Injector Supports Power Inductor Testing under Bias

The J2131A DC Bias Source enables accurate shunt-through inductance measurement of power inductors at various bias levels—up to and including saturation currents up to 125ADC.

The J2131ABUNDLE includes the J2131A DC Bias Source, a P9610A Power Supply, J2113A Differential Amp, and Two (2) PDN Cables, 1 meter each.

For simulation, modeling, component selection, counterfeit magnetics material detection and failure analysis, testing power inductor performance—up to and including saturation—is a key capability in the engineer's toolbox. Used with a stable, constant-current lab supply, the Picotest J2131A DC Bias Source creates stable, repeatable bias currents injected into the inductor Device Under Test (DUT).

Convenient connections allow accurate shunt-through measurements of the combined signal and DC Bias Sources. This system enables engineers to know precisely the performance of power inductors under the bias currents which will be present in their actual design implementation. Without this valuable information, the engineer assumes the inductor performance is linear—which all too often, is incorrect.

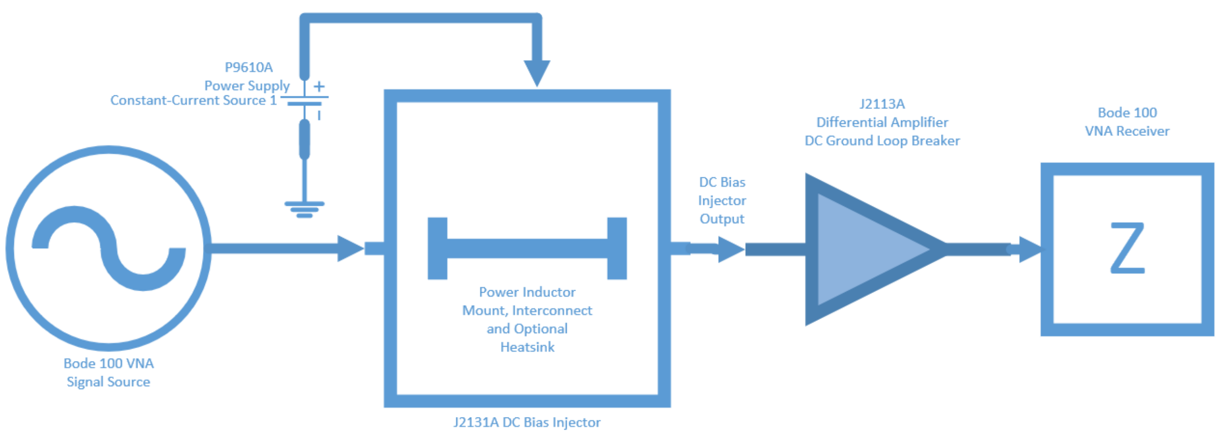

Figure 1: Test Setup Block Diagram

In this sample application, we will demonstrate test tools that couple with your network analyzer that support power inductor characterization. Figure 1 shows the interconnection of the Picotest power inductor J2131ABUNDLE.

The circuit schematic in Figure 2 shows the LDO linear regulator (LT1086) that powers the 125MHz clock oscillator, OSC401 through a slide switch (SEL1). Of note is the 0.01uF decoupling capacitor C402 (on the right).

Figure 2: Inductor Mount Example

Testing under-bias performance of power inductors requires the injection of a stable, adjustable, high-current. The Picotest J2131A is a key part of this test system. In this application note, we will evaluate the performance of a planar Standex Mader PQ2007 power inductor (PQ2002-0R4-70-G) with ratings of nominal 70A (-20% @83A), 400nH and a DCR of 700µOhms.

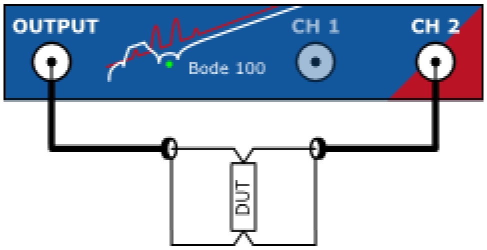

Figure 3: VNA Shunt-Thru Connection Overview

Most well-equipped power labs have a Vector Network Analyzer (VNA). Picotest supports various versions. For this application note, the Bode 100 will be used.

The J2131A takes in a stable constant-current source from a lab power supply. In this case, we know the Picotest P9610A works well. In its constant-current mode, a programmed current level is internally multiplied by a factor of 24 and mixed with the signal source of the VNA. This mixed signal is applied to the power inductor DUT. There are various methods of limiting measurement errors due to ground loop currents. In this application note, we will use the J2113A Differential Amplifier.

The output of the Differential Amplifier is connected to the receiver input of the Bode 100 VNA to complete the test circuit wiring.

The interconnect wiring is shown in the block diagram above. Engineers are urged to use high-quality cables—we don't want weak performance of cables and interconnects to be the limiting factors in these tests.

When invoking the VNA, select the Shunt-Thru impedance measurement method.

Note: in the interconnect drawing below, insert a ground loop breaking differential amplifier (J2113A) in series with the CH 2 receiver. The DUT is connected to the J2131A DC Bias Source which sums the VNA output with the current bias control signal.

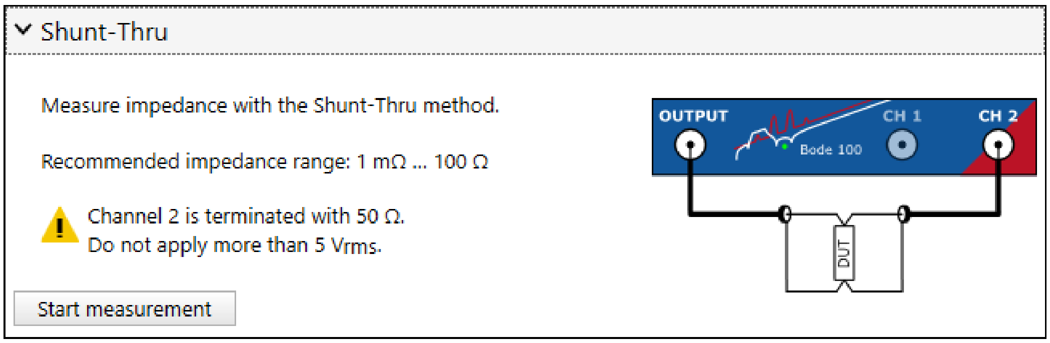

Figure 4: Shunt-Thru Test Selection

Figure 5: Test Setup Wiring Example with J2113A Differential Amplifier

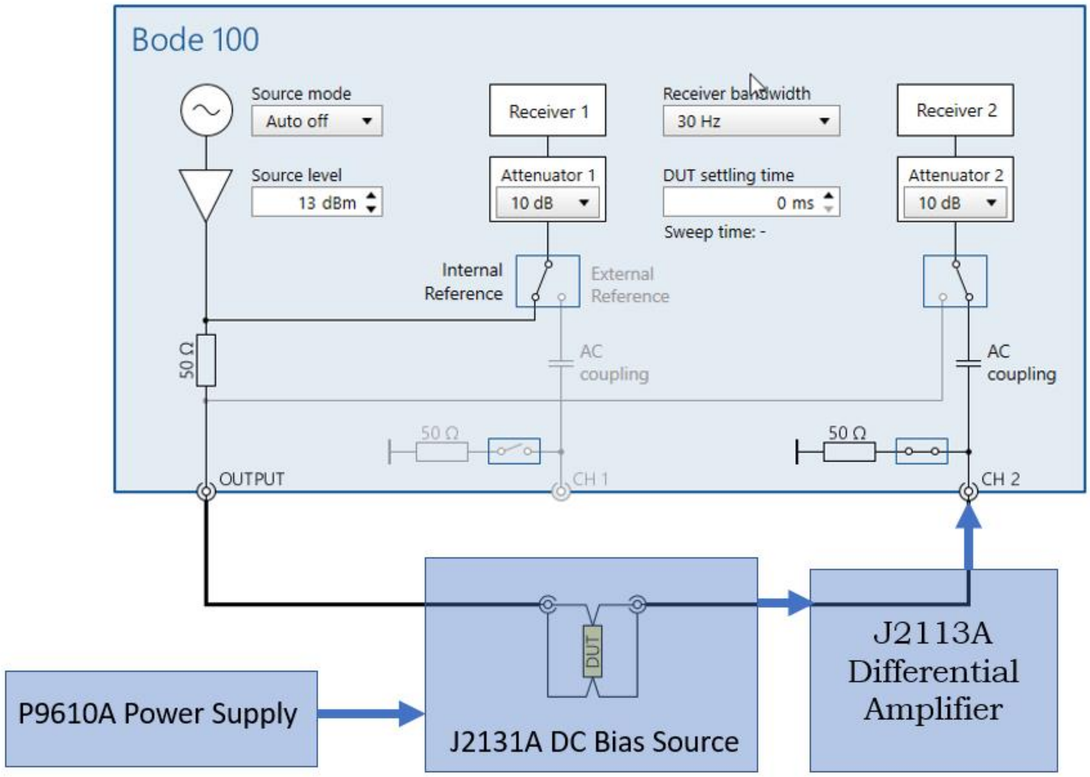

Figure 6: Test Equipment Configuration

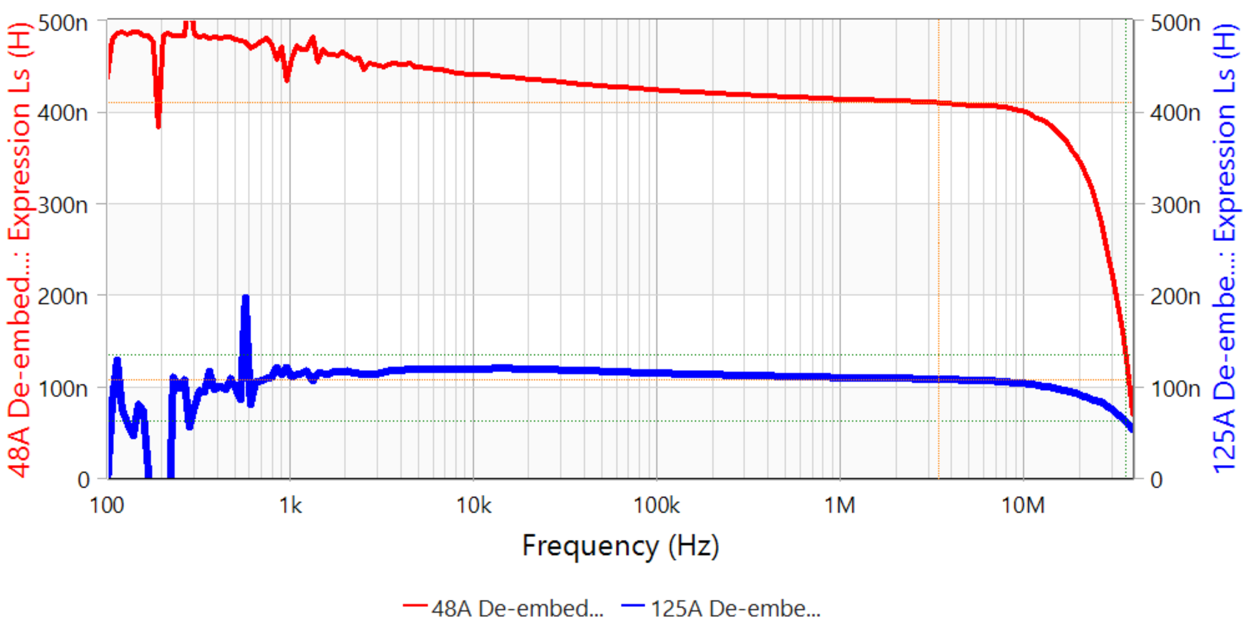

Figure 7: 48 Amp Under-Bias Inductance Measurement with Mount De-Embedded

By taking a measurement with the DUT connections on the inductor mount shorted out, the mount can be characterized and subtracted from the inductor measurement. This math is shown in Formula 1.

$$\frac{48A * Mount}{Mount - 48A}$$

Formula 1: Using a Math Function to De-Embed the Inductor Mount

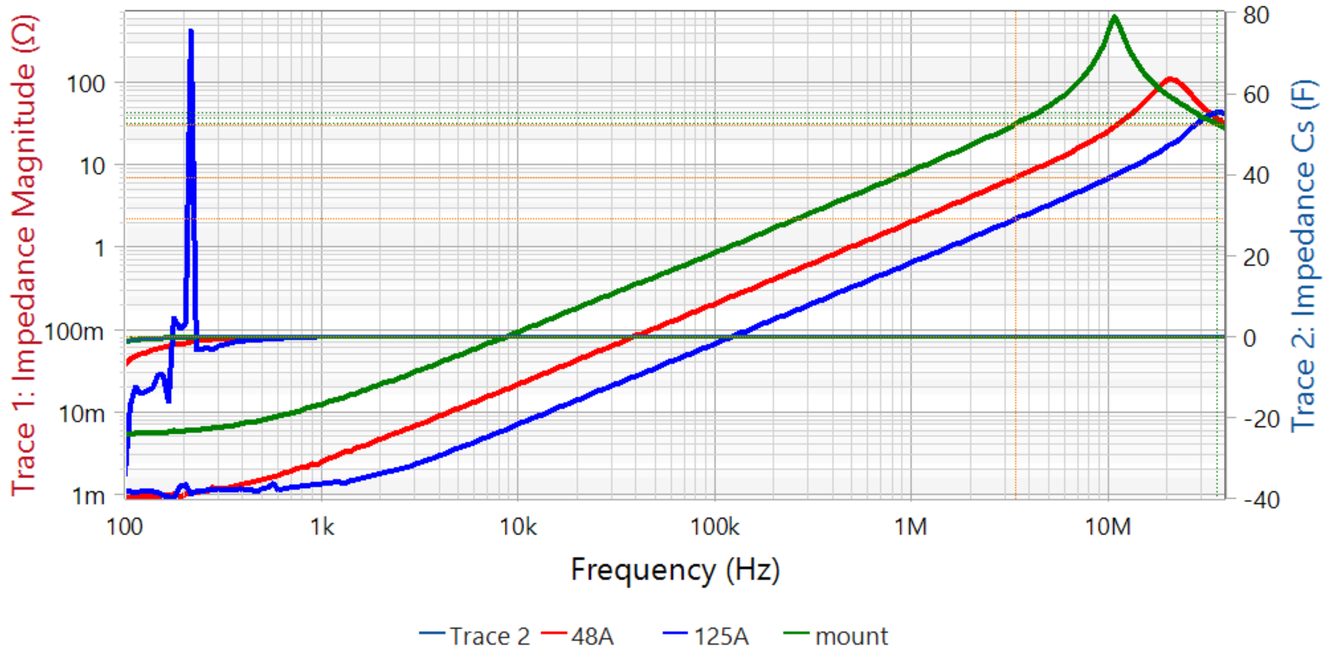

Figure 7: Mount/48 Amp/125 Amp Under-Bias Inductance Measurements

Notes

1. The J2131A DC Bias Source includes an internal transient suppressor to protect the external test equipment if a fault occurs, for example, if the DUT inductor overheats and unsolders itself from the mount. With high currents flowing in the DUT and mount, high temperatures can melt the solder and cause an open circuit. Then, the energy stored in the inductor flux can discharge and cause Electrical Over Stress (EOS) damage. The user is urged to be aware of the fixture and inductor heating effects and make sure high currents are not applied for extended periods.
2. The copper wiring of the inductor and mount circuit board interconnects have a positive temperature coefficient of 0.393% per degree C of temperature rise. At high currents, this resistance change can be significant. The user is urged to consider this self-heating effect and its impact on the test.

Conclusion

Many power supply topologies use power inductors in a single BH quadrant with a large DC bias current.

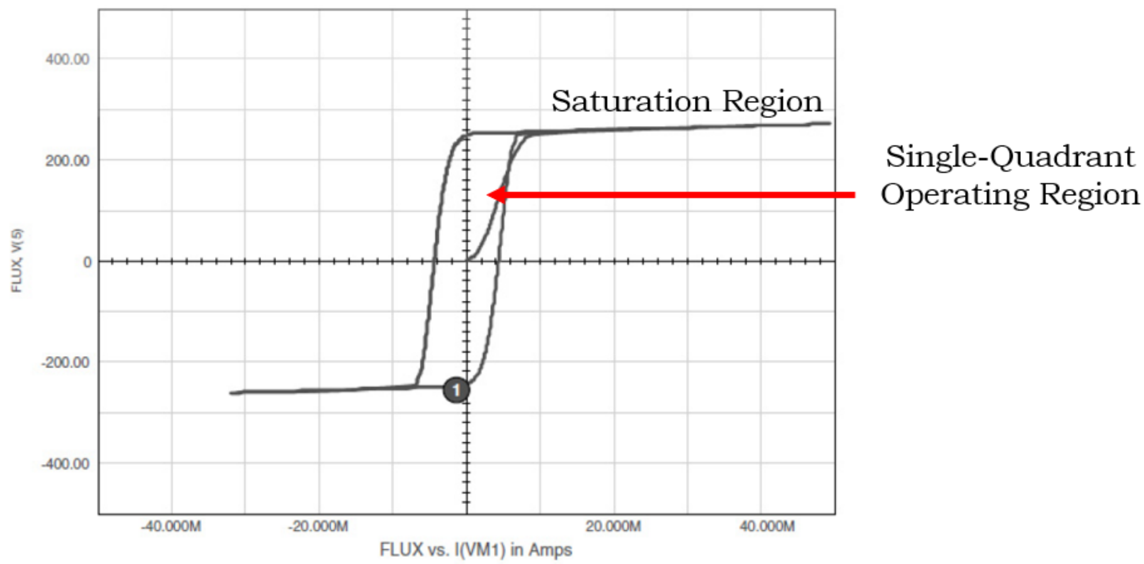

Figure 8: Single-Quadrant Inductor Operation

To properly understand, characterize, model and troubleshoot power inductors, their operation under bias current conditions must be tested. The powerful Picotest J2131A DC Bias Source enables this type of testing.

References

[1] S. M. Sandler, *Switched-Mode Power Supply Design with SPICE*, Faraday Press, 2018

[2] S. M. Sandler, *Extending the Usable Range of the 2-port Shunt-Through Impedance Measurement*, *IEEE MTT-S Lat. Am. Microw. Conf. (LAMC)*, pp. 1–3, Dec 2016.

[3] S. M. Sandler, *How to Measure Ultra-Low Impedance (100uOhm and Lower) PDNs*, *EDICON*, Oct. 2018.

The BH plot of Figure 8 was taken from *Switched-Mode Power Supply Design with SPICE*.
Sandler, Steve, *Switched-Mode Power Supply Design with SPICE*, Faraday Press, 2018

