

Application Note

Applying DC Bias to Inductors with the 1910 Inductance Analyzer

The newest instrument in IET Labs.'s LCR Product Line is the 1910 Inductance Analyzer. Designed primarily for production testing of inductors, the 1910 instrument is capable of measuring L, C, D_F , Q, Y, G, B, Z, R, X, ESR, θ , DCR as well as the AC & DC voltage and current to the DUT. It has a wide frequency range (20Hz to 1MHz), 0.1% basic measurement accuracy, 4-terminal Kelvin connections, and remote control (IEEE-488, RS232, Handler & I/O) capability. The 1910 unit can be programmed for internal DC Bias current ranging from 0.0A – 1.0A in 1mA steps.

Reality Check: Use of DC Bias

In order to get an accurate inductance measurement the inductor must be tested under actual conditions for current flowing through the coil. This cannot always be done with the typical AC source and a standard LCR meter, as the typical source in an LCR meter is normally only capable of supplying small amounts of current. This level of current is not satisfactory for testing most inductors used in power supplies. Rather than using a larger AC current source, inductors are usually tested with a combination of DC current and AC current. DC bias current provides a way of biasing the inductor to normal operating conditions where the inductance can then be measured under actual conditions. The 1910 can internally provide up to 1A DC Bias Current to the device under test.



Figure 1: 1910 Inductance Analyzer

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Safety Precautions

The voltage across an inductor is proportional to its inductance and the **rate of change** of the current through it. $E = L \, di/dt$. If the current could be instantly switched off, then the voltage would in theory become infinite. This does not occur because the high voltage develops an arc across the switch as contact is broken, keeping di/dt from becoming infinite. This does not however prevent the voltage from increasing to potentially **lethal** levels. If a person breaks the contact without the proper protection, the inductor induces a high voltage, forcing the current through the person (arm to arm across the heart). Refer to Figure 2.

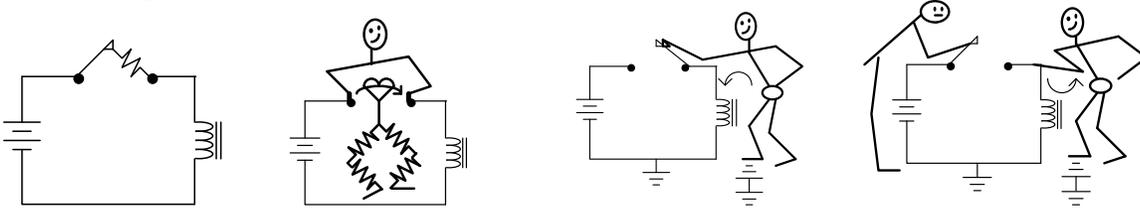


Figure 2: Breaking the Contact across an Inductor

WARNING

Inductors carrying current may contain lethal energy. Dangerous voltages are generated if connections are broken while the current is flowing.

Always set all power sources to zero before making or breaking connections.

Limit Supply Voltages to 200V or less.

A person does not have to be **across** the broken connection to receive a dangerous shock because the current can flow through ground. So breaking the circuit with one hand is **not** necessarily safe. If the switching is done remotely by another person even at some distance, the person touching the inductor could still get a **lethal** shock. A disconnection of the circuit could also be the result of a component or wiring failure that could occur at any time.

So, armed with all these safety considerations, IET Labs. suggests the following safety precautions be used when measuring biased inductors to avoid shock hazard.

1. Instruct the operator on all possible dangers.
2. Enclose the inductor in an insulated box with an interlock switch so that the current cannot flow when the box is open.
3. Use a double-throw switch and rectifiers.
4. Connect the inductor in a method that prevents the operator from directly touching the conducting connectors.
5. Use a power supply to indicate the current is ZERO and instruct the operator to NOT touch the box if the current is not zero.
6. Make sure the floor and the work surface are non-conductive.
7. Inspect the test setup regularly to ensure the safety mechanisms are functioning correctly.

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Connection of Device Under Test

Figure 3 illustrates the simplified internal DC bias circuit of the 1910 Inductance Analyzer. Up to 1A DC is supplied to the IH terminal per programmed test current. IL shunts the DC through an inductor to ground and sends the AC through an I-to-V converter.

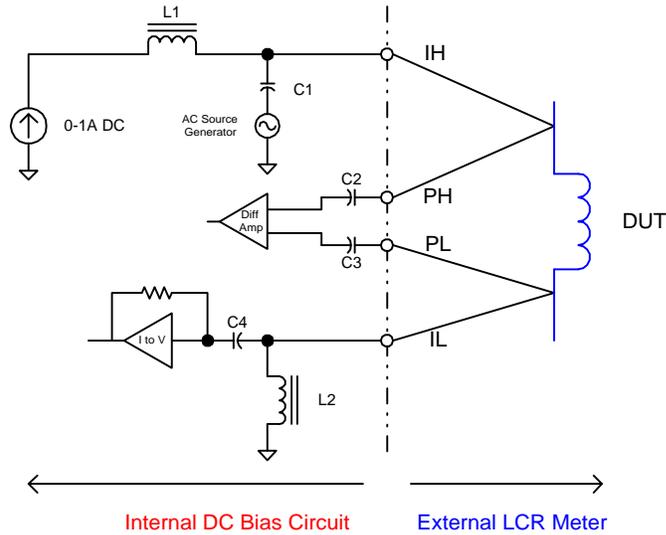


Figure 3: 1910 Internal DC Bias Circuit

Figure 4 illustrates the connection of the DUT to the 1910 Inductance Analyzer using the 1700-03 4-BNC to 2-Kelvin Clip Cable Lead Set.

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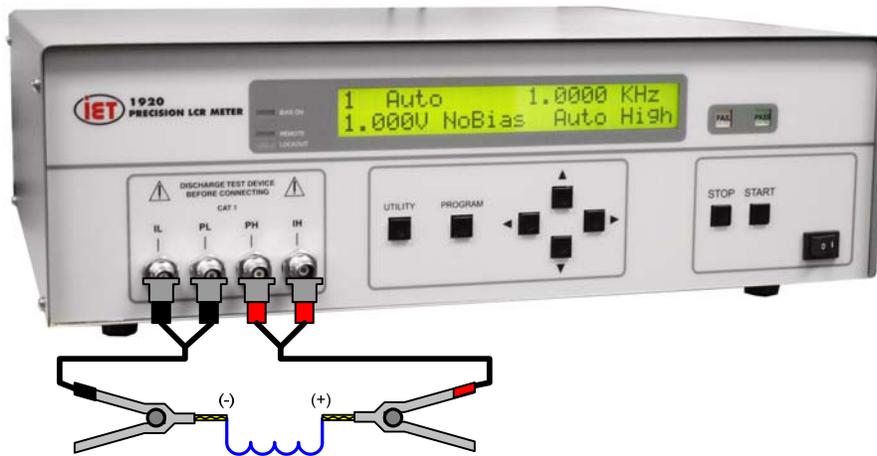


Figure 4: Connection of DUT to 1910

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Programming the 1910 for 1A DC Bias Current

The DC Bias Current feature on the 1910 analyzer can be set to [OFF] or programmed from 1mA – 1.0A

For Bias Current Test

Press [BUTTON]

[POWER]

Allow 1910 unit to initialize.

[PROGRAM]

Does Display read Automatic?

Press Down ▼ until Display reads **Automatic**.

Press Right ► until Display reads **Bias Current**.

Press Down ▼ until Display reads **desired Bias Current value**.

Press **[PROGRAM]** to exit programming mode.

Connect **DUT** to 1910 test terminals.

Press **[START]** to initiate test.

BIAS ON LED should light.

Press **[STOP]** to end test.

Typical Scroll Through of 1910 Initialization

Press [BUTTON]

Display will show:

[POWER]

Initializing
2

QuadTech
Model 1910 V1.4

1 Ls Rs 1.000kHz
1.000V No Bias Auto High

[PROGRAM]

1 Prim Param Program
Automatic

▲ or ▼

1 Prim Param Program
Ls

Right ►

1 Sec Param Program
No secondary param

▲ or ▼

1 Sec Param Program
Q

Right ►

1 Frequency Program
20.000 Hz

▲ or ▼

1 Frequency Program
1.0000 kHz

Right ►

1 Amplitude Program
20.00 mV

▲ or ▼

1 Amplitude Program
1.0000 V

Right ►

1 Bias Current Program
1.00 mA

▲ or ▼

1 Bias Current Program
1.000 A

Right ►

1 Range Select Program
Lock 200 mA any F 1.0 V

▲ or ▼

1 Range Select Program
Auto

in 1mA steps with a maximum compliance voltage of 10V ($I \cdot R \leq 10V$). Shown on the right is the typical 1910 initialization sequence and on the left is the Bias Current test setup.

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Product Specifications

1910 Inductance Analyzer

General Features

Measurement Parameter	Measurement Range	Measurement Accuracy		
		Low	Medium	High
Ls, Lp	0.001nH – 99.999H	$\pm (0.5\%) \pm (0.25\%)$	$\pm (0.1\%)$	
Cs, Cp	1pF – 9.9999pF	$\pm (0.5\%) \pm (0.25\%)$	$\pm (0.1\%)$	
DF	0.00001 – 99.999 $\pm (0.005)$	$\pm (0.0025)$	$\pm (0.001)$	
Q	0.00000 – 9999.9 $\pm (0.005)$	$\pm (0.0025)$	$\pm (0.001)$	
Y, Gp, Bp	10nS – 9999.9S	$\pm (0.005)$	$\pm (0.0025)$	$\pm (0.001)$
Z, Rs, Rp, Xs, ESR	0.0001m Ω – 99.999M Ω	$\pm (0.5\%) \pm (0.25\%)$	$\pm (0.1\%)$	
Phase Angle (θ)	-180.00° – +179.99°	$\pm (1.8^\circ)$	$\pm (0.9^\circ)$	$\pm (0.18^\circ)$
DCR	0.1m Ω – 100k Ω	$\pm (0.5\%) \pm (0.25\%)$	$\pm (0.1\%)$	
Test Frequency:	27,000 user programmable frequencies from 20Hz to 1MHz			
Frequency Accuracy:	• $\pm (0.02\% + 0.02\text{Hz})$			
Measurement Delay:	• Programmable from 0ms – 1000ms, in 10ms steps			
Averaging:	• Programmable from 1 – 1000 measurements			
Median Value:	• Averaged over last three measurements			
Measurement Speed:	• Fast (40m/s) • Medium (10m/s) • Slow (1m/s) • m/s = measurements/second			
Source Impedance:	• 5 Ω • 25 Ω • 50 Ω • 100 Ω			
Ranging:	• Automatic • Range Hold (Locked) • Manual			
Trigger:	• Manual • Internal (Automatic) • External (IEEE-488, RS232, Handler)			
Interface:	• RS232 • IEEE-488 • Handler			
DC Bias Current:	• Internal (1A) • External (20A, 1320) • External (100A, QT 1320 & 1320S)			
Results Format:	• Engineering • Δ Nominal • $\Delta\%$ Nominal • Pass/Fail • No Display			