The **DC1000A** - Measuring Inductance in the presence of DC BIAS current – What's the problem?

Voltech

WHY TEST WITH DC BIAS SIGNALS PRESENT?

Confirming the inductance of transformers or inductors with a DC BIAS current applied is a common test requirement in many applications, as it confirms that the chosen core material will operate over a range of AC and DC signal loads.

As the DC bias current is increased beyond its operating level, the core will saturate, and the inductance will drop.

Design engineers and component manufacturers need to confirm that the part still operates correctly up to their specified design current level.

LCR MEASUREMENT THEORY

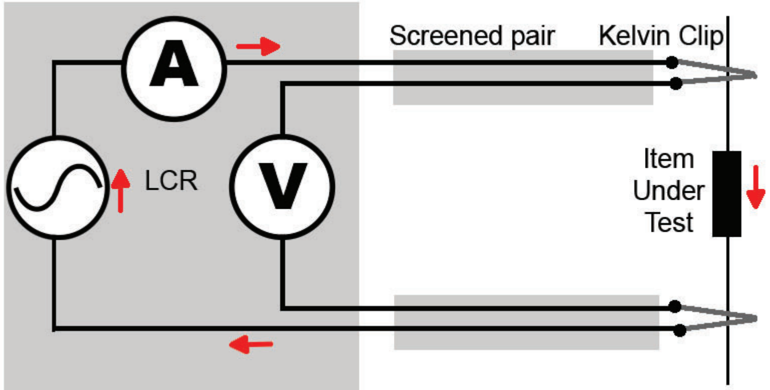
LCR meters are typically used to measure a range of parameters on magnetics, such as impedance, inductance and resistance

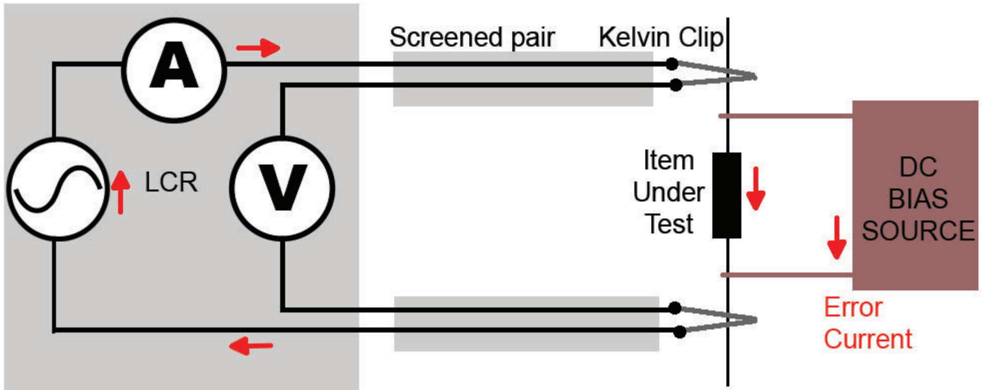
This is achieved by applying a fixed voltage at a chosen frequency and then measuring
a the actual voltage across the part under test
b the actual current flowing through the part under test.
c the phase difference between the voltage and current.

Practically all LCR meters also employ a "4 wire Kelvin" technique. This uses pairs of connections, as shown in the diagram. (Right, top)

The current flowing through the UUT does not travel through the (high impedance) voltage measurement circuit.
Hence there is no voltage drop across the voltage measurement leads or circuit, so less error.

However, Introducing a DC current source into the circuit (to check the UUT with DC Bias applied), can potentially introduce another path for the LCR current to flow through. (Right, bottom).
This extra "error current" flow will thus cause an error in the LCR reading of the UUT.





REAL LIFE FACTORS CAUSING MEASUREMENT ERROR

Accurately measuring the inductance with a conventional LCR meter with no DC bias is straightforward but becomes much more difficult if attempting to do this using an external power supply to generate the DC Bias current. The difficulty here is stopping any AC current flowing from the LCR through the DC current source.
There are four main factors causing an AC current leak through the DC Bias supply

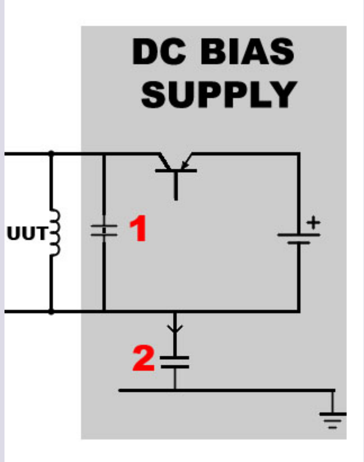
1, Output capacitance of the source
A conventional bench PSU usually contains an output capacitor to smooth its supply.
This would sink the AC current from the LCR supply and result in a measurement error. See **(1)** right

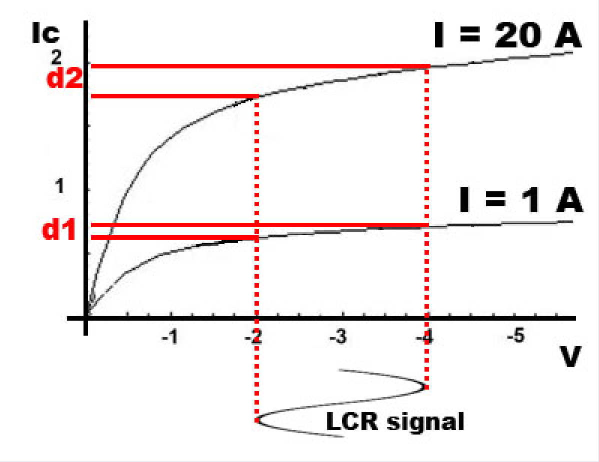
2, Capacitance between the DC source and ground.
See **(2)** right

3, Nonlinear response of the transistors used in constant current PSUs
See diagram right, showing collector current to voltage.
In an ideal transistor the curves are flat, but in reality, there is a characteristic slope.
As the LCR AC signal is added to the DC voltage drop across the UUT, the collector current varies slightly, causing error.

4 Change of transistor response over DC current.
As well as being nonlinear, this error current also changes over varying DC current output.
See diagram (Right)
The response curve at 1 A is different to 20 A, and so the current leak **d2** is larger than **d1**

This in turn means that a conventional LCR compensation performed at 0 DC Amps will not be valid at 5, 10, 20... DC Amps.





REMOVING ERROR - THE DC1000A

Voltech has overcome these issues with our patented correction technique, which addresses these 4 causes of error.
It removes the four error currents that can affect your readings and allows you to measure the UUT with real life test conditions over high (and variable) DC current.
To demonstrate the effectiveness of our solution, we have tested a simple 1 mH inductor, over 0-25 DC Amps Bias @1 V RMS
We have performed this at a range of frequencies and have measured the error current flowing through the DC1000A.
This has been tested with our patented correction circuit deliberately disabled and then tested again with it enabled, to show the effectiveness of our solution.

THE DC1000A IN ACTION

As can be seen from the graphs to the right

Without the DC1000A correction technology;

The orange lines show the AC error current (per Volt across the inductor we are testing).

These error currents vary for the DC BIAS applied, and are also nonlinear, hence almost impossible to compensate out. They also vary in magnitude and linearity at different frequencies.

Most critically it should be noted that the RMS error currents are of the same order of magnitude as the AC current that the LCR is attempting to measure through the UUT – the error current will have a real effect on the inductance you are trying to measure.

With the DC1000A correction technology;

The green lines show the massive reduction in the error current with the DC1000a correction circuit enabled.

The technique reduces any AC current leak to typically better than 1 mA in all cases, allowing your LCR meter to make an effective and real measurement of the inductance under DC load.

One Solution for all frequencies, all currents.

Typically test engineers would measure AC inductance over a range of different DC bias currents at a fixed frequency, the frequency being suitable for that specific part.

We can help you remove virtually all measurement error across all frequencies and all currents – The DC BIAS solution for the full scope of your manufacturing.

Conclusion

It is possible to characterise a non-ideal power supply to remove its error current over varying loads, varying frequencies and varying bias currents. However, this is time consuming, could be different for every source, and not a solution that can easily be scaled up and deployed to a production test environment.

The DC1000A gives test engineers the solution to this problem.