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Application Note

USING EXTERNAL DC BIAS CURRENT SOURCES WITH LCR METERS R&S®LCX

Products:

- R&S®LCX100
- R&S®LCX200

Thomas Lechner | 1GP174 | Version 0e | 06.2026

https://www.rohde-schwarz.com/appnote/1GP174

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Contents

1 Overview

Ideal inductors are assumed to have linear behavior, i.e. their properties should not depend on signal amplitudes or superimposed DC bias current. Real inductors often contain magnetic core material, in order to achieve higher inductance within an available volume. All magnetic core materials exhibit nonlinear behavior in the shape of hysteresis and saturation effects. Testing the properties of an inductor depending on test signal amplitude and DC bias current is therefore indispensable for the component characterization.

With option R&S®LCX-K108, LCR meters R&S®LCX100 and R&S®LCX200 can superimpose DC bias current up to 200 mA. For higher DC bias currents, an external source is required. This external source can be connected in parallel if it has a sufficiently high impedance over the measurement frequency range.

This application note explains how to connect an external DC bias current source, avoid risks and hazards, and perform corrections for optimum measurement accuracy.

2 Safety Precautions

When a current flows through them, inductances store energy in the magnetic field. If the circuit is opened while a high Current is flowing, this leads to a high voltage peak. This effect is commonly used in the ignition of combustion engines to generate the sparks in the spark plugs. Depending on the amount of stored energy, touching the terminals of the inductor at this time may be dangerous to life.

⚠ WARNING

Shock hazard.

- ► **Do not touch the terminals of the component during testing.**
- ► **If the energy stored in the inductor exceeds the safe amount, place it in a container with means to deactivate the current source while the container is open.**

Apart from hazards to persons, the LCR meter may be damaged by high voltage peaks.

- ► **Make sure that the connections for the DC bias current are mechanically reliable and do not get accidentally disconnected.**
- ► **If possible, connect the LCR meter to the inductor under test after the DC bias current has been established, and disconnect it before removing the bias current.**
- ► **If this is not possible, ramp the bias current up and down instead of hard switching.**

3 Background

3.1 LCR Meters R&S®LCX100 and R&S®LCX200

The R&S®LCX LCR meters, further herein below called “LCX”, are versatile, extremely accurate and perform measurements quickly. They are ideal for challenging applications in research, development and production. Two instrument models and various options cover applications with a test signal frequency of up to 10 MHz. Internal and external bias functions, comprehensive analysis options and versatile test fixtures expand the wide range of possible applications.

The R&S®LCX100 LCR meter covers the frequency range from 4 Hz to 300 kHz. The R&S®LCX200 has an upper frequency limit of 500 kHz and can be extended to 1 MHz or 10 MHz using software options when needed.

Internal bias generation offers DC bias voltages up to 10 V and (with option R&S®LCX-K108 installed) DC bias currents up to 200 mA. External DC bias voltage up to 40 V can be applied with option R&S®LCX-K108 installed.

3.2 Inductance Measurement

For the measurement, the R&S®LCX LCR meters apply a test signal to the component under test between HCUR and LCUR connections and measure the voltage across the component (differentially between HPOT and LPOT) and the current through the component (at the LCUR connection). From the amplitudes of voltage and current and the phase between both, the complex impedance of the component is calculated. Using either serial or parallel equivalent circuit, the inductance and quality or loss resistance of the inductor are calculated.

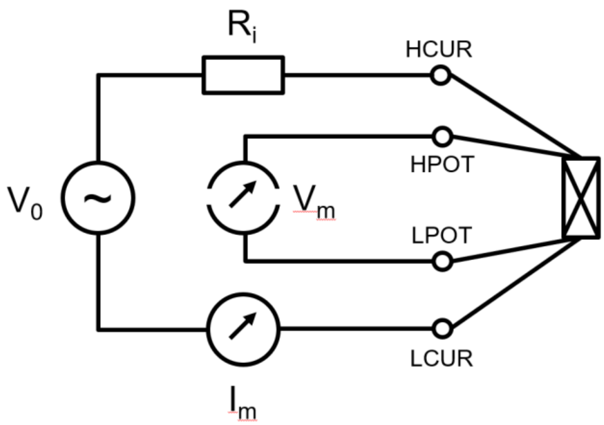

Figure 1 Principle schematic of the impedance measurement in R&S®LCX

3.3 High Z Mode and Low Z Mode

The signal source can be regarded as voltage source with either 10 Ω (LowZ) or 100 Ω (highZ) source resistance. LowZ mode is best for measured impedances up to 100 Ω absolute value. HighZ mode is more accurate for impedances above 100 Ω

3.4 Correction Measurements

The measurement setup introduces parasitic elements to the measurement setup. These are mainly parallel capacitances and serial inductances. The effect of these parasitic elements is partly mitigated by the four-wire connection between instrument and component under test. It can be further reduced by corrections.

To obtain the values for the corrections, correction measurements are performed. Open correction measurements are performed with the component under test removed. They mainly cover parallel parasitic elements. Parasitic elements in series to the component under test are determined with the short correction measurement, whereby the component under test is replaced by a short circuit.

Both open and short correction measurements in the LCX make plausibility checks on the results. If the absolute impedance value is too low during open correction measurement or too high during short correction measurement, the result is refused and not stored.

Open and short correction measurements can be run over the complete frequency and impedance range (full correction) or just for the set frequency and impedance range (spot correction). Full correction measures at a number of points and interpolates for each measurement according to the actual settings.

If the measurement result is expected in a narrow impedance value range, the measurement accuracy can be further improved with a load correction. Load correction is always a spot correction. It requires a components with an exactly known complex impedance value ("golden sample"). This known value has to be entered before the correction measurement. With this load correction active, the golden sample produces with high precision the known value as measurement result.

4 Preparations

4.1 Correction Measurements without DC Bias Source

If you intend to measure at more than one frequency, run full open and short correction measurements with the fixture you intend to use for the component measurements. If you intend to measure at one frequency only, spot open and short correction measurements at the measurement frequency are sufficient.

If you use Kelvin clamps R&S®LCX-Z2, place them on the test bench for the correction measurements the same way as they will be placed during the component measurements. For higher frequencies it is recommended to fix the cables, such that they move as little as possible between correction measurement and component measurement.

If your LCX has firmware version 03.010 or higher installed, store these correction values for later use and note the storage slot.

Activate open and short correction for the subsequent measurements.

4.2 Component Measurement without DC Bias Source

Set the “L” measurement function and choose “Rs – X” for one of the measurement pairs and “Z – Θd” for the other.

Set the desired measurement frequency and test signal level.

For best measurement accuracy, set the measurement speed to “slow” in the measurement settings.

Start continuous measurement (“Meas. Mode” button is not lit).

Connect the inductor under test.

If $Z \leq 100\ \Omega$, choose the LowZ mode in the measurement settings, If $Z > 100\ \Omega$, choose the HighZ mode.

Note the measured Rs and X values together with measurement frequency and test signal level for subsequent load correction.

Repeat the measurement for all frequencies and test signal levels which should be applied later with the DC bias current enabled.

4.3 Correction Measurements with DC Bias Source Connected in Parallel

Disconnect the inductor under test and connect the bias current source to the LCX. Set test frequency and signal level to the desired values. Set the bias current value to zero and activate the output of the DC bias current source. Short the high and low connections additionally and run a spot short correction.

You can also try an open correction measurement, but it may fail if the impedance of the DC bias current source is too low.

Now, connect the inductor under test between the joined high connections and the joined low connections of both LCX and DC bias current source. Open the load correction page in the Open/Short/Load correction menu and enter the Rs and X values obtained in section 4.2 with this component at the currently set test frequency.

With firmware version 03.010 or higher installed, these correction values can be stored in a different slot then those obtained in section 4.1. For a small number of different frequencies, you can keep the correction values in different slots of the correction memory and recall the appropriate value set after each frequency change.

5 Measurements

On the LCX home page, select the measurement pairs with the desired result values.

With the inductor under test connected, ramp up the DC bias current from 0 A to the desired value and read the result. You can measure at different DC bias current values without changing anything else. Before measuring at a different frequency, you must repeat the correction measurements described in section 4.3 or recall the appropriate stored value sets.

6 Example for External Bias Current Source

6.1 Voltech DC1000A

The Voltech Instruments DC1000A Precision DC Bias Current Source is optimized for high AC source impedance. It delivers between 0 A and 25 A, configurable in steps of 10 mA. Up to 20 units can be stacked for a total bias current up to 500 A. A safety interlock input inhibits the output when it is open. This can be used for a safety switch on an eclosure. This source has been evaluated for use together with the R&S®LCX LCR meters.

7 Literature

[1] Rohde & Schwarz, "R&S®LCX Series LCR Meter User Manual," 2025. [Online]. Available: https://www.rohde-schwarz.com/manual/lcx. [Accessed 19 June 2026].

[2] Voltech Instruments, "DC1000A Precision DC Bias Current Source User Manual," 20 July 2021. [Online]. Available: https://www.voltech.com/media/kyzeopad/dc1000a-user-manual-98-102iss8.pdf. [Accessed 19 June 2026].

8 Ordering information

Designation	Type	Order No.
LCR meter, 300 kHz	R&S®LCX100	3629.8856.02
LCR meter, 500 kHz	R&S®LCX200	3629.8856.03
Frequency upgrade to 1 MHz, for R&S®LCX200	R&S®LCX-K201	3630.1880.03
Frequency upgrade to 10 MHz, for R&S®LCX200	R&S®LCX-K210	3630.1900.03
Extended bias functions	R&S®LCX-K108	3692.9791.03
Kelvin clip lead	R&S®LCX-Z2	3638.6446.02

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