:DPLus:SOURce <SourceDplus>

Selects the D+ source of the provided single-ended signal, if `BUS<m>:EBTB:TYPE SINGle` is set.

Suffix:
<m> 1..4

Parameters:
<SourceDplus> NONE | C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
*RST: C1W1

Usage: Asynchronous command

BUS<m>:EBTB:DPLus:THReshold <ThresholdDplus>

Sets the high threshold (D +) of the signal, if `BUS<m>:EBTB:TYPE SINGle`.

Suffix:
<m> 1..4

Parameters:
<ThresholdDplus> Range: -10 to 10
Increment: 1E-3
*RST: 0
Default unit: V

BUS<m>:EBTB:FCSY <CustSync>

Sets a pattern value, if `BUS<m>:EBTB:SYNC CUS`.

Suffix:
<m> 1..4

Parameters:
<CustSync>

BUS<m>:EBTB:SCOunt?

Returns the symbol count for the selected serial bus, i.e. the number of symbols in the present acquisition.

Suffix:
<m> 1..4

Return values:
<Count> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:EBTB:SCSY <CustSync2>

Sets the value for the second pattern, if `BUS<m>:EBTB:SYNC CUS` and `BUS<m>:EBTB:USCS ON`.

Suffix:

<m>	1..4

Parameters:

<CustSync2>

BUS<m>:EBTB:SYNC <CommaSymbol>

Sets the sync symbol, a control symbol used for low level control functions.

Suffix:

<m>	1..4

Parameters:

<CommaSymbol>	K285 | K281 | K287 | CUS
	*RST: K285

BUS<m>:EBTB:TYPE <SignalType>

Selects the signal type that is used for the decoding. You can choose between a differential and single-ended signal.

Suffix:

<m>	1..4

Parameters:

<SignalType>	DIFFerential | SINGle
	*RST: DIFFerential

BUS<m>:EBTB:USCS <IsSecondSync>

Selects whether the second pattern is enabled, if `BUS<m>:EBTB:SYNC CUS`.

Suffix:

<m>	1..4

Parameters:

<IsSecondSync>	ON | OFF
	*RST: OFF

BUS<m>:EBTBBITDetermi

Starts a software algorithm for the automatic determination of the bitrate.

Suffix:

<m>	1..4

Usage: Event
Asynchronous command

BUS<m>:EBTBFAUToscale

Starts software algorithms for determining the signal threshold levels and bitrate.

Suffix:
<m> 1..4

Usage: Event
Asynchronous command

20.17.14.2 Trigger Settings

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:EBTB:DISParityerr <DispError>

Defines, if a trigger on a disparity error is activated or not.

Parameters:
<DispError> ON | OFF
*RST: OFF

TRIGger<m>:EBTB:DX <DXSymbol>

Sets thex value of the data character Dx.y to be triggered on, if `TRIGger<m>:EBTB:SYMType` is set to `Dxy`.

Parameters:

<DXSymbol> Range: 0 to 31
Increment: 1
*RST: 0

TRIGger<m>:EBTB:DY <DYSymbol>

Sets the y value of the data character Dx.y to be triggered on, if `TRIGger<m>:EBTB:SYMType` is set to `Dxy`.

Parameters:

<DYSymbol> Range: 0 to 7
Increment: 1
*RST: 0

TRIGger<m>:EBTB:EBPA <EBPattern>

Sets the 8-bit pattern to be triggered on, if `TRIGger<m>:EBTB:SYMFormat` is set to `EB`.

Parameters:

<EBPattern>

TRIGger<m>:EBTB:GLITcherror <GlitchError>

Defines, if a trigger on a glitch error is activated or not.

Parameters:

<GlitchError> ON | OFF
*RST: OFF

TRIGger<m>:EBTB:SSTYpe <SymbolType>

Selects the symbol type to be triggered on. You can select a single symbol or an expression (defined series of symbols).

Parameters:

<SymbolType> SYMBol | EXPRession
*RST: SYMBol

TRIGger<m>:EBTB:SYME <Expression>

Selects the format of the symbol to be triggered on, if `TRIGger<m>:EBTB:SSTYpe` is set to `EXPRession`.

Parameters:

<Expression>

TRIGger<m>:EBTB:SYMFormat <Format>

Selects the format of the symbol to be triggerd on, if `TRIGger<m>:EBTB:SSTYpe` is set to `SYMBol`.

Parameters:

<Format>	KD | EB | TB	
	*RST:	KD

TRIGger<m>:EBTB:SYMType <SymbolType>

Selects the data character (Dx.y) or control character to bea triggered on. You can specify he value of the data character to be triggered on with `TRIGger<m>:EBTB:DX` and `TRIGger<m>:EBTB:DY`.

Parameters:

<SymbolType>	DXY | K280 | K281 | K282 | K283 | K284 | K285 | K286 | K287 | K237 | K277 | K297 | K307	
	*RST:	K285

TRIGger<m>:EBTB:TBPA <TBPattern>

Sets the 10-bit pattern to be triggered on, if `TRIGger<m>:EBTB:SYMFormat` is set to `TB`.

Parameters:

<TBPattern>

TRIGger<m>:EBTB:TYPE <Type>

Selects the type of condition to be triggered on. You can trigger on a certain symbol or enable a specific error condition.

Parameters:

<Type>	SYMBol | ERRor	
	*RST:	SYMBol

TRIGger<m>:EBTB:UNK <UnkError>

Defines, if a trigger on a unknown symbol error is activated or not.

Parameters:

<UnkError>	ON | OFF	
	*RST:	OFF

20.17.14.3 Decode Results

In all `BUS<m>:EBTB:SYMBol<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the symbol in the decode table.

BUS<m>:EBTB:SYMBol<n>:DATA?

Returns the data of the specified symbol.

The format is determined by the remote command `BUS<m>:EBTB:DISF`.

Suffix:

<m> 1..4

<n> *

Return values:

<Data>

Example:
```
BUS<m>:EBTB:DISF EB
BUS:EBTB:SYMBol5:DATA?
<-- BC+
```

Example:
```
BUS<m>:EBTB:DISF KD
BUS:EBTB:SYMBol5:DATA?
<-- K28.5+
```

Example:
```
BUS<m>:EBTB:DISF TB
BUS:EBTB:SYMBol5:DATA?
<-- 305
```

Usage: Query only

BUS<m>:EBTB:SYMBol<n>:STARt?

Returns the start time of the specified symbol.

Suffix:

<m> 1..4

<n> *

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:EBTB:SYMBol<n>:STATus?

Returns the status of the specified symbol. It can show what kind of error was detected or no error.

Suffix:

<m> 1..4

<n> *

Return values:

<State> OK | UNK | DISPARITY | DISParity | GLITCH | GLITch

OK
There are no errors in the state of the specified symbol.

UNK
An unknown error was detected for the specified symbol.

DISPARITY = DISParity
A disparity error was detected for the specified symbol.

GLITCH = GLITch
A glitch error was detected for the specified symbol.

*RST: OK

Usage: Query only

BUS<m>:EBTB:SYMBol<n>:STOP?

Returns the stop time of the specified symbol.

Suffix:

<m> 1..4

<n> *

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:EBTB:SYMBol<n>:BYTE?

Returns the symbol byte value.

Suffix:

<m> 1..4

<n> *

Return values:

<Byte> Range: 0 to 0
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:EBTB:SYMBol<n>:KDCode?

Returns the K/D code.

Suffix:

<m> 1..4

<n> *

Return values:

<KDCode>

Usage: Query only

BUS<m>:EBTB:SYMBol<n>:TENBit?

Returns the 10-bit symbol.

Suffix:

<m> 1..4

<n> *

Return values:

<TenBit>

Usage: Query only

20.17.14.4 Search Settings

SEARch:TRIGger:EBTB:DISParityerr <SearchName>,<DispError>
SEARch:TRIGger:EBTB:DISParityerr? <SearchName>

Defines, if a search for any disparity error is activated or not.

Parameters:
<DispError> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:DX <SearchName>,<DXSymbol>
SEARch:TRIGger:EBTB:DX? <SearchName>

Sets the x value of the data character Dx.y to be searched for, if `SEARch:TRIGger:EBTB:SYMType` is set to `Dxy`.

Parameters:
<DXSymbol> Range: 0 to 31
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:DY <SearchName>,<DYSymbol>
SEARch:TRIGger:EBTB:DY? <SearchName>

Sets the y value of the data character Dx.y to be searched for, if `SEARch:TRIGger:EBTB:SYMType` is set to `Dxy`.

Parameters:
<DYSymbol> Range: 0 to 7
Increment: 1
*RST: 0

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:EBPA <SearchName>,<EBPattern>
SEARch:TRIGger:EBTB:EBPA? <SearchName>

Sets the 8-bit pattern to be searched for, if `SEARch:TRIGger:EBTB:SYMFormat` is set to `EB`.

Parameters:
<EBPattern>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:GLITcherror <SearchName>,<GlitchError>
SEARch:TRIGger:EBTB:GLITcherror? <SearchName>

Defines, if a search for any glitch error is activated or not.

Parameters:

<GlitchError> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:EBTB:SSTYpe <SearchName>,<SymbolType>
SEARch:TRIGger:EBTB:SSTYpe? <SearchName>

Selects the symbol type to be searched for. You can select a single symbol or an expression (defined series of symbols).

Parameters:

<SymbolType> SYMBol | EXPRession

*RST: SYMBol

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:EBTB:SYME <SearchName>,<Expression>
SEARch:TRIGger:EBTB:SYME? <SearchName>

Selects the format of the symbol to be searched for, if `SEARch:TRIGger:EBTB:SSTYpe` is set to `EXPRession`.

Parameters:

<Expression>

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:EBTB:SYMFormat <SearchName>,<Format>
SEARch:TRIGger:EBTB:SYMFormat? <SearchName>

Selects the format of the symbol to be searched for, if `SEARch:TRIGger:EBTB:SSTYpe` is set to `SYMBol`.

Parameters:

<Format> KD | EB | TB

KD: K/D codes
EB: 8-bit pattern
TB: 10-bit pattern

*RST: KD

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:SYMType <SearchName>,<SymbolType>
SEARch:TRIGger:EBTB:SYMType? <SearchName>

Selects the data character (Dx.y) or control character to bea searched for. You can specify he value of the data character to be searched for with `SEARch:TRIGger:EBTB:DX` and `SEARch:TRIGger:EBTB:DY`.

Parameters:

<SymbolType>	DXY | K280 | K281 | K282 | K283 | K284 | K285 | K286 | K287 | K237 | K277 | K297 | K307	
	*RST:	K285

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:TBPA <SearchName>,<TBPattern>
SEARch:TRIGger:EBTB:TBPA? <SearchName>

Sets the 10-bit pattern to be searched for, if `SEARch:TRIGger:EBTB:SYMFormat` is set to `TB`.

Parameters:
<TBPattern>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:TYPE <SearchName>,<Type>
SEARch:TRIGger:EBTB:TYPE? <SearchName>

Selects the type of condition to be searched for. You can search for a certain symbol or enable a specific error condition.

Parameters:

<Type>	SYMBol | ERRor	
	*RST:	SYMBol

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:EBTB:UNK <SearchName>,<UnkError>
SEARch:TRIGger:EBTB:UNK? <SearchName>

Defines, if a search for any unknown symbol error is activated or not.

Parameters:

<UnkError>	ON | OFF	
	*RST:	OFF

Parameters for setting and query:
<SearchName>

20.17.14.5 Search Results

In all `SEARch:RESult:EBTB:SYMBol<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:EBTB:SCOunt? <SearchName>

Returns the symbol count, i.e. the number of symbols found in the specified search result.

Query parameters:
<SearchName>

Return values:
<Count> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:EBTB:SYMBol<m>:DATA? <SearchName>

Returns the data of the specified symbol.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:EBTB:SYMBol<m>:STARt? <SearchName>

Returns the start time of the specified symbolwithin the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:EBTB:SYMBol<m>:STATus? <SearchName>

Returns the status of the specified symbol within the search result. It can show what kind of error was detected or no error.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<State> OK | UNK | DISPARITY | DISParity | GLITCH | GLITch

OK
There are no errors in the state of the specified symbol.

UNK
An unknown error was detected for the specified symbol.

DISPARITY = DISParity
A disparity error was detected for the specified symbol.

GLITCH = GLITch
A glitch error was detected for the specified symbol.

*RST: OK

Usage: Query only

SEARch:RESult:EBTB:SYMBol<m>:STOP? <SearchName>

Returns the stop time of the specified symbol within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

20.17.15 MDIO (Option R&S RTP-K55)

20.17.15.1 Configuration

In all `BUS<m>:MDIO` commands, the suffix <m> selects the serial bus.

BUS<m>:MDIO:CLOCk:SOURce <SourceClock>

Selects the source for the clock line (management data clock, MDC). Permitted selections are the analog channels "C1"–"C4" and the digital channels "D0"–"D15".

Suffix:

<m> 1..4

Parameters:

<SourceClock> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data and clock lines. For triggering on a serial bus, analog or digital input channels are required.
See Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C2W1

BUS<m>:MDIO:DATA:SOURce <SourceData>

Selects the source for the data signal. Permitted selections are the analog channels "C1"–"C4" and the digital channels "D0"–"D15", but not the same as for "Clock".

Suffix:

<m> 1..4

Parameters:

<SourceData> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Digital and analog channels cannot be used at the same time for data and clock lines. For triggering on a serial bus, analog or digital input channels are required.

See Chapter 20.4.2, "Waveform Parameter", on page 970

*RST: C1W1

BUS<m>:MDIO:CLOCk:THReshold:HIGH <ThresClkHigh>

Defines the upper threshold level for the clock signal.

Suffix:

<m> 1..4

Parameters:

<ThresClkHigh> Range: -5 to 5
Increment: 0.1
*RST: 2
Default unit: V

BUS<m>:MDIO:CLOCk:THReshold:LOW <ThresClkLow>

Defines the lower threshold level for the clock signal.

Suffix:

<m> 1..4

Parameters:

<ThresClkLow> Range: -5 to 5
Increment: 0.1
*RST: 0.8
Default unit: V

BUS<m>:MDIO:DATA:THReshold:HIGH <ThresDatHigh>

Defines the upper threshold level for the data signal.

Suffix:

<m> 1..4

Parameters:

<ThresDatHigh> Range: -5 to 5
Increment: 0.1
*RST: 2
Default unit: V

BUS<m>:MDIO:DATA:THReshold:LOW <ThresDatLow>

Defines the lower threshold level for the data signal.

Suffix:

<m>	1..4

Parameters:

<ThresDatLow>	Range: -5 to 5 Increment: 0.1 *RST: 0.8 Default unit: V

BUS<m>:MDIO:PRESet <Preset>

Selects the default threshold settings according to the Ethernet standard: 2.0 V and 0.8 V.

Suffix:

<m>	1..4

Parameters:

<Preset>	DEFault | MANual *RST: DEFault

BUS<m>:MDIO:COUPling <ThresCpl>

Overwrites the data thresholds with the clock thresholds.

Suffix:

<m>	1..4

Parameters:

<ThresCpl>	ON | OFF *RST: ON

20.17.15.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:MDIO:TYPE <Type>

Selects the trigger type for MDIO analysis.

Parameters:

<Type> STARt | STOP | DATA

STARt
Sets the trigger to the start of frame (SOF) field. The start of frame condition and the trigger instant is the end of the preamble. Trigger pattern: preamble (32 bits "1")

STOP
Sets the trigger to the end of frame (EOF) field. The trigger instant is after the last data bit. Trigger pattern: preamble (32 bits "1") + 32 bits "X"

DATA
Sets the trigger to the data field. For more information on the data condition, see MDIO in the Ethernet standard. The trigger instant is at the end of the frame after the last data bit, as indicated in the GUI. Trigger pattern: preamble (32 bits "1") + 2 bits "ST" (Start of Frame Code) + 2 bits "OP" (Frame Type Code, or "OpCode") + 5 bits "PHYAD/PRTAD" (Physical Layer Entity Address / Port Address) + 5 bits "REGAD/DEVAD" (Register Address / Device Address) + 2 bits "TA" (turnaround time, X bits) + 16 bits "DATA/ADDRESS"

*RST: STARt

TRIGger<m>:MDIO:ST <StartCode>

Selects the start of frame code of the frame pattern; available only in trigger type "Data".

Note that Clause 22 is coded by "01", while Clause 45 is coded by "00", thus the lower Clause number is represented by the higher parameter value.

Parameters:

<StartCode> ST00 | ST01 | ST0X

ST00
Clause 45

ST01
Clause 22

ST0X
Any permissible start pattern

*RST: ST0X

TRIGger<m>:MDIO:FRAMetype <FrameType>

Selects the Type of Frame code (or OP code, OpCode, operation code); available only in trigger type "Data".

Note that the same OpCode may have different meanings in Clause 22 and Clause 45.

Parameters:

<FrameType> OP00 | OP01 | OP10 | OP11 | OPXX

OP00
Address frame (in Clause 45, only)

OP01
Write frame (in Clause 22 or Clause 45)

OP10
Read frame (in Clause 22) or Post-Read increment address frame (in Clause 45)

OP11
Read frame (in Clause 45)

OPXX
Any frame type

*RST: OPXX

Note that the user interface shows interpretations of the numerical OpCode values corresponding to Clause 45. Clause 22 is not represented by this interpretation.

TRIGger<m>:MDIO:PHYS <PhyAddr>

Sets the physical address (in Clause 22) or port address (in Clause 45) of the frame pattern (5 bits); available only in trigger type "Data".

Parameters:

<PhyAddr>

TRIGger<m>:MDIO:REGI <RegAddr>

Sets the register address (in Clause 22) or device address (in Clause 45) of the frame pattern (5 bits); available only in trigger type "Data".

Parameters:

<RegAddr>

TRIGger<m>:MDIO:DATA <Data>

Defines the 16-bit payload data pattern (both in Clause 22 or Clause 45) or the address pattern (in Clause 45, only) to trigger for; available only in trigger type "Data".

Parameters:

<Data>

20.17.15.3 Decode Results

In all `BUS<m>:MDIO:WORD<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the word number in the decode table.

BUS<m>:MDIO:WCOunt?

Returns the word count for the selected serial bus, i.e. the number of words in the present acquisition.

Suffix:

<m> 1..4

Return values:

<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:MDIO:WORD<n>:DATA?

Returns the 16-bit payload data field content (in Clause 22 or Clause 45), or the 16-bit address field content (in Clause 45, only) in the present acquisition of the selected word and the selected serial bus. The most significant bit (MSB) is transmitted first.

Suffix:

<m> 1..4

<n> *

Return values:

<Data>

Usage: Query only

BUS<m>:MDIO:WORD<n>:PHYS?

Returns the 5-bit address field content (PHYAD/PRTAD) in the present acquisition of the selected word and the selected serial bus.

Suffix:

<m>	1..4
<n>	*

Return values:

<PhyAd>
Range: 0 to 32
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:MDIO:WORD<n>:REGI?

Returns the 5-bit register or device address field content (REGAD/DEVAD) in the present acquisition of the selected word and the selected serial bus.

Suffix:

<m>	1..4
<n>	*

Return values:

<RegAd>
Range: 0 to 32
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:MDIO:WORD<n>:ST?

Returns the Start Code (= start of frame code) in the present acquisition of the selected word and the selected serial bus.

Suffix:

<m>	1..4
<n>	*

Return values:

<StartCode>
Range: 0 to 3
Increment: 1
*RST: 0
The parameter value "0" represents Clause 45, and "1" stands for Clause 22.
The values "2" and "3" do not correspond with any legal parameters according to the standard, but they can be searched for.

Usage: Query only

BUS<m>:MDIO:WORD<n>:STARt?

Returns the start time of the frame in the selected word of the selected serial bus.

Suffix:

<m>	1..4
<n>	*

Return values:

<Start>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:MDIO:WORD<n>:STATe?

Returns the state of the frame in the present acquisition of the selected serial bus.

Suffix:

<m>	1..4
<n>	*

Return values:

<State>
OK | UNSYN | UNSYncronized | OPCO | TA_ERROR | INComplete | SHORT | SHORt

OK
No error detected

UNSYN = UNSYncronized
UNSYncronized happens when bits are found, but they are not correlated with any synchronization sequence. We don't know what these bits are, but they are there. These bits receive a flag, but they are not decoded.

OPCO
OPcode Error

TA_ERROR
Tirnaround time error

INComplete
Incomplete Frame

SHORT = SHORt
Length Error

*RST: OK

Usage: Query only

BUS<m>:MDIO:WORD<n>:STOP?

Returns the stop time of the frame from the selected word within the search result.

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:MDIO:WORD<n>:SYMBol?

Returns a textual translation (called Register Name) of the PHY or port address label in the present acquisition of the selected word and the selected serial bus.

The translation is defined in the label list.

Suffix:

<m> 1..4

<n> *

Return values:

<Translation>

Usage: Query only

BUS<m>:MDIO:WORD<n>:TYPE?

Returns the OpCode (= operation code or frame type) in the present acquisition of the selected word and the selected serial bus.

Suffix:

<m> 1..4

<n> *

Return values:

<FrameType> Range: 0 to 3
Increment: 1
*RST: 0
The parameter value "0" represents Clause 45, and "1" stands for Clause 22.
The values "2" and "3" do not correspond with any legal parameters according to the standard, but they can be searched for.

Usage: Query only

20.17.15.4 Search Settings

SEARch:TRIGger:MDIO:DATA <SearchName>,<Data>
SEARch:TRIGger:MDIO:DATA? <SearchName>

Allows to define the 16-bit payload data pattern (both in Clause 22 or Clause 45) or the address pattern (in Clause 45, only) to search for; available only in search criteria type "Data".

Parameters:
<Data>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:FRAMetype <SearchName>,<FrameType>
SEARch:TRIGger:MDIO:FRAMetype? <SearchName>

Allows to select the Type of Frame code (or OP code, OpCode, operation code); available only in search criteria type "Data".

Note that the same OpCode may have different meanings in Clause 22 and Clause 45.

Parameters:
<FrameType> OP00 | OP01 | OP10 | OP11 | OPXX

OP00
Address frame (in Clause 45, only)

OP01
Write frame (in Clause 22 or Clause 45)

OP10
Read frame (in Clause 22) or Post-Read increment address frame (in Clause 45)

OP11
Read frame (in Clause 45)

OPXX
Any frame type

*RST: OPXX

Note that the user interface shows interpretations of the numerical OpCode values corresponding to Clause 45. Clause 22 is not represented by this interpretation.
Also, note that OPXX will never be a result of decoding, but it is still an option for triggering.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:PHYS <SearchName>,<PhyAddr>
SEARch:TRIGger:MDIO:PHYS? <SearchName>

Allows to set the physical address (in Clause 22) or port address (in Clause 45) of the frame pattern (5 bits); available only in search criteria type "Data".

Parameters:
<PhyAddr>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:REGI <SearchName>,<RegAddr>
SEARch:TRIGger:MDIO:REGI? <SearchName>

Allows to set the register address (in Clause 22) or device address (in Clause 45) of the frame pattern (5 bits); available only in search criteria type "Data".

Parameters:
<RegAddr>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:ST <SearchName>,<StartCode>
SEARch:TRIGger:MDIO:ST? <SearchName>

Allows to select the start of frame code of the frame pattern; available only in search criteria type "Data".

Parameters:
<StartCode> ST00 | ST01 | ST0X

ST00
Clause 45

ST01
Clause 22

ST0X
Any permissible start pattern

*RST: ST0X

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:MDIO:TYPE <SearchName>,<Type>
SEARch:TRIGger:MDIO:TYPE? <SearchName>

Selects the event type to search for.

Parameters:
<Type> STARt | STOP | DATA

STARt
Searches for the start of frame (SOF).

STARt
Searches for the end of frame (EOF).

DATA
Allows to specify a payload data pattern (both in Clause 22 or Clause 45) or an address pattern (in Clause 45, only) to search for.

*RST: STARt

Parameters for setting and query:
<SearchName>

20.17.15.5 Search Results

In all `SEARch:RESult:MDIO:WORD<m>` commands, the suffix <m> selects the packet number in the list of search results.

SEARch:RESult:MDIO:WORD<m>:DATA? <SearchName>

Returns the 16-bit payload data field content (in Clause 22 or Clause 45), or the 16-bit address field content (in Clause 45, only) from the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:PHYS? <SearchName>

Returns the 5-bit address field content (PHYAD/PRTAD) from the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<PhyAd> Range: 0 to 32
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:REGI? <SearchName>

Returns the 5-bit register or device address field content (REGAD/DEVAD) from the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<RegAd> Range: 0 to 32
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:ST? <SearchName>

Returns the start of frame code from the selected word within the search result.

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<StartCode> Range: 0 to 3
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:STARt? <SearchName>

Returns the start time of the frame from the selected word within the search result.

Suffix:

<m> *

Query parameters:
<SearchName>

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:STATe? <SearchName>

Returns the state of the frame from the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<State> OK | UNSYN | UNSYncronized | OPCO | TA_ERROR | INComplete | SHORT | SHORt

OK
No error detected

UNSYN = UNSYncronized
UNSYncronized happens when bits are found, but they are not correlated with any synchronization sequence. We don't know what these bits are, but they are there. These bits receive a flag, but they are not decoded.

OPCO
OPcode error

TA_ERROR
turnaround time error

INComplete
Incomplete Frame

SHORT = SHORt
Length Error

*RST: OK

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:STOP? <SearchName>

Returns the stop time of the frame from the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<Stop>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:SYMBol? <SearchName>

Returns a textual translation (called Register Name) of the PHY or port address label from the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Translation>

Usage: Query only

SEARch:RESult:MDIO:WORD<m>:TYPE? <SearchName>

Returns the frame type (= operation code or OpCode) for the selected word within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FrameType>	Range:	0 to 3
	Increment:	1
	*RST:	0

Note that the user interface shows interpretations of the numerical OpCode values corresponding to Clause 45: "0" (= [bin]00) represents Address, "1" (= [bin]01" represents Write, "2" (= [bin]10) represents Post Read, "3" (= [bin]11) represents Read. Clause 22 is not represented by this interpretation.

Usage: Query only

SEARch:RESult:MDIO:WCOunt? <SearchName>

Returns the word count within the search result.

Query parameters:
<SearchName>

Return values:

<FrameCount>	Range:	0 to 100000
	Increment:	1
	*RST:	0

Usage: Query only

20.17.16 USB 3.1 (Option R&S RTP-K61)

20.17.16.1 Configuration

In all `BUS<m>:USBT` commands, the suffix <m> selects the serial bus.

BUS<m>:USBThree:SOURce <SourceData>

Selects the source for the data signal in the USB 3.1 protocol.

Suffix:
<m> 1..4

Parameters:
<SourceData> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
*RST: C1W1

Usage: Asynchronous command

BUS<m>:USBThree:POLarity <Polarity>

Defines the polarity of the data signal for the active (U0) state of the port.

Suffix:
<m> 1..4

Parameters:
<Polarity> NORMal | INVert

NORMal
Normal (non-inverted) data signal polarity

INVert
Inverted data signal polarity

*RST: NORMal

BUS<m>:USBThree:THRHigh <ThresholdUpper>

Defines the upper threshold level for digitization of the data signal in the USB 3.1 protocol.

Suffix:
<m> 1..4

Parameters:
<ThresholdUpper> Range: -2 to 2
Increment: 0.01
*RST: 0.05
Default unit: V

BUS<m>:USBThree:THRLow <ThresholdLower>

Defines the lower threshold level for digitization of the data signal in the USB 3.1 protocol.

Suffix:
<m> 1..4

Parameters:
<ThresholdLower> Range: -2 to 2
Increment: 0.01
*RST: -0.05
Default unit: V

BUS<m>:USBThree:SCRMode <ScrambleMode>

Selects if the data pattern is scrambled or unscambled.

Suffix:
<m> 1..4

Parameters:
<ScrambleMode> SCRM | NSCR

SCRM
Scrambling is enabled as specified in the standard, to minimize EMI emissions.

NSCR
No scrambling: To simplify testing and debugging, scrambling is disabled.

*RST: SCRM

BUS<m>:USBThree:TYPE <Protocol>

Selects the USB 3.1 protocol type.

Suffix:
<m> 1..4

Parameters:
<Protocol> SS | SSP
*RST: SS

Usage: Asynchronous command

20.17.16.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

There are two commands for each parameter, that you can use for defining the USB 3.1 settings.

For example, to set the *Frame type =ACK* > *Field =Route String* >*Data* value you can use one of the following commands:

- `TRIGger:USBThree:FRAMe13:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number. For an overview, see Table 20-11.
- `TRIGger:USBThree:DMIN "ACK", "Route String", 01100`
  Defines the parameter by using the frame and field name.

Table 20-11 gives an overview of the available frame and field numbers. Those numbers follow the GUI numbers.

Table 20-11: Overview of frame and field numbers for USB 3.1

Frame number	Frame name	Field number	Field name
1	TSEQ	1	Symbol
2	TS1	1	Train
		2	Loop
		3	Scramble
		4	LL
		5	Retimer
3	TS1A	-	-

Frame number	Frame name	Field number	Field name
4	TS1B	-	-
5	TS2	1	Train
		2	Loop
		3	Scramble
		4	LL
		5	Retimer
6	Set Link Function	1	SLF
		2	HDr #
		3	Hub #
		4	DLY
		5	DFR
7	U2 Inactivity Timeout	1	U2 IT
		2	HDr #
		3	Hub #
		4	DLY
		5	DFR
8	Vendor Device Test	1	VDT
		2	Vendor Def
		3	HDr #
		4	Hub #
		5	DLY
		6	DFR
9	Port Capability	1	Link Speed
		2	Num HP Buf
		3	Dir
		4	OTG
		5	Tiebreake
		6	HDr #
		7	Hub #
		8	DLY
		9	DFR
10	Port Config	1	Link Speed
		2	HDr #

Frame number	Frame name	Field number	Field name
		3	Hub #
		4	DLY
		5	DFR
11	Port Config Rsp	1	Response Code
		2	HDr #
		3	Hub #
		4	DLY
		5	DFR
12	Link Delay Meas	1	LDM Type
		2	LDMS
		3	Response Delay
		4	HDr #
		5	Hub #
		6	DLY
		7	DFR
13	ACK	1	Route String
		2	Device Address
		3	rty
		4	D
		5	EPTNum
		6	TT
		7	HE
		8	NumP
		9	SeqNum
		10	TPF
		11	StreamId
		12	SSI
		13	WPA
		14	DBI
		15	PP
		16	NBI
		17	HDr #
		18	Hub #

Frame number	Frame name	Field number	Field name
		19	DLY
		20	DFR
14	NRDY	1	Device Address
		2	D
		3	EPTNum
		4	StreamId
		5	HDr #
		6	Hub #
		7	DLY
		8	DFR
15	ERDY	1	Device Address
		2	D
		3	EPTNum
		4	NumP
		5	StreamId
		6	HDr #
		7	Hub #
		8	DLY
		9	DFR
16	Status	1	Route String
		2	Device Address
		3	D
		4	EPTNum
		5	PP
		6	HDr #
		7	Hub #
		8	DLY
		9	DFR
17	Stall	1	Device Address
		2	D
		3	EPTNum
		4	HDr #
		5	Hub #

Frame number	Frame name	Field number	Field name
		6	DLY
		7	DFR
18	Function Wake	1	Device Address
		2	Interface
		3	HDr #
		4	Hub #
		5	DLY
		6	DFR
19	Latency Tolerance	1	Device Address
		2	BELT
		3	HDr #
		4	Hub #
		5	DLY
		6	DFR
20	Bus Interval Adjust	1	Device Address
		2	BusIntAdj
		3	HDr #
		4	Hub #
		5	DLY
		6	DFR
21	Host Role Req	1	Device Address
		2	RSP
		3	HDr #
		4	Hub #
		5	DLY
		6	DFR
22	Sublink Speed	1	Device Address
		2	TPF
		3	LSE
		4	ST
		5	Lanes
		6	LP
		7	LSM

Frame number	Frame name	Field number	Field name
		8	HDr #
		9	Hub #
		10	DLY
		11	DFR
23	Ping	1	Route String
		2	Device Address
		3	D
		4	EPTNum
		5	HDr #
		6	Hub #
		7	DLY
		8	DFR
24	Ping Rsp	1	Device Address
		2	D
		3	EPTNum
		4	HDr #
		5	Hub #
		6	DLY
		7	DFR
25	Data Packet Header	1	Route String
		2	Device Address
		3	SeqNum
		4	EOB
		5	D
		6	EPTNum
		7	TT
		8	S
		9	Length
		10	StreamId
		11	SSI
		12	WPA
		13	DBI
		14	PP

Frame number	Frame name	Field number	Field name
		15	NBI
		16	HDr #
		17	Hub #
		18	DLY
		19	DFR
26	Data Packet Payload	1	Data
27	DPP Aborted	1	Data
28	ITP	1	Counter
		2	Delta
		3	Adj Ctrl
		4	Corr
		5	HDr #
		6	Hub #
		7	DLY
		8	DFR
29	Link Command	1	Sub-type
30	Skip	-	-
31	BRST	-	-
32	BDAT	-	-
33	BERC	-	-
34	BCNT	1	EC
35	Idle	-	-

TRIGger<m>:USBThree:ERENable <ErrorName>, <Enabler>
TRIGger<m>:USBThree:ERRor<n>:ENABle <Enable>

Defines the error type to be triggered on. You can trigger on all error types in parallel.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the error number.

Parameters:

<Enable> ON | OFF
*RST: ON

Example: Trigger on CRC and length errors:
`TRIGger:USBThree:ERRor1:ENABle ON`
Enables CRC Error.
`TRIGger:USBThree:ERENable "Length Error",ON`
Enables Length Error.

TRIGger<m>:USBThree:FRENable <Frame>, <Enabler>
TRIGger<m>:USBThree:FRAMe<n>:ENABle <Enable>

Enables or disables the checking condition for the selected frame.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the frame number.

Parameters:

<Enable> ON | OFF
*RST: OFF

Example: `TRIGger:USBThree:FRAMe1:ENABle ON`
Enables the checking condition for the TSEQ frame.
`TRIGger:USBThree:FRENable "TS1" ON`
Enables the checking condition for the TS1 frame.

TRIGger<m>:USBThree:FIENable <Frame>, <Field>, <Enabler>
TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:ENABle <CondEnabler>

Enables or disables the checking condition for the selected field of the selected frame.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the frame number.

<o> *
Specifies the field number within the frame.

Parameters:

<CondEnabler> ON | OFF

ON
Checking condition enabled

OFF
Checking condition disabled

*RST: OFF

Example: `TRIGger:USBThree:FRAMe1:FLD1:ENABle ON`
Enables the checking condition for the Symbol field of the TSEQ frame.
`TRIGger:USBThree:FRENable "TS1", "Loop" ON`
Enables the checking condition for the Loop field of the TS1 frame.

TRIGger<m>:USBThree:DOPerator <Frame>, <Field>, <Operator>
TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:DOPerator <DataOperator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the field number within the frame.

<o> *

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:DMIN`.

INRange | OORange
In range, out of range. These conditions require a range of endpoint values to be set using `TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:DMIN` and `TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:DMAX`.

*RST: EQUal

TRIGger<m>:USBThree:DMIN <Frame>, <Field>, <Data>
TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:DMIN <DataMin>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the field number within the frame.

<o> *

Parameters:

<DataMin>

TRIGger<m>:USBThree:DMAX <Frame>, <Field>, <Data>
TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:DMAX <DataMax>

Sets the end value of a data pattern range if `TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:DOPerator` is set to `INRange` or `OORange`.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the field number within the frame.

<o> *

Parameters:

<DataMax>

TRIGger<m>:USBThree:BIT <Frame>, <Field>, <Bit>
TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the field number within the frame.

<o> *

Parameters:

<BitState> ONE | ZERO | DC

ONE
1

ZERO
0

DC
"Don't care" (DC) = X

*RST: DC

TRIGger<m>:USBThree:IOPerator <Frame>, <Field>, <Operator>
TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:IOPerator <IndexOperator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the field number within the frame.

<o> *

Parameters:

<IndexOperator> EQUal | INRange | RANGe

EQUal
This condition requires one endpoint value to be set using `TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:IMIN`.

INRange | RANGe
This condition requires a range of endpoint values to be set using `TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:IMIN` and `TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:IMAX`.

*RST: INRange

TRIGger<m>:USBThree:IMIN <Frame>, <Field>, <Data>
TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:IMIN <IndexMin>

Specifies the index, or sets the start value of an index range.

Suffix:

<m> 1..3

<n> *
Specifies the field number within the frame.

<o> *

Parameters:

<IndexMin> Specifies the index value or index start value within the field.
The index range, increment and *RST values depend on the field type.

TRIGger<m>:USBThree:IMAX <Frame>, <Field>, <Data>
TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:IMAX <IndexMax>

Sets the end value of an index range if `TRIGger<m>:USBThree:FRAMe<n>:FLD<o>:IOPerator` is set to `INRange` or `RANGe`.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	* Specifies the field number within the frame.
<o>	*

Parameters:

<IndexMax>	Specifies the end value for the index range within the field. The index range, increment and *RST values depend on the field type.

20.17.16.3 Decode Results

In all `BUS<m>:USBT:RESult:FRAMe<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the frame number in the decode table.

BUS<m>:USBThree:RESult:FCOunt?

Returns the number of decoded frames in the selected serial bus.

Suffix:

<m>	1..4

Return values:

<FrameCount>	Range:	0 to 100000
	Increment:	1

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:INFO?

Returns specific frame information details of the selected frame. This information is also shown in the "Info" column of the decode results table, see Figure 12-86.

Suffix:

<m> 1..4

<n> *

Specifies the frame number.

Return values:

<Info>

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:TYPE?

Returns the frame type for the selected serial bus and frame number.

Suffix:

<m> 1..4

<n> *

Selects the frame number.

Return values:

<FrameType> TSEQ | TS1 | TS1A | TS1B | TS2 | SLF | U2IT | VDT | PCAP | PCNF | PCNR | LDM | ACK | NRDY | ERDY | STATus | STALI | FWAKe | LTM | BIAM | HRR | SSPD | PING | PNGR | DPH | DPHN | DPP | DPPA | ITP | LC | SKIP | BRST | BDAT | BERC | BCNT | IDLE | UHP | ULMP | UTP | UDVN | UDEF | ERRor | CTLB | DATB | SYNC | SDS

For a description of the frame types, see "Frame types" on page 753.

*RST: UDEF

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:STATe?

Returns the status of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m> 1..4

<n> *

Selects the frame number.

Return values:

<State>	OK | INComplete | UNCorrelated | UNKNown | AMB | CRC | LENGth | VOOR | SYMB **VOOR** Value out of range

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:STARt?

Returns the start time of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 Default unit: s

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:STOP?

Returns the stop time of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 Default unit: s

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:TYPE?

Returns the type of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.

<o> *
Selects the field number.

Return values:
<FieldType>

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:STATus?

Returns the status of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:
<m> 1..4

<n> *
Selects the frame number.

<o> *
Selects the field number.

Return values:
<FieldState> OK | INComplete | UNCorrelated | UNKNown | AMB | CRC | LENGth | VOOR | SYMB

VOOR
Value out of range

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:STARt?

Returns the start time of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:
<m> 1..4

<n> *

<o> *

Return values:
<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:STOP?

Returns the stop time of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*
<o>	*

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:VAL?

Returns the value of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:

<FrameValue>

Usage: Query only

BUS<m>:USBThree:RESult:FRAMe<n>:FLD<o>:FVAL?

Returns the formatted value of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:

<ValueFormatted>

Usage: Query only

20.17.16.4 Search Settings

There are two commands for each parameter, that you can use for defining the SSIC search settings.

For example, to set the *Frame type =ACK > Field =Route String >Data* value you can use one of the following commands:

- `SEARch:TRIGger:MPHY:SSIC:FRAMe13:FLD1:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number. For an overview, see Table 20-11.
- `SEARch:TRIGger:MPHY:SSIC:DMIN "ACK", "Route String", 01100`
  Defines the parameter by using the frame and field name.

SEARch:TRIGger:USBThree:ERENable <SearchName>,<ErrorName>, <Enabler>
SEARch:TRIGger:USBThree:ERRor<m>:ENABle <SearchName>,<Enable>
SEARch:TRIGger:USBThree:ERRor<m>:ENABle? <SearchName>

Enables the search for errors. You can search for all error types in parallel.

Suffix:

<m>	* Specifies the error.

Parameters:

<Enable>	ON | OFF *RST: ON

Parameters for setting and query:

<SearchName>	String with the name of the search.

Example: Searches for CRC and length errors:
`SEARch:TRIGger:USBThree:ERRor1:ENABle ON`
Enables searching for CRC Error.
`SEARch:TRIGger:USBThree:ERENable "Length Error",ON`
Enables searching for Length Error.

SEARch:TRIGger:USBThree:FRENable <SearchName>,<Frame>, <Enabler>
SEARch:TRIGger:USBThree:FRAMe<m>:ENABle <SearchName>,<Enable>
SEARch:TRIGger:USBThree:FRAMe<m>:ENABle? <SearchName>

Defines the frame type to be searched for.

Suffix:
<m> *

Parameters:
<Enable> ON | OFF

*RST: OFF

Parameters for setting and query:
<SearchName>

Example: `SEARch:TRIGger:USBThree:FRAMe1:ENABle ON`
Enables searching for the TSEQ frame.
`SEARch:TRIGger:USBThree:FRENable "TS1" ON`
Enables searching for the TS1 frame.

SEARch:TRIGger:USBThree:FIENable <SearchName>,<Frame>, <Field>, <Enabler>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:ENABle <SearchName>,<CondEnabler>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:ENABle? <SearchName>

Enables or disables the checking condition for searching a specific field of the selected frame.

Suffix:
<m> *
Specifies the frame.

<n> *
Specifies the field number within the frame.

Parameters:
<CondEnabler> ON | OFF

ON
Checking condition enabled

OFF
Checking condition disabled

*RST: OFF

Parameters for setting and query:

<SearchName> String with the name of the search.

Example:
`SEARch:TRIGger:USBThree:FRAMe1:FLD1:ENABle ON`
Enables searching for the Symbol field of the TSEQ frame.
`SEARch:TRIGger:USBThree:FRENable "TS1", "Loop" ON`
Enables searching for the Loop field of the TS1 frame.

SEARch:TRIGger:USBThree:DOPerator <SearchName>,<Frame>, <Field>, <Operator>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:DOPerator <SearchName>,<DataOperator>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:DOPerator? <SearchName>

Sets the operator to set a specific data pattern to be searched in the selected field of the selected frame.

Suffix:

<m> *
Specifies the field number within the frame.

<n> *

Parameters:

<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMIN`.

INRange | OORange
In range, out of range. These conditions require a range of endpoint values to be set using `SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMIN` and `SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMAX` on page 1691.

*RST: EQUal

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:USBThree:DMIN <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:DMIN <SearchName>,<DataMin>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:DMIN? <SearchName>

Specifies the data pattern to be searched, or sets the start value of a data pattern range to be searched.

Suffix:

<m> *
Specifies the field number within the frame.

<n> *

Parameters:

<DataMin> Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBThree:FRAMe<m>:TYPE?` on page 1691.

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:USBThree:DMAX <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:DMAX <SearchName>,<DataMax>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:DMAX? <SearchName>

Sets the end value of a data pattern range if `SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:DOPerator` is set to `INRange` or `OORange`.

Suffix:

<m> *
Specifies the field number within the frame.

<n> *

Parameters:

<DataMax> Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBThree:FRAMe<m>:TYPE?` on page 1691.

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:USBThree:BIT <SearchName>,<Frame>, <Field>, <Bit>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:BIT <SearchName>,<BitState>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:BIT? <SearchName>

Sets the bit state of a field to be searched that only consists of one bit.

Suffix:

<m> *
Specifies the frame.

<n> *
Specifies the field number within the frame.

Parameters:

<BitState> ONE | ZERO | DC

ONE
1

ZERO
0

DC
"Don't care" (DC) = X

*RST: DC

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:USBThree:IOPerator <SearchName>,<Frame>, <Field>, <Operator>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IOPerator <SearchName>,<IndexOperator>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IOPerator? <SearchName>

Sets the operator for the index for searching in the selected field of the selected frame.

Suffix:

<m> *
Specifies the field number within the frame.

<n> *

Parameters:

<IndexOperator> EQUal | INRange | RANGe

EQUal
This condition requires one endpoint value to be set using `SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMIN`.

INRange | RANGe
This condition requires a range of endpoint values to be set using `SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMIN` and `SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMAX`.

*RST: INRange

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:USBThree:IMIN <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMIN <SearchName>,<IndexMin>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMIN? <SearchName>

Specifies the index at which the data is to be searched, or sets the start value of an index range in which the data is to be searched.

Suffix:

<m> *
Specifies the field number within the frame.

<n> *

Parameters:

<IndexMin> Specifies the index value or the start value of an index range within the field.
The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:USBThree:IMAX <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMAX <SearchName>,<IndexMax>
SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IMAX? <SearchName>

Sets the end value of an index range if `SEARch:TRIGger:USBThree:FRAMe<m>:FLD<n>:IOPerator` is set to `INRange` or `RANGe`.

Suffix:

<m> *
Specifies the field number within the frame.

<n> *

Parameters:

<IndexMax> Specifies the end value for the index range within the field.
The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<SearchName> String with the name of the search.

20.17.16.5 Search Results

In all `SEARch:RESult:USBThree:FRAMe<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:USBThree:FRAMe<m>:TYPE? <SearchName>

Returns the frame type for the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameType> TSEQ | TS1T | TS2T | SLF | U2IT | VDT | PCAP | PCNF | PCNR | LDM | ACK | NRDY | ERDY | STATus | STALI | FWAKe | LTM | BIAM | HRR | SSPD | PING | PNGR | DPH | DPP | DPPA | ITP | LC | SKIP | BRST | BDAT | BERC | BCNT | IDLE | UHP | ULMP | UTP | UDVN | UDEF | ERRor

For a description of the frame types, see "Frame types" on page 753.

Usage: Query only

SEARch:RESult:USBThree:FRAMe<m>:INFO? <SearchName>

Returns specific frame information details of the selected frame in the search result. This information is also shown in the "Info" column of the decode results table, see Figure 12-86.

Suffix:
<m> *
Specifies the frame number.

Query parameters:
<SearchName>

Return values:
<Info>

Usage: Query only

SEARch:RESult:USBThree:FCOunt? <SearchName>

Returns the number of decoded frames in the search result.

Query parameters:
<SearchName>

Return values:
<FrameCount>

Usage: Query only

SEARch:RESult:USBThree:FRAMe<m>:STATe? <SearchName>

Returns the status of the frame with the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<State> OK | INComplete | UNCorrelated | UNKNown | AMB | CRC | LENGth | VOOR | SYMB

VOOR
Value out of range

Usage: Query only

SEARch:RESult:USBThree:FRAMe<m>:STARt? <SearchName>

Returns the start time of the frame with the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

SEARch:RESult:USBThree:FRAMe<m>:STOP? <SearchName>

Returns the stop time of the frame with the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:TYPE? <SearchName>

Returns the field name of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:
<m> *

<n> *
Selects the field number.

Query parameters:
<SearchName>

Return values:
<FieldType>

Usage: Query only

SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:STATus? <SearchName>

Returns the field status of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:
<m> *

<n> *
Selects the field number.

Query parameters:
<SearchName>

Return values:
<FieldState> OK | INComplete | UNCorrelated | UNKNown | AMB | CRC | LENGth | VOOR | SYMB

VOOR
Value out of range

Usage: Query only

SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:STARt? <SearchName>

Returns the start time of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<Start>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:STOP? <SearchName>

Returns the stop time of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:VAL? <SearchName>

Returns the value of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	* Selects the field number.

Query parameters:
<SearchName>

Return values:
<ByteValue>

Usage: Query only

SEARch:RESult:USBThree:FRAMe<m>:FLD<n>:FVAL? <SearchName>

Returns the formatted value of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	* Selects the field number.

Query parameters:
<SearchName>

Return values:
<ValueFormatted>

Usage: Query only

20.17.17 USBPD (Option R&S RTP-K63)

20.17.17.1 Configuration

In all `BUS<m>:USBPd` commands, the suffix <m> selects the serial bus.

BUS<m>:USBPd:DETail <Detail>

If enabled, the data words are broken down into subframes. If not enabled the data words are displayed as 32-bit data words.

Suffix:
<m> 1..4

Parameters:
<Detail> ON | OFF
*RST: OFF

BUS<m>:USBPd:HYSTeresis <Hysteresis>

Sets a value for the hysteresis of the data.

Suffix:
<m> 1..4

Parameters:
<Hysteresis> Range: -10 to 10
Increment: 0.01
*RST: 0.05
Default unit: V

BUS<m>:USBPd:SOURce <SourceData>

Selects the source for the data signal in the USBPD protocol.

For triggering on a serial bus, analog input channels are required.

Suffix:
<m> 1..4

Parameters:
<SourceData> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
*RST: C1W1

Usage: Asynchronous command

BUS<m>:USBPd:THReshold <Threshold>

Sets the threshold value of the data.

Suffix:
<m> 1..4

Parameters:
<Threshold> Range: -10 to 10
Increment: 0.01
*RST: 0.6
Default unit: V

BUS<m>:USBPd:THRBottom <ThresholdBot>

Sets the bottom threshold (for the low current) for the current advertisment mode.

Suffix:
<m> 1..4

Parameters:
<ThresholdBot> Range: -10 to 10
Increment: 0.01
*RST: 0.2
Default unit: V

BUS<m>:USBPd:THRMid <ThresholdMid>

Sets the middle threshold (at default USB Type-C currnet) for the current advertisment mode.

Suffix:
<m> 1..4

Parameters:
<ThresholdMid> Range: -10 to 10
Increment: 0.01
*RST: 0.66
Default unit: V

BUS<m>:USBPd:THRTop <ThresholdTop>

Sets the top threshold (at USB Type-C currnet of 1.5 A) for the current advertisment mode.

Suffix:
<m> 1..4

Parameters:
<ThresholdTop> Range: -10 to 10
Increment: 0.01
*RST: 1.23
Default unit: V

20.17.17.2 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

There are two commands for each parameter, that you can use for defining the USBPD settings.

For example, to set the *Frame type =Control Frame* > *Field =MsgID >Data* value you can use one of the following commands:

- `TRIGger:USBPD:FRAMe3:FLD3:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number. For an overview, see Overview of frame and field numbers for USBPD.
- `TRIGger:USBPD:DMIN "Control", "MsgID", 01100`
  Defines the parameter by using the frame and field name.

Table 20-12 gives an overview of the available frame and field numbers. Those numbers follow the GUI numbers.

Table 20-12: Overview of frame and field numbers for USBPD

Frame number	Frame name	Field number	Field name
1	Test Frame	-	-
2	Reset	-	-
3	Control frame	1	Extended
		2	NumDataObjs
		3	MsgID

Frame number	Frame name	Field number	Field name
		4	PwrRole/Plug
		5	Rev
		6	DataRole
		7	MsgType
4	Data Frame	1	Extended
		2	NumDataObjs
		3	MsgID
		4	PwrRole/Plug
		5	Rev
		6	DataRole
		7	MsgType
		8	DATA
5	Extended	1	Extended
		2	NumDataObjs
		3	MsgID
		4	PwrRole/Plug
		5	Rev
		6	DataRole
		7	MsgType
		8	Chunked
		9	Chunk Num
		10	Req Chunk
		11	Data Size
		12	DATA

TRIGger<m>:USBPd:ERENable <ErrorName>, <Enabler>
TRIGger<m>:USBPd:ERRor<n>:ENABle <Enable>

Enables or disables the checking condition for a specific error in the selected field of the selected frame.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the error number.

Parameters:

<Enable> ON | OFF
*RST: ON

Example: `TRIGger:USBPd:ERRor1:ENABle ON`
Enables CRC Error.
`TRIGger:USBPd:ERENable "Length Error",ON`
Enables Length Error.

TRIGger<m>:USBPd:FRENable <Frame>, <Enabler>
TRIGger<m>:USBPd:FRAMe<n>:ENABle <Enable>

Enables or disables the checking condition for the selected frame.

Suffix:

<m> 1..3
Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.

<n> *
Specifies the frame number.

Parameters:

<Enable> ON | OFF
*RST: OFF

Example: `TRIGger:USBPd:FRAMe1:ENABle ON`
Enables searching for for the Test frame.
`TRIGger:USBPd:FRENable "Control Frame" ON`
Enables searching for the Control frame.

TRIGger<m>:USBPd:FIENable <Frame>, <Field>, <Enabler>
TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:ENABle <CondEnabler>

Enables or disables the checking condition for a specific data pattern in the selected field of the selected frame.

Suffix:

<m>	1..3 Only 1 = A-trigger, 2 | 3 = not available. Can be omitted.
<n>	* Specifies the frame.
<o>	* Specifies the field number within the frame.

Parameters:

<CondEnabler> ON | OFF

ON
Checking condition enabled

OFF
Checking condition disabled

*RST: OFF

Example:

```
TRIGger:USBPd:FRAMe3:FLD1:ENABle ON
```
Enables the checking condition for the Extended field of the Control frame.
```
TRIGger:USBPd:FRENable "Data Frame", "Data
Role" ON
```
Enables the checking condition for the Data Role field of the Data frame.

TRIGger<m>:USBPd:BIT <Frame>, <Field>, <Bit>
TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:BIT <BitState>

Sets the bit state of a field that only consists of one bit.

Suffix:

<m>	1..3
<n>	*
<o>	* Specifies the field number within the frame.

Parameters:

<BitState> ONE | ZERO | DC

ONE
1

ZERO
0

DC
"Don't care" (DC) = X

*RST: DC

TRIGger<m>:USBPd:DMAX <Frame>, <Field>, <Data>
TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:DMAX <DataMax>

Sets the end value of a data pattern range if TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:DMAX is set to INRange or OORange.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.
<o>	*

Parameters:

<DataMax>	Specifies the name of the generic trigger setting frame, see BUS<m>:USBPd:RESult:FRAMe<n>:TYPE? on page 1709.

TRIGger<m>:USBPd:DMIN <Frame>, <Field>, <Data>
TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:DMIN <DataMin>

Specifies the data pattern, or sets the start value of a data pattern range.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.
<o>	*

Parameters:

<DataMin>

TRIGger<m>:USBPd:DOPerator <Frame>, <Field>, <Operator>
TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:DOPerator <DataOperator>

Sets the operator for the data pattern in the selected field of the selected frame.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.
<o>	*

Parameters:

<DataOperator>	EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:DMIN.

INRange | OORange
In range, out of range. These conditions require a range of endpoint values to be set using TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:DMIN and TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:DMAX.

*RST: EQUal

TRIGger<m>:USBPd:IMAX <Frame>, <Field>, <Data>
TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:IMAX <IndexMax>

Sets the end value of an index range if TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:IOPerator on page 1704 is set to INRange or RANGe.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.
<o>	*

Parameters:

<IndexMax>	Specifies the end value for the index range within the field. The index range, increment and *RST values depend on the field type.

TRIGger<m>:USBPd:IMIN <Frame>, <Field>, <Data>
TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:IMIN <IndexMin>

Specifies the index, or sets the start value of an index range.

Suffix:

<m>	1..3
<n>	* Specifies the field number within the frame.
<o>	*

Parameters:

<IndexMin>	Specifies the index value or index start value within the field. The index range, increment and *RST values depend on the field type.

TRIGger<m>:USBPd:IOPerator <Frame>, <Field>, <Operator>
TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:IOPerator <IndexOperator>

Sets the operator for the index in the selected field of the selected frame.

Suffix:

<m>	1..3
<n>	*
<o>	*

Parameters:

<IndexOperator> EQUal | INRange | RANGe

EQUal
This condition requires one endpoint value to be set using `TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:IMIN`.

INRange | RANGe
This condition requires a range of endpoint values to be set using `TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:IMIN` and `TRIGger<m>:USBPd:FRAMe<n>:FLD<o>:IMAX`.

*RST: INRange

20.17.17.3 Decode Results

In all `BUS<m>:USBPd:RESult:FRAMe<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the frame number in the decode table.

BUS<m>:USBPd:RESult:FCOunt?

Returns the number of decoded frames in the selected serial bus.

Suffix:

<m> 1..4

Return values:

<FrameCount> Range: 0 to 100000
Increment: 1

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:DATA?

Returns the data from the frame with the selected frame number (for the selected serial bus). This is the hex value of the first four bytes of data fields, prefixed by the total number of data fields (in square brackets), e.g. `[5]FF008041`.

Suffix:

<m> 1..4

<n> *

Return values:

<Data>

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:FVAL?

Returns the formatted value of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m> 1..4

<n> *
Selects the frame number.

<o> *
Selects the field number.

Return values:

<FrameByteValue>

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:STATus?

Returns the status of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m> 1..4

<n> *
Selects the frame number.

<o> *
Selects the field number.

Return values:

<FieldState> OK | UNKNown | INComplete | PREamble | SOP | CRC | LENGth | FBFB

SOP
Start of packet warning

CRC
Cyclic redundancy check error

FBFB
4b5b error

*RST: OK

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:STARt?

Returns the start time of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m> 1..4

<n> *

<o> *

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:STOP?

Returns the stop time of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m> 1..4

<n> *

<o> *

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:TYPE?

Returns the type of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:
<FieldType>

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:FLD<o>:VAL?

Returns the value of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:
<FrameByteValue>

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:INFO?

Returns information on the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:
<Info>

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:STARt?

Returns the start time of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<Start>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:STATe?

Returns the status of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<State>
OK | UNKNown | INComplete | PREamble | SOP | CRC | LENGth | FBFB

SOP
Start of packet warning

CRC
Cyclic redundancy check error

FBFB
4b5b error

*RST: OK

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:STOP?

Returns the stop time of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:USBPd:RESult:FRAMe<n>:TYPE?

Returns the frame type for the selected serial bus and frame number.

Suffix:

<m> 1..4

<n> *

Return values:

<FrameType> STARt | RESet | CTRL | DATA | BIST | RQST | SINK | SRC | VEND | BATT | ALRT | XMSG | XSRC | XSTA | XGBC | XGBS | XBAC | XGMI | XMFI | XSRQ | XSRS | XFRQ | XFRS | TEST | LOWP | UNKNown

For a description of the frame types, see "Frame packet types" on page 773.

*RST: UNKNown

Usage: Query only

20.17.17.4 Search Settings

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.
- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

There are two commands for each parameter, that you can use for defining the USBPD settings.

For example, to set the *Frame type =Control Frame > Field =MsgID >Data* value you can use one of the following commands:

- `SEARch:TRIGger:USBPD:FRAMe3:FLD3:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number. For an overview, see Table 20-12.
- `SEARch:TRIGger:USBPD:DMIN "Control", "MsgID", 01100`
  Defines the parameter by using the frame and field name.

SEARch:TRIGger:USBPd:ERENable <SearchName>,<ErrorName>, <Enabler>
SEARch:TRIGger:USBPd:ERRor<m>:ENABle <SearchName>,<Enable>
SEARch:TRIGger:USBPd:ERRor<m>:ENABle? <SearchName>

Enables or disables the checking condition for searching a specific error in the selected field of the selected frame.

Suffix:

<m> *
Specifies the error number.

Parameters:

<Enable> ON | OFF
*RST: ON

Parameters for setting and query:

<SearchName>

Example:
`SEARch:TRIGger:USBPd:ERRor1:ENABle ON`
Enables searching for CRC Error.
`SEARch:TRIGger:USBPd:ERENable "Length Error",ON`
Enables searching for Length Error.

SEARch:TRIGger:USBPd:FRENable <SearchName>,<Frame>, <Enabler>
SEARch:TRIGger:USBPd:FRAMe<m>:ENABle <SearchName>,<Enable>
SEARch:TRIGger:USBPd:FRAMe<m>:ENABle? <SearchName>

Suffix:

<m> *
Specifies the frame number.

Parameters:

<Enable> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName>

Example:

```
SEARch:TRIGger:USBPd:FRAMe1:ENABle ON
```

Enables the checking condition for the Test frame.

```
SEARch:TRIGger:USBPd:FRENable "Control Frame"
ON
```

Enables the checking condition for the Control frame.

SEARch:TRIGger:USBPd:FIENable <SearchName>,<Frame>, <Field>, <Enabler>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:ENABle <SearchName>,<CondEnabler>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:ENABle? <SearchName>

Enables or disables the checking condition for searching a specific data pattern in the selected field of the selected frame.

Suffix:

<m> *
Specifies the frame.

<n> *
Specifies the field number within the frame.

Parameters:

<CondEnabler> ON | OFF

ON
Checking condition enabled

OFF
Checking condition disabled

*RST: OFF

Parameters for setting and query:

<SearchName> String with the name of the search.

Example:

```
SEARch:TRIGger:USBPd:FRAMe3:FLD1:ENABle ON
```

Enables searching for the Extended field of the Control frame.

```
SEARch:TRIGger:USBPd:FRENable "Data Frame",
"Data Role" ON
```

Enables searching for the Data Role field of the Data frame.

SEARch:TRIGger:USBPd:BIT <SearchName>,<Frame>, <Field>, <Bit>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:BIT <SearchName>,<BitState>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:BIT? <SearchName>

Sets the bit state of a field to be searched that only consists of one bit.

Suffix:

<m> *
Specifies the frame.

<n> *
Specifies the field number within the frame.

Parameters:

<BitState> ONE | ZERO | DC

ONE
1

ZERO
0

DC
"Don't care" = X

*RST: DC

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:USBPd:DMAX <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DMAX <SearchName>,<DataMax>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DMAX? <SearchName>

Sets the end value of a data pattern range if `SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DOPerator` is set to `INRange` or `OORange`.

Suffix:

<m> *
Specifies the frame.

<n> *
Specifies the field number within the frame.

Parameters:

<DataMax> Specifies the name of the generic trigger setting frame, see `SEARch:RESult:USBPd:FRAMe<m>:TYPE?` on page 1719.

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:USBPd:DMIN <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DMIN <SearchName>,<DataMin>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DMIN? <SearchName>

Specifies the data pattern to be searched, or sets the start value of a data pattern range to be searched.

Suffix:

<m> *
Specifies the frame.

<n> *
Specifies the field number within the frame.

Parameters:
<DataMin> Specifies the name of the generic trigger setting frame, see SEARch:RESult:USBPd:FRAMe<m>:TYPE? on page 1719.

Parameters for setting and query:
<SearchName> String with the name of the search.

SEARch:TRIGger:USBPd:DOPerator <SearchName>,<Frame>, <Field>, <Operator>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DOPerator <SearchName>,<DataOperator>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DOPerator? <SearchName>

Sets the operator to set a specific data pattern to be searched in the selected field of the selected frame.

Suffix:
<m> *
Specifies the frame.

<n> *
Specifies the field number within the frame.

Parameters:
<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DMIN.

INRange | OORange
In range, out of range. These conditions require a range of endpoint values to be set using SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DMIN and SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:DMAX.

*RST: EQUal

Parameters for setting and query:
<SearchName> String with the name of the search.

SEARch:TRIGger:USBPd:IMAX <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IMAX <SearchName>,<IndexMax>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IMAX? <SearchName>

Sets the end value of an index range if SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IOPerator is set to INRange or RANGe.

Suffix:

<m> *
Specifies the frame.

<n> *
Specifies the field number within the frame.

Parameters:

<IndexMax> Specifies the end value for the index range within the field.
The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:USBPd:IMIN <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IMIN <SearchName>,<IndexMin>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IMIN? <SearchName>

Specifies the index at which the data is to be searched, or sets the start value of an index range in which the data is to be searched.

Suffix:

<m> *
Specifies the frame.

<n> *
Specifies the field number within the frame.

Parameters:

<IndexMin> Specifies the index value or the start value of an index range within the field.
The index range, increment and *RST values depend on the field type.

Parameters for setting and query:

<SearchName> String with the name of the search.

SEARch:TRIGger:USBPd:IOPerator <SearchName>,<Frame>, <Field>, <Operator>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IOPerator <SearchName>,<IndexOperator>
SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IOPerator? <SearchName>

Sets the operator for the index for searching in the selected field of the selected frame.

Suffix:

<m> *
Specifies the frame.

<n> *
Specifies the field number within the frame.

Parameters:

<IndexOperator> EQUal | INRange | RANGe

EQUal
This condition requires one endpoint value to be set using `SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IMIN`.

INRange | RANGe
This condition requires a range of endpoint values to be set using `SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IMIN` and `SEARch:TRIGger:USBPd:FRAMe<m>:FLD<n>:IMAX`.

*RST: INRange

Parameters for setting and query:
<SearchName> String with the name of the search.

20.17.17.5 Search Results

In all `SEARch:RESult:USBPd:FRAMe<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:USBPd:FCOunt? <SearchName>

Returns the number of decoded frames in the search result.

Query parameters:
<SearchName>

Return values:
<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:DATA? <SearchName>

Searches for data from the frame with the selected frame number (for the selected serial bus). This is the hex value of the first four bytes of data fields, prefixed by the total number of data fields (in square brackets), e.g. `[5]FF008041`.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:FVAL? <SearchName>

Returns the formatted value of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:
<m> *

<n> *
Selects the field number.

Query parameters:
<SearchName>

Return values:
<ValueFormatted>

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:STATus? <SearchName>

Returns the field status of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:
<m> *

<n> *
Selects the field number.

Query parameters:
<SearchName>

Return values:
<FieldState> OK | UNKNown | INComplete | PREamble | SOP | CRC | LENGth | FBFB

SOP
Start of packet warning

CRC
Cyclic redundancy check error

FBFB
4b5b error

*RST: OK

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:STARt? <SearchName>

Returns the start time of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:STOP? <SearchName>

Returns the stop time of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	*

Query parameters:

<SearchName>

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:TYPE? <SearchName>

Returns the field name of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	* Selects the field number.

Query parameters:
<SearchName>

Return values:
<FieldType>

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:FLD<n>:VAL? <SearchName>

Returns the value of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:
<m> *

<n> *
Selects the field number.

Query parameters:
<SearchName>

Return values:
<ByteValue>

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:INFO? <SearchName>

Returns specific frame information details of the selected frame in the search result. This information is also shown in the "Info" column of the decode results table.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Info>

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:STARt? <SearchName>

Returns the start time of the frame with the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:STATe? <SearchName>

Returns the status of the frame with the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<State> OK | UNKNown | INComplete | PREamble | SOP | CRC | LENGth | FBFB

SOP
Start of packet warning

CRC
Cyclic redundancy check error

FBFB
4b5b error

*RST: OK

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:STOP? <SearchName>

Returns the stop time of the frame with the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
Default unit: s

Usage: Query only

SEARch:RESult:USBPd:FRAMe<m>:TYPE? <SearchName>

Returns the frame type for the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameType> STARt | RESet | CTRL | DATA | BIST | RQST | SINK | SRC | VEND | BATT | ALRT | XMSG | XSRC | XSTA | XGBC | XGBS | XBAC | XGMI | XMFI | XSRQ | XSRS | XFRQ | XFRS | TEST | LOWP | UNKNown

For a description of the frame types, see "Frame packet types" on page 773.

*RST: UNKNown

Usage: Query only

20.17.18 PCIe Gen 1/2 (Option R&S RTP-K72)

20.17.18.1 Configuration

In all `BUS<m>:PCIE` commands, the suffix <m> selects the serial bus.

BUS<m>:PCIE:DSCRambling <Active>

Enables descrambling of the data.

Suffix:
<m> 1..4

Parameters:
<Active> ON | OFF
*RST: ON

BUS<m>:PCIE:GEN <Generation>

Sets the generation of the PCIe technology.

Suffix:
<m> 1..4

Parameters:
<Generation> V1 | V2

V1
PCIe Gen1 (2.5 Gbit/s)

V2
PCIe Gen2 (5 Gbit/s)

*RST: V1

BUS<m>:PCIE:LNKW <LinkWidth>

Sets the link width, the number of lanes that are used for the transmission of the data.

Suffix:
<m> 1..4

Parameters:
<LinkWidth> X1 | X2 | X4
*RST: X1

BUS<m>:PCIE:LZER:SOURce <SourceL0>

Sets the signal sources for Lane 0.

Suffix:
<m> 1..4

Parameters:
<SourceL0> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4
*RST: C1W1

BUS<m>:PCIE:LONE:SOURce <SourceL1>
BUS<m>:PCIE:LTWO:SOURce <SourceL2>
BUS<m>:PCIE:LTHRee:SOURce <SourceL3>

Sets the signal sources for the corresponding logical lane.

Suffix:

<m>	1..4

Parameters:

<SourceL3> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | NONE

*RST: LONe: C2W1, LTWo: C3W1, LTHree: C4W1

BUS<m>:PCIE:LZER:THRHigh <ThresholdL0High>
BUS<m>:PCIE:LONE:THRHigh <ThresholdL1High>
BUS<m>:PCIE:LTWO:THRHigh <ThresholdL2High>
BUS<m>:PCIE:LTHRee:THRHigh <ThresholdL3High>

Sets the high threshold value for the respective lane.

Suffix:

<m>	1..4

Parameters:

<ThresholdL3High>

Range: -5 to 5
Increment: 1E-3
*RST: 0.02
Default unit: V

BUS<m>:PCIE:LZER:THRLow <ThresholdL0Low>
BUS<m>:PCIE:LONE:THRLow <ThresholdL1Low>
BUS<m>:PCIE:LTWO:THRLow <ThresholdL2Low>
BUS<m>:PCIE:LTHRee:THRLow <ThresholdL3Low>

Sets the lower threshold value for the respective lane.

Suffix:

<m>	1..4

Parameters:

<ThresholdL3Low>

Range: -5 to 5
Increment: 1E-3
*RST: -0.02
Default unit: V

20.17.18.2 Clock Data Recovery

BUS<m>:CDR:BITRate <Bitrate>

Sets the quiescent frequency of the PLL. It corresponds to the data rate of the data stream from which the clock is to be recovered.

Suffix:

<m>	1..4

Parameters:

<Bitrate>	Range:	100 to 5E+9
	Increment:	10
	*RST:	1E+9
	Default unit:	bps

BUS<m>:CDR:PLL:BWIDth <PLLBandwidth>

Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization. The PLL bandwidth is usually defined by the transmission standard.

Suffix:

<m>	1..4

Parameters:

<PLLBandwidth>	Range:	20E+3 to 10E+6
	Increment:	10
	*RST:	599.88E+3
	Default unit:	Hz

BUS<m>:CDR:PLL:DAMPing <DampingFactor>

Sets the damping factor, which is only relevant for second order PLL.

Suffix:

<m>	1..4

Parameters:

<DampingFactor>	Range:	0.5 to 1
	Increment:	0.01
	*RST:	0.7

BUS<m>:CDR:PLL:ORDer <PLLOrder>

Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.

Suffix:

<m>	1..4

Parameters:

<PLLOrder>	FIRSt | SECond	
	*RST:	FIRSt

BUS<m>:CDR:PLL:RELBwidth <PLLRelBw>

Sets the relative bandwidth, that is the ratio of the nominal bit rate to the PLL bandwidth.

Suffix:
<m> 1..4

Parameters:
<PLLRelBw> Range: 10 to 5000
Increment: 1
*RST: 1667

BUS<m>:CDR:RESults <Results>

The PLL requires some time to synchronize to the phase of the data stream. You can select when the CDR algorithm returns clock edges.

Suffix:
<m> 1..4

Parameters:
<Results> ALL | AISYnc
*RST: AISYnc

BUS<m>:CDR:SYNC <InitialSync>

Defines the phase reference for the first clock edge.

Suffix:
<m> 1..4

Parameters:
<InitialSync> SAMPle | DATaedge

SAMPle
The first clock edge matches the first sample of the waveform at the left border of the display.

DATaedge
The first clock edge matches the first edge of the data signal.

*RST: SAMPle

20.17.18.3 Trigger

The trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on serial buses.

To trigger on a serial bus, make sure that:

- `TRIGger<m>:SOURce` is set to `SBUS`.
- The source(s) of the serial bus are channel signals: use `BUS<m>:...:SOURce` commands.

- Decoding is enabled: `BUS<m>[:STATe]` is set to `ON`.

TRIGger<m>:PCIE:DLLP:FCTL:CRET <CreditType>

Sets credit type value to be triggered on for the data link layer trigger.

Parameters:

<CreditType>	ANY | P | NP | CPL
	*RST: ANY

TRIGger<m>:PCIE:DLLP:FCTL:VCID <VirtualChnID>

Sets the virtual channel ID to be triggered on for the data link layer trigger.

Parameters:

<VirtualChnID>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN
	*RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:AUTH <Authorized>

Sets the authorized presence state to be triggered on for the data link layer trigger.

Parameters:

<Authorized>	ANY | YES | NO
	*RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:CRET <CreditType>

Sets the credit type to be triggered on for the multi-root data link layer trigger.

Parameters:

<CreditType>	ANY | DATA | HEADER
	*RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:DVPT <DevicePortType>

Sets the device/port type to be triggered on for the data link layer trigger.

Parameters:

<DevicePortType>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN | EIGHT | NINE | TEN | ELEVEN | TWELVE | THIRTEEN | FOURTEEN | FIFTEEN
	*RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:HABS <VHAbsent>

Sets the state of the absent virtual hieararchies (VH) to be triggered on for the data link layer trigger.

Parameters:

<VHAbsent>	ANY | YES | NO
	*RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:MIXT <MixedType>

Sets the mixed type presence state to be triggered on for the data link layer trigger.

Parameters:
<MixedType> ANY | YES | NO
*RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:PHAS <Phase>

Sets the phase state to be triggered on for the data link layer trigger.

Parameters:
<Phase> ANY | YES | NO
*RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:RESA <ResetA>

Sets the on the value of the A bit to be triggered on for the data link layer trigger.

Parameters:
<ResetA> ANY | ACK | REQUEST
*RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:TLPT <TLPType>

Sets the multi-root type to be triggered on for the data link layer trigger.

Parameters:
<TLPType> ANY | P | NP | CPL

P
Posted credit.

NP
Non posted credit.

CL
Completion credit.

*RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:TYPE <Type>

Sets the multi-root type for the data link layer to be triggered on.

Parameters:
<Type> MRINIT | MRRESET | MRUPDATEFC | MRINITFC1 | MRINITFC2
*RST: MRINIT

TRIGger<m>:PCIE:DLLP:MULT:VHFC <InitVHFC>

Sets the virtual hierarchies flow control presence state to be triggered on for the data link layer trigger.

Parameters:

<InitVHFC>	ANY | YES | NO *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:VHGR <ResetVHGroup>

Sets the virtual hierarchies group to be triggered on for the data link layer trigger.

Parameters:

<ResetVHGroup>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN | EIGHT | NINE | TEN | ELEVEN | TWELVE | THIRTEEN | FOURTEEN | FIFTEEN *RST: ANY

TRIGger<m>:PCIE:DLLP:MULT:VLNR <VirtualLink>

Sets the virtual link (VL) number to be triggered on for the data link layer trigger.

Parameters:

<VirtualLink>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN *RST: ANY

TRIGger<m>:PCIE:DLLP:POWM <PowerMngtType>

Sets the power management type to be triggered on for the data link layer trigger.

Parameters:

<PowerMngtType>	ANY | ENTERL1 | ENTERL23 | ACTREQL1 | REQUESTACK *RST: ANY

TRIGger<m>:PCIE:DLLP:SEQ <ACKNAKSequence>

Sets the sequence field, indicating what TLPs are affected by the ACK/NAK, to be triggered on for the data link layer trigger.

Parameters:

<ACKNAKSequence>

TRIGger<m>:PCIE:DLLP:TYPE <Type>

Sets the DLLP t type to be triggered on for the data link layer trigger.

Parameters:

<Type>	ANY | MRDLLP | ACK | NAK | INITFC1 | INITFC2 | UPDATEFC | PM | VENDOR *RST: ANY

TRIGger<m>:PCIE:DLLP:VPAT <VendorBtPatt>

Sets the vendor pattern to be triggered on for the data link layer trigger.

Parameters:

<VendorBtPatt>	24-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:ERRC:CRC <CRC16>

Enables triggering on 16-bit cyclic redundancy check (CRC) errors.

Parameters:

<CRC16>	ON | OFF
	*RST: OFF

TRIGger<m>:PCIE:ERRC:DISP <Disparity>

Enables triggering on disparity errors.

Parameters:

<Disparity>	ON | OFF
	*RST: OFF

TRIGger<m>:PCIE:ERRC:ECRC <ECRC>

Enables triggering on end-to-end cyclic redundancy checksum (ECRC) errors.

Parameters:

<ECRC>	ON | OFF
	*RST: OFF

TRIGger<m>:PCIE:ERRC:INVP <InvalidSymbol>

Enables triggering on invalid symbol errors.

Parameters:

<InvalidSymbol>	ON | OFF
	*RST: OFF

TRIGger<m>:PCIE:ERRC:LCRC <LCRC>

Enables triggering on link cyclic redundancy check (LCRC) errors.

Parameters:

<LCRC>	ON | OFF
	*RST: OFF

TRIGger<m>:PCIE:OSET:TYPE <Type>

Sets the ordered set to be triggered on.

Parameters:

<Type> SKP | TS1 | TS2 | FTS | EIOS | EIEOS | COMP

SKP
SKP ordered sets

TS1
Training sequence 1

TS2
Training sequence 2

FTS
Fast training sequence

EIOS
Electrical idle ordered set

EIEOS
Electrical idle exit ordered set

COMP
Compliance pattern

*RST: SKP

TRIGger<m>:PCIE:TLP:ADRT <AddressType>

Sets the address type to be triggered on for the transaction layer type trigger.

Parameters:

<AddressType> ANY | X32 | X64

*RST: ANY

TRIGger<m>:PCIE:TLP:CFGT <ConfigType>

Sets the configuration type to be triggered on for the transaction layer type trigger.

Parameters:

<ConfigType> ANY | TYPE0 | TYPE1

*RST: ANY

TRIGger<m>:PCIE:TLP:CPID <TLPCompleterID>

Sets the completer ID to be triggered on for the transaction layer type trigger.

Parameters:

<TLPCompleterID> 16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:TLP:CPLS <CplStatus>

Sets the completion status to be triggered on for the transaction layer type trigger.

Parameters:

<CplStatus>	ANY | SUCCESS | UNSUPPORTED | RETRY | ABORT *RST: ANY

TRIGger<m>:PCIE:TLP:DEID <TLPDeviceID>

Sets the device ID to be triggered on for the transaction layer type trigger.

Parameters:

<TLPDeviceID>	16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:TLP:MERW <MemRW>

Sets the read/ write type to be triggered on for the transaction layer type trigger.

Parameters:

<MemRW>	ANY | READ | WRITE *RST: ANY

TRIGger<m>:PCIE:TLP:MSGC <TLPMessageCode>

Sets the message code to be triggered on for the transaction layer type trigger.

Parameters:

<TLPMessageCode>	8-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:TLP:MSGR <MsgRouting>

Sets the message routing type to be triggered on for the transaction layer type trigger.

Parameters:

<MsgRouting>	ANY | ROOTCOMPLEX | ADDRESS | DEVICEID | BROADCAST | LOCAL | GATHERED *RST: ANY

TRIGger<m>:PCIE:TLP:ORDE <Ordering>

Sets the ordering type to be triggered on for the transaction layer type trigger.

Parameters:

<Ordering>	ANY | STRONG | RELAX *RST: ANY

TRIGger<m>:PCIE:TLP:REID <TLPRequesterID>

Sets the requester ID to be triggered on for the transaction layer type trigger.

Parameters:

<TLPRequesterID> 16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:TLP:SNOO <Snoop>

Sets the snoop state to be triggered on for the transaction layer type trigger.

Parameters:

<Snoop> ANY | YES | NO

*RST: ANY

TRIGger<m>:PCIE:TLP:SNUM <TLPSeqNo>

Sets the sequence numbe to be triggered on for the transaction layer type trigger.

Parameters:

<TLPSeqNo> 12-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

TRIGger<m>:PCIE:TLP:TCHN <TrafficClass>

Sets the traffic class to be triggered on for the transaction layer type trigger.

Parameters:

<TrafficClass> ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN

*RST: ANY

TRIGger<m>:PCIE:TLP:TYPE <Type>

Sets the transaction type to be triggered on for the transaction layer type trigger.

Parameters:

<Type> ANY | MEM | IO | CFG | MSG | CPL | FETCH | SWAP | CAS

*RST: ANY

TRIGger<m>:PCIE:TYPE <Type>

Sets the trigger type for the PCI express analysis..

Parameters:

<Type> TLP | DLLP | ORD | ERR

*RST: TLP

20.17.18.4 Decode Results

In all `BUS<m>:PCIE:RESult:PACKet<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the frame number in the decode table.

BUS<m>:PCIE:RESult:PACKet<n>:ADDR?

Returns the packet address for the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<Address>	Range:	0 to 0
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:CPID?

Returns the completer ID of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<CompleterID> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:CPS?

Returns the completion status field value of the specified packet.

Suffix:

<m> 1..4

<n> *

Return values:

<CplStatus> RESERVED | SC | UR | CRS | CA

RESERVED
Others

SC
Successful Completion

UR
Unsupported Request

CRS
Configuration Request Retry Status

CA
Completer Abort

*RST: RESERVED

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:DATA?

Returns the data value of the specified packet.

Suffix:

<m> 1..4

<n> *

Return values:

<Data>

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:DFC?

Returns the credit value of the payload data of the specified packet.

Suffix:

<m> 1..4

<n> *

Return values:

<DataFC>	Range:	0 to 4095
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:FCOunt?

Returns the number of decoded fields in the selected packet.

Suffix:

<m> 1..4

<n> *

Return values:

<FieldCount>	Range:	0 to 65535
	Increment:	1
	*RST:	0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:FLD<o>:FVAL?

Returns the formatted value of the field with the selected field number within the frame with the selected packet number (for the selected serial bus).

Suffix:

<m> 1..4

<n> *

<o> *
Selects the field number.

Return values:

<ValueFormatted> String parameter

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:FLD<o>:STATus?

Returns the status of the frame with the selected field number within the packet with the selected packet number (for the selected serial bus).

Suffix:

<m> 1..4

<n> *

<o> *
Selects the field number.

Return values:
<State> OK | MALF | CRC16 | ECRC | LCRC | LEN | POE | MEE | UNCorrelated

MALF
Mal formated packet

CRC16
CRC16 error

ECRC
ECRC error

LCRC
LCRC error

LEN
Length error

POE
TLP prefix error

MEE
Max end-end TLP prefix error

*RST: OK

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:FLD<o>:TYPE?

Returns the type of the field with the selected field number within the frame with the selected packet number (for the selected serial bus).

Suffix:
<m> 1..4

<n> *

<o> *
Selects the field number.

Return values:
<Type>

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:FLD<o>:VAL?

Returns the value of the field with the selected field number within the packet with the selected packet number (for the selected serial bus).

Suffix:
<m> 1..4

<n> *

<o> *
Selects the field number.

Return values:
<FieldValue> Range: 0 to 0
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:HFC?

Returns the credit value of the header of the specified packet.

Suffix:
<m> 1..4

<n> *

Return values:
<HeaderFC> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:LEN?

Returns the length of the specified packet.

Suffix:
<m> 1..4

<n> *

Return values:
<Length> Range: 0 to 1023
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:RQID?

Returns the requester ID of the specified packet.

Suffix:
<m> 1..4

<n> *

Return values:
<RequesterID> Range: 0 to 65535
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:SEQN?

Returns the sequence number of the specified packet.

Suffix:

<m> 1..4

<n> *

Return values:

<SequenceNumber> Range: 0 to 4095
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:STARt?

Returns the start time of the specified packet.

Suffix:

<m> 1..4

<n> *

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:STATe?

Returns the state of the specified packet.

Suffix:

<m> 1..4

<n> *

Return values:

<State> OK | MALF | CRC16 | ECRC | LCRC | LEN | POE | MEE | UNCorrelated

MALF
Mal formated packet

CRC16
CRC16 error

ECRC
ECRC error

LCRC
LCRC error

LEN
Length error

POE
TLP prefix error

MEE
Max end-end TLP prefix error

*RST: OK

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:STOP?

Returns the stop time of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop>
Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:TAG?

Returns the tag of the specified packet.

Suffix:

<m>	1..4
<n>	*

Return values:

<Tag>
Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:PCIE:RESult:PACKet<n>:TYPE?

Returns the type of the specified packet. For a description of the packet types, see Chapter 12.17.1, "The PCIe Protocol", on page 789.

Suffix:

<m>	1..4

<n> *

Return values:

<Type> MRD32 | MRD64 | MRDLK32 | MRDLK64 | MWR32 | MWR64 | IORD | IOWR | CFGRD0 | CFGWR0 | CFGRD1 | CFGWR1 | MSG | MSGD | CPL | CPLD | CPLLK | CPLDLK | FA32 | FA64 | SWP32 | SWP64 | CAS32 | CAS64 | LPRFX | EPRFX | ACK | NAK | PMEL1 | PMEL23 | PMASRL1 | PMRA | VENDS | IFC1P | IFC1NP | IFC1CPL | IFC2P | IFC2NP | IFC2CPL | UPDFCP | UPDFCNP | UPDFCCPL | MRUPDFC | MRIFC1 | MRIFC2 | MRINIT | MRRESET | UNK | SKPOS | EIOS | FTSOS | TS1OS | TS2OS | EIEOS | COMPL | MCOMPL

*RST: UNK

Usage: Query only

BUS<m>:PCIE:RESult:PCOunt?

Returns the packet count for the selected serial bus, i.e. the number of packets in the present acquisition.

Suffix:

<m> 1..4

Return values:

<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

20.17.18.5 Search Settings

SEARch:TRIGger:PCIE:DLLP:FCTL:CRET <SearchName>,<CreditType>
SEARch:TRIGger:PCIE:DLLP:FCTL:CRET? <SearchName>

Sets credit type value to be searched for, for the data link layer.

Parameters:

<CreditType> ANY | P | NP | CPL

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:DLLP:FCTL:VCID <SearchName>,<VirtualChnID>
SEARch:TRIGger:PCIE:DLLP:FCTL:VCID? <SearchName>

Sets the virtual channel ID to be searched for, for the data link layer.

Parameters:

<VirtualChnID> ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:AUTH <SearchName>,<Authorized>
SEARch:TRIGger:PCIE:DLLP:MULT:AUTH? <SearchName>

Sets the authorized presence state to be searched for, for the data link layer.

Parameters:

<Authorized>	ANY | YES | NO *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:CRET <SearchName>,<CreditType>
SEARch:TRIGger:PCIE:DLLP:MULT:CRET? <SearchName>

Sets the credit type to be searched for, for the data link layer.

Parameters:

<CreditType>	ANY | DATA | HEADER *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:DVPT <SearchName>,<DevicePortType>
SEARch:TRIGger:PCIE:DLLP:MULT:DVPT? <SearchName>

Sets the device/port type to be searched for, for the data link layer.

Parameters:

<DevicePortType>	ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN | EIGHT | NINE | TEN | ELEVEN | TWELVE | THIRTEEN | FOURTEEN | FIFTEEN *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:HABS <SearchName>,<VHAbsent>
SEARch:TRIGger:PCIE:DLLP:MULT:HABS? <SearchName>

Sets the state of the absent virtual hieararchies (VH) to be searched for, for the data link layer.

Parameters:

<VHAbsent>	ANY | YES | NO *RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:MIXT <SearchName>,<MixedType>
SEARch:TRIGger:PCIE:DLLP:MULT:MIXT? <SearchName>

Sets the mixed type presence state to be searched for, for the data link layer.

Parameters:

<MixedType> ANY | YES | NO

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:PHAS <SearchName>,<Phase>
SEARch:TRIGger:PCIE:DLLP:MULT:PHAS? <SearchName>

Sets the phase state to be searched for, for the data link layer.

Parameters:

<Phase> ANY | YES | NO

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:RESA <SearchName>,<ResetA>
SEARch:TRIGger:PCIE:DLLP:MULT:RESA? <SearchName>

Sets the on the value of the A bit to be searched for, for the data link layer.

Parameters:

<ResetA> ANY | ACK | REQUEST

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:TLPT <SearchName>,<Type>
SEARch:TRIGger:PCIE:DLLP:MULT:TLPT? <SearchName>

Sets the multi-root type to be searched for, for the data link layer.

Parameters:

<Type> ANY | P | NP | CPL

P
Posted credit.

NP
Non posted credit.

CL
Completion credit.
*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:TYPE <SearchName>,<MRType>
SEARch:TRIGger:PCIE:DLLP:MULT:TYPE? <SearchName>

Sets the multi-root type to be searched for, for the data link layer.

Parameters:
<MRType> MRINIT | MRRESET | MRUPDATEFC | MRINITFC1 | MRINITFC2
*RST: MRINIT

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:VHFC <SearchName>,<InitVHFC>
SEARch:TRIGger:PCIE:DLLP:MULT:VHFC? <SearchName>

Sets the virtual hierarchies flow control presence state to be searched for, for the data link layer.

Parameters:
<InitVHFC> ANY | YES | NO
*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:VHGR <SearchName>,<ResetVHGroup>
SEARch:TRIGger:PCIE:DLLP:MULT:VHGR? <SearchName>

Sets the virtual hierarchies group to be searched for, for the data link layer.

Parameters:
<ResetVHGroup> ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN | EIGHT | NINE | TEN | ELEVEN | TWELVE | THIRTEEN | FOURTEEN | FIFTEEN
*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:MULT:VLNR <SearchName>,<VirtualLink>
SEARch:TRIGger:PCIE:DLLP:MULT:VLNR? <SearchName>

Sets the virtual link (VL) number to be searched for, for the data link layer.

Parameters:
<VirtualLink> ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:POWM <SearchName>,<PowerMngtType>
SEARch:TRIGger:PCIE:DLLP:POWM? <SearchName>

Sets the power management type to be searched for, for the data link layer.

Parameters:
<PowerMngtType> ANY | ENTERL1 | ENTERL23 | ACTREQL1 | REQUESTACK

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:SEQ <SearchName>,<ACKNAKSequence>
SEARch:TRIGger:PCIE:DLLP:SEQ? <SearchName>

Sets the sequence field, indicating what TLPs are affected by the ACK/NAK, to be searched for, for the data link layer.

Parameters:
<ACKNAKSequence>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:TYPE <SearchName>,<Type>
SEARch:TRIGger:PCIE:DLLP:TYPE? <SearchName>

Sets the DLLP t type to be searched for, for the data link layer.

Parameters:
<Type> ANY | MRDLLP | ACK | NAK | INITFC1 | INITFC2 | UPDATEFC | PM | VENDOR

*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:DLLP:VPAT <SearchName>,<VendorBtPatt>
SEARch:TRIGger:PCIE:DLLP:VPAT? <SearchName>

Sets the vendor pattern to be searched for, for the data link layer.

Parameters:

<VendorBtPatt> 24-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:ERRC:CRC <SearchName>,<CRC16>
SEARch:TRIGger:PCIE:ERRC:CRC? <SearchName>

Enables searching for 16-bit cyclic redundancy check (CRC) errors.

Parameters:

<CRC16> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:ERRC:DISP <SearchName>,<Disparity>
SEARch:TRIGger:PCIE:ERRC:DISP? <SearchName>

Enables searching for disparity errors.

Parameters:

<Disparity> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:ERRC:ECRC <SearchName>,<ECRC>
SEARch:TRIGger:PCIE:ERRC:ECRC? <SearchName>

Enables searching for end-to-end cyclic redundancy checksum (ECRC) errors.

Parameters:

<ECRC> ON | OFF

*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:ERRC:INVP <SearchName>,<InvalidSymbol>
SEARch:TRIGger:PCIE:ERRC:INVP? <SearchName>

Enables searching for invalid symbol errors.

Parameters:
<InvalidSymbol> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:ERRC:LCRC <SearchName>,<LCRC>
SEARch:TRIGger:PCIE:ERRC:LCRC? <SearchName>

Enables searching for link cyclic redundancy check (LCRC) errors.

Parameters:
<LCRC> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:OSET:COMP <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:COMP? <SearchName>

Enables searching forcompliance pattern ordered sets.

Parameters:
<Format> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:OSET:EIDE <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:EIDE? <SearchName>

Enables searching for electrical idle exit ordered sets.

Parameters:
<Format> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:OSET:EIDL <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:EIDL? <SearchName>

Enables searching for electrical idle ordered sets.

Parameters:

<Format> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:OSET:FTS <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:FTS? <SearchName>

Enables searching for fast training sequence ordered sets.

Parameters:

<Format> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:OSET:SKIP <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:SKIP? <SearchName>

Enables searching for SKP ordered sets.

Parameters:

<Format> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:OSET:TSONe <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:TSONe? <SearchName>

Enables searching for training sequence 1 ordered sets.

Parameters:

<Format> ON | OFF
*RST: OFF

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:OSET:TSTWo <SearchName>,<Format>
SEARch:TRIGger:PCIE:OSET:TSTWo? <SearchName>

Enables searching for training sequence 2 ordered sets.

Parameters:
<Format> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:ADRT <SearchName>,<AddressType>
SEARch:TRIGger:PCIE:TLP:ADRT? <SearchName>

Sets the address type to be searched for in the transaction layer type.

Parameters:
<AddressType> ANY | X32 | X64
*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:CFGT <SearchName>,<CfgType>
SEARch:TRIGger:PCIE:TLP:CFGT? <SearchName>

Sets the configuration type to be searched for in the transaction layer type.

Parameters:
<CfgType> ANY | TYPE0 | TYPE1
*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:CPID <SearchName>,<TLPCompleterID>
SEARch:TRIGger:PCIE:TLP:CPID? <SearchName>

Sets the completer ID to be searched for in the transaction layer type.

Parameters:
<TLPCompleterID> 16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:CPLS <SearchName>,<CplStatus>
SEARch:TRIGger:PCIE:TLP:CPLS? <SearchName>

Sets the completion status to be searched for in the transaction layer type.

Parameters:
<CplStatus> ANY | SUCCESS | UNSUPPORTED | RETRY | ABORT
*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:DEID <SearchName>,<TLPDeviceID>
SEARch:TRIGger:PCIE:TLP:DEID? <SearchName>

Sets the device ID to be searched for in the transaction layer type.

Parameters:
<TLPDeviceID> 16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:MERW <SearchName>,<MemRW>
SEARch:TRIGger:PCIE:TLP:MERW? <SearchName>

Sets the read/ write type to be searched for in the transaction layer type.

Parameters:
<MemRW> ANY | READ | WRITE
*RST: ANY

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:MSGC <SearchName>,<TLPMessageCode>
SEARch:TRIGger:PCIE:TLP:MSGC? <SearchName>

Sets the message code to be searched for in the transaction layer type.

Parameters:
<TLPMessageCode> 8-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:PCIE:TLP:MSGR <SearchName>,<MsgRouting>
SEARch:TRIGger:PCIE:TLP:MSGR? <SearchName>

Sets the message routing type to be searched for in the transaction layer type.

Parameters:

<MsgRouting> ANY | ROOTCOMPLEX | ADDRESS | DEVICEID | BROADCAST | LOCAL | GATHERED

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:TLP:ORDE <SearchName>,<Ordering>
SEARch:TRIGger:PCIE:TLP:ORDE? <SearchName>

Sets the ordering type to be searched for in the transaction layer type.

Parameters:

<Ordering> ANY | STRONG | RELAX

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:TLP:REID <SearchName>,<TLPRequesterID>
SEARch:TRIGger:PCIE:TLP:REID? <SearchName>

Sets the requester ID to be searched for in the transaction layer type.

Parameters:

<TLPRequesterID> 16-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:TLP:SNOO <SearchName>,<Snoop>
SEARch:TRIGger:PCIE:TLP:SNOO? <SearchName>

Sets the snoop state to be searched for in the transaction layer type.

Parameters:

<Snoop> ANY | YES | NO

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:TLP:SNUM <SearchName>,<TLPSeqNo>
SEARch:TRIGger:PCIE:TLP:SNUM? <SearchName>

Sets the sequence numbe to be searched for in the transaction layer type.

Parameters:

<TLPSeqNo> 12-bit pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The string parameter accepts the bit value X (don't care).

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:TLP:TCHN <SearchName>,<TrafficClass>
SEARch:TRIGger:PCIE:TLP:TCHN? <SearchName>

Sets the traffic class to be searched for in the transaction layer type.

Parameters:

<TrafficClass> ANY | ZERO | ONE | TWO | THREE | FOUR | FIVE | SIX | SEVEN

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:TLP:TYPE <SearchName>,<Type>
SEARch:TRIGger:PCIE:TLP:TYPE? <SearchName>

Sets the transaction type to be searched for in the transaction layer type.

Parameters:

<Type> ANY | MEM | IO | CFG | MSG | CPL | FETCH | SWAP | CAS

*RST: ANY

Parameters for setting and query:

<SearchName>

SEARch:TRIGger:PCIE:TYPE <SearchName>,<Type>
SEARch:TRIGger:PCIE:TYPE? <SearchName>

Parameters:

<Type> TLP | DLLP | ORD | ERR

*RST: TLP

Parameters for setting and query:

<SearchName>

20.17.18.6 Search Results

In all `SEARch:RESult:PCIE:PACKet<m>` commands, the suffix <m> selects the frame number in the list of search results.

In search result commands, you have to specify the `<SearchName>` parameter. It is a string parameter that contains the search definition name.

For a description of the returned values, see the corresponding commands in Chapter 20.17.18.4, "Decode Results", on page 1733.

SEARch:RESult:PCIE:PACKet<m>:ADDR? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Address>

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:CPID? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<CompleterID>	Range:	0 to 65535
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:CPS? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<CompleteState> RESERVED | SC | UR | CRS | CA
*RST: RESERVED

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:DATA? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Data>

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:DFC? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<DataFC>	Range:	0 to 4095
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:FCOunt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<FieldCount>	Range: 0 to 65535 Increment: 1 *RST: 0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:FLD<n>:FVAL? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName> String parameter

Return values:
<ValueFormatted> String parameter

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:FLD<n>:STATus? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<State> OK | MALF | CRC16 | ECRC | LCRC | LEN | POE | MEE | UNCorrelated
*RST: OK

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:FLD<n>:TYPE? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<Type>

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:FLD<n>:VAL? <SearchName>

Suffix:
<m> *

<n> *

Query parameters:
<SearchName>

Return values:
<FieldValue> Range: 0 to 0
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:HFC? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<HeaderFC> Range: 0 to 255
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:LEN? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Length> Range: 0 to 1023
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:RQID? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<RequesterID>	Range:	0 to 65535
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:SEQN? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<SequenceNumber>	Range:	0 to 4095
	Increment:	1
	*RST:	0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:STARt? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:STATe? <SearchName>

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<State> OK | MALF | CRC16 | ECRC | LCRC | LEN | POE | MEE | UNCorrelated

*RST: OK

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:STOP? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Stop>

Range: -100E+24 to 100E+24

Increment: 100E-12

*RST: 0

Default unit: s

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:TAG? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Tag>

Range: 0 to 255

Increment: 1

*RST: 0

Usage: Query only

SEARch:RESult:PCIE:PACKet<m>:TYPE? <SearchName>

Suffix:

<m> *

Query parameters:

<SearchName>

Return values:

<Type>

MRD32 | MRD64 | MRDLK32 | MRDLK64 | MWR32 | MWR64 | IORD | IOWR | CFGRD0 | CFGWR0 | CFGRD1 | CFGWR1 | MSG | MSGD | CPL | CPLD | CPLLK | CPLDLK | FA32 | FA64 | SWP32 | SWP64 | CAS32 | CAS64 | LPRFX | EPRFX | ACK | NAK | PMEL1 | PMEL23 | PMASRL1 | PMRA | VENDS | IFC1P | IFC1NP | IFC1CPL | IFC2P | IFC2NP | IFC2CPL | UPDFCP | UPDFCNP | UPDFCCPL | MRUPDFC | MRIFC1 | MRIFC2 | MRINIT | MRRESET | UNK | SKPOS | EIOS | FTSOS | TS1OS | TS2OS | EIEOS | COMPL | MCOMPL

*RST: UNK

Usage: Query only

SEARch:RESult:PCIE:PCOunt? <SearchName>

Query parameters:
<SearchName>

Return values:
<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

20.17.19 DDR3 (Option R&S RTP-K91)

20.17.19.1 Configuration

In all `BUS<m>:DDRThree` commands, the suffix <m> selects the serial bus.

BUS<m>:DDRThree:DATA:HYSTeresis <DataHysteresis>

Sets a value for the hysteresis of the data.

Suffix:
<m> 1..4

Parameters:
<DataHysteresis> Range: 0 to 10
Increment: 0.01
*RST: 0.15
Default unit: V

Usage: Asynchronous command

BUS<m>:DDRThree:DATA:SOURce <DataSource>

Selects the source for the data output signal.

Suffix:
<m> 1..4

Parameters:
<DataSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: C1W1

Usage: Asynchronous command

BUS<m>:DDRThree:STRBe:HYSTeresis <StrobeHyst>

Sets a value for the hysteresis of the strobe.

Suffix:
<m> 1..4

Parameters:
<StrobeHyst> Range: 0 to 10
Increment: 0.01
*RST: 0.35
Default unit: V

Usage: Asynchronous command

BUS<m>:DDRThree:STRBe:SOURce <StrobeSource>

Selects the source for the strobe signal.

Suffix:
<m> 1..4

Parameters:
<StrobeSource> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4 | D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: C2W1

Usage: Asynchronous command

BUS<m>:DDRThree:DATA:THReshold <DataThreshold>

Sets the threshold value for the digitization of the data line.

Suffix:
<m> 1..4

Parameters:

<DataThreshold> Range: -10 to 10
Increment: 0.01
*RST: 0.75
Default unit: V

Usage: Asynchronous command

BUS<m>:DDRThree:STRBe:THReshold <StrobeThreshold>

Sets the threshold value for the digitization of the strobe line.

Suffix:

<m> 1..4

Parameters:

<StrobeThreshold> Range: -10 to 10
Increment: 0.01
*RST: 0
Default unit: V

Usage: Asynchronous command

20.17.19.2 Decode Results

In all `BUS<m>:DDRThree:RESult:FRAMe<n>` commands, the suffix <m> selects the serial bus and the suffix <n> selects the frame number in the decode table.

BUS<m>:DDRThree:RESult:FCOunt?

Returns the number of decoded frames in the selected serial bus.

Suffix:

<m> 1..4

Return values:

<FrameCount> Range: 0 to 100000
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:DDRThree:RESult:FRAMe<n>:FLD<o>:FVAL?

Returns the formatted value of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:
<FrameByteValue>

Usage: Query only

BUS<m>:DDRThree:RESult:FRAMe<n>:FLD<o>:STARt?

Returns the start time of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:

<Start>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:DDRThree:RESult:FRAMe<n>:FLD<o>:STATus?

Returns the status of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:

<State>	OK | UNKNown | INComplete | LENGth *RST: OK

Usage: Query only

BUS<m>:DDRThree:RESult:FRAMe<n>:FLD<o>:STOP?

Returns the stop time of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:

<Stop>	Range: -100E+24 to 100E+24 Increment: 100E-12 *RST: 0 Default unit: s

Usage: Query only

BUS<m>:DDRThree:RESult:FRAMe<n>:FLD<o>:VAL?

Returns the value of the field with the selected field number within the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	* Selects the frame number.
<o>	* Selects the field number.

Return values:

<FrameByteValue>	Range: 0 to 0 Increment: 1 *RST: 0

Usage: Query only

BUS<m>:DDRThree:RESult:FRAMe<n>:NWRDs?

Returns the number of words for the selected serial bus and frame number.

Suffix:

<m>	1..4
<n>	*

Return values:

<NumWords> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

BUS<m>:DDRThree:RESult:FRAMe<n>:STARt?

Returns the start time of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

BUS<m>:DDRThree:RESult:FRAMe<n>:STATe?

Returns the status of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<State> OK | UNKNown | INComplete | LENGth
*RST: OK

Usage: Query only

BUS<m>:DDRThree:RESult:FRAMe<n>:STOP?

Returns the stop time of the frame with the selected frame number (for the selected serial bus).

Suffix:

<m>	1..4
<n>	*

Return values:

<Stop>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

BUS<m>:DDRThree:RESult:FRAMe<n>:TYPE?

Returns the frame type for the selected serial bus and frame number.

Suffix:

<m> 1..4

<n> *

Return values:

<FrameType> READ | WRITe | UNKNown

*RST: UNKNown

Usage: Query only

20.17.19.3 Search Settings

There are two commands for each parameter, that you can use for defining the SSIC search settings.

For example, to set the *Frame type =Read* > *Field =Data* >*Data* value you can use one of the following commands:

- `SEARch:TRIGger:DDRThree:FRAMe1:ENABle:DMIN 01100`
  Defines the parameter by using the index <m> for the frame number and <n> for the field number.
- `SEARch:TRIGger:DDRThree:DMIN "Read", "Data", 01100`
  Defines the parameter by using the frame and field name.

SEARch:TRIGger:DDRThree:ERENable <SearchName>,<ErrorName>, <Enabler>
SEARch:TRIGger:DDRThree:ERRor<m>:ENABle <SearchName>,<Enable>
SEARch:TRIGger:DDRThree:ERRor<m>:ENABle? <SearchName>

Defines the error type to be searched for. You can search for all error types in parallel.

Suffix:
<m> *
Specifies the error.

Parameters:
<Enable> ON | OFF
*RST: ON

Parameters for setting and query:
<SearchName>

Example: `SEARch:TRIGger:DDRThree:ERRor1:ENABle ON`
Enables searching for Frame Incomplete error.
`SEARch:TRIGger:USBThree:ERENable "Length Error",ON`
Enables searching for Length Error.

SEARch:TRIGger:DDRThree:FIENable <SearchName>,<Frame>, <Field>, <Enabler>

Enables or disables the specific field within the defined frame to be searched for.

Setting parameters:
<SearchName>

<Frame>

<Field>

<Enabler> ON | OFF

Usage: Setting only

SEARch:TRIGger:DDRThree:FRAMe<m>:ENABle <SearchName>,<Enable>
SEARch:TRIGger:DDRThree:FRAMe<m>:ENABle? <SearchName>

Enables or disables the specific frame to be searched for.

Suffix:
<m> *

Parameters:
<Enable> ON | OFF
*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DDRThree:DMAX <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DMAX <SearchName>,<DataMax>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DMAX? <SearchName>

Sets the end value of a data pattern range if `SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DOPerator` is set to `INRange` or `OORange`.

Suffix:
<m> *

<n> *

Parameters:
<DataMax>

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DDRThree:DMIN <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DMIN <SearchName>,<DataMin>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DMIN? <SearchName>

Specifies the data pattern to be searched, or sets the start value of a data pattern range to be searched.

Suffix:
<m> *

<n> *

Parameters:
<DataMin> Specifies the name of the generic trigger setting frame.

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DDRThree:DOPerator <SearchName>,<Frame>, <Field>, <Operator>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DOPerator <SearchName>,<DataOperator>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DOPerator? <SearchName>

Sets the operator to set a specific data pattern to be searched in the selected field of the selected frame.

Suffix:
<m> *

<n> *

Parameters:
<DataOperator> EQUal | NEQual | LTHan | LETHan | GTHan | GETHan | INRange | OORange

EQUal | NEQual | LTHan | LETHan | GTHan | GETHan
Equal, Not equal, Less than, Less than or equal, Greater than, Greater than or equal. These conditions require one endpoint value to be set using `SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DMIN`.

INRange | OORange
In range, out of range. These conditions require a range of end-point values to be set using `SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DMIN` and `SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:DMAX`.

*RST: EQUal

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DDRThree:FRENable <SearchName>,<Frame>, <Enabler>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:ENABle <SearchName>,<CondEnabler>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:ENABle? <SearchName>

Enables or disables the checking condition for searching a specific data pattern in the selected field of the selected frame.

Suffix:
<m> *

<n> *

Parameters:
<CondEnabler> ON | OFF

ON
Checking condition is enabled.

OFF
Checking condition is disabled.

*RST: OFF

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DDRThree:IMAX <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IMAX <SearchName>,<IndexMax>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IMAX? <SearchName>

Sets the end value of the bit index range (data position range), if `SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IMAX` is set to `INRange` or `RANGe`.

Suffix:

<m>	*
<n>	*

Parameters:

<IndexMax>
Range: 1 to 65534
Increment: 1
*RST: 65534

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DDRThree:IMIN <SearchName>,<Frame>, <Field>, <Data>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IMIN <SearchName>,<IndexMin>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IMIN? <SearchName>

Sets the index at which the data is to be searched, or sets the start value of an index range in which the data is to be searched.

Suffix:

<m>	*
<n>	*

Parameters:

<IndexMin>
Specifies the index value or the start value of an index range within the field.
The index range, increment and *RST values depend on the field type.
Range: 1 to 65534
Increment: 1
*RST: 1

Parameters for setting and query:
<SearchName>

SEARch:TRIGger:DDRThree:IOPerator <SearchName>,<Frame>, <Field>, <Operator>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IOPerator <SearchName>,<IndexOperator>
SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IOPerator? <SearchName>

Sets the operator for the index for searching in the selected field of the selected frame.

Suffix:

<m> *

<n> *

Parameters:

<IndexOperator> EQUal | INRange | RANGe

EQUal

This condition requires one endpoint value to be set using `SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IMIN`.

INRange | RANGe

This condition requires a range of endpoint values to be set using `SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IMIN` and `SEARch:TRIGger:DDRThree:FRAMe<m>:FLD<n>:IMAX`.

*RST: INRange

Parameters for setting and query:

<SearchName>

20.17.19.4 Search Results

In all `SEARch:RESult:DDRThree:FRAMe<m>` commands, the suffix <m> selects the frame number in the list of search results.

SEARch:RESult:DDRThree:FCOunt? <SearchName>

Returns the number of decoded frames in the search result.

Query parameters:

<SearchName>

Return values:

<FrameCount> Range: 0 to 100000

Increment: 1

*RST: 0

Usage: Query only

SEARch:RESult:DDRThree:FRAMe<m>:FLD<n>:FVAL? <SearchName>

Returns the formatted value of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*	
<n>	*	Selects the field number.

Query parameters:
<SearchName>

Return values:
<BteFormattedVal>

Usage: Query only

SEARch:RESult:DDRThree:FRAMe<m>:FLD<n>:STARt? <SearchName>

Returns the start time of the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*	
<n>	*	Selects the field number.

Query parameters:
<SearchName>

Return values:

<Start>	Range:	-100E+24 to 100E+24
	Increment:	100E-12
	*RST:	0
	Default unit:	s

Usage: Query only

SEARch:RESult:DDRThree:FRAMe<m>:FLD<n>:STATus? <SearchName>

Returns the field status of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m>	*
<n>	*

Query parameters:
<SearchName>

Return values:

<State> OK | UNKNown | INComplete | LENGth

*RST: OK

Usage: Query only

SEARch:RESult:DDRThree:FRAMe<m>:FLD<n>:STOP? <SearchName>

Returns the stop time of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m> *

<n> *

Selects the field number.

Query parameters:

<SearchName>

Return values:

<Stop> Range: -100E+24 to 100E+24

Increment: 100E-12

*RST: 0

Default unit: s

Usage: Query only

SEARch:RESult:DDRThree:FRAMe<m>:FLD<n>:VAL? <SearchName>

Returns the value of the field with the selected field number within the frame with the selected frame number within the search result.

Suffix:

<m> *

<n> *

Selects the field number.

Query parameters:

<SearchName>

Return values:

<ByteValue> Range: 0 to 0

Increment: 1

*RST: 0

Usage: Query only

SEARch:RESult:DDRThree:FRAMe<m>:NWRDs? <SearchName>

Returns the number of words of the selected frame in the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<NumWords> Range: 0 to 4294967295
Increment: 1
*RST: 0

Usage: Query only

SEARch:RESult:DDRThree:FRAMe<m>:STARt? <SearchName>

Returns the start time of the frame with the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Start> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:DDRThree:FRAMe<m>:STATe? <SearchName>

Returns the status of the frame with the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<State> OK | UNKNown | INComplete | LENGth
*RST: OK

Usage: Query only

SEARch:RESult:DDRThree:FRAMe<m>:STOP? <SearchName>

Returns the stop time of the frame with the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<Stop> Range: -100E+24 to 100E+24
Increment: 100E-12
*RST: 0
Default unit: s

Usage: Query only

SEARch:RESult:DDRThree:FRAMe<m>:TYPE? <SearchName>

Returns the frame type for the selected frame number within the search result.

Suffix:
<m> *

Query parameters:
<SearchName>

Return values:
<FrameType> READ | WRITe | UNKNown
*RST: UNKNown

Usage: Query only

20.17.19.5 Eye Diagram Analysis

The suffix EYE<m> selects the eye diagram to which the command applies. You can configure and analyze up to four eye diagrams in parallel.

Basic Setup

EYE<m>[:STATe] <State>

Activates or deactivates the eye diagram.

Suffix:

<m>	1..4

Parameters:

<State>	ON | OFF
	*RST: OFF

EYE<m>:SOURce <MainSource>

Selects the waveform from which the eye diagram is generated (data source). For analog channels, peak detect, envelope, and average waveforms are not supported.

Suffix:

<m>	1..4

Parameters:

<MainSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

EYE<m>:TREFerence[:SOURce] <TimeRefSource>

Selects the waveform that is used to obtain the timing information required to slice the data source waveform.

Suffix:

<m>	1..4

Parameters:

<TimeRefSource>	C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

EYE<m>:TREFerence:SLOPe <TimeRefSlope>

Sets the edge on the timing reference waveform to define the timestamps for slicing the data waveform. A timestamp is set each time, when the selected slope of the timing waveform crosses the selected reference level.

Suffix:

<m>	1..4

Parameters:

<TimeRefSlope>	POSitive | NEGative | EITHer
	*RST: EITHer

EYE<m>:TREFerence:LEVel <TimeRefLevel>

Sets the reference level on the timing reference waveform to define the timestamps for slicing the data waveform. A timestamp is set each time, when the selected slope of the timing waveform crosses the selected reference level.

Suffix:

<m>	1..4

Parameters:

<TimeRefLevel> UPPer | MIDDle | LOWer

*RST: MIDDle

EYE<m>:HORizontal[:UNIT] <TimeUnits>

Sets the method to define the horizontal scale of the eye diagram.

Suffix:

<m> 1..4

Parameters:

<TimeUnits> ATIMe | UINTerval

ATIMe
Absolute time

UINTerval
Unit intervals. You can use unit interval, if the nominal frequency of the clock signal is known.

*RST: UINTerval

EYE<m>:HORizontal:ABSolute:RANGe <HorizontalRange>

Sets the time range that is covered by the eye diagram.

Suffix:

<m> 1..4

Parameters:

<HorizontalRange> Range: 100E-12 to 100
Increment: 1E-9
*RST: 200E-9
Default unit: s

EYE<m>:HORizontal:ABSolute:POSition <HorizPosition>

Sets the place of the zero point in the diagram, in seconds. The zero point is the alignment point on which the slice timestamps are superimposed.

Suffix:

<m> 1..4

Parameters:

<HorizPosition> Range: -100 to 100
Increment: 1E-9
*RST: 0
Default unit: s

EYE<m>:HORizontal:UINTerval:BITRate <Bitrate>

Sets the nominal frequency or bit rate of the data signal.

Suffix:

<m>	1..4

Parameters:

<Bitrate>	Range:	1 to 10E+9
	Increment:	1
	*RST:	10E+6
	Default unit:	bps

EYE<m>:HORizontal:UINTerval:RANGe <RangeUI>

Sets the number of unit intervals that are visible in the eye diagram.

Suffix:

<m>	1..4

Parameters:

<RangeUI>	Range:	1E-6 to 100E+9
	Increment:	0.01
	*RST:	2

EYE<m>:HORizontal:UINTerval:POSition <PositionUI>

Sets the zero point in the diagram, in unit intervals. The zero point is the alignment point on which the segment timestamps are superimposed.

Suffix:

<m>	1..4

Parameters:

<PositionUI>	Range:	-100E+9 to 100E+9
	Increment:	0.01
	*RST:	0

Display

EYE<m>:MSLices <MaxSliceCount>

Sets the number of waveform slices for a single acquisition.

Suffix:

<m>	1..4

Parameters:

<MaxSliceCount>	Range:	1 to 1000000
	Increment:	1
	*RST:	2000

EYE<m>:DISPlay[:MODE] <EyestripeMode>

Defines when the eye stripe is shown: always, never, or during mask tests.

Suffix:
<m> 1..4

Parameters:
<EyestripeMode> ALWays | MTONly | NEVer

MTONly: Mask test only

*RST: MTONly

Qualify: Gate Settings

EYE<m>:QUALify:GATE[:STATe] <State>

Enables the gate.

Suffix:
<m> 1..4

Parameters:
<State> ON | OFF

*RST: OFF

EYE<m>:QUALify:GATE:COUPling <CouplingMode>

Sets the gate coupling. To use cursor lines or zoom areas as gate limits, the cursor or zoom must be defined before.

Suffix:
<m> 1..4

Parameters:
<CouplingMode> NONE | CURSor | ZOOM

*RST: NONE

EYE<m>:QUALify:GATE:MODE <Mode>

Defines whether the gate limit is defined in absolute or relative values when no gate coupling is set.

Suffix:
<m> 1..4

Parameters:

<Mode> ABS | REL

*RST: ABS

EYE<m>:QUALify:GATE:ABSolute:STARt <Start>
EYE<m>:QUALify:GATE:ABSolute:STOP <Stop>

Set the absolute time values for gate start and gate end.

Suffix:

<m> 1..4

Parameters:

<Start>, <Stop> Range: -100E+24 to 100E+24
Increment: 0.01
*RST: 0.01

Example: Gate definition for eye diagram 2 in absolute time values:

```
EYE2:QUALify:GATE:COUPling NONE
EYE2:QUALify:GATE:MODE ABS
EYE2:QUALify:GATE:ABSolute:STARt -0.0002
EYE2:QUALify:GATE:ABSolute:STOP 0.0002
```

EYE<m>:QUALify:GATE:RELative:STARt <RelativeStart>
EYE<m>:QUALify:GATE:RELative:STOP <RelativeStop>

Set the relative values for gate start and gate end.

Suffix:

<m> 1..4

Parameters:

<RelativeStart>, <RelativeStop> Range: 0 to 100
Increment: 0.1
*RST: 100
Default unit: %

Example: Gate definition for eye diagram 2 in relative values:

```
EYE2:QUALify:GATE:COUPling NONE
EYE2:QUALify:GATE:MODE REL
EYE2:QUALify:GATE:RELative:STARt 10
EYE2:QUALify:GATE:RElative:STOP 90
```

EYE<m>:QUALify:GATE:CURSor <Cursorset>

Selects the cursor set to be used for eye gating. The gate area is defined by the cursor lines.

Suffix:

<m> 1..4

Parameters:

<Cursorset>	CURSOR1 | CURSor1 | CURSOR2 | CURSor2 | CURSOR3 | CURSor3 | CURSOR4 | CURSor4 CURSOR1 = CURSor1, CURSOR2 = CURSor2, CURSOR3 = CURSor3, CURSOR4 = CURSor4 *RST: CURSOR1

Example: Gate definition for eye diagram 2 with cursor coupling:

```
EYE2:QUALify:GATE:COUPling CURSor
EYE2:QUALify:GATE:CURSor CURSor1
```

EYE<m>:QUALify:GATE:ZDIagram <ZoomDiagram>

Selects the zoom diagram to be used for eye gating. The zoom area is is used as gate.

Suffix:

<m>	1..4

Parameters:

<ZoomDiagram>	String with the name of the zoom diagram

Example: Gate definition for eye diagram 2 with zoom coupling:

```
EYE2:QUALify:GATE:COUPling ZOOM
EYE2:QUALify:GATE:ZDIagram "Zoom1"
```

Qualify: Signal Settings

EYE<m>:QUALify:SIGNal[:STATe] <State>

Enables the waveform-based qualification for the eye generation.

Suffix:

<m>	1..4

Parameters:

<State>	ON | OFF *RST: OFF

EYE<m>:QUALify:SIGNal:SOURce <Source>

Selects the waveform to be compared.

Suffix:

<m>	1..4

Parameters:

<Source> C1W1 | C2W1 | C3W1 | C4W1 | M1 | M2 | M3 | M4 | R1 | R2 | R3 | R4

EYE<m>:QUALify:SIGNal:CONDition <Condition>

Selects the comparison condition: the waveform level must be greater or less than the threshold.

Suffix:

<m> 1..4

Parameters:

<Condition> LTHan | GTHan

*RST: GTHan

EYE<m>:QUALify:SIGNal:LSELect <LevelSelection>

Selects the threshold. You can use the lower, middle, or upper reference level. These levels are the reference levels that are defined for measurements.

Suffix:

<m> 1..4

Parameters:

<LevelSelection> UPPer | MIDDle | LOWer

*RST: MIDDle

Example: The slices of the channel 1 signal only contribute to the eye generation if the voltage level of the signal on channel 2 is higher than the upper reference level.

```
EYE:SOURce C1W1
EYE:QUALify:SIGNal:SOURce C2W1
EYE:QUALify:SIGNal:CONDition GTHan
EYE:QUALify:SIGNal:LSELect UPPer
EYE:QUALify:SIGNal ON
```

Filter

EYE<m>:FILTer:STATe <State>

Applies the filter settings to the data signal.

Suffix:
<m> 1..4

Parameters:
<State> ON | OFF

*RST: OFF

EYE<m>:FILTer:BPATtern:MODE <Mode>

Selects which bits contribute to the eye generation.

Suffix:
<m> 1..4

Parameters:
<Mode> ABITs | LTRansition | CLEVel | BPATtern

ABITs
All bits contribute to the eye diagram, same as `EYE<m>:FILTer:STATe` is OFF.

LTRansition
Level transition, only bits after a signal transition contribute (0 to 1, or 1 to 0).

CLEVel
Constant level, only bits without a preceding signal transition contribute (0 to 0, or 1 to 1).

BPATtern
Only bits contribute that match the defined pattern before and after the center eye.

*RST: ABITs

EYE<m>:FILTer:BPATtern:PREFix<1..8> <Bit>
EYE<m>:FILTer:BPATtern:CENTer <BitValue>
EYE<m>:FILTer:BPATtern:SUFFix<1..5> <Bit>

Set the values of the indicated prefix, center, and suffix bits.

Suffix:
<m> 1..4

Parameters:
<Bit> ONE | ZERO | DC

DC: don't care

EYE<m>:FILTer:BPATtern:SLEFt

Shifts the pattern one bit to the left.

Suffix:
<m> 1..4

Usage: Event

EYE<m>:FILTer:BPATtern:SRIGht

Shifts the pattern one bit to the right.

Suffix:
<m> 1..4

Usage: Event

EYE<m>:FILTer:BPATtern:RESet

Resets the bit sequence filter to the default (DC for all bits).

Suffix:
<m> 1..4

Usage: Event

Results of Mask Tests on Eye Diagrams

If option R&S RTP-K91 is installed, you can perform mask tests on eye diagrams E1 to E4.

MTESt:RESult:COUNt:SLICes? <MaskTestName>

Returns the number of slices that contributed to the eye diagram.

Query parameters:
<MaskTestName> String parameter

Return values:
<SlicesCompleted> Range: 0 to 100E+24
Increment: 1
*RST: 0

Usage: Query only

MTESt:RESult:COUNt:FSLices? <MaskTestName>

Returns the number of slices that violated the mask.

Query parameters:
<MaskTestName> String parameter

Return values:

<SliceHits>	Range:	0 to 100E+24
	Increment:	1
	*RST:	0

Usage: Query only

MTESt:RESult:VIOLation<m>:COUNt? <MaskTestName>

Suffix:

<m> *

Violation index, corresponds to the number in the "Violation" column of mask test result.

Query parameters:

<MaskTestName>

Return values:

<Count>

Usage: Query only

MTESt:RESult:VIOLation<m>[:SLICe]? <MaskTestName>

Suffix:

<m> *

Violation index, corresponds to the number in the "Violation" column of mask test result.

Query parameters:

<MaskTestName>

Return values:

<Slice>	Range:	0 to 4294967295
	Increment:	1
	*RST:	0

Usage: Query only

MTESt:RESult:VIOLation<m>:STARt? <MaskTestName>
MTESt:RESult:VIOLation<m>:STOP? <MaskTestName>

Return the start and stop time of the slice with the indicated violation.

Suffix:

<m> *

Violation index, corresponds to the number in the "Violation" column of mask test result.

Query parameters:

<MaskTestName>

Return values:

<Time>	Range:	-100 to 100
	Increment:	1E-3
	*RST:	0
	Default unit:	s

Usage: Query only

20.18 Mixed Signal Option (MSO, R&S RTP-B1)

This chaptes decribes the remote commands of MSO option R&S RTP-B1.

20.18.1 Digital Channels

All `DIGital:` commands affect only the settings of the first MSO bus (Bus1). The settings of all other parallel buses (Bus 2, 3,4) remain unchanged.

DIGital<m>:DISPlay <Display>

Enables or disables the indicated digital channel, displays it, and enables the parallel Bus1 if the bus was disabled. That is, `BUS<m>:PARallel:DISPlay:SHDI` and `BUS<m>:PARallel:STATe` are set to ON automatically.

If another active bus already uses the selected digital channel, the instrument disables the other bus to avoid conflicts.

For Bus1, the `DIG:DISP` command has the same effect as `BUS<m>:PARallel:BIT<n>[:STATe]`. To enable digital channels for buses 2, 3 and 4, use the `BUS:PAR:BIT[:STAT]` command.

Suffix:

<m> 0..15
Number of the digital channel

Parameters:

<Display> ON | OFF

Firmware/Software: V 1.30

DIGital<m>:TECHnology <Technology>

Selects the threshold voltage for various types of integrated circuits and applies it to all digital channels.

The setting affects only the settings of the first MSO bus (Bus1). You can set the technology value for all buses with BUS<m>:PARallel:TECHnology.

Suffix:

<m>	0..15 The suffix is irrelevant.

Parameters:

<Technology>	V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN See BUS<m>:PARallel:TECHnology

Firmware/Software: V 1.40

DIGital<m>:THReshold <Value>

Sets the logical threshold for the channel group to which the indicated digital channel belongs. The setting affects only the settings of the first MSO bus (Bus1).

The setting affects only the settings of the first MSO bus (Bus1). You can set the threshold for all buses with BUS<m>:PARallel:TECHnology or BUS<m>:PARallel:THReshold<n>.

See also: DIGital<m>:THCoupling

Suffix:

<m>	0..15 Number of the digital channel. Channel groups: 0..3; 4..7; 8..11; 12..15

Parameters:

<Value>	Range: -8.0 to 8.0 Increment: 200.0e-12 *RST: 0 Default unit: V

Firmware/Software: V 1.30

DIGital<m>:THCoupling <State>

Sets the threshold and the hysteresis for all digital channels of parallel bus 1 to the same value.

The command BUS<m>:PARallel:THCoupling is used to set all buses.

Suffix:

<m> 0..15
The suffix is irrelevant.

Parameters:

<State> ON | OFF

Firmware/Software: V 1.30

DIGital<m>:HYSTeresis <Hysteresis>

Defines the size of the hysteresis to avoid the change of signal states due to noise for the channel group to which the indicated digital channel belongs.

The setting affects only the settings of the first MSO bus (Bus1). You can set the hysteresis for all buses with `BUS<m>:PARallel:HYSTeresis<n>`.

See also: `DIGital<m>:THCoupling`

Suffix:

<m> 0..15
Number of the digital channel
Channel groups: 0..3; 4..7; 8..11; 12..15

Parameters:

<Hysteresis> MAXIMUM | MAXimum | ROBUST | ROBust | NORMAL | NORMal

MAXIMUM = MAXimum
Maximum value that is possible and useful for the signal and its settings

ROBUST = ROBust
Different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system.

NORMAL = NORMal
The instrument sets a value suitable for the signal and its settings.

Firmware/Software: V 1.30

DIGital<m>:LABel <Label>

Sets a name for the indicated digital channel. The name is displayed in the diagram.

The setting affects only the settings of the first MSO bus (Bus1). You can set the label for all buses with `BUS<m>:PARallel:BIT<n>:LABel`.

Suffix:

<m> 0..15
Number of the digital channel

Parameters:

<Label> String containing the channel name

Firmware/Software: V 1.30

DIGital<m>:DESKew <Deskew>

Sets an individual delay for each digital channel to time-align it with other digital channels. The deskew value compensates delays that are known from the circuit specifics or caused by the different length of cables.

The setting affects only the settings of the first MSO bus (Bus1). You can set the deskew for all buses with `BUS<m>:PARallel:BIT<n>:DESKew`.

Suffix:
<m> 0..15
Number of the digital channel

Parameters:
<Deskew> Range: -200.0E-09 to 200.0E-09
Increment: 200.0E-12
*RST: 0
Default unit: s

20.18.2 Parallel Bus Configuration

The following commands configure the four parallel buses of R&S RTP-B1.

BUS<m>:PARallel:STATe <Enable>

Enables or disables the indicated parallel bus. The threshold settings of the bus take effect for all *active* parallel buses.

Dependencies: At least one digital channel must be enabled for the selected bus, otherwise the command does not work. The bus is enabled automatically if the first digital channel is enabled with `BUS<m>:PARallel:BIT<n>[:STATe]` or `DIGital<m>:DISPlay`.

Suffix:

<m> 1..4

Selects the parallel bus.

Parameters:

<Enable> ON | OFF

*RST: OFF

Firmware/Software: V 1.30

BUS<m>:PARallel:BIT<n>[:STATe] <Assigned>

Assigns the selected digital channel to the indicated bus, displays it, and enables the bus if the bus was disabled. That is, `BUS<m>:PARallel:DISPlay:SHDI` and `BUS<m>:PARallel:STATe` are set to ON automatically.

If another active bus already uses the selected digital channel, the instrument disables the other bus to avoid conflicts.

For parallel bus 1, the `BUS:PAR:BIT[:STATe]` command has the same effect as `DIGital<m>:DISPlay`.

Suffix:

<m> 1..4

Selects the parallel bus.

<n> 0..15

Selects the digital channel. Each digital channel provides a definite bit of the bus word.

Parameters:

<Assigned> ON | OFF

*RST: OFF

Firmware/Software: V 1.40

BUS<m>:PARallel:THReshold<n> <Threshold>

Sets the logical threshold for the indicated channel group.

Alternatively, you can set the threshold with `BUS<m>:PARallel:TECHnology`. For the parallel bus 1, you can also use `DIGital<m>:THReshold`.

See also: `DIGital<m>:THCoupling`

Suffix:

<m> 1..4

Selects the parallel bus.

<n> 1..4
Selects the channel group:
1 = dig. channels 0..3;
2 = dig. channels 4..7
3 = dig. channels 8..11
4 = dig. channels 12..15

Parameters:
<Threshold> Range: -8.0 to 8.0
Increment: 200.0e-12
*RST: 0
Default unit: V

BUS<m>:PARallel:TECHnology <Technology>

Selects the threshold voltage for various types of integrated circuits and applies it to all digital channels.

Suffix:
<m> 1..4
Selects the parallel bus.

Parameters:
<Technology> V15 | V25 | V165 | V125 | V09 | VM13 | V38 | V20 | V0 | MAN

V15: TTL
V25: CMOS 5.0 V
V165: CMOS 3.3 V
V125: CMOS 2.5 V
V09: CMOS 1.85 V
VM13: ECL, -1.3 V
V38: PECL
V20: LVPECL
V0: Ground
MAN: Set a user-defined threshold value with `DIGital<m>:THReshold`

*RST: V165

Firmware/Software: V 1.36

BUS<m>:PARallel:THCoupling <LevelCoupling>

Sets the threshold for all digital channels of the selected bus to the same value. Also the hysteresis value is applied to all digital channels.

Tor parallel bus 1, the command `DIGital<m>:THCoupling` has the same effect.

Suffix:
<m> 1..4
The suffix is irrelevant.

Parameters:
<LevelCoupling> ON | OFF
*RST: ON

Firmware/Software: V 1.30

BUS<m>:PARallel:HYSTeresis<n> <Hysteresis>

Defines the size of the hysteresis for the channel group to avoid the change of signal states due to noise.

For the parallel bus 1, you can also use `DIGital<m>:HYSTeresis`.

Suffix:
<m> 1..4
Selects the parallel bus.

<n> 1..4
Selects the channel group:
1 = dig. channels 0..3;
2 = dig. channels 4..7
3 = dig. channels 8..11
4 = dig. channels 12..15

Parameters:
<Hysteresis> MAXIMUM | MAXimum | ROBUST | ROBust | NORMAL | NORMal

MAXIMUM = MAXimum
Maximum value that is possible and useful for the signal and its settings

ROBUST = ROBust
Different hysteresis values for falling and rising edges to avoid an undefined state of the trigger system.

NORMAL = NORMal
The instrument sets a value suitable for the signal and its settings.

BUS<m>:PARallel:BIT<n>:DESKew <Deskew>

Sets an individual delay for each digital channel to time-align it with other digital channels. The deskew value compensates delays that are known from the circuit specifics or caused by the different length of cables.

For the parallel bus 1, you can also use `DIGital<m>:DESKew`.

Suffix:
<m> 1..4
Selects the parallel bus.

<n> 0..15
Number of the digital channel

Parameters:

<Deskew> Range: -200E-9 to 200E-9
Increment: 200E-12
*RST: 0
Default unit: s

BUS<m>:PARallel:DESoffset <DeskewOffset>

Sets a general delay for all digital channels. The resulting deskew of a digital channel is the sum of this general value and the individual value set with `BUS<m>:PARallel:BIT<n>:DESKew`.

Suffix:

<m> 1..4
Selects the parallel bus.

Parameters:

<DeskewOffset> Range: -200E-9 to 200E-9
Increment: 200E-12
*RST: 0
Default unit: s

BUS<m>:PARallel:BIT<n>:LABel <Label>

Sets a name for the indicated digital channel. The name is displayed in the diagram.

For the parallel bus 1, you can also use `DIGital<m>:LABel`.

Suffix:

<m> 1..4
Selects the parallel bus.

<n> 0..15
Number of the digital channel

Parameters:

<Label> String containing the channel name

Firmware/Software: V 1.40

BUS<m>:PARallel:DISPlay:SHDI <ShwDigSigns>

If enabled, the selected digital signals are shown in the diagram. Each channel is displayed as a logic signal.

See also: `DIGital<m>:DISPlay`

Suffix:

<m> 1..4
Selects the parallel bus.

Parameters:
<ShwDigSigns> ON | OFF
*RST: OFF

Firmware/Software: V 1.30

BUS<m>:PARallel:DISPlay:SHBU <ShowBus>

Shows or hides the indicated parallel bus. If enabled, the resulting bus signal and bus values are displayed in the diagram.

Suffix:
<m> 1..4
Selects the parallel bus.

Parameters:
<ShowBus> ON | OFF
*RST: OFF

Firmware/Software: V 1.30

BUS<m>:PARallel:DISPlay:BTYP <BusRepres>

Selects the display type of the indicated parallel bus.

Suffix:
<m> 1..4
Selects the parallel bus.

Parameters:
<BusRepres> COMB | ANALog

COMB
Displays the decoded bus signal with bus values.

ANALog
Displays the bus value as amplitude, similar to an analog waveform.

*RST: COMB

Firmware/Software: V 1.30

BUS<m>:PARallel:CLON <Clocked>

Defines if the bus is a clocked bus - one of the digital channels serves as clock of the bus.

Suffix:
<m> 1 | 2
Selects the parallel bus. The clocked bus is available on parallel buses 1 and 2.

Parameters:

<Clocked> ON | OFF

*RST: OFF

BUS<m>:PARallel:CLOCk <ClockSource>

Selects the digital channel used as clock of the indicated parallel bus.

Suffix:

<m> 1 | 2
Selects the parallel bus. The clocked bus is available on parallel buses 1 and 2.

Parameters:

<ClockSource> D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

Clock channel

*RST: D1

BUS<m>:PARallel:CLSLope <ClockSlope>

Selects the slope of the clock signal at which all digital channels of the bus are analyzed.

Suffix:

<m> 1 | 2
Selects the parallel bus. The clocked bus is available on parallel buses 1 and 2.

Parameters:

<ClockSlope> POSitive | NEGative | EITHer

*RST: POSitive

BUS<m>:PARallel:CLEar

Removes all assigned digital channels from the bus

Suffix:

<m> 1..4
Selects the parallel bus.

Usage: Event

Firmware/Software: V 1.30

20.18.3 Digital Resolution

ACQuire:DRESolution?

Returns the current digital resolution of the digital channels.

Return values:

<DigRes>	Default unit: s
Usage:	Query only

ACQuire:POINts:DVALue?

Returns the current digital record length used by each digital channel.

Return values:

<DigReclgth>	Range: 1000 to 200E6 Increment: 2 *RST: 1000 Default unit: Sa
Usage:	Query only

20.18.4 Trigger Settings for Digital Signals and Parallel Buses

In all `TRIGger<m>:PARallel` commands, the trigger suffix <m> is always 1 and can be omitted. It selects the trigger event: Only the A-trigger is available for triggering on digital signals and parallel buses.

20.18.4.1 General Commands

TRIGger<m>:SOURce <SourceDetailed>

Selects the source of the trigger signal.

Suffix:

<m> 1..3
1 = A-trigger, 2 = B-trigger, 3 = R-event
Available values depend on the selected trigger source. For input channels CHAN1...4, a trigger sequence can be configured.
For all other trigger sources, only suffix 1 is allowed.
See also: `TRIGger<m>:SEQuence:MODE`

Parameters:

<SourceDetailed> CHAN1 | CHANNEL1 | CHAN2 | CHANNEL2 | CHAN3 | CHANNEL3 | CHAN4 | CHANNEL4 | EXTernanalog

CHAN1 = CHANNEL1, CHAN2 = CHANNEL2, CHAN3 = CHANNEL3, CHAN4 = CHANNEL4
Input channels

EXTernanalog
External analog signal connected to the External Trigger Input.
For this source, only the analog edge trigger is available.

SBUS
Serial bus

D0...D15
Digital channels (option R&S RTP-B1)
See also: Chapter 20.18.4, "Trigger Settings for Digital Signals and Parallel Buses", on page 1795

LOGIc
Logic combination of digital channels, used as trigger source (option R&S RTP-B1)

MSOB1 | MSOB2 | MSOB3 | MSOB4
Parallel bus (option R&S RTP-B1)

*RST: CHAN1

TRIGger<m>:PARallel:TYPE <Type>

Selects the trigger type to trigger on digital channels and parallel buses.

To trigger on analog channels or the external trigger input, use `TRIGger<m>:TYPE`.

Parameters:

<Type> EDGE | WIDTh | TIMeout | DATatoclock | STATe | PATTern | SERPattern

*RST: EDGE

TRIGger<m>:PARallel:DATatoclock:CSOurce[:VALue] <ClockSource>
TRIGger<m>:PARallel:STATe:CSOurce:VALue <ClockSource>
TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue] <ClockSource>

Selects the digital channel of the clock signal.

Parameters:

<ClockSource> D0 | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 | D11 | D12 | D13 | D14 | D15

*RST: D0

TRIGger<m>:PARallel:EDGE:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:WIDTh:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:STATe:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:PATTern:EXPRession[:DEFine] <LogicalExpr>
TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine] <LogicalExpr>

Defines a logical combination of several digital channels as trigger condition if `TRIGger<m>:SOURce` is set to LOGIC.

Parameters:

<LogicalExpr> String with logical expression

Example: `TRIGger:PARallel:EDGE:EXPRession 'D1 and D2'`

20.18.4.2 Edge Trigger

See also:

- `TRIGger<m>:PARallel:EDGE:EXPRession[:DEFine]` on page 1797

TRIGger<m>:PARallel:EDGE:SLOPe <Slope>

Defines the edge - the state transition - of the signal to trigger on a single digital channel (a logic bit), or a logical combination of digital channels.

Parameters:

<Slope> POSitive | NEGative | EITHer

*RST: POSitive

20.18.4.3 Width Trigger

See also:

- `TRIGger<m>:PARallel:WIDTh:EXPRession[:DEFine]` on page 1797

TRIGger<m>:PARallel:WIDTh:POLarity <Polarity>

Sets the polarity of a pulse. When triggering on a positive pulse, the trigger event occurs on the high to low transition of the pulse if the timing condition is true. When triggering on a negative pulse, the trigger event occurs on the low to high transition of the pulse if the timing condition is true.

Parameters:

<Polarity> POSitive | NEGative | EITHer

*RST: POSitive

TRIGger<m>:PARallel:WIDTh:RANGe <RangeMode>

Selects how the range of a pulse width is defined:

Parameters:

<RangeMode> WITHin | OUTSide | SHORter | LONGer

WITHin | OUTSide
Pulses inside or outside a given time range. The time range *Width ± Delta* is defined by `TRIGger<m>:PARallel:WIDTh:WIDTh` and `TRIGger<m>:PARallel:WIDTh:DELTa`.

SHORter | LONGer
Pulses shorter or longer than a given width defined by `TRIGger<m>:PARallel:WIDTh:WIDTh`

*RST: WITHin

TRIGger<m>:PARallel:WIDTh:WIDTh <Width>

Sets the limit for the pulse width.

The effect depends on `TRIGger<m>:PARallel:WIDTh:RANGe`.

- For the ranges SHORter and LONGer, the width defines the maximum and minimum pulse width, respectively.
- For the ranges WITHin and OUTSide, the width defines the center of a range which is defined by the limits `TRIGger<m>:PARallel:WIDTh:DELTa`.

Parameters:

<Width> Range: 200E-12 to 10000
Increment: 200E-9
*RST: 5E-9
Default unit: s

TRIGger<m>:PARallel:WIDTh:DELTa <WidthDelta>

Defines a range around the given width value. the setting is relevant if `TRIGger<m>:PARallel:WIDTh:RANGe` is set to WITHin or OUTSide. The width is set with `TRIGger<m>:PARallel:WIDTh:WIDTh`.

Parameters:

<WidthDelta>	Range:	0 to 432
	Increment:	600E-12
	*RST:	0
	Default unit:	s

20.18.4.4 Timeout Trigger

See also:

- `TRIGger<m>:PARallel:TIMeout:EXPRession[:DEFine]` on page 1797

TRIGger<m>:PARallel:TIMeout:RANGe <TimeoutMode>

Sets the state condition.

Parameters:

<TimeoutMode> HIGH | LOW | EITHer

HIGH
The level of a digital channel stays above the threshold, or the logical expression for LOGic trigger source is true.

LOW
The level of a digital channel stays below the threshold, or the logical expression for LOGic trigger source is false.

EITHer
The signal state remains unchanged.

*RST: HIGH

TRIGger<m>:PARallel:TIMeout:TIME <Time>

Defines the time limit for the timeout at which the instrument triggers.

Parameters:

<Time>	Range:	100E-12 to 10000
	Increment:	100E-9
	*RST:	100E-9
	Default unit:	s

20.18.4.5 State Trigger

See also:

- `TRIGger<m>:PARallel:STATe:CSOurce:VALue` on page 1797
- `TRIGger<m>:PARallel:STATe:EXPRession[:DEFine]` on page 1797

TRIGger<m>:PARallel:STATe:CSOurce:EDGE <Slope>

Sets the edge of the clock signal. The crossing of the clock edge and the logical threshold defines the time at which the logical states and the bus value are analyzed.

Parameters:

<Slope> POSitive | NEGative | EITHer

*RST: POSitive

TRIGger<m>:PARallel:STATe:BIT<n> <Bit>

Sets the required state for each digital channel that is used in the bus.

Suffix:

<n> 0..15
Number of the digital channel

Parameters:

<Bit> HIGH | LOW | DONTCARE | DONTcare

Bit value: 1 (HIGH), 0 (LOW), or X (DONTCARE = DONTcare)

20.18.4.6 Pattern Trigger

TRIGger<m>:PARallel:PATTern:BIT<n> <Bit>

Sets the required state for each digital channel that is used in the bus.

Suffix:

<n> 0..15
Number of the digital channel

Parameters:

<Bit> HIGH | LOW | DONTCARE | DONTcare

Bit value: 1 (HIGH), 0 (LOW), or X (DONTCARE = DONTcare)

TRIGger<m>:PARallel:PATTern:MODE <Mode>

Sets the mode of the timing condition.

Parameters:

<Mode> OFF | TIMeout | WIDTh

OFF
No timing condition, only the logical pattern condition is relevant.

TIMeout
Defines a minimum time qualification to avoid triggering on unstable or transitional conditions. Use `TRIGger<m>:PARallel:PATTern:TIMeout:MODE` and `TRIGger<m>:PARallel:PATTern:TIMeout[:TIME]` to specify the timeout.

WIDTh
Sets a pulse width as timing condition. The pulse starts when the pattern comes true, and the trigger event occurs when the pattern comes false during the specified time limit. Use `TRIGger<m>:PARallel:PATTern:WIDTh:RANGe`, `TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh]`, and `TRIGger<m>:PARallel:PATTern:WIDTh:DELTa` to specify the width.
*RST: OFF

TRIGger<m>:PARallel:PATTern:TIMeout:MODE <TimeoutMode>

Sets the state condition for the timeout qualification if `TRIGger<m>:PARallel:PATTern:MODE` is set to TIMeout. To set the time limit, use `TRIGger<m>:PARallel:PATTern:TIMeout[:TIME]`.

Parameters:
<TimeoutMode> HIGH | LOW | EITHer
HIGH: The pattern stays true for the specified time.
LOW: The pattern stays false for the specified time.
EITHER: The pattern remains unchanged for the specified time.
*RST: HIGH

TRIGger<m>:PARallel:PATTern:TIMeout[:TIME] <Time>

Defines the time limit for the timeout at which the instrument triggers.

Parameters:
<Time> Range: 100E-12 to 10000
Increment: 100E-9
*RST: 100E-9
Default unit: s

TRIGger<m>:PARallel:PATTern:WIDTh:RANGe <WidthRangeMode>

Selects how the range of a pulse width is defined if `TRIGger<m>:PARallel:PATTern:MODE` is set to WIDTh.

Parameters:
<WidthRangeMode> WITHin | OUTSide | SHORter | LONGer
WITHin
Triggers when the pattern comes false inside a given time range. The time limit is defined by `TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh]` and `TRIGger<m>:PARallel:PATTern:WIDTh:DELTa` (*Width ± Delta*).

OUTSide
Triggers when the pattern comes false before or after the given time range. The time limit definition is the same as for WITHin range.

SHORter | LONGer
Triggers when the pattern comes false before or after the given width has expired. Width is set with TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh].

*RST: WITHin

TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh] <Width>

The effect depend on the setting of the TRIGger<m>:PARallel:PATTern:WIDTh:RANGecommand.

For the ranges SHOrter and LONGer, the width defines the maximum and minimum time limit, respectively.

For the ranges WITHin and OUTSide, the width defines the center of a range which is defined by the limits "±Delta".

Parameters:

<Width>
Range: 100E-12 to 10000
Increment: 100E-9
*RST: 5E-9
Default unit: s

TRIGger<m>:PARallel:PATTern:WIDTh:DELTa <WidthDelta>

Defines a range around the width value set with TRIGger<m>:PARallel:PATTern:WIDTh[:WIDTh].

Parameters:

<WidthDelta>
Range: 0 to 432
Increment: 500E-12
*RST: 0
Default unit: s

20.18.4.7 Serial Pattern Trigger

See also:

- TRIGger<m>:PARallel:SPATtern:CSOurce[:VALue] on page 1797
- TRIGger<m>:PARallel:SPATtern:EXPRession[:DEFine] on page 1797

TRIGger<m>:PARallel:SPATtern:CSOurce:EDGE <ClockEdge>

Sets the edge of the clock signal. The bit value is determined at the crossing of the clock edge and the logical threshold.

Parameters:

<ClockEdge> POSitive | NEGative | EITHer

*RST: POSitive

TRIGger<m>:PARallel:SPATtern:PATTern <Pattern>

Defines the serial bit string on which to trigger.

Parameters:

<Pattern> Numeric or string pattern, see Chapter 20.4.6, "Bit Pattern Parameter", on page 971. The bit value X (don't care) is not allowed.

20.18.5 MSO Data

To export data of digital channels and parallel buses to file, use the following commands:

- `EXPort:WAVeform:SOURce` on page 1281
- `BUSFormat` on page 1301
- `EXPort:WAVeform:NAME` on page 1282
- `EXPort:WAVeform:SAVE` on page 1282

The remote export for transmission from the instrument to the controlling computer is performed using the following commands:

`FORMat[:DATA]` on page 977

and

BUSFormat <DataFormat>

Sets the number format for decoded data values in the "Decode table" and on the display for all parallel and serial buses.

For serial buses, the command overwrites the the bus-specific format setting `BUS<m>:FORMat`.

For parallel buses, the command sets also the number representation for data export. In case of export to BIN file or remote data transfer, SIGN returns signed values, and all other formats return unsigned values.

Parameters:
<DataFormat> HEX | OCT | BIN | ASCII | ASCii | SIGN | USIG
ASCII = ASCii
*RST: HEX

Usage: Asynchronous command

Firmware/Software: FW 1.45

DIGital<m>:DATA:HEADer?

Returns the header of digital channel data

Table 20-13: Header data

Position	Meaning	Example
1	XStart, acquisition time before trigger, in s	-5E-008 = - 50 ns
2	XStop, acquisition time after trigger, in s	5E-008 = 50 ns
3	Record length of the waveform in Samples	1000
4	Number of values per sample interval. For digital data the result is 1.	1

Suffix:
<m> 0..15
Number of the digital channel

Usage: Query only

DIGital<m>:DATA[:VALues]?

Returns the data of the indicated digital channel for transmission from the instrument to the controlling computer. The data can be used in MATLAB, for example.

To set the export format, use `FORMat[:DATA]` and `BUSFormat`.

Suffix:
<m> 0..15
Selects the digital channel.

Return values:
<Data> List of values according to the format settings.

Usage: Query only

BUS<m>:PARallel:DATA:HEADer?

Returns the header data of the indicated bus.

For a detailed description, see `DIGital<m>:DATA:HEADer?`.

Suffix:
<m> 1..4
Selects the parallel bus.

Usage: Query only

Firmware/Software: V 2.40

BUS<m>:PARallel:DATA[:VALues]?

Returns the data of the indicated parallel bus.

Requirements:
- `BUS<m>:PARallel:STATe` is set to `ON`.
- `BUS<m>:PARallel:DISPlay:SHBU` is set to `ON`.
- To set the number format, use `BUSFormat`.

Suffix:
<m> 1..4
Selects the parallel bus.

Return values:
<Data> List of decimal values (signed or unsigned).

Example:
```
BUS:PAR:STAT ON
BUS:PAR:DISP:SHBU ON
BUS:PAR:DISP:BTYP COMB
BUSFormat HEX
BUS:PAR:DATA:VAL?
```

Usage: Query only

20.19 Waveform Generator (Option R&S RTP-B6)

20.19.1 Waveform Generator Setup

20.19.1.1 General

WGENerator<m>:ACOPy

Copies all settings from Gen1/Gen2 and applies them to Gen2/Gen1.

Suffix:
<m> 1..2

Usage: Event

WGENerator<m>[:ENABle] <State>

Enables the waveform generator and outputs the waveform.

Suffix:
<m> 1..2

Parameters:
<State> ON | OFF

Usage: Asynchronous command

WGENerator<m>:SOURce <OperationMode>

Sets the operation mode for the the waveform generator.

Suffix:
<m> 1..2

Parameters:
<OperationMode> FUNCgen | MODulation | SWEep | ARBGenerator
*RST: FUNCgen

WGENerator<m>:PRESet

Sets the parameters of the waveform generator to their default values.

Suffix:
<m> 1..2

Usage: Event

20.19.1.2 Function Generator

WGENerator<m>:FUNCtion[:SELect] <FunctionType>

Sets the type of waveform to be generated for the function generator.

Suffix:
<m> 1..2

Parameters:

<FunctionType> SINusoid | SQUare | RAMP | DC | PULSe | SINC | CARDiac | GAUSs | LORNtz | EXPRise | EXPFall

SINC: Cardial sine

*RST: SINusoid

WGENerator<m>:FREQuency <Frequency>

Sets the frequency of the waveform. The available frequency range depends on the selected function type.

Suffix:

<m> 1..2

Parameters:

<Frequency> Range: 1E-3 to 100E+6
Increment: 1
*RST: 1E+6
Default unit: Hz

WGENerator<m>:PERiod <Period>

Sets the period of the waveform. The available period range depends on the selected function type.

Suffix:

<m> 1..2

Parameters:

<Period> Range: 8E-9 to 1000
Increment: 1
*RST: 1E-6
Default unit: s

WGENerator<m>:FUNCtion:PULSe[:WIDTh] <PulseWidth>

Sets the pulse duration for a pulse waveform.

Suffix:

<m> 1..2

Parameters:

<PulseWidth> Range: 16.5E-9 to 90E+3
Increment: 1
*RST: 500E-9
Default unit: s

WGENerator<m>:FUNCtion:RAMP[:SYMMetry] <RampSymmetry>

Sets the symmetry for a ramp waveform.

Suffix:

<m>	1..2

Parameters:

<RampSymmetry>
Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

WGENerator<m>:FUNCtion:SQUare:DCYCle <SquareDutyCycle>

Sets the duty cycle for a square waveform.

Suffix:

<m>	1..2

Parameters:

<SquareDutyCycle>
Range: 0.01 to 99.99
Increment: 1
*RST: 50
Default unit: %

20.19.1.3 Modulation

WGENerator<m>:MODulation:TYPE <ModulationType>

Sets the modulation type.

Suffix:

<m>	1..2

Parameters:

<ModulationType>	AM | FM | PWM | FSK	
	*RST:	AM

WGENerator<m>:MODulation:AM:DCYCle <SquareDutyCycle>

Sets the duty cycle of a square waveform for amplitude modulation, if `WGENerator<m>:MODulation:TYPE` is set to `AM`.

Suffix:

<m>	1..2

Parameters:

<SquareDutyCycle>	Range:	10 to 90
	Increment:	1
	*RST:	50
	Default unit:	%

WGENerator<m>:MODulation:AM:DEPTh <Depth>

Sets the amplitude modulation depth.

Suffix:

<m>	1..2

Parameters:

<Depth>	Range:	0 to 100
	Increment:	1
	*RST:	50
	Default unit:	%

WGENerator<m>:MODulation:AM:FREQuency <Frequency>

Sets the frequency of the modulation waveform for amplitude modulation, if `WGENerator<m>:MODulation:TYPE` is set to `AM`.

Suffix:

<m>	1..2

Parameters:

<Frequency>	Range:	1E-3 to 1E+6
	Increment:	1
	*RST:	1000
	Default unit:	Hz

WGENerator<m>:MODulation:AM:SYMMetry <RampSymmetry>

Sets the symmetry, the percentage of time the ramp modulation waveform is rising, for amplitude modulation, if `WGENerator<m>:MODulation:TYPE` is set to `AM`.

Suffix:

<m> 1..2

Parameters:

<RampSymmetry> Range: 0 to 100
Increment: 1
*RST: 50
Default unit: %

WGENerator<m>:MODulation:CARRier:FREQuency <CarrierFreq>

Sets the frequency of the carrier signal for a modulation waveform.

Suffix:

<m> 1..2

Parameters:

<CarrierFreq> Range: 1E-3 to 100E+6
Increment: 10
*RST: 1E+6
Default unit: Hz

WGENerator<m>:MODulation:CARRier:PERiod <CarrierPeriod>

Sets the period of the carrier signal for a modulation waveform.

Suffix:

<m> 1..2

Parameters:

<CarrierPeriod> Range: 8E-9 to 1000
Increment: 10
*RST: 1E-6
Default unit: s

WGENerator<m>:MODulation:AM[:FUNCtion] <SignalType>

Sets the type of the modulation signal for the amplitude modulation, if `WGENerator<m>:MODulation:TYPE` is set to `AM`.

Suffix:

<m> 1..2

Parameters:

<SignalType> SINusoid | SQUare | RAMP

*RST: SINusoid

WGENerator<m>:MODulation:FM:DCYCle <SquareDutyCycle>

Sets the duty cycle of a square waveform for frequency modulation, if `WGENerator<m>:MODulation:TYPE` is set to `FM`.

Suffix:

<m> 1..2

Parameters:

<SquareDutyCycle> Range: 10 to 90
Increment: 1
*RST: 50
Default unit: %

WGENerator<m>:MODulation:FM:DEViation <Deviation>

Sets the frequency modulation deviation.

Suffix:

<m> 1..2

Parameters:

<Deviation> Range: 1E-3 to 10E+6
Increment: 1
*RST: 1000
Default unit: Hz

WGENerator<m>:MODulation:FM:FREQuency <Frequency>

Sets the frequency of the modulation waveform for frequency modulation, if `WGENerator<m>:MODulation:TYPE` is set to `FM`.

Suffix:

<m> 1..2

Parameters:

<Frequency> Range: 1E-3 to 1E+6
Increment: 1
*RST: 1000
Default unit: Hz

WGENerator<m>:MODulation:FM:SYMMetry <RampSymmetry>

Sets the symmetry, the percentage of time the ramp modulation waveform is rising, for frequency modulation, if `WGENerator<m>:MODulation:TYPE` is set to `FM`.

Suffix:

<m> 1..2

Parameters:

<RampSymmetry>	Range: 0 to 100 Increment: 1 *RST: 50 Default unit: %

WGENerator<m>:MODulation:FM[:FUNCtion] <SignalType>

Sets the type of the modulation signal for the frequency modulation, if `WGENerator<m>:MODulation:TYPE` is set to `FM`.

Suffix:

<m> 1..2

Parameters:

<SignalType>	SINusoid | SQUare | RAMP *RST: SINusoid

WGENerator<m>:MODulation:FSK:FONE <Frequency1>

Sets the frequency of the carrier waveform, if `WGENerator<m>:MODulation:TYPE` is set to `FSK`.

Suffix:

<m> 1..2

Parameters:

<Frequency1>	Range: 1E-3 to 100E+6 Increment: 1 *RST: 1E+6 Default unit: Hz

WGENerator<m>:MODulation:FSK:FTWO <Frequency2>

Sets the frequency of the modulated waveform, if `WGENerator<m>:MODulation:TYPE` is set to `FSK`.

Suffix:

<m> 1..2

Parameters:

<Frequency2>	Range: 1E-3 to 100E+6 Increment: 1 *RST: 1000 Default unit: Hz

WGENerator<m>:MODulation:FSK[:RATE] <Rate>

Sets the hop rate, the time before a switch from the carrier frequency set with `WGENerator<m>:MODulation:FSK:FONE` and the modulation frequency set with `WGENerator<m>:MODulation:FSK:FTWO`.

Suffix:

<m>	1..2

Parameters:

<Rate>	Range: 1E-3 to 1E+6 Increment: 1 *RST: 1000 Default unit: Hz

WGENerator<m>:MODulation:PWM:DCYCle <SquareDutyCycle>

Sets the duty cycle of a square waveform for pulse width modulation, if `WGENerator<m>:MODulation:TYPE` is set to `PWM`.

Suffix:

<m>	1..2

Parameters:

<SquareDutyCycle>	Range: 10 to 90 Increment: 1 *RST: 50 Default unit: %

WGENerator<m>:MODulation:PWM:DEPTh <Depth>

Sets the modulation depth for pulse width modulation.

Suffix:

<m>	1..2

Parameters:

<Depth>	Range: 0 to 100 Increment: 1 *RST: 50 Default unit: %

WGENerator<m>:MODulation:PWM:FREQuency <Frequency>

Sets the frequency of the modulation waveform for pulse width modulation, if `WGENerator<m>:MODulation:TYPE` is set to `PWM`.

Suffix:

<m>	1..2

Parameters:

<Frequency>	Range: 1E-3 to 1E+6 Increment: 1 *RST: 1000 Default unit: Hz

---

WGENerator<m>:MODulation:PWM:SYMMetry <RampSymmetry>

Sets the symmetry, the percentage of time the ramp modulation waveform is rising, for pulse width modulation, if `WGENerator<m>:MODulation:TYPE` is set to `PWM`.

Suffix:

<m>	1..2

Parameters:

<RampSymmetry>	Range: 0 to 100 Increment: 1 *RST: 50 Default unit: %

WGENerator<m>:MODulation:PWM[:FUNCtion] <SignalType>

Sets the type of the modulation signal for the pulse width modulation, if `WGENerator<m>:MODulation:TYPE` is set to `PWM`.

Suffix:

<m>	1..2

Parameters:

<SignalType>	SINusoid | SQUare | RAMP *RST: SINusoid

20.19.1.4 Sweep

WGENerator<m>:SWEep:FSTart <StartFrequency>

Sets the start frequency of the sweep range.

Suffix:

<m>	1..2

Parameters:

<StartFrequency>	Range: 1E-3 to 100E+6 Increment: 1 *RST: 1000 Default unit: Hz

WGENerator<m>:SWEep:TIME <Time>

Sets the duration of the sweep.

Suffix:

<m>	1..2

Parameters:

<Time>	Range: 1E-3 to 500 Increment: 1 *RST: 1E-3 Default unit: s

WGENerator<m>:SWEep[:FEND] <StopFrequency>

Sets the stop frequency of the sweep range.

Suffix:

<m>	1..2

Parameters:

<StopFrequency>	Range: 1E-3 to 100E+6 Increment: 1 *RST: 1E+6 Default unit: Hz

20.19.1.5 ARB

WGENerator<m>:ARBGen:COPY

Loads the waveform from the selected signal source (`WGENerator<m>:ARBGen:SELect`).

Suffix:

<m>	1..2

Usage: Event
Asynchronous command

WGENerator<m>:ARBGen:MULTichannel:IMPort <SavedWfmSrc>

Assigns a waveform from the multichannel file to the arbitrary waveform generator.

Suffix:
<m> 1..2

Parameters:
<SavedWfmSrc> WFM1 | WFM2 | WFM3 | WFM4
*RST: WFM1

Example:
```
WGENerator1:ARBGen:MULTichannel:NAME
ArbMultichannelCurve_2017-02-16_01.bin
WGENerator1:ARBGen:MULTichannel:IMPort WF1
WGENerator1:ARBGen:MULTichannel:OPEN
```

WGENerator<m>:ARBGen:MULTichannel:NAME <FilePath>

Defines the path and the multichannel arbitrary waveform file to be imported. If not path is given, the default path `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\RefWaveforms` is used.

Suffix:
<m> 1..2

Parameters:
<FilePath>

Example: See WGENerator<m>:ARBGen:MULTichannel:IMPort on page 1816.

WGENerator<m>:ARBGen:MULTichannel:OPEN

Loads the arbitrary waveform.

Suffix:
<m> 1..2

Example: See WGENerator<m>:ARBGen:MULTichannel:IMPort on page 1816.

Usage: Event
Asynchronous command

WGENerator<m>:ARBGen:NAME <FilePath>

Sets the file path and the file for an arbitrary waveform, if WGENerator<m>:ARBGen[:SOURce] on page 1818 is set to `ARBitrary`.

If not path is given, the default path `C:\Users\Public\Public Documents\Rohde-Schwarz\RTx\RefWaveforms` is used.

This command is only relevant for files with one waveform defined. For multichannel arbitrary waveform files, see `WGENerator<m>:ARBGen:MULTichannel:OPEN`.

Suffix:

<m>	1..2

Parameters:

<FilePath>

WGENerator<m>:ARBGen:OPEN

Loads the arbitrary waveform, that is selected with the `WGENerator<m>:ARBGen:NAME` command.

This command is only relevant for files with one waveform defined. For multichannel arbitrary waveform files, see `WGENerator<m>:ARBGen:MULTichannel:OPEN`.

Suffix:

<m>	1..2

Usage: Event
Asynchronous command

WGENerator<m>:ARBGen:RUNMode <RunMode>

Sets the duration for which the signal of the arbitrary generator will be output after the trigger event.

Suffix:

<m>	1..2

Parameters:

<RunMode>	SINGle | CONTinuous *RST: CONTinuous

WGENerator<m>:ARBGen:SAMPles?

Displays the number of samples for the arbitrary waveform.

Suffix:

<m>	1..2

Return values:

<NumSamples>	Range: 0 to 128000000 Increment: 10 *RST: 0 Default unit: Sa

Usage: Query only

WGENerator<m>:ARBGen:SELect <ScopeSignSrc>

Selects the oscilloscope source, from which the arbitrary signal is loaded, if `WGENerator<m>:ARBGen[:SOURce]` is set to `SCOPe`.

Suffix:

<m>	1..2

Parameters:

<ScopeSignSrc>	C1W1 | C1W2 | C1W3 | C2W1 | C2W2 | C2W3 | C3W1 | C3W2 | C3W3 | C4W1 | C4W2 | C4W3 | R1 | R2 | R3 | R4 *RST: C1W1

WGENerator<m>:ARBGen:SRATe <SampleRate>

Sets the sample rate for the arbitrary waveform.

Suffix:

<m>	1..2

Parameters:

<SampleRate>	Range: 1 to 250E+6 Increment: 10 *RST: 1E+6 Default unit: Sa/s

WGENerator<m>:ARBGen[:SOURce] <WaveformSource>

Sets the arbitrary waveform source.

Suffix:

<m>	1..2

Parameters:

<WaveformSource>	ARBitrary | SCOPe **ARBitrary** Enables you to load an existing arbitrary file. **SCOPe** Enables you to load a scope waveform. *RST: ARBitrary

20.19.1.6 Output

WGENerator<m>:OUTPut[:LOAD] <Load>

Sets the load of the DUT at its connection.

Suffix:
<m> 1..2

Parameters:
<Load> FIFTy | HIZ

HIZ: high input impedance

*RST: HIZ

WGENerator<m>:VOLTage[:VPP] <Amplitude>

Sets the amplitude, peak to peak voltage, of the output waveform. This is defined as the voltage difference between the maximum (`WGENerator<m>:VOLTage:HIGH`) and the minimum (`WGENerator<m>:VOLTage:LOW`) voltage levels.

The value is set for the currently selected load (`WGENerator<m>:OUTPut[:LOAD]`). If the load is changed, the value of the amplitude is adapted to this new setting.

Suffix:
<m> 1..2

Parameters:
<Amplitude> Range: 0.01 to 12
Increment: 0.1
*RST: 1
Default unit: Vpp

WGENerator<m>:VOLTage:DCLevel <DCLevel>

Sets the DC level of the generated DC signal.

Suffix:
<m> 1..2

Parameters:
<DCLevel> Range: -5.995 to 5.995
Increment: 0.1
*RST: 0
Default unit: V

WGENerator<m>:VOLTage:HIGH <High>

Sets the high signal level of the output waveform.

Suffix:
<m> 1..2

Parameters:

<High>	Range: -5.99 to 6 Increment: 0.1 *RST: 0.5 Default unit: V

WGENerator<m>:VOLTage:INVersion <Inversion>

Enables inversion, which swaps the two poles of the waveform.

Suffix:

<m>	1..2

Parameters:

<Inversion>	ON | OFF *RST: OFF

WGENerator<m>:VOLTage:LOW <Low>

Sets the low signal level of the output waveform.

Suffix:

<m>	1..2

Parameters:

<Low>	Range: -6 to 5.99 Increment: 0.1 *RST: -0.5 Default unit: V

WGENerator<m>:VOLTage:OFFSet <Offset>

Sets a voltage offset.

Suffix:

<m>	1..2

Parameters:

<Offset>	Range: -5.995 to 5.995 Increment: 0.1 *RST: 0 Default unit: V

20.19.1.7 Noise

WGENerator<m>:MODulation:NDCLevel <LevelDC>

Sets the DC noise level.

Suffix:

<m>	1..2

Parameters:

<LevelDC>	Range: 0 to 12 Increment: 0.1 *RST: 0.01 Default unit: Vpp

WGENerator<m>:MODulation:NLABsolute?

Queries the level of the noise in volts.

Suffix:

<m>	1..2

Return values:

<LevelAbs>	Range: 0 to 12 Increment: 0.1 *RST: 0 Default unit: Vpp
Usage:	Query only

WGENerator<m>:MODulation:NLPCent <LevelPct>

Sets the noise level in percentage of the amplitude.

Suffix:

<m>	1..2

Parameters:

<LevelPct>	Range: 0 to 100 Increment: 1 *RST: 0 Default unit: %

WGENerator<m>:MODulation:NOISe <State>

Enables the adding of noise to the waveform.

Suffix:

<m>	1..2

Parameters:

<State>	ON | OFF *RST: OFF

20.19.2 Pattern Generator Setup

PGENerator:BITRate <BitRate>

Sets the number of transmitted bits per second for the pattern generator.

Parameters:

<BitRate>	Range: 1 to 40E+6 Increment: 10 *RST: 1E+6 Default unit: bps

---

PGENerator:ENABle <State>

Enables the pattern generator and outputs the waveform.

Parameters:

<State>	ON | OFF

PGENerator:FILE:OPEN

Loads the specified pattern file to the instrument.

Usage:	Event Asynchronous command

PGENerator:FILE[:NAME] <FilePath>

Specifies a file path to open a pattern generator file.

Parameters:

<FilePath>	String with the name of the file.

PGENerator:HLEVel <HighLevel>

Sets the high level of the pattern generator signal.

Parameters:

<HighLevel>	Range: 1.2 to 5 Increment: 0.1 *RST: 1.2 Default unit: V

PGENerator:PRESet

Sets the default pattern generator settings.

Usage: Event

PGENerator:RUNMode <RunMode>

Sets the duration for which the signal of the pattern generator will be output after the trigger event.

Parameters:

<RunMode> SINGle | CONTinuous

*RST: CONTinuous

20.19.3 Coupling & Sync

WGENerator<m>:COUPling:ALL <CoupleAll>

Enables the coupling of all parameters of the generators, except of load and inversion.

Suffix:

<m> 1..2

Parameters:

<CoupleAll> ON | OFF

*RST: OFF

WGENerator<m>:COUPling:AMPLitude <CoupleAmplitude>

Enables the coupling of all amplitude parameters of the generators.

Suffix:

<m> 1..2

Parameters:

<CoupleAmplitude> ON | OFF

*RST: OFF

WGENerator<m>:COUPling:PHASeshift <PhaseShift>

Sets the phase shift between the waveform of Gen1 and Gen2 when the frequency parameters of the two waveforms are coupled.

Suffix:

<m>	1..2

Parameters:

<PhaseShift>	Range: -180 to 180 Increment: 1 *RST: 0 Default unit: °

WGENerator<m>:COUPling[:FREQuency] <CoupleFrequency>

Enables the coupling of all frequency parameters of the generators.

Suffix:

<m>	1..2

Parameters:

<CoupleFrequency>	ON | OFF *RST: OFF

GENerator:SYNC[:COMBination] <Combination>

Sets which signals generated from the waveform generator are synchronized.

Parameters:

<Combination>	NONE | GEN12 | G1PG | G2PG | G12PG GEN12: Gen1 and Gen 2 GEN1PG/GEN2PG: Gen1/Gen 2 and Patt Gen GEN12PG: Gen1,Gen 2 and Patt Gen *RST: NONE

20.19.4 DC Offset Alignment

GENerator:ALIGnment:DC:ABORt

Aborts a DC offset alignment.

Usage: Event
Asynchronous command

GENerator:ALIGnment:DC:RESult:DATE?

Queries the date of the last performed DC offset alignment.

Return values:
<Date>

Usage: Query only

GENerator:ALIGnment:DC:RESult:TIME?

Queries the time of the last performed DC offset alignment.

Return values:
<Time>

Usage: Query only

GENerator:ALIGnment:DC:RESult[:STATe]?

Queries the result of a DC offset alignment.

Return values:
<State> PASSed | FAILed | NOALigndata

*RST: NOALigndata

Usage: Query only

GENerator:ALIGnment:DC[:STARt]

Starts a DC offset alignment.

Usage: Event
Asynchronous command

20.20 Pulse Source (Option R&S RTP-B7)

PSRC[:STAT] <State>

Switches the pulse output on and off.

Parameters:
<State> ON | OFF

*RST: OFF

PSRC:OUTPutlow <OutputLowLevel>

Sets the low level of the output pulse.

Parameters:

<OutputLowLevel>
Range: -0.2 to -0.05
Increment: 0.01
*RST: -0.05
Default unit: V

PSRC:REPRate <RepetitionRate>

Sets the pulse frequency, the repetition rate of the pulse.

Parameters:

<RepetitionRate>
Available values depend on the selected clock mode:
Locked: 5/10/20/50/100/200/500 Hz, 1/5/10/25/50/100/250 MHz
Free running: 5/10/20/50/100/200/500 Hz, 1/5/10/25/50 MHz
*RST: 1E+6
Default unit: Hz

PSRC:DUTYcycle <DutyCycle>

Sets the duty cycle of the pulse, which is the ratio of the positive pulse width to the period of the signal.

Parameters:

<DutyCycle>
For repetition rates > 5 MHz, the value is fixed at 50 %.
Range: 10 to 90
Increment: 10
*RST: 50
Default unit: %

PSRC:CLOCkmode <ClockMode>

Sets the dependency of the pulse clock on the instrument's reference clock.

Parameters:

<ClockMode>
LOCKed | FREerunning

LOCKed
The pulse source is locked to the reference clock of the instrument.

FREerunning
The clock of the pulse source is independent. Deviations of the system do not affect the pulse clock, and deterministic conditions are avoided.

*RST: FREerunning

PSRC:RST

Resets the pulse source to the default state.

Usage: Event

20.21 Jitter Analysis and Clock Data Recovery (Option R&S RTP-K12)

This chaptes decribes the remote commands of jitter option R&S RTP-K12

20.21.1 Jitter Measurements (Option R&S RTP-K12)

The following table lists the measurement suffixes and the <MeasType> parameter value with a short description.

For a detailed description, see Chapter 16.1.2, "Jitter Measurements", on page 893.

Table 20-14: Jitter measurements

Meas. suffix	<MeasType> parameter value	Meas. type	Description/Result
37	CCJitter	Cycle-cycle jitter	Difference between the periods of two adjacent cycles. The measurement is based on the period measurement.
38	NCJitter	N-cycle jitter	Difference between the time of two adjacent groups of N cycles (periods) each.
39	CCWidth	Cycle-cycle width	Difference between the pulse width of two adjacent cycles. The measurement is based on the pulse width measurement.
40	CCDutycycle	Cycle-cycle duty cycle	Difference between the duty cycle of two adjacent cycles. The measurement is based on the duty cycle measurement.
41	TIE	Time interval error	Time difference between the slope of the input signal and the slope of a reference signal. The reference signal can be a captured clock waveform, or a clock generated by clock data recovery (CDR, software algorithm or hardware generation).
42	UINTerval	Unit interval	Period of the clock signal. If no clock signal is available, it is recovered by CDR. The period is calculated as the time difference between two consecutive clock edges of the same polarity.
43	DRATe	Data rate	Frequency of the clock signal. If no clock signal is available, it is recovered by CDR. The measurement is based on the unit interval measurement.
44	SKWDelay	Skew delay	Delay between the edges of two interdependent waveforms.

Meas. suffix	<MeasType> parameter value	Meas. type	Description/Result
45	SKWPhase	Skew phase	Phase difference between the edges of two waveforms.
1 to 36; 46	Used for amplitude/time measurements (limit checks). The jitter category uses the same limit checks as amplitude/time. See Chapter 20.12.3, "Amplitude/Time Measurements", on page 1144.		

MEASurement<m>:JITTer:CCSLope <JitterCCSlope>

Selects the slope at which the periods and thus the jitter is measured.

The command is available for the following measurements: cycle-cycle jitter, N-cycle jitter, and cycle-cycle duty cycle (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurements CCJitter | NCJitter | CCDutycycle).

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<JitterCCSlope> FIRSt | POSitive | NEGative | EITHer

FIRSt
Measures the period from the first edge that is found, no matter of its direction.

POSitive
Measures the period at positive going edges.

NEGative
Measures the period at negative going edges.

EITHer
Measures the period at both positive and negative going edges. This option is useful, for example, to check the clock stability of a double data rate clock.

*RST: FIRSt

MEASurement<m>:JITTer:PULSe <JitterPulsePolarity>

Sets the polarity of pulses for which the pulse width is measured to obtain the cycle-cycle width and the cycle-cycle duty cycle.

The command is available for the following measurements: cycle-cycle width and cycle-cycle duty cycle (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurements CCWidth | CCDutycycle).

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<JitterPulsePolarity> POSitive | NEGative

Pulse width of positive or negative pulses is measured, respectively.

*RST: POSitive

MEASurement<m>:JITTer:NCYCles <JitterNofCycles>

Sets the number of periods (cycles) that are accumulated to measure the N-cycle jitter.

See also: Table 16-1

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<JitterNofCycles> Range: 1 to 2147483647

Increment: 1

*RST: 2

Firmware/Software: FW 2.60. The algorithm of N-cycle measurement has been changed and `MEASurement:JITTer:COFFset` has been removed.

MEASurement<m>:JITTer:CDRMode <JitterCDRMode>

Defines the origin of the clock signal - wether a real clock signal or a clock generated using one of the CDR methods.

The command is available for the following measurements: time-interval error, unit interval and data rate (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurements TIE | UINTerval | DRATe).

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<JitterCDRMode> SIGNal | SW1 | SW2 | HW

SIGNal
The clock is a real clock signal.

SW1 | SW2
The clock is generated by a software algorithm. You can define two software algorithms for CDR. To configure the CDR, use the `CDR:SOFTware` commands.

HW
The clock is generated from the source signal by the integrated CDR circuitry. The HW CDR must be active to acquire the jitter data (trigger type = CDR or serial pattern with CDR)

*RST: SW1

MEASurement<m>:JITTer:SOURce<n>:TIESlope <JitterTIESlope>

Sets the clock and data edges that are used for measurements. Clock or data is defined by the SOURce suffix <n>.

The command is available for the following measurements: time-interval error, unit interval and data rate (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurements TIE | UINTerval | DRATe.

Suffix:

<m> 1..10
See "Selection of the measurement group: MEASurement<m>" on page 1133.

<n> 1..2
1 = data slope (only relevant for time interval error measurements with explicit clock signal)
2 = clock slope

Parameters:

<JitterTIESlope> POSitive | NEGative | EITHer

POSitive
The positive clock slope can be used, for example, for single data rate (SDR) signals with bit start at the positive clock edge.

NEGative
The negative clock slope can be used, for example, for SDR signals with bit start at the negative clock edge.

EITHer
For clock edges, this option can be used for double data rate (DDR) signals.
For data edges, it is the most common setting.

*RST: EITHer

MEASurement<m>:JITTer:SKWSlope <JitterSkewSlope>

Sets the edge of the first waveform from which the skew delay or phase is measured: positive, negative or both.

The command is available for the following measurement: skew delay and skew phase (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurements SKWDelay | SKWPhase).

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<JitterSkewSlope> POSitive | NEGative | EITHer

*RST: POSitive

MEASurement<m>:JITTer:SKWRelation <JittSkewRelation>

Sets the edge of the second waveform relative to the first waveform.

The command is available for the following measurements: skew delay and skew phase (`MEASurement<m>:MAIN` and/or `MEASurement<m>:ADDitional` are set to measurements SKWDelay | SKWPhase).

Suffix:

<m> 1..10

See "Selection of the measurement group: MEASurement<m>" on page 1133.

Parameters:

<JittSkewRelation> MATChing | INVerse

MATChing
Measures from positive to positive edge or from negative to negative edge.

INVerse
Measures from positive to negative edge or from negative to positive edge.

*RST: MATChing

20.21.2 Clock Data Recovery (Software-based, Option R&S RTP-K12)

CDR:SOFTware<m>:ALGorithm <Algorithm>

Sets the software algorithm that is used for clock data recovery.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<Algorithm>	CFRequency | PLL PLL is the phase-locked loop control system. Itcan follow slow deviations in the frequency of the data stream. CFRequency = Constant frequency. CDR uses the nominal bit rate to generate the clock signal. The method assumes that the frequency of the signal is constant during the complete acquisition. *RST: PLL

CDR:SOFTware<m>:BITRate <Bitrate>

Sets the quiescent frequency of the PLL. It corresponds to the data rate of the data stream from which the clock is to be recovered.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<Bitrate>	Range:	100 to max {5 Gbps, <available instrument bandwidth}
	Increment:	10
	*RST:	1E+9
	Default unit:	bps

CDR:SOFTware<m>:ESLope <Edge>

Selects the edges of the data stream that are used for the clock recovery.

- "Either": Both positive and negative edges are used
- "Positive / Negative": Only one edge direction is used. Use one of these settings if the other edge might deliver unreliable results.

Suffix:

<m>	1..2 Number of the software CDR setup

Parameters:

<Edge>	POSitive | NEGative | EITHer *RST: EITHer

CDR:SOFTware<m>:SYNC <InitialSync>

Defines the phase reference for the first clock edge.

Suffix:

<m> 1..2
Number of the software CDR setup

Parameters:

<InitialSync> SAMPle | DATaedge

SAMPle
The first clock edge matches the first sample of the waveform at the left border of the display.

DATaedge
The first clock edge matches the first edge of the data signal.

*RST: SAMPle

CDR:SOFTware<m>:RESults <Results>

The PLL requires some time to synchronize to the phase of the data stream. You can select when the CDR algorithm returns clock edges.

Suffix:

<m> 1..2
Number of the software CDR setup

Parameters:

<Results> ALL | AISYnc

ALL
All clock edges are used.

AISYnc
The clock edges of the synchronization time are discarded; results are gathered after initial synchronization of the CDR. Thus, meaningful TIE measurement results can be obtained.

*RST: AISYnc

CDR:SOFTware<m>:PLL:ORDer <PLLOrder>

Sets the order of the PLL: first or second order. PLL of higher order can compensate for more complex jitter behavior.

Suffix:

<m> 1..2
Number of the software CDR setup

Parameters:

<PLLOrder> FIRSt | SECond

*RST: FIRSt

CDR:SOFTware<m>:PLL:BWIDth <PLLBandwidth>

Sets the PLL bandwidth. It defines the part of the spectrum that the PLL can follow during synchronization. The PLL bandwidth is usually defined by the transmission standard.

Suffix:

<m>	1..2 Number of the software CDR setup	

Parameters:

<PLLBandwidth>	Range:	Nominal BITRate * Range of RELBwidth (dependent range)
	Increment:	10
	*RST:	599.88E+3
	Default unit:	Hz

CDR:SOFTware<m>:PLL:RELBwidth <PLLRelBw>

Sets the relative bandwidth, that is the ratio of the nominal bit rate to the PLL bandwidth.

Suffix:

<m>	1..2 Number of the software CDR setup	

Parameters:

<PLLRelBw>	Range:	10 to 5000
	Increment:	1
	*RST:	1667

CDR:SOFTware<m>:PLL:DAMPing <DampingFactor>

Sets the damping factor, which is only relevant for second order PLL.

Suffix:

<m>	1..2 Number of the software CDR setup	

Parameters:

<DampingFactor>	Range:	0.5 to 1
	Increment:	0.01
	*RST:	0.7

20.21.3 Eye Mask Testing

The eye mask testing is available if the option R&S RTP-K12 is activated on the instrument.

The commands for eye mask testing are described in Chapter 20.14.7, "Eye Mask Testing ", on page 1231.

20.22 Deembedding (Option R&S RTP-K121/-K122)

20.22.1 Measurement Setup

DEEMbedding<m>[:STATe] <State>

Activates the deembedding - the correction of parasitic effects of the measurement setup on the measured signal.

Suffix:

<m> 1..4
Selects the channel that is configured for deembedding.

Parameters:

<State> ON | OFF
*RST: OFF

DEEMbedding<m>:ADD <Index>, [<Type>]

Adds a component to the measurement setup.

Suffix:

<m> 1..4
Selects the channel that is configured for deembedding.

Setting parameters:

<Index> Defines the place of the component in the measurement path. The DUT is always the first component (index = 1), the probe or input is the last component.

<Type> PROBe | FIXTure | CABLe | DUT | ADAPter | INPut | OTHer | RTZA10 | RTZA16 | RTZA17
RTZA10 | RTZA16 | RTZA17
SMA adapters and cable offered by Rohde & Schwarz

Usage: Setting only

DEEMbedding<m>:REMove <Index>

Deletes the component with the indicated index from the measurement setup.

Suffix:

<m>	1..4 Selects the channel that is configured for deembedding.

Setting parameters:

<Index>	Defines the place of the component in the measurement path. The DUT is always the first component (index = 1), the probe or input is the last component.

Usage: Setting only

DEEMbedding<m>:CCOunt?

Returns the total number of components in the measurement setup, including disabled components.

Suffix:

<m>	1..4 Selects the channel that is configured for deembedding.

Return values:

<Value>	Integer value, number of components

Usage: Query only

DEEMbedding<m>:REALtime <IsRealTime>

Requires realtime extension option R&S RTP-K122.

If ON, the deembedding calculation is done by the hardware in real time. You can trigger on the corrected signal, and the acquisition rate remains unchanged.

If OFF, the deembedding calculation is done by software. This method is slower, therefore, triggering on the corrected signal is not possible.

Suffix:

<m>	1..4

Parameters:

<IsRealTime>	ON | OFF *RST: OFF

DEEMbedding<m>:BANDwidth <Bandwidth>

Sets the maximum bandwidth until which the signal is corrected. This maximum value is the minimum bandwidth value of probe, probe tip and oscilloscope bandwidth, and can not be higher than the highest frequency in a used S-parameter file.

Suffix:
<m> 1..4
Selects the channel that is configured for deembedding.

Parameters:
<Bandwidth> Bandwidth limit for correction.

Range: 1E+9 to 16E+9
Increment: 10
*RST: 4E+9
Default unit: Hz

DEEMbedding<m>:CMPDelay <DelayCompens>

Enables the compensation for the group delay of the complete measurement setup. If enabled, the calibration time reference point is the start point of the measurement setup. If disabled, the calibration time reference point is the oscilloscope's channel input.

Suffix:
<m> 1..4
Selects the channel that is configured for deembedding.

Parameters:
<DelayCompens> ON | OFF

*RST: ON

DEEMbedding<m>:PRESet

Sets the complete deembedding configuration to the default values.

Suffix:
<m> 1..4
Selects the channel that is configured for deembedding.

Usage: Event

20.22.2 Save and Load the Deembedding Setup

DEEMbedding<m>:NAME <Path>

Sets the file name, file format and path of the deembedding setup file. The file format is always `.xml`.

Suffix:
<m> 1..4
Selects the channel that is configured for deembedding.

Parameters:
<Path> String with path and file name with extension `.xml`

DEEMbedding<m>:SAVE

Saves the deembedding configuration to the file specified with `DEEMbedding<m>:NAME`.

Suffix:
<m> 1..4
Selects the channel that is configured for deembedding.

Usage: Event

DEEMbedding<m>:OPEN

Opens and loads the deembedding configuration from the file specified with `DEEMbedding<m>:NAME`.

Suffix:
<m> 1..4
Selects the channel that is configured for deembedding.

Usage: Event

DEEMbedding<m>:DELete

Deletes the deembedding configuration file specified with `DEEMbedding<m>:NAME`.

Suffix:
<m> 1..4
Selects the channel that is configured for deembedding.

Usage: Event

20.22.3 Components

20.22.3.1 General Settings

DEEMbedding<m>:COMPonent<n>[:STATe] <IsEnabled>

Enables or disables the indicated component for deembedding.

The first and the last component are always enabled and cannot be disabled.

Suffix:

<m> 1..4
Selects the channel that is configured for deembedding.

<n> 2..n-1
Index of the component in the measurement setup. The DUT has index 1, the probe has index n.

Parameters:

<IsEnabled> ON | OFF

*RST: OFF

DEEMbedding<m>:COMPonent<n>:TYPE <Type>

Sets the type of the indicated component. The first component is always DUT, the last component is PROBe or INPut.

Suffix:

<m> 1..4
Selects the channel that is configured for deembedding.

<n> 1..n
Index of the component in the measurement setup. The DUT has index 1, the probe has index n.

Parameters:

<Type> PROBe | FIXTure | CABLe | DUT | ADAPter | INPut | OTHer | RTZA10 | RTZA16 | RTZA17

RTZA10 | RTZA16 | RTZA17
SMA adapters and cable offered by Rohde & Schwarz

*RST: CABLe

DEEMbedding<m>:COMPonent<n>:NAME <Name>

Sets a name for the indicated component that helps you identifying it.

Suffix:

<m> 1..4
Selects the channel that is configured for deembedding.

<n> 1..n
Index of the component in the measurement setup. The DUT has index 1, the probe has index n.

Parameters:

<Name>	String parameter, name of the component

DEEMbedding<m>:COMPonent<n>:PCOunt?

Returns the number of all ports of the selected component (input ports and output ports).

The number of ports depends on the attached probe. If a modular probe R&S RT-ZM or differential probe R&S RT-ZD is used, the number of ports is 4. Otherwise, 2 ports are available.

Suffix:

<m>	1..4 Selects the channel that is configured for deembedding.
<n>	1..n Index of the component in the measurement setup. The DUT has index 1, the probe has index n.

Return values:

<TotalPorts>	ONE | TWO | THRee | FOUR *RST: TWO

Usage: Query only

20.22.3.2 DUT Settings

DEEMbedding<m>:COMPonent<n>:MODE <Mode>

Sets the probing mode.

Suffix:

<m>	1..4 Selects the channel that is configured for deembedding.
<n>	1, only for available DUT

Parameters:

<Mode>	PROBing | TERMinating **PROBing** For measurements with a high-ohmic probe and measure on an existing line in parallel to the load. **TERMinating** For measurements if the measuring equipment is the load of the line.

*RST: PROBing

DEEMbedding<m>:COMPonent<n>:LOAD:REMProbeload <Value>

Removes the loading of the probe if `DEEMbedding<m>:COMPonent<n>:MODE` is set to `PROBing`.

If the probe loading is removed, you see the signal that would be at the measurement point if the probe's input impedance is ideal (infinite impedance).

Without removing the loading, you see the real signal at the measurement point, including the probe loading.

Suffix:

<m>	1..4 Selects the channel that is configured for deembedding.
<n>	1, only for available DUT

Parameters:

<Value>	OFF | ON

DEEMbedding<m>:COMPonent<n>:LOAD[:TYPE] <Value>

Sets the impedance type of the DUT.

Suffix:

<m>	1..4 Selects the channel that is configured for deembedding.
<n>	1, only for available DUT

Parameters:

<Value> DEFault | CONStant | S1P | S2P

DEFault
The default value depends on the selected probing mode and the connected modular or differential probe. The impedance is a constant value over frequency. If the default value does not match to the DUT, select "Constant" or "Touchstone".

CONStant
The source impedance is a constant value over frequency. Set the value with `DEEMbedding<m>:COMPonent<n>:LOAD:IMPedance` on page 1842.

S1P | S2P
Touchstone file. If the complete measurement setup is a 2-port (1 input and 1 output), you need a S1P file. If the complete measurement setup is a 3-port (2 inputs and 1 output), you need a S2P file.
See also: "Impedance type" on page 154.

DEEMbedding<m>:COMPonent<n>:LOAD:IMPedance <Value>

Impedance of the DUT. Shows the default source impedance or sets the user-defined constant impedance value. If an R&S RT-ZM probe is connected, the value depends on the selected probe mode: common mode, differential, or single-ended measurement.

See also: DEEMbedding<m>:COMPonent<n>:LOAD[:TYPE] on page 1841.

Suffix:

<m>	1..4 Selects the channel that is configured for deembedding.
<n>	1, only for available DUT

Parameters:

<Value>	Numeric value

DEEMbedding<m>:COMPonent<n>:LOAD:FILE <Value>

Sets the file name, file format and path of the S-parameter file, and loads the S-parameters.

The command is relevant if:

- `DEEMbedding<m>:COMPonent<n>:MODE` is `PROBing`
- `DEEMbedding<m>:COMPonent<n>:LOAD:REMProbeload` on page 1841 is `ON`
- `DEEMbedding<m>:COMPonent<n>:LOAD[:TYPE]` is `S1P | S2P`

Suffix:

<m>	1..4 Selects the channel that is configured for deembedding.
<n>	1, only for available DUT

Parameters:

<Value>	String with path and file name with extension `s2p` or `s1p`.

20.22.3.3 R&S RT-ZM Probe Settings

This chapter lists the commands that correspond to the "Deembedding" > "RT-ZMxx" dialog box. More commands are provided in Chapter 20.8.7.6, "Modular Probes, Deembedding", on page 1031.

PROBe<m>:DEEMbedding:TIPModule[:SELect] <ProbeTip>

Selects the tip module that is used for measurement.

Suffix:
<m> 1..4
Selects the channel to which the probe is connected.

Parameters:
<ProbeTip> NONE | ZMA10 | ZMA12 | ZMA15 | ZMA30 | ZMA40 | ZMA50
*RST: ZMA10

PROBe<m>:DEEMbedding:TIPModule:ZMA<n>:SUBModule <Value>

Defines additional settings for some tip modules:

For the browser module R&S RT-ZMA30, measure the space between the pins, and select the appropriate value.

If R&S RT-ZMA40 is selected, choose the used submodule: semi-rigid cables or none.

Suffix:
<m> 1..4
Selects the channel to which the probe is connected.

<n> 30 (R&S RT-ZMA30) or 40 (R&S RT-ZMA40)

Parameters:
<Value> D16 | D25 | D45 | D75 | NONE | SRCS

For R&S RT-ZMA30:
D16 = 1.6 mm
D25 = 2.5 mm
D45 = 4.5 mm
D75 = 7.5 mm
For R&S RT-ZMA40:
NONE = no submodule
SRCS = semi-rigid cables

PROBe<m>:DEEMbedding:BANDwidth <ProbeBandwidth>

Sets the maximum bandwidth until which the signal is corrected. This maximum value is the minimum bandwidth value of probe, probe tip and oscilloscope bandwidth, and can not be higher than the highest frequency in a used S-parameter file. Consider that most tip modules support the full bandwidth of the probe amplifier, but some tip modules have limited bandwidth.

Suffix:
<m> 1..4
Selects the channel to which the probe is connected.

Parameters:
<ProbeBandwidth> Range: 1E+9 to 16E+9
Increment: 10
*RST: 4E+9
Default unit: Hz

20.22.3.4 Cable, Adapter, Fixture and Custom Settings

DEEMbedding<m>:COMPonent<n>:IDENtical <MatchedPaths>

The setting is relevant if the measurement setup is a 4-port, and the component is a 2-port. Usually, these components are cables and adapters, which are described by *.s2p files. In case of a 4-port setup, 2 cables or 2 adapters are used. If they are identical, for example, when a matched-pair cable is used, they can be described by the same file. In this case, set the command to ON.

Suffix:

<m>	1..4 Selects the channel that is configured for deembedding.
<n>	1..* Selects the component. The DUT has suffix 1.

Parameters:

<MatchedPaths>	ON | OFF *RST: OFF

DEEMbedding<m>:COMPonent<n>:IPONe <InputPort1>
DEEMbedding<m>:COMPonent<n>:IPTWo <InputPort2>
DEEMbedding<m>:COMPonent<n>:OPONe <OutputPort1>
DEEMbedding<m>:COMPonent<n>:OPTWo <OutputPort2>

Assign the ports to the input and output of the component according to the data in the Touchstone file. This information is not directly written in the file. You need background information how the S-parameters were determined, i.e. which port was input and which port was output.

Suffix:

<m>	1..4 Selects the channel that is configured for deembedding.
<n>	1..* Selects the component. The DUT has suffix 1.

Parameters:

<InputPort1> <InputPort2> <OutputPort1> <OutputPort2>	ONE | TWO | THRee | FOUR Port number that is assigned to the input or output. *RST: ONE for input 1, TWO for output 1, THRee for input 2, FOUR for output 4

DEEMbedding<m>:COMPonent<n>:SPONe <SParamFilePath>
DEEMbedding<m>:COMPonent<n>:SPTWo <SParamFilePath>

Set the file name, file format and path of the S-parameter file, and load the S-parameters.

See also: "S-Parameters, Filetype" on page 919.

Suffix:

<m> 1..4
Selects the channel that is configured for deembedding.

<n> 1..*
Selects the component. The DUT has suffix 1.

Parameters:

<SParamFilePath> String with path and file name with extension `s2p` (2-port component) or `s4p` (4-port component).

20.22.4 Responses

DEEMbedding<m>:CADC?

Maximum attenuation or gain of the measurement setup before deembedding at DC. This value is the expected basic attenuation or gain, which is corrected by deembedding.

Suffix:

<m> 1..4
Selects the channel that is configured for deembedding.

Return values:

ValueAtDC
Range: -1E+9 to 1E+9
Increment: 0.01
*RST: 0
Default unit: dB

Usage: Query only

DEEMbedding<m>:MATTenuation?

Maximum attenuation of the measurement setup before deembedding, with reference to a frequency response normalized at DC to 0 dB. The deembedding filter must amplify the amplitude response by the "Att_{max}" value, and thus also increases the noise by this value. The value also helps to decide whether deembedding is useful for the defined effective bandwidth.

Suffix:

<m> 1..4
Selects the channel that is configured for deembedding.

Return values:

<MaxFilterAtt> Range: -1E+9 to 1E+9
Increment: 0.01
*RST: 0
Default unit: dB

Usage: Query only

DEEMbedding<m>:MGAin?

Maximum gain of the measurement setup before deembedding, with reference to a frequency response normalized at DC to 0 dB. The deembedding filter must attenuate the amplitude response by this value. The value helps also to avoid an overload of the ADC.

Suffix:

<m> 1..4
Selects the channel that is configured for deembedding.

Return values:

<MaxFilterGn> Range: -1E+9 to 1E+9
Increment: 0.01
*RST: 0
Default unit: dB

Usage: Query only

20.23 Maintenance

DIAGnostic:SERVice:WFAModel?

Returns the model name of the oscilloscope.

Return values:

<WFAModel> Product type

Usage: Query only

DIAGnostic:SERVice:WFASeries?

Returns the model series of the oscilloscope.

Return values:

<WFASeries> RTO | RTE | RTP

*RST: RTO

Usage: Query only

DIAGnostic:SERVice:WFAType?

Returns the instrument family of the oscilloscope.

Return values:

<WFAType> RTO | RTO2000 | RTEM | RTE | RTP

*RST: RTO2000

Usage: Query only

DIAGnostic:SERVice:STST:EXECute

Starts the selftest.

Usage: Event
Asynchronous command

DIAGnostic:SERVice:STST:STATe?

Returns the summary result of the selftest.

Return values:

<State> PSSD | FAILed | UNDefined

*RST: UNDefined

Usage: Query only

DIAGnostic:SERVice:PWD <Password>

Sets the password to enter the service mode.

Setting parameters:

<Password> Password string

Usage: Setting only

20.24 Status Reporting

This chapter describes the remote commands that are used to read the status registers.

For information on structure, hierarchy, and contents of the status registers, see Chapter C, "Remote Control - Status Reporting System", on page 1880.

20.24.1 STATus:OPERation Register

`STATus:OPERation` commands provide information on the activity of the instrument.

See also: Chapter C.3.4, "STATus:OPERation Register", on page 1885

STATus:OPERation:CONDition?
STATus:OPERation[:EVENt]?

The CONDition command returns information on actions the instrument is currently executing. The contents of the register is retained.

The EVENt command returns information on actions the instrument has executed since the last reading. Reading the EVENt register deletes its contents.

Bits:

- 0 = ALIGnment
- 2 = AUToset
- 3= WTRIgger (wait for trigger)
- 4= MEASuring

Usage: Query only

STATus:OPERation:ENABle <Enable>

Controls the ENABle part of the STATus:OPERation register. The ENABle defines which events in the EVENt part of the status register are forwarded to the OPERation summary bit (bit 7) of the status byte. The status byte can be used to create a service request.

Parameters:

<Enable> Range: 1 to 65535
Increment: 1

Example: `STATus:OPERation:ENABle 5`
The ALIGnment event (bit 0) and AUToset event (bit 2) are forwarded to the OPERation summary bit of the status byte.

20.24.2 STATus:QUEStionable Registers

The commands of the `STATus:QUEStionable` subsystem control the status reporting structures of the STATus:QUEStionable registers.

See also: Chapter C.3.5, "STATus:QUEStionable Register", on page 1886

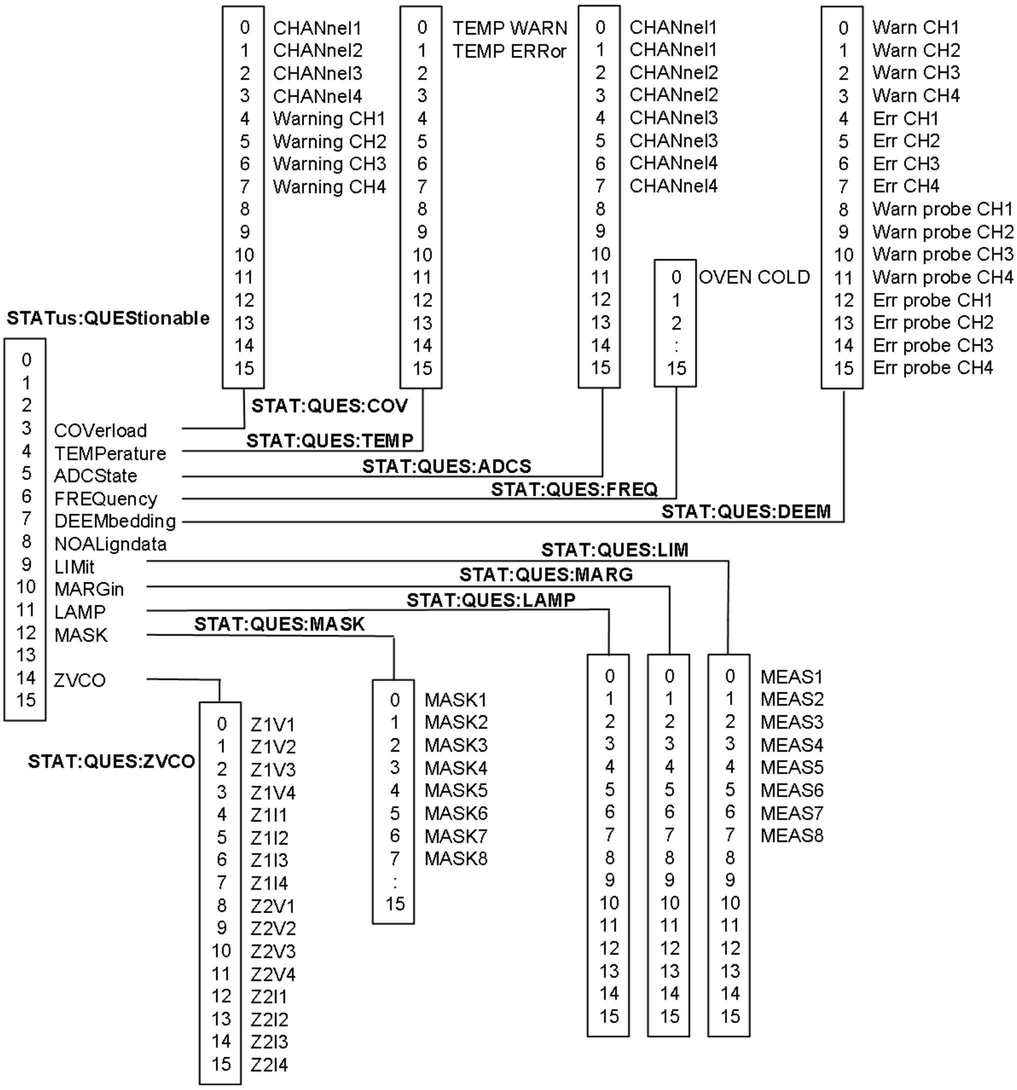


Figure 20-1: Overview of the STATus:QUEStionable register

The following commands are available:

STATus:QUEStionable:COVerload:CONDition?
STATus:QUEStionable:TEMPerature:CONDition?
STATus:QUEStionable:ADCState:CONDition?
STATus:QUEStionable:LIMit:CONDition?
STATus:QUEStionable:MARGin:CONDition?
STATus:QUEStionable:FREQuency:CONDition?

STATus:QUEStionable:DEEMbedding:CONDition?
STATus:QUEStionable:LAMPlitude:CONDition?
STATus:QUEStionable:ZVCoverload:CONDition?
STATus:QUEStionable:MASK:CONDition?

Returns the contents of the CONDition part of the status register to check for questionable instrument or measurement states. Reading the CONDition registers does not delete the contents.

Usage: Query only

STATus:QUEStionable:COVerload:ENABle <Value>
STATus:QUEStionable:TEMPerature:ENABle <Value>
STATus:QUEStionable:ADCState:ENABle <Value>
STATus:QUEStionable:LIMit:ENABle <Value>
STATus:QUEStionable:MARGin:ENABle <Value>
STATus:QUEStionable:FREQuency:ENABle <Value>
STATus:QUEStionable:DEEMbedding:ENABle <Value>
STATus:QUEStionable:LAMPlitude:ENABle <Value>
STATus:QUEStionable:ZVCoverload:ENABle <Value>
STATus:QUEStionable:MASK:ENABle <Value>

Sets the ENABle part that allows true conditions in the EVENt part to be reported in the summary bit. If a bit is set to 1 in the enable part and its associated event bit transitions to true, a positive transition occurs in the summary bit and is reported to the next higher level.

Parameters:
<Value> Bit mask in decimal representation

Example: `STATus:QUEStionable:MASK:ENABle 24`
Set bits no. 3 and 4 of the STATus:QUEStionable:MASK:ENABle register part: *24 = 8 + 16 =* $2^3 + 2^4$

STATus:QUEStionable:COVerload[:EVENt]?
STATus:QUEStionable:TEMPerature[:EVENt]?
STATus:QUEStionable:ADCState[:EVENt]?
STATus:QUEStionable:LIMit[:EVENt]?
STATus:QUEStionable:MARGin[:EVENt]?
STATus:QUEStionable:FREQuency:EVENt?
STATus:QUEStionable:DEEMbedding[:EVENt]?
STATus:QUEStionable:LAMPlitude[:EVENt]?
STATus:QUEStionable:ZVCoverload[:EVENt]?
STATus:QUEStionable:MASK[:EVENt]?

Returns the contents of the EVENt part of the status register to check whether an event has occurred since the last reading. Reading an EVENt register deletes its contents.

Usage: Query only

STATus:QUEStionable:COVerload:NTRansition <Value>
STATus:QUEStionable:TEMPerature:NTRansition <Value>
STATus:QUEStionable:ADCState:NTRansition <Value>
STATus:QUEStionable:LIMit:NTRansition <Value>
STATus:QUEStionable:MARGin:NTRansition <Value>
STATus:QUEStionable:FREQuency:NTRansition <Value>
STATus:QUEStionable:DEEMbedding:NTRansition <Value>
STATus:QUEStionable:LAMPlitude:NTRansition <Value>
STATus:QUEStionable:ZVCoverload:NTRansition <Value>
STATus:QUEStionable:MASK:NTRansition <Value>

Sets the negative transition filter. If a bit is set, a 1 to 0 transition in the corresponding bit of the condition register causes a 1 to be written in the corresponding bit of the event register.

Parameters:

<Value> Bit mask in decimal representation

Example: `STATus:QUEStionable:MASK:NTRansition 24`
Set bits no. 3 and 4 of the STATus:QUEStionable:MASK:NTRansition register part: $24 = 8 + 16 = 2^3 + 2^4$

STATus:QUEStionable:COVerload:PTRansition <Value>
STATus:QUEStionable:TEMPerature:PTRansition <Value>
STATus:QUEStionable:ADCState:PTRansition <Value>
STATus:QUEStionable:LIMit:PTRansition <Value>
STATus:QUEStionable:MARGin:PTRansition <Value>
STATus:QUEStionable:FREQuency:PTRansition <Value>
STATus:QUEStionable:DEEMbedding:PTRansition <Value>
STATus:QUEStionable:LAMPlitude:PTRansition <Value>
STATus:QUEStionable:ZVCoverload:PTRansition <Value>
STATus:QUEStionable:MASK:PTRansition <Value>

Sets the positive transition filter. If a bit is set, a 0 to 1 transition in the corresponding bit of the condition register causes a 1 to be written in the corresponding bit of the event register.

Parameters:

<Value> Bit mask in decimal representation

Example: `STATus:QUEStionable:MASK:PTRansition 24`
Set bits no. 3 and 4 of the STATus:QUEStionable:MASK:PTRansition register part: $24 = 8 + 16 = 2^3 + 2^4$

20.25 Remote Trace

The commands in this section configure tracing of the remote control interface and of events. They also configure the display of the SCPI remote trace.

Before you start tracing, configure all settings as desired. Modifying settings while tracing is active may result in loss of already traced data. Useful exception: Selecting a new target file while tracing is allowed. For start mode `EXPLicit` a restart of the instrument resets the settings to the documented default values.

If you want to start tracing already during startup of the instrument, configure all settings (including start mode `AUTO`). Then restart your instrument. Tracing will be started automatically during the restart, using the already configured settings.

If you use an XML file as trace file, ensure that tracing is stopped properly. If tracing is aborted instead of stopped, for example by shutting down the instrument for stop mode `EXPLicit`, the XML file will be invalid, because some tags are not closed.

When the maximum file size is reached (except for stop mode `BUFFerfull`) or if tracing is started with an already existing trace file, a backup of the trace file is created and the file itself is reset and overwritten. When the file is full for the second time or when tracing is started the next time, the first backup file is lost because it is overwritten by the next backup. In order to prevent loss of data, set a sufficient file size, select an appropriate stop mode and archive/copy completed trace files if you want to keep them.

20.25.1 Standard Commands

TRACe:REMote:MODE:FILE:NAME <FilePath>

Sets the directory and file name where the remote trace file is stored.

Parameters:

<FilePath>	String parameter

TRACe:REMote:MODE:FILE:FORMat <Format>

Sets the file format of the remote trace file.

Parameters:

<Format>	ASCii | XML

TRACe:REMote:MODE:FILE:SIZE <FileSize>

Sets the maximum size of the remote trace file.

Parameters:

<FileSize>	Integer value

TRACe:REMote:MODE:FILE:STARtmode <StartMode>

Defines how the remote trace is started.

Parameters:

<StartMode> AUTO | EXPLicit

AUTO
Starts the remote trace immediately.

EXPLicit
Starts remote trace with `TRACe:REMote:MODE:FILE:ENABle ON`

TRACe:REMote:MODE:FILE:STOPmode <StopMode>

Defines when the remote trace is stopped.

Parameters:

<StopMode> AUTO | EXPLicit | ERRor | BUFFerfull

AUTO
Ends the remote trace on device shutdown.

EXPLicit
Ends remote trace with `TRACe:REMote:MODE:FILE:ENABle OFF`

ERRor
Ends remote trace when a SCPI error occurs.

BUFFerfull
Ends remote trace when the maximum file size is reached.

TRACe:REMote:MODE:FILE:ENABle <Enable>

Enables and disables the remote trace to file.

Parameters:

<Enable> ON | OFF

TRACe:REMote:MODE:FILE:FILTer <Input>, <Output>, <Error>, <Trigger>, <DeviceClear>, <StatusRegister>, <Connection>, <RemoteLocalEvents>, <Locking>

Defines the content of the remote trace file.

Parameters:

<Input> ON | OFF

Input data

<Output> ON | OFF

Output data

<Error>	ON | OFF New SCPI error queue entries
<Trigger>	ON | OFF Trigger events
<DeviceClear>	ON | OFF Device clear events
<StatusRegister>	ON | OFF Status register conditions
<Connection>	ON | OFF Open/close connection events
<RemoteLocalEvents>	ON | OFF Local/remote transition events
<Locking>	ON | OFF Remote locking events

20.25.2 Diagnostic Remote Trace Commands

TRACe:REMote:MODE:FILE:DEXecution:DURation <Enable>

Traces the device execution time of a command

Parameters:

<Enable> ON | OFF

TRACe:REMote:MODE:FILE:RPC <Enable>

Enables and disables output of rpc calls to remote trace.

Parameters:

<Enable> ON | OFF

TRACe:REMote:MODE:FILE:PARSer <Enable>

Enables and disables output of parser transitions to remote trace.

Parameters:

<Enable> ON | OFF

TRACe:REMote:MODE:FILE:FUNCtions <Enable>

Enables and disables output of function names to remote trace.

Parameters:

<Enable>	ON | OFF

21 Maintenance

The instrument does not need periodic maintenance. Only the cleaning of the instrument is essential.

To protect the front panel and to transport the instrument to another workplace safely and easily, various accessories are provided. Refer to the data sheet for available covers and cases and their order numbers.

The adjustment of the OCXO oscillator is described in the service manual.

The addresses of Rohde & Schwarz support centers can be found at www.customer-support.rohde-schwarz.com. A list of all service centers is available on www.services.rohde-schwarz.com.

21.1 Cleaning

WARNING

Risk of electric shock

If moisture enters the casing, for example if you clean the instrument using a moist cloth, contact with the instrument can lead to electric shock. Before cleaning the instrument other than with a dry cloth, make sure that the instrument is switched off and disconnected from all power supplies.

NOTICE

Instrument damage caused by cleaning agents

Cleaning agents contain substances such as solvents (thinners, acetone, etc.), acids, bases, or other substances. Solvents can damage the front panel labeling, plastic parts, or screens, for example.

Never use cleaning agents to clean the outside of the instrument. Use a soft, dry, lint-free dust cloth instead.

NOTICE

Risk of instrument damage due to obstructed fans

If the instrument is operated in dusty areas, the fans become obstructed by dust or other particles over time. Check and clean the fans regularly to ensure that they always operate properly. If the instrument is run with obstructed fans for a longer period, the instrument overheats, which can disturb the operation and even cause damage.

1. Clean the outside of the instrument using a soft, dry, lint-free dust cloth.

2. Check and clean the fans regularly to ensure that they always operate properly.
3. Clean the touchscreen as follows:
   a) Apply a small amount of standard screen cleaner to a soft cloth.
   b) Wipe the screen gently with the moist, but not wet, cloth.
   c) If necessary, remove any excess moisture with a dry, soft cloth.

21.2 Information for Technical Support

If you encounter problems that you cannot solve yourself, contact your Rohde & Schwarz support center at www.customersupport.rohde-schwarz.com. The staff of our support center is optimally trained to assist you in solving the problems. The support center finds solutions more quickly and efficiently if you provide them with information on the instrument and an error description.

To create, collect and save the required information, you can use the RTxServiceReporter. The RTxServiceReporter creates a ZIP file with a complete bug report, all relevant setup information, reporting and log files, and the instrument configuration (device footprint).

1. Open the App Cockpit: tap .
2. On the "R&S Apps" tab, tap "Service".

   The RTxServiceReporter creates the report and saves it as ZIP file directly on the Windows desktop.
3. Attach the report file to an email in which you describe the problem. Send the email to the customer support address for your region as listed in the Internet

On the instrument, you can find log files, the device footprint and report files, and other information in the "AppData" folder on the Windows desktop (`C:\ProgramData\Rohde-Schwarz\RTx`).

The "Board Detection/Maintenance" dialog box also provides information on your instrument configuration which may be helpful in case you need support.

21.3 Data Security

If you have to send the instrument to the service, or if the instrument is used in a secured environment, consider the document "Instrument Security Procedures" that is delivered on the R&S RTP web page.

Instrument configuration data and user data are stored on a removable hard disk only. Thus it is sufficient to remove the hard disk before the instrument leaves a secured environment. Details are given in the document mentioned above.

21.4 Storing and Packing

The storage temperature range of the instrument is given in the data sheet. If the instrument is to be stored for a longer period of time, it must be protected against dust.

Repack the instrument as it was originally packed when transporting or shipping. The two protective foam plastic parts prevent the control elements and connectors from being damaged. The antistatic packing foil avoids any undesired electrostatic charging to occur.

If you do not use the original packaging, use a sturdy cardboard box of suitable size and provide for sufficient padding to prevent the instrument from slipping inside the package. Wrap antistatic packing foil around the instrument to protect it from electrostatic charging.

21.5 Performing a Self-test

The instrument self-test checks the hardware for correct operation. Perform the self-test if you suspect problems in hardware operation.

1. From the "File" menu, select "Selftest".
2. Tap "Selftest".

   The test can take several minutes. The summary result is shown in the "State" field. If you require support, you may be asked to provide this information.

21.6 Reference for Maintenance Settings

21.6.1 Board Detection/Maintenance

The "Board Detection/Maintenance" dialog box in the "File" menu provides service information for your R&S RTP. In case you require support, you may be asked to provide this information.

21.6.1.1 System Info

This tab provides general information on the hardware configuration, and indicates where system information can be found on the instrument.

21.6.1.2 Mainboard

This tab provides information on the mainboard configuration in your instrument.

21.6.1.3 Frontend

This tab provides information on the frontend configuration in your instrument.

21.6.1.4 Frontpanel

This tab provides information on the frontpanel module installed in your instrument.

21.6.1.5 MSO Option

This tab is only relevant if the MSO option R&S RTP-B1 is installed. The tab provides information on the MSO hardware module that is installed in your instrument.

21.6.1.6 Service

This tab allows the service personnel to enter a password that activates further service functions.

Remote command:
- `DIAGnostic:SERVice:PWD` on page 1847

21.6.2 Selftest

The instrument selftest checks the hardware for correct operation. Perform the selftest if you suspect problems in hardware operation.

Selftest
Starts the selftest.

Remote command:
`*TST?` on page 976

State
Shows the summary result of the selftest: Pass or Fail.

Remote command:
`DIAGnostic:SERVice:STST:STATe?` on page 1847

Result
Opens a log file with detailed information on the selftest steps and hardware components operation. In case you require support, you may be asked to provide this information.

Annex

A Menu Overview

This section provides an overview of the menus together with a short description or link to the description.

A.1 File Menu

Menu item	Description	Corresponding key
Save Recall	Chapter 11.1, "Instrument Settings", on page 420 Chapter 11.2.1, "Waveform Export Files", on page 429 Chapter 11.5, "Autonaming", on page 456	[Save Recall]
Setup	Chapter 3, "Instrument Setup", on page 78	[Setup]
Print Setup	Chapter 11.3, "Screenshots", on page 448 Chapter 11.3.2, "Printing Screenshots", on page 453	[Camera]
Report Setup	Chapter 11.4, "Reports", on page 454	
Frontpanel Setup	Chapter 3.3, "Frontpanel Setup", on page 85	
External Setup	Chapter 3.5, "External Application", on page 102	
Preset Setup	Chapter 11.6, "Preset Setup", on page 459	
Help	Chapter 2.3.10, "Getting Information and Help", on page 75	[Help]
Mode	Chapter 3.8.5, "Options in Beta State", on page 109	
Maintenance	Chapter 21.6.1, "Board Detection/Maintenance", on page 1859	
Selfalignment	Chapter 3.6, "Self-alignment", on page 103	
Selftest	Chapter 21.6.2, "Selftest", on page 1860	

Menu item	Description	Corresponding key
Tutorials	Opens a dialog box with tutorial videos that explain how to use the instrument.	
Demo Board	For internal use only. Opens a setup dialog box for the demo board If a demo board is connected to the instrument.	
Minimize Application	Shows the Windows desktop with the application icon of the R&S RTP firmware.	
Exit	Shuts down the firmware.	

A.2 Horizontal Menu

Menu item	Description	Corresponding key
Setup	Chapter 4.2.1, "Setup", on page 121	[Horizontal]
Acquisition	Chapter 4.2.2, "Acquisition", on page 125	[Acquisition]
Fast Segmentation	Chapter 4.2.3, "Fast Segmentation", on page 129	
Skew	Chapter 4.8.2, "Skew", on page 174	

A.3 Trigger Menu

Menu item	Description	Corresponding key
Setup	Chapter 5.3, "Trigger Types", on page 184	[Trigger]
Noise Reject	Chapter 5.6, "Noise Reject", on page 209	
Holdoff	Chapter 5.5, "Holdoff", on page 208	
Ctrl/Action	Chapter 5.7, "Control / Action", on page 211	
Extern		
Digital Filter	Chapter 4.7, "Digital Filter Setup", on page 171	
Acquisition Info	Shows the current number of acquisitions that have been acquired.	

A.4 Vertical Menu

Menu item	Description	Corresponding key
Channels	Chapter 4.3.1, "Channels", on page 132	[Ch <n>]
Coupled Channels		

Menu item	Description	Corresponding key
Power Calculation	Chapter 4.3.3, "Power Calculation", on page 134	
Probe Setup	Chapter 4.5, "Probes", on page 139	
Probe Attributes	Chapter 4.5.9, "Probe Attributes", on page 161	
Calibration Results	Chapter 4.5.10, "Calibration Results", on page 162	
Digital Filter	Chapter 4.7, "Digital Filter Setup", on page 171	
ZVC Multi-Channel Probe	Chapter 4.6, "R&S RT-ZVC Probe", on page 162	

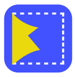
A.5 Math Menu

Menu item	Description	Key / Icon
Math Setup	Chapter 6.3.4, "Math Setup - General Settings", on page 256	[Math]
FFT Setup	Chapter 8.1.3.1, "FFT Setup", on page 354	
FFT Overlap		
FFT Gating	Chapter 8.1.3.3, "FFT Gating", on page 359	
FFT Y-Units		
Reference Waveform	Submenu: Setup, Scaling, Original Attributes: Chapter 6.2.2, "Settings for Reference Waveforms", on page 240	

A.6 Cursor Menu

Menu item	Description	Key / Icon
Setup	Chapter 7.1.3.1, "Cursor Setup", on page 275	[Cursor] 
Label	Chapter 7.1.3.2, "Cursor Labels", on page 278	
Peak Search	Chapter 7.1.3.3, "Peak Search ", on page 279	

A.7 Meas Menu

Menu item	**Description**	**Key / Icon**
"Meas Group"	Chapter 7.2.1.3, "General Measurement Settings", on page 285	[Meas] 
Result Analysis	Chapter 7.2.10.5, "Settings for Result Analysis", on page 336	
Gate/Display	Chapter 7.2.3.2, "Gate Settings for Measurements", on page 292 Chapter 7.2.2.3, "Display Settings for Results", on page 289	
Limit Check	Chapter 7.2.11.3, "Actions on Limit Check Results", on page 343	
Histogram	Chapter 7.2.8.4, "Histogram Setup", on page 328	
Reference Level	Submenu: Levels, Hysteresis, Tube: Chapter 7.2.4.2, "Level Settings", on page 297	

A.8 Masks Menu

Menu item	**Description**	**Key / Icon**
Test Definition	Chapter 9.2.1, "Test Definition", on page 373	[Mask] Opens the last selected tab in the "Masks" dialog box. 
Mask Definition	Chapter 9.2.2.1, "Mask Definition: User Mask", on page 375	
Event Actions / Reset	Chapter 9.2.3, "Event Actions /Reset ", on page 382	
Mask Display	Chapter 9.2.4, "Mask Display", on page 384	

A.9 Analysis Menu

The content of the menu depends on the installed options.

Menu item	**Description**	**Corresponding key**
Deembedding	Chapter 17, "Deembedding (Option R&S RTP-K121/-K122)", on page 907	
Compliance Test	Chapter 18, "Compliance Tests", on page 923	
Jitter Wizard	Chapter 16.1.1, "Jitter Wizard", on page 892	
CDR	Chapter 16.2, "Clock Data Recovery", on page 902	

Menu item	Description	Corresponding key
Parallel bus	Chapter 13.1.1, "Parallel Buses - Configuration", on page 838	[Logic]
Search	Chapter 10, "Search Functions", on page 396	[Search]
Serial Bus	Chapter 12, "Protocol Analysis", on page 463	[Protocol]

A.10 Display Menu

Menu item	Description	Key / Icon
Signal Colors / Persistence	Chapter 3.4.2.1, "Colors / Persistence", on page 89	[Display] Opens the last selected tab in the "Display" dialog box.
Color Tables	Chapter 3.4.2.2, "Color Tables", on page 92	
Diagram Layout	Chapter 3.4.2.3, "Diagram Layout", on page 93	
XY-Diagram	Chapter 6.5, "XY-Diagram", on page 266	
Labels		
Zoom	Chapter 6.1, "Zoom", on page 226	[Zoom] 
Show history	Enables the history mode and opens the quick-access "History" dialog box. Chapter 6.4, "History", on page 259	[History]
History setup	Opens the "History" configuration dialog box without starting the history mode. Chapter 6.4.2, "History Setup", on page 260	
Show performance	Displays the current performance values of the instrument.	
Clear all	Deletes all measurement results including long term measurement and statistics, all waveforms, and the history.	
Toolbar	Chapter 2.3.5.2, "Configuring the Toolbar", on page 64	

B Remote Control - Basics

B.1 Messages

B.1.1 Instrument Messages

Instrument messages are employed in the same way for all interfaces, if not indicated otherwise in the description.

There are different types of instrument messages, depending on the direction they are sent:

- Commands
- Instrument responses

Structure and syntax of the instrument messages are described in Chapter B.2, "SCPI Command Structure", on page 1868.

Commands

Commands (program messages) are messages that the controller sends to the instrument. They operate the instrument functions and request information. The commands are subdivided according to two criteria:

- According to the effect on the instrument:
  – **Setting commands** cause instrument settings such as a reset of the instrument or setting the frequency.
  – **Queries** cause data to be provided for remote control, e.g. for identification of the instrument or polling a parameter value. Queries are formed by directly appending a question mark to the command header.
- According to their definition in standards:
  – **Common commands**: their function and syntax are precisely defined in standard IEEE 488.2. They are employed identically on all instruments (if implemented). They refer to functions such as management of the standardized status registers, reset and self-test.
  – **Instrument control commands** refer to functions depending on the features of the instrument such as frequency settings. Many of these commands have also been standardized by the SCPI committee. These commands are marked as "SCPI compliant" in the command reference chapters. Commands without this SCPI label are device-specific, however, their syntax follows SCPI rules as permitted by the standard.

Instrument responses

Instrument responses (response messages and service requests) are messages that the instrument sends to the controller after a query. They can contain measurement results, instrument settings and information on the instrument status.

B.1.2 Interface Massages

Interface messages are transmitted to the instrument on the data lines. They are used to communicate between the controller and the instrument.

B.1.2.1 GPIB Interface Messages

Interface messages are transmitted to the instrument on the data lines, with the attention line (ATN) being active (LOW). They are used for communication between the controller and the instrument and can only be sent by a computer which has the function of a GPIB bus controller. GPIB interface messages can be further subdivided into:

- **Universal commands**: act on all instruments connected to the GPIB bus without previous addressing
- **Addressed commands**: only act on instruments previously addressed as listeners

Universal Commands

Universal commands are encoded in the range 10 through 1F hex. They affect all instruments connected to the bus and do not require addressing.

Command	Effect on the instrument
DCL (Device Clear)	Aborts the processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument settings.
IFC (Interface Clear) *)	Resets the interfaces to the default setting.
LLO (Local Lockout)	The "Local" softkey is disabled. Manual operation is no longer available until `GTL` is executed.
SPE (Serial Poll Enable)	Ready for serial poll.
SPD (Serial Poll Disable)	End of serial poll.
PPU (Parallel Poll Unconfigure)	End of the parallel-poll state.
*) IFC is not a real universal command, it is sent via a separate line; however, it also affects all instruments connected to the bus and does not require addressing	

Addressed Commands

Addressed commands are encoded in the range 00 through 0F hex. They only affect instruments addressed as listeners.

Command	Effect on the instrument
GET (Group Execute Trigger)	Triggers a previously active instrument function (e.g. a sweep). The effect of the command is the same as with that of a pulse at the external trigger signal input.
GTL (Go to Local)	Transition to the "local" state (manual control).
GTR (Go to Remote)	Transition to the "remote" state (remote control).
PPC (Parallel Poll Configure)	Configures the instrument for parallel poll.
SDC (Selected Device Clear)	Aborts the processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument setting.

B.1.2.2 LAN Interface Messages

In the LAN connection, the interface messages are called low–level control messages. These messages can be used to emulate interface messages of the GPIB bus.

Command	Long term	Effect on the instrument
&ABO	Abort	Aborts processing of the commands just received.
&DCL	Device Clear	Aborts processing of the commands just received and sets the command processing software to a defined initial state. Does not change the instrument setting.
&GTL	Go to Local	Transition to the "local" state (manual control). (The instrument automatically returns to remote state when a remote command is sent UNLESS `&NREN` was sent before.)
&GTR	Go to Remote	Enables automatic transition from local state to remote state by a subsequent remote command (after `&NREN` was sent).
&GET	Group Execute Trigger	Triggers a previously active instrument function (e.g. a sweep). The effect of the command is the same as with that of a pulse at the external trigger signal input.
&LLO	Local Lockout	Disables transition from remote control to manual control by means of the front panel keys.
&NREN	Not Remote Enable	Disables automatic transition from local state to remote state by a subsequent remote command. (To re-activate automatic transition use `&GTR`.)
&POL	Serial Poll	Starts a serial poll.

B.2 SCPI Command Structure

SCPI commands consist of a header and, in most cases, one or more parameters. The header and the parameters are separated by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank). The headers may consist of several mnemonics (keywords). Queries are formed by appending a question mark directly to the header.

The commands can be either device-specific or device-independent (common commands). Common and device-specific commands differ in their syntax.

B.2.1 Syntax for Common Commands

Common (= device-independent) commands consist of a header preceded by an asterisk (*), and possibly one or more parameters.

Table B-1: Examples of common commands

*RST	RESET	Resets the instrument.
*ESE	EVENT STATUS ENABLE	Sets the bits of the event status enable registers.
*ESR?	EVENT STATUS QUERY	Queries the contents of the event status register.
*IDN?	IDENTIFICATION QUERY	Queries the instrument identification string.

B.2.2 Syntax for Device-Specific Commands

Not all commands used in the following examples are necessarily implemented in the instrument. For demonstration purposes only, assume the existence of the following commands for this section:

- DISPlay[:WINDow<1...4>]:MAXimize <Boolean>
- FORMat:READings:DATA <type>[,<length>]
- HCOPy:DEVice:COLor <Boolean>
- HCOPy:DEVice:CMAP:COLor:RGB <red>,<green>,<blue>
- HCOPy[:IMMediate]
- HCOPy:ITEM:ALL
- HCOPy:ITEM:LABel <string>
- HCOPy:PAGE:DIMensions:QUADrant[<N>]
- HCOPy:PAGE:ORIentation LANDscape | PORTrait
- HCOPy:PAGE:SCALe <numeric value>
- MMEMory:COPY <file_source>,<file_destination>
- SENSE:BANDwidth|BWIDth[:RESolution] <numeric_value>
- SENSe:FREQuency:STOP <numeric value>
- SENSe:LIST:FREQuency <numeric_value>{,<numeric_value>}

B.2.2.1 Long and short form

The mnemonics feature a long form and a short form. The short form is marked by upper case letters, the long form corresponds to the complete word. Either the short form or the long form can be entered; other abbreviations are not permitted.

Example:

`HCOPy:DEVice:COLor ON` is equivalent to `HCOP:DEV:COL ON`.

Case-insensitivity

Upper case and lower case notation only serves to distinguish the two forms in the manual, the instrument itself is case-insensitive.

B.2.2.2 Numeric Suffixes

If a command can be applied to multiple instances of an object, e.g. specific channels or sources, the required instances can be specified by a suffix added to the command. Numeric suffixes are indicated by angular brackets (<1...4>, <n>, <i>) and are replaced by a single value in the command. Entries without a suffix are interpreted as having the suffix 1.

Example:

Definition: `HCOPy:PAGE:DIMensions:QUADrant[<N>]`

Command: `HCOP:PAGE:DIM:QUAD2`

This command refers to the quadrant 2.

Different numbering in remote control

For remote control, the suffix may differ from the number of the corresponding selection used in manual operation. SCPI prescribes that suffix counting starts with 1. Suffix 1 is the default state and used when no specific suffix is specified.

Some standards define a fixed numbering, starting with 0. If the numbering differs in manual operation and remote control, it is indicated for the corresponding command.

B.2.2.3 Optional Mnemonics

Some command systems permit certain mnemonics to be inserted into the header or omitted. These mnemonics are marked by square brackets in the description. The instrument must recognize the long command to comply with the SCPI standard. Some commands are considerably shortened by these optional mnemonics.

Example:

Definition: `HCOPy[:IMMediate]`

Command: `HCOP:IMM` is equivalent to `HCOP`

Optional mnemonics with numeric suffixes

Do not omit an optional mnemonic if it includes a numeric suffix that is relevant for the effect of the command.

Example:

Definition:`DISPlay[:WINDow<1...4>]:MAXimize <Boolean>`

Command: `DISP:MAX ON` refers to window 1.

In order to refer to a window other than 1, you must include the optional `WINDow` parameter with the suffix for the required window.

`DISP:WIND2:MAX ON` refers to window 2.

B.2.3 SCPI Parameters

Many commands are supplemented by a parameter or a list of parameters. The parameters must be separated from the header by a "white space" (ASCII code 0 to 9, 11 to 32 decimal, e.g. blank).

The parameters required for each command and the allowed range of values are specified in the command description.

Allowed parameters are:

B.2.3.1 Numeric Values

Numeric values can be entered in any form, i.e. with sign, decimal point and exponent. Values exceeding the resolution of the instrument are rounded up or down. The mantissa may comprise up to 255 characters, the exponent must lie inside the value range -32000 to 32000. The exponent is introduced by an "E" or "e". Entry of the exponent alone is not allowed.

Example:

`SENS:FREQ:STOP 1500000` = `SENS:FREQ:STOP 1.5E6`

Units

For physical quantities, the unit can be entered. If the unit is missing, the basic unit is used. Allowed unit prefixes are:

- G (giga)
- MA (mega), MOHM, MHZ
- K (kilo)

- M (milli)
- U (micro)
- N (nano)

Example:

`SENSe:FREQ:STOP 1.5GHz` = `SENSe:FREQ:STOP 1.5E9`

Some settings allow relative values to be stated in percent. According to SCPI, this unit is represented by the `PCT` string.

Example:

`HCOP:PAGE:SCAL 90PCT`

B.2.3.2 Special Numeric Values

The following mnemonics are special numeric values. In the response to a query, the numeric value is provided.

- **MIN and MAX**: denote the minimum and maximum value.
- **DEF**: denotes a preset value which has been stored in the EPROM. This value conforms to the default setting, as it is called by the *RST command.
- **UP and DOWN**: increases or reduces the numeric value by one step. The step width can be specified via an allocated step command for each parameter which can be set via UP and DOWN.
- **INF and NINF**: INFinity and negative INFinity (NINF) represent the numeric values 9.9E37 or -9.9E37, respectively. INF and NINF are only sent as instrument responses.
- **NAN**: Not A Number (NAN) represents the value 9.91E37. NAN is only sent as a instrument response. This value is not defined. Possible causes are the division of zero by zero, the subtraction of infinite from infinite and the representation of missing values.

Example:

Setting command: `SENSe:LIST:FREQ MAXimum`

Query: `SENS:LIST:FREQ?`

Response: `3.5E9`

Queries for special numeric values

The numeric values associated to `MAXimum/MINimum/DEFault` can be queried by adding the corresponding mnemonic after the quotation mark.

Example: `SENSe:LIST:FREQ? MAXimum`

Returns the maximum numeric value as a result.

B.2.3.3 Boolean Parameters

Boolean parameters represent two states. The "ON" state (logically true) is represented by "ON" or a numeric value 1. The "OFF" state (logically untrue) is represented by "OFF" or the numeric value 0. The numeric values are provided as the response for a query.

Example:

Setting command: `HCOPy:DEV:COL ON`

Query: `HCOPy:DEV:COL?`

Response: `1`

B.2.3.4 Text Parameters

Text parameters observe the syntactic rules for mnemonics, i.e. they can be entered using a short or long form. Like any parameter, they have to be separated from the header by a white space. In the response to a query, the short form of the text is provided.

Example:

Setting command: `HCOPy:PAGE:ORIentation LANDscape`

Query: `HCOP:PAGE:ORI?`

Response: `LAND`

B.2.3.5 Character Strings

Strings must always be entered in quotation marks (' or ").

Example:

```
HCOP:ITEM:LABel "Test1"
HCOP:ITEM:LABel 'Test1'
```

B.2.3.6 Block Data

Block data is a format which is suitable for the transmission of large amounts of data. For example, a command using a block data parameter has the following structure:

```
FORMat:READings:DATA #45168xxxxxxxx
```

The ASCII character # introduces the data block. The next number indicates how many of the following digits describe the length of the data block. In the example the 4 following digits indicate the length to be 5168 bytes. The data bytes follow. During the transmission of these data bytes all end or other control signs are ignored until all bytes are transmitted.

#0 specifies a data block of indefinite length. The use of the indefinite format requires a `NL^END` message to terminate the data block. This format is useful when the length of

the transmission is not known or if speed or other considerations prevent segmentation of the data into blocks of definite length.

B.2.4 Overview of Syntax Elements

The following tables provide an overview of the syntax elements and special characters.

Table B-2: Syntax elements

:	The colon separates the mnemonics of a command.
;	The semicolon separates two commands of a command line. It does not alter the path.
,	The comma separates several parameters of a command.
?	The question mark forms a query.
*****	The asterisk marks a common command.
' ' **"**	Quotation marks introduce a string and terminate it (both single and double quotation marks are possible).
#	The hash symbol introduces binary, octal, hexadecimal and block data. ● Binary: #B10110 ● Octal: #O7612 ● Hexa: #HF3A7 ● Block: #21312
	A "white space" (ASCII-Code 0 to 9, 11 to 32 decimal, e.g. blank) separates the header from the parameters.

Table B-3: Special characters

|	**Parameters**
	A vertical stroke in parameter definitions indicates alternative possibilities in the sense of "or". The effect of the command differs, depending on which parameter is used.
	Example:
	Definition:`HCOPy:PAGE:ORIentation LANDscape | PORTrait`
	Command `HCOP:PAGE:ORI LAND` specifies landscape orientation
	Command `HCOP:PAGE:ORI PORT` specifies portrait orientation
	Mnemonics
	A selection of mnemonics with an identical effect exists for several commands. These mnemonics are indicated in the same line; they are separated by a vertical stroke. Only one of these mnemonics needs to be included in the header of the command. The effect of the command is independent of which of the mnemonics is used.
	Example:
	Definition`SENSE:BANDwidth|BWIDth[:RESolution] <numeric_value>`
	The two following commands with identical meaning can be created:
	`SENS:BAND:RES 1`
	`SENS:BWID:RES 1`

[ ]	Mnemonics in square brackets are optional and may be inserted into the header or omitted. Example: `HCOPy[:IMMediate]` `HCOP:IMM` is equivalent to `HCOP`

{ }	Parameters in curly brackets are optional and can be inserted once or several times, or omitted.
	Example: `SENSe:LIST:FREQuency <numeric_value>{,<numeric_value>}`
	The following are valid commands:
	`SENS:LIST:FREQ 10`
	`SENS:LIST:FREQ 10,20`
	`SENS:LIST:FREQ 10,20,30,40`

B.2.5 Structure of a Command Line

A command line may consist of one or several commands. It is terminated by one of the following:

- <New Line>
- <New Line> with EOI
- EOI together with the last data byte

Several commands in a command line must be separated by a semicolon ";".

Example:

```
MMEM:COPY "Test1","MeasurementXY";:HCOP:ITEM ALL
```

This command line contains two commands. The first command belongs to the MMEM system, the second command belongs to the HCOP system. If the next command belongs to a different command system, the semicolon is followed by a colon.

Example:

`HCOP:ITEM ALL;:HCOP:IMM`

This command line contains two commands. Both commands are part of the `HCOP` command system, i.e. they have one level in common.

If the successive commands belong to the same system, having one or several levels in common, the command line can be abbreviated. When abbreviating the command line, the second command begins with the level below HCOP. The colon after the semicolon is omitted. The abbreviated form of the command line reads as follows:

`HCOP:ITEM ALL;IMM`

Example:

`HCOP:ITEM ALL`

`HCOP:IMM`

A new command line always begins with the complete path.

B.2.6 Responses to Queries

A query is defined for each setting command unless explicitly specified otherwise. It is formed by adding a question mark to the associated setting command. According to SCPI, the responses to queries are partly subject to stricter rules than in standard IEEE 488.2.

- The requested parameter is transmitted without a header.
  Example: `HCOP:PAGE:ORI?`, Response: `LAND`
- Maximum values, minimum values and all other quantities that are requested via a special text parameter are returned as numeric values.
  Example: `SENSe:FREQuency:STOP? MAX`, Response: `3.5E9`
- Numeric values are output without a unit. Physical quantities are referred to the basic units or to the units set using the `Unit` command. The response `3.5E9` in the previous example stands for 3.5 GHz.
- Truth values (Boolean values) are returned as `0` (for OFF) and `1` (for ON).
  Example:
  Setting command: `HCOPy:DEV:COL ON`
  Query: `HCOPy:DEV:COL?`
  Response: `1`
- Text (character data) is returned in a short form.
  Example:
  Setting command: `HCOPy:PAGE:ORIentation LANDscape`
  Query: `HCOP:PAGE:ORI?`
  Response: `LAND`
- Invalid numerical results
  In some cases, particularly when a result consists of multiple numeric values, invalid values are returned as 9.91E37 (not a number).

B.3 Command Sequence and Synchronization

IEEE 488.2 defines a distinction between overlapped (asynchronous) and sequential commands:

- A sequential command finishes executing before the next command starts executing. Commands that are processed quickly are usually implemented as sequential commands.
- An overlapping or asynchronous command does not automatically finish executing before the next command starts executing. Usually, overlapping commands take longer to process and allow the program to do other tasks while being executed. If overlapping commands must be executed in a defined order, e.g. to avoid wrong measurement results, they must be serviced sequentially. This method is called synchronization between the controller and the instrument.

As a rule, send commands and queries in different program messages, i.e. in separate command lines.

Do not combine queries with commands that affect the queried value in one program message because the response to the query is not predictable.

The following messages always return correct results:

`:CHAN:SCAL 0.01;POS 1`

`:CHAN:SCAL?`

Result: `0.01` (10 mV/div)

Reason: Setting commands within one command line, even though they are implemented as sequential commands, are not necessarily serviced in the order in which they have been received.

For further information, refer to:

- rohde-schwarz.com/rckb: Rohde & Schwarz web page that provides information on instrument drivers and remote control.
- "Automatic Measurement Control - A tutorial on SCPI and IEEE 488.2" from John M. Pieper (R&S order number 0002.3536.00). The book offers detailed information on concepts and definitions of SCPI.

B.3.1 Preventing Overlapping Execution

To prevent an overlapping execution of commands, one of the commands `*OPC`, `*OPC?` or `*WAI` can be used. All three commands cause a certain action only to be carried out after the hardware has been set. The controller can be forced to wait for the corresponding action to occur.

*Table B-4: Synchronization using *OPC, *OPC? and *WAI*

Command	Action	Programming the controller
*OPC	Sets the Operation Complete bit in the ESR after all previous commands have been executed.	• Setting bit 0 in the ESE • Setting bit 5 in the SRE • Waiting for service request (SRQ)
*OPC?	Stops command processing until 1 is returned. This occurs when all pending operations are completed.	Send *OPC? directly after the command whose processing must be terminated before other commands can be executed.
*WAI	Stops further command processing until all commands sent before *WAI have been executed.	Send *WAI directly after the command whose processing must be terminated before other commands are executed.

Command synchronization using `*WAI` or `*OPC?` is a good choice if the overlapped command takes only little time to process. The two synchronization commands simply block overlapped execution of the command. Append the synchronization command to the overlapping command, for example:

```
SINGle; *OPC?
```

For time consuming overlapped commands, you can allow the controller or the instrument to do other useful work while waiting for command execution. Use one of the following methods:

***OPC with a service request**

1. Set the OPC mask bit (bit no. 0) in the ESE: *ESE 1
2. Set bit no. 5 in the SRE: `*SRE 32` to enable ESB service request.
3. Send the overlapped command with `*OPC` .
4. Wait for a service request.

   The service request indicates that the overlapped command has finished.

***OPC? with a service request**

1. Set bit no. 4 in the SRE: `*SRE 16` to enable MAV service request.
2. Send the overlapped command with `*OPC?`.
3. Wait for a service request.

   The service request indicates that the overlapped command has finished.

Event status register (ESE)

1. Set the OPC mask bit (bit no. 0) in the ESE: `*ESE 1`
2. Send the overlapped command without `*OPC`, `*OPC?` or `*WAI`.

3. Poll the operation complete state periodically (with a timer) using the sequence: `*OPC; *ESR?`

   A return value (LSB) of 1 indicates that the overlapped command has finished.

B.4 General Programming Recommendations

Initial instrument status before changing settings

Manual operation is designed for maximum possible operating convenience. In contrast, the priority of remote control is the "predictability" of the instrument status. Thus, when a command attempts to define incompatible settings, the command is ignored and the instrument status remains unchanged, i.e. other settings are not automatically adapted. Therefore, control programs should always define an initial instrument status (e.g. using the *RST command) and then implement the required settings.

Command sequence

As a general rule, send commands and queries in different program messages. Otherwise, the result of the query may vary depending on which operation is performed first (see also Preventing Overlapping Execution).

Reacting to malfunctions

The service request is the only possibility for the instrument to become active on its own. Each controller program should instruct the instrument to initiate a service request in case of malfunction. The program should react appropriately to the service request.

Error queues

The error queue should be queried after every service request in the controller program as the entries describe the cause of an error more precisely than the status registers. Especially in the test phase of a controller program the error queue should be queried regularly since faulty commands from the controller to the instrument are recorded there as well.

C Remote Control - Status Reporting System

The status reporting system stores all information on the current operating state of the instrument, and on errors which have occurred. This information is stored in the status registers and in the error queue. Both can be queried via GPIB bus or LAN interface (`STATus`... commands).

C.1 Structure of a SCPI Status Register

Each standard SCPI register consists of 5 parts. Each part has a width of 16 bits and has different functions. The individual bits are independent of each other, i.e. each hardware status is assigned a bit number which is valid for all five parts. Bit 15 (the most significant bit) is set to zero for all parts. Thus the contents of the register parts can be processed by the controller as positive integers.

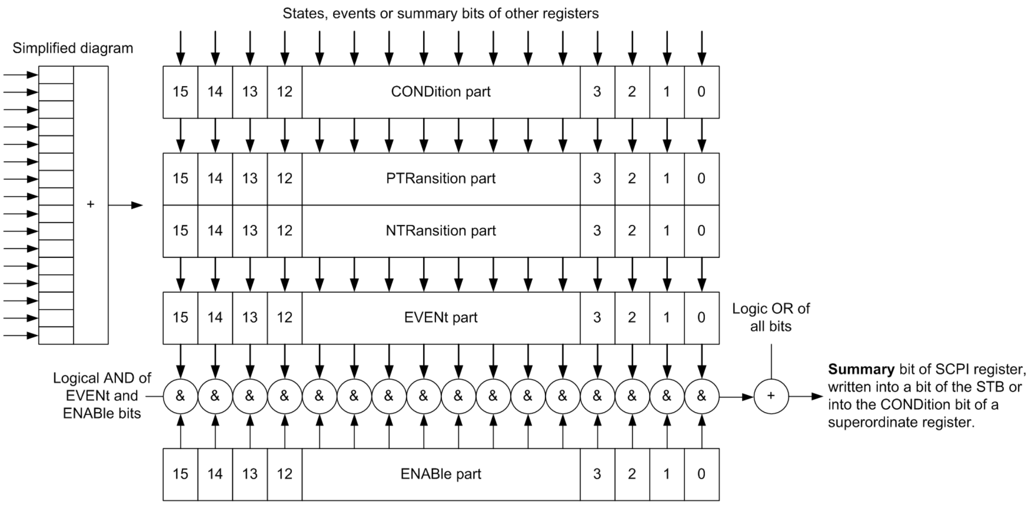


Figure C-1: The status-register model

Description of the five status register parts

The five parts of a SCPI register have different properties and functions:

- **CONDition**
  The `CONDition` part is written into directly by the hardware or the sum bit of the next lower register. Its contents reflect the current instrument status. This register part can only be read, but not written into or cleared. Its contents are not affected by reading.
- **PTRansition / NTRansition**
  The two transition register parts define which state transition of the `CONDition` part (none, 0 to 1, 1 to 0 or both) is stored in the `EVENt` part.
  The **Positive-TRansition** part acts as a transition filter. When a bit of the `CONDition` part is changed from 0 to 1, the associated `PTR` bit decides whether the `EVENt` bit is set to 1.

– PTR bit =1: the EVENt bit is set.
– PTR bit =0: the EVENt bit is not set.

This part can be written into and read as required. Its contents are not affected by reading.
The **Negative-TRansition** part also acts as a transition filter. When a bit of the CONDition part is changed from 1 to 0, the associated NTR bit decides whether the EVENt bit is set to 1.

– NTR bit =1: the EVENt bit is set.
– NTR bit =0: the EVENt bit is not set.

This part can be written into and read as required. Its contents are not affected by reading.

- **EVENt**
  The EVENt part indicates whether an event has occurred since the last reading, it is the "memory" of the condition part. It only indicates events passed on by the transition filters. It is permanently updated by the instrument. This part can only be read by the user. Reading the register clears it. This part is often equated with the entire register.
- **ENABle**
  The ENABle part determines whether the associated EVENt bit contributes to the sum bit (see below). Each bit of the EVENt part is "ANDed" with the associated ENABle bit (symbol '&'). The results of all logical operations of this part are passed on to the sum bit via an "OR" function (symbol '+').
  ENABle bit = 0: the associated EVENt bit does not contribute to the sum bit
  ENABle bit = 1: if the associated EVENt bit is "1", the sum bit is set to "1" as well.
  This part can be written into and read by the user as required. Its contents are not affected by reading.

Sum bit

The sum bit is obtained from the EVENt and ENABle part for each register. The result is then entered into a bit of the CONDition part of the higher-order register.

The instrument automatically generates the sum bit for each register. Thus an event can lead to a service request throughout all levels of the hierarchy.

C.2 Hierarchy of Status Registers

As shown in the following figure, the status information is of hierarchical structure.

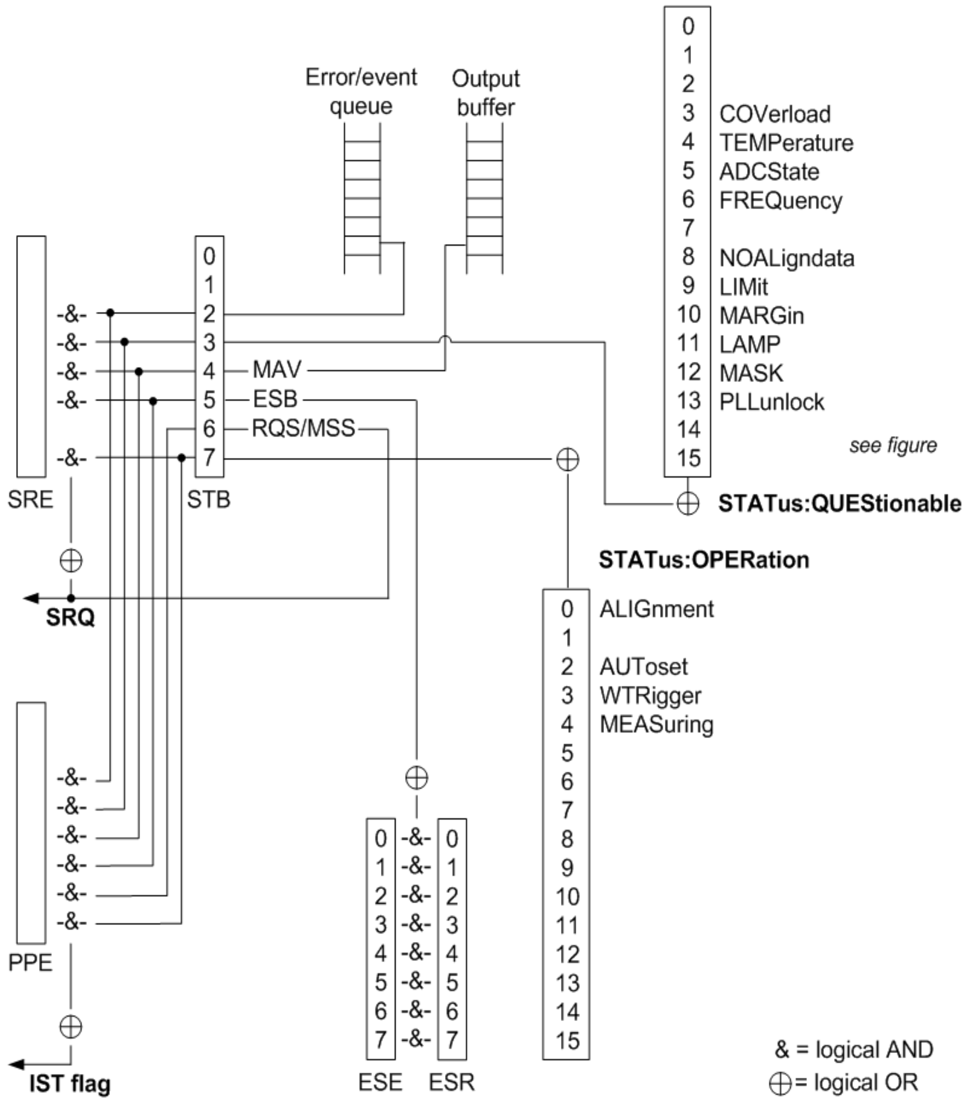


Figure C-2: Overview of the status registers hierarchy

- **STB, SRE**
  The STatus Byte (`STB`) register and its associated mask register Service Request Enable (`SRE`) form the highest level of the status reporting system. The `STB` provides a rough overview of the instrument status, collecting the information of the lower-level registers.
- **ESR, SCPI registers**
  The STB receives its information from the following registers:
  – The Event Status Register (`ESR`) with the associated mask register standard Event Status Enable (`ESE`).
  – The `STATus:OPERation` and `STATus:QUEStionable` registers which are defined by SCPI and contain detailed information on the instrument.
- **IST, PPE**

The IST flag ("Individual STatus"), like the SRQ, combines the entire instrument status in a single bit. The PPE fulfills the same function for the IST flag as the SRE for the service request.

- **Output buffer**
  The output buffer contains the messages the instrument returns to the controller. It is not part of the status reporting system but determines the value of the MAV bit in the STB and thus is represented in the overview.

All status registers have the same internal structure.

SRE, ESE

The service request enable register SRE can be used as ENABle part of the STB if the STB is structured according to SCPI. By analogy, the ESE can be used as the ENABle part of the ESR.

C.3 Contents of the Status Registers

In the following sections, the contents of the status registers are described in more detail.

C.3.1 Status Byte (STB) and Service Request Enable Register (SRE)

The STatus Byte (STB) is already defined in IEEE 488.2. It provides a rough overview of the instrument status by collecting the pieces of information of the lower registers. A special feature is that bit 6 acts as the sum bit of the remaining bits of the status byte.

The STB can thus be compared with the CONDition part of an SCPI register and assumes the highest level within the SCPI hierarchy.

The STB is read using the command *STB? or a serial poll.

The STatus Byte (STB) is linked to the Service Request Enable (SRE) register. Each bit of the STB is assigned a bit in the SRE. Bit 6 of the SRE is ignored. If a bit is set in the SRE and the associated bit in the STB changes from 0 to 1, a service request (SRQ) is generated. The SRE can be set using the command *SRE and read using the command *SRE?.

Table C-1: Meaning of the bits used in the status byte

Bit No.	Meaning
0...1	Not used
2	Error Queue not empty The bit is set when an entry is made in the error queue. If this bit is enabled by the SRE, each entry of the error queue generates a service request. Thus an error can be recognized and specified in greater detail by polling the error queue. The poll provides an informative error message. This procedure is to be recommended since it considerably reduces the problems involved with remote control.

Bit No.	Meaning
3	QUEStionable status register summary bit The bit is set if an `EVENt` bit is set in the `QUEStionable` status register and the associated `ENABle` bit is set to 1. A set bit indicates a questionable instrument status, which can be specified in greater detail by querying the `STATus:QUEStionable` status register.
4	MAV bit (message available) The bit is set if a message is available in the output queue which can be read. This bit can be used to enable data to be automatically read from the instrument to the controller.
5	ESB bit Sum bit of the event status register. It is set if one of the bits in the event status register is set and enabled in the event status enable register. Setting of this bit indicates a serious error which can be specified in greater detail by polling the event status register.
6	MSS bit (master status summary bit) The bit is set if the instrument triggers a service request. This is the case if one of the other bits of this registers is set together with its mask bit in the service request enable register SRE.
7	`STATus:OPERation` status register summary bit The bit is set if an `EVENt` bit is set in the `OPERation` status register and the associated `ENABle` bit is set to 1. A set bit indicates that the instrument is just performing an action. The type of action can be determined by querying the `STATus:OPERation` status register.

C.3.2 IST Flag and Parallel Poll Enable Register (PPE)

As with the SRQ, the IST flag combines the entire status information in a single bit. It can be read by means of a parallel poll (see Chapter C.4.3, "Parallel Poll", on page 1893) or using the command `*IST?`.

The parallel poll enable register (PPE) determines which bits of the STB contribute to the IST flag. The bits of the STB are "ANDed" with the corresponding bits of the PPE, with bit 6 being used as well in contrast to the SRE. The IST flag results from the "ORing" of all results. The PPE can be set using commands `*PRE` and read using command *PRE?.

C.3.3 Event Status Register (ESR) and Event Status Enable Register (ESE)

The ESR is defined in IEEE 488.2. It can be compared with the `EVENt` part of a SCPI register. The event status register can be read out using command `*ESR?`.

The ESE corresponds to the `ENABle` part of a SCPI register. If a bit is set in the ESE and the associated bit in the ESR changes from 0 to 1, the ESB bit in the STB is set. The ESE register can be set using the command `*ESE` and read using the command `*ESE?`.

Table C-2: Meaning of the bits used in the event status register

Bit No.	Meaning
0	Operation Complete This bit is set on receipt of the command *OPC exactly when all previous commands have been executed.
1	Not used
2	Query Error This bit is set if either the controller wants to read data from the instrument without having sent a query, or if it does not fetch requested data and sends new instructions to the instrument instead. The cause is often a query which is faulty and hence cannot be executed.
3	Device-dependent Error This bit is set if a device-dependent error occurs. An error message with a number between -300 and -399 or a positive error number, which denotes the error in greater detail, is entered into the error queue.
4	Execution Error This bit is set if a received command is syntactically correct but cannot be performed for other reasons. An error message with a number between -200 and -300, which denotes the error in greater detail, is entered into the error queue.
5	Command Error This bit is set if a command is received, which is undefined or syntactically incorrect. An error message with a number between -100 and -200, which denotes the error in greater detail, is entered into the error queue.
6	User Request This bit is set when the instrument is switched over to manual control.
7	Power On (supply voltage on) This bit is set on switching on the instrument.

C.3.4 STATus:OPERation Register

In the `CONDition` part, this register contains information on which actions the instrument is executing. In the `EVENt` part, it contains information on which actions the instrument has executed since the last reading.

It can be read using the commands `STATus:OPERation:CONDition?` or `STATus:OPERation[:EVENt]?`, see also Chapter 20.24.1, "STATus:OPERation Register", on page 1848.

Table C-3: Bits in the STATus:OPERation register

Bit No.	Meaning
0	`ALIGnment` This bit is set as long as the instrument is performing a self-alignment.
1	Not used
2	`AUToset` This bit is set while the instrument is performing an auto setup.

Bit No.	Meaning
3	`WTRIgger` The wait for trigger status bit indicates that the instrument is ready to trigger, and the pre-trigger time is expired. The bit is set if the instrument did not trigger for more than 10 ms. The bit is only valid if the trigger event is initiated by the user, for example, using an external generator. If the instrument triggers on signals or if it is in auto trigger mode, the bit status is undefined.
4	`MEASuring` The bit is set as long as an acquisition - sampling and postprocessing - is running. In run continuous mode, the bit is always set.
5 - 15	Not used

C.3.5 STATus:QUEStionable Register

This register contains information about indefinite states which may occur if the unit is operated without meeting the specifications. It can be read using the commands `STATus:QUEStionable:CONDition?` and `STATus:QUEStionable[:EVENt]?`

The remote commands for the STATus:QUEStionable register are described in Chapter 20.24.2, "STATus:QUEStionable Registers", on page 1849.

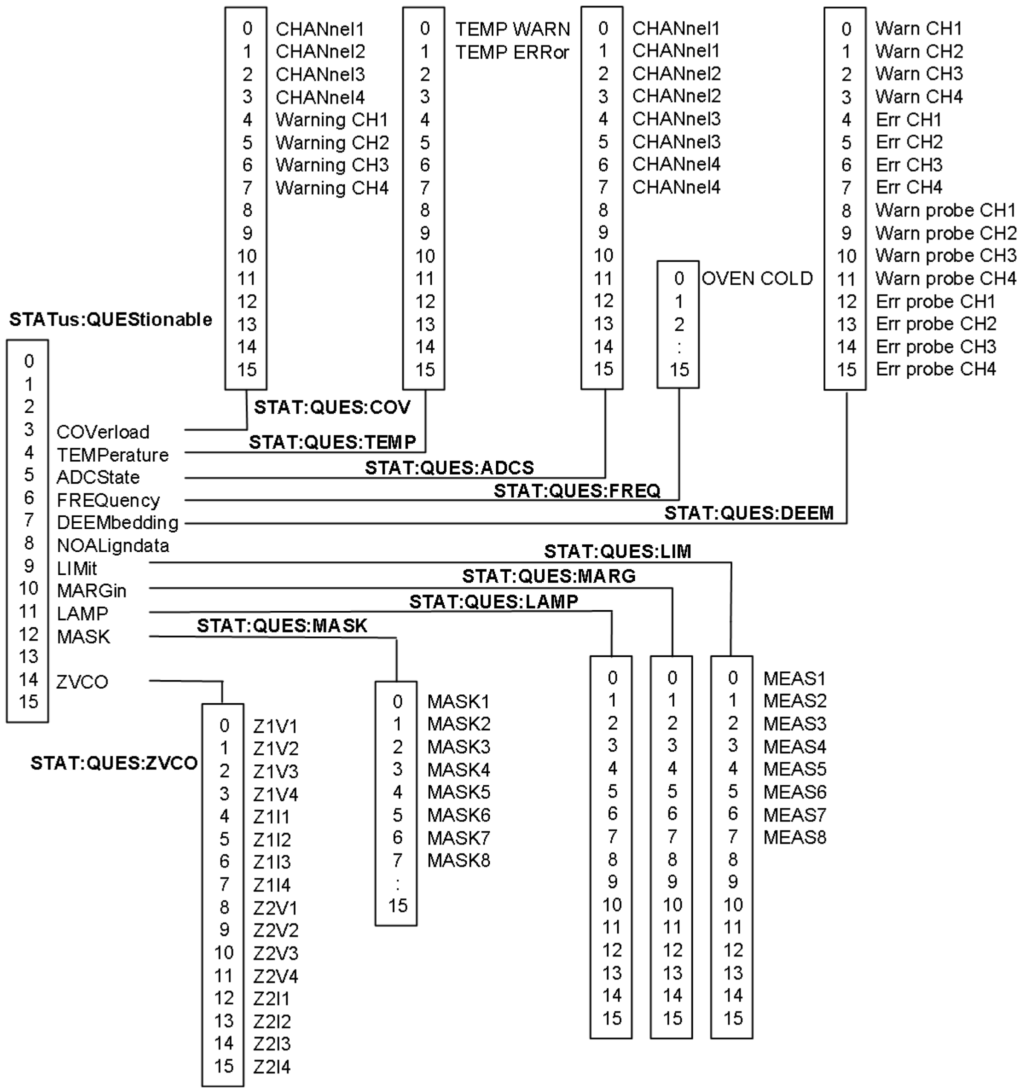


Figure C-3: Overview of the STATus:QUEStionable register

Table C-4: Bits in the STATus:QUEStionable register

Bit No.	Meaning
0 to 2	not used
3	`COVerload` This bit is set if a questionable channel overload occurs (see Chapter C.3.5.1, "STATus:QUEStionable:COVerload Register", on page 1888).
4	`TEMPerature` This bit is set if a questionable temperature occurs (see Chapter C.3.5.2, "STATus:QUEStionable:TEMPerature Register", on page 1889).
5	`ADCState` The bit is set if the signal is clipped on the upper or lower edge of the screen -overflow of the ADC occurs (see Chapter C.3.5.3, "STATus:QUEStionable:ADCState Register", on page 1889).

Bit No.	Meaning
6	`FREQuency` This bit is set if there is anything wrong with the frequency of the local oscillator or the reference frequency (see Chapter C.3.5.4, "STATus:QUEStionable:FREQuency Register", on page 1890).
7	`DEEMbedding` The bit is set if a warning or an error occurs during deembedding (see Chapter C.3.5.5, "STATus:QUEStionable:DEEMbedding Register", on page 1890).
8	`NOALigndata` This bit is set if no alignment data is available - the instrument is uncalibrated.
9	`LIMit` This bit is set if a limit value is violated (see Chapter C.3.5.6, "STATus:QUEStionable:LIMit, STATus:QUEStionable:MARGin Registers", on page 1890).
10	`MARGin` This bit is set if a margin value is violated, and the limit value is not violated (see Chapter C.3.5.6, "STATus:QUEStionable:LIMit, STATus:QUEStionable:MARGin Registers", on page 1890).
11	`LAMP` (Low AMPlitude) This bit is set if the magnitude of the signal is too low to get reliable measurement results. See Chapter C.3.5.7, "STATus:QUEStionable:LAMP Register", on page 1891.
12	`MASK` This bit is set if a mask value is violated (see Chapter C.3.5.8, "STATus:QUEStionable:MASK Register", on page 1891
13	Not used
14	`ZVCO`: This bit is set if a channel overload occurs at one or more input channels of the R&S RT-ZVC multi-channel power probe. See Chapter C.3.5.9, "STATus:QUEStionable:ZVCO Register", on page 1892.
15	This bit is always 0.

C.3.5.1 STATus:QUEStionable:COVerload Register

This register contains all information about overload of the channels. The bit is set if the assigned channel is overloaded, or if an overload risk occurred (overload warning).

Table C-5: Bits in the STATus:QUEStionable:COVerload register

Bit No.	Meaning
0	Overload on `CHANnel1`
1	Overload on `CHANnel2`
2	Overload on `CHANnel3`
3	Overload on `CHANnel4`
4	Overload warning for `CHANnel1`
5	Overload warning for `CHANnel2`

Bit No.	Meaning
6	Overload warning for `CHANnel3`
7	Overload warning for `CHANnel4`
8	Overload on external trigger input
9	Overload warning for external trigger input

C.3.5.2 STATus:QUEStionable:TEMPerature Register

This register contains information about the instrument's temperature.

Table C-6: Bits in the STATus:QUEStionable:TEMPerature register

Bit No.	Meaning
0	`TEMP WARN` This bit is set if a temperature warning on channel 1, 2, 3 or 4 occurred.
1	`TEMP ERRor` This bit is set if a temperature error on channel 1, 2, 3 or 4 occurred.

C.3.5.3 STATus:QUEStionable:ADCState Register

This register contains all information about overflow of the ADC.

The bit is set if the assigned channel signal is clipped on the upper or lower edge of the screen. In this case, the signal does not fit in the range of the ADC and overflow occurs.

Table C-7: Bits in the STATus:QUEStionable:ADCState register

Bit No.	Meaning
0	`CHANnel1`, clipping on the upper limit
1	`CHANnel1`, clipping on the lower limit
2	`CHANnel2`, clipping on the upper limit
3	`CHANnel2`, clipping on the lower limit
4	`CHANnel3`, clipping on the upper limit
5	`CHANnel3`, clipping on the lower limit
6	`CHANnel4`, clipping on the upper limit
7	`CHANnel4`, clipping on the lower limit

C.3.5.4 STATus:QUEStionable:FREQuency Register

Table C-8: Bits in the STATus:QUEStionable:FREQuency register

Bit No.	Meaning
0	Oven cold. This bit is set if the reference oscillator has not yet attained its operating temperature.

C.3.5.5 STATus:QUEStionable:DEEMbedding Register

Table C-9: Bits in the STATus:QUEStionable:DEEMbedding register

Bit No.	Meaning
0 1 2 3	Warning for channel 1, 2, 3, 4 accordingly. The bits are set if there are problems in the deembedding configuration of the assigned channel.
4 5 6 7	Error for channel 1, 2, 3, 4 accordingly. The bits are set if the deembedding configuration of the assigned channel causes an error.
8 9 10 11	Warning for channel 1, 2, 3, 4 accordingly. The bits are set if there are problems in the probe deembedding of the assigned channel.
12 13 14 15	Error for channel 1, 2, 3, 4 accordingly. The bits are set if the probe deembedding of the assigned channel causes an error.

C.3.5.6 STATus:QUEStionable:LIMit, STATus:QUEStionable:MARGin Registers

These registers contain information about the observance of the limits or margins of measurements.

The LIMit bit is set if the limit of the assigned measurement is violated. The MARGin bit is set if the margin of the assigned measurement is violated but not the limit (the limit bit is not set).

The status bits are set if the limits or margins of one or more assigned measurements are violated.

If multiple measurements are active, all measurement results affect the status bits. Statistical results do not change the status bits.

Table C-10: Bits in the STATus:QUEStionable:LIMit and STATus:QUEStionable.MARGin registers

Bit No.	Meaning
0	MEAS1
1	MEAS2
2	MEAS3
3	MEAS4
4	MEAS5
5	MEAS6
6	MEAS7
7	MEAS8

C.3.5.7 STATus:QUEStionable:LAMP Register

The LAMP (Low AMPlitude) bit is set if the magnitude of the signal is too low to get reliable measurement results.

Table C-11: Bits in the STATus:QUEStionable:LAMP register

Bit No.	Meaning
0	MEAS1
1	MEAS2
2	MEAS3
3	MEAS4
4	MEAS5
5	MEAS6
6	MEAS7
7	MEAS8

C.3.5.8 STATus:QUEStionable:MASK Register

This register contains information about the violation of masks. This bit is set if the assigned mask is violated.

Table C-12: Bits in the STATus:QUEStionable:MASK register

Bit No.	Meaning
0	MASK1
1	MASK2
2	MASK3
3	MASK4
4	MASK5

Bit No.	Meaning
5	MASK6
6	MASK7
7	MASK8

C.3.5.9 STATus:QUEStionable:ZVCO Register

This register contains all information about overload of the R&S RT-ZVC input channels. The bit is set if the assigned channel is overloaded.

Table C-13: Bits in the STATus:QUEStionable:ZVCO register

Bit No.	Meaning
0	Overload on Z1V1
1	Overload on Z1V2
2	Overload on Z1V3
3	Overload on Z1V4
4	Overload on Z1I1
5	Overload on Z1I2
6	Overload on Z1I3
7	Overload on Z1I4
8	Overload on Z2V1
9	Overload on Z2V2
10	Overload on Z2V3
11	Overload on Z2V4
12	Overload on Z2I1
13	Overload on Z2I2
14	Overload on Z2I3
15	Overload on Z2I4

C.4 Application of the Status Reporting System

The purpose of the status reporting system is to monitor the status of one or several devices in a measuring system. To do this and react appropriately, the controller must receive and evaluate the information of all devices. The following standard methods are used:

- **Service request** (SRQ) initiated by the instrument

- **Serial poll** of all devices in the bus system, initiated by the controller to find out who sent an SRQ and why
- **Parallel poll** of all devices
- Query of a **specific instrument status** by commands
- Query of the **error queue**

C.4.1 Service Request

Under certain circumstances, the instrument can send a service request (SRQ) to the controller. Usually this service request initiates an interrupt at the controller, to which the control program can react appropriately. As evident from Figure C-2, an SRQ is always initiated if one or several of bits 2, 3, 4, 5 or 7 of the status byte are set and enabled in the SRE. Each of these bits combines the information of a further register, the error queue or the output buffer. The `ENABle` parts of the status registers can be set such that arbitrary bits in an arbitrary status register initiate an SRQ. To make use of the possibilities of the service request effectively, all bits should be set to "1" in enable registers SRE and ESE.

The SRQ is the only possibility for the instrument to become active on its own. Each controller program should cause the instrument to initiate a service request if errors occur. The program should react appropriately to the service request.

C.4.2 Serial Poll

In a serial poll, just as with command `*STB`, the status byte of an instrument is queried. However, the query is realized via interface messages and is thus clearly faster.

The serial poll method is defined in IEEE 488.1 and used to be the only standard possibility for different instruments to poll the status byte. The method also works for instruments which do not adhere to SCPI or IEEE 488.2.

The serial poll is mainly used to obtain a fast overview of the state of several instruments connected to the controller.

C.4.3 Parallel Poll

In a parallel poll, up to eight instruments are simultaneously requested by the controller using a single command to transmit 1 bit of information each on the data lines, i.e., to set the data line allocated to each instrument to a logical "0" or "1".

In addition to the SRE register, which determines the conditions under which an SRQ is generated, there is a Parallel Poll Enable register (PPE) which is ANDed with the STB bit by bit, considering bit 6 as well. This register is ANDed with the STB bit by bit, considering bit 6 as well. The results are ORed, the result is possibly inverted and then sent as a response to the parallel poll of the controller. The result can also be queried without parallel poll using the command `*IST?`.

The instrument first has to be set for the parallel poll using the command PPC. This command allocates a data line to the instrument and determines whether the response is to be inverted. The parallel poll itself is executed using PPE.

The parallel poll method is mainly used to find out quickly which one of the instruments connected to the controller has sent a service request. To this effect, SRE and PPE must be set to the same value.

C.4.4 Query of an instrument status

Each part of any status register can be read using queries. There are two types of commands:

- The common commands *ESR?, *IDN?, *IST?, *STB? query the higher-level registers.
- The commands of the STATus system query the SCPI registers (STATus:QUEStionable...)

The returned value is always a decimal number that represents the bit pattern of the queried register. This number is evaluated by the controller program.

Queries are usually used after an SRQ in order to obtain more detailed information on the cause of the SRQ.

C.4.4.1 Decimal representation of a bit pattern

The STB and ESR registers contain 8 bits, the SCPI registers 16 bits. The contents of a status register are specified and transferred as a single decimal number. To make this possible, each bit is assigned a weighted value. The decimal number is calculated as the sum of the weighted values of all bits in the register that are set to 1.

Bits	0	1	2	3	4	5	6	7	...
Weight	1	2	4	8	16	32	64	128	...

Example:

The decimal value 40 = 32 + 8 indicates that bits no. 3 and 5 in the status register (e.g. the QUEStionable status summary bit and the ESB bit in the STatus Byte) are set.

C.4.5 Error Queue

Each error state in the instrument leads to an entry in the error queue. The entries of the error queue are detailed plain text error messages that can be looked up in the Error Log or queried via remote control using SYSTem:ERRor[:NEXT]?. Each call of

`SYSTem:ERRor[:NEXT]?` provides one entry from the error queue. If no error messages are stored there any more, the instrument responds with 0, "No error".

The error queue should be queried after every SRQ in the controller program as the entries describe the cause of an error more precisely than the status registers. Especially in the test phase of a controller program the error queue should be queried regularly since faulty commands from the controller to the instrument are recorded there as well.

C.5 Reset Values of the Status Reporting System

The following table contains the different commands and events causing the status reporting system to be reset. None of the commands, except `*RST` and `SYSTem:PRESet`, influence the functional instrument settings. In particular, `DCL` does not change the instrument settings.

Table C-14: Resets of the status reporting system

Event	**Switching on supply voltage** **Power-On-Status-Clear**		**DCL, SDC** **(Device Clear, Selected Device Clear)**	***RST or SYS-Tem:PRESet**	**STA-Tus:PRE-Set**	***CLS**
Effect	**0**	**1**				
Clear STB, ESR	-	yes	-	-	-	yes
Clear SRE, ESE	-	yes	-	-	-	-
Clear PPE	-	yes	-	-	-	-
Clear EVENt parts of the registers	-	yes	-	-	-	yes
Clear ENABle parts of all OPERation and QUEStionable registers; Fill ENABle parts of all other registers with "1".	-	yes	-	-	yes	-
Fill PTRansition parts with "1"; Clear NTRansition parts	-	yes	-	-	yes	-
Clear error queue	yes	yes	-	-	-	yes
Clear output buffer	yes	yes	yes	1)	1)	1)
Clear command processing and input buffer	yes	yes	yes	-	-	-

1) The first command in a command line that immediately follows a <PROGRAM MESSAGE TERMINATOR> clears the output buffer.

List of Commands

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