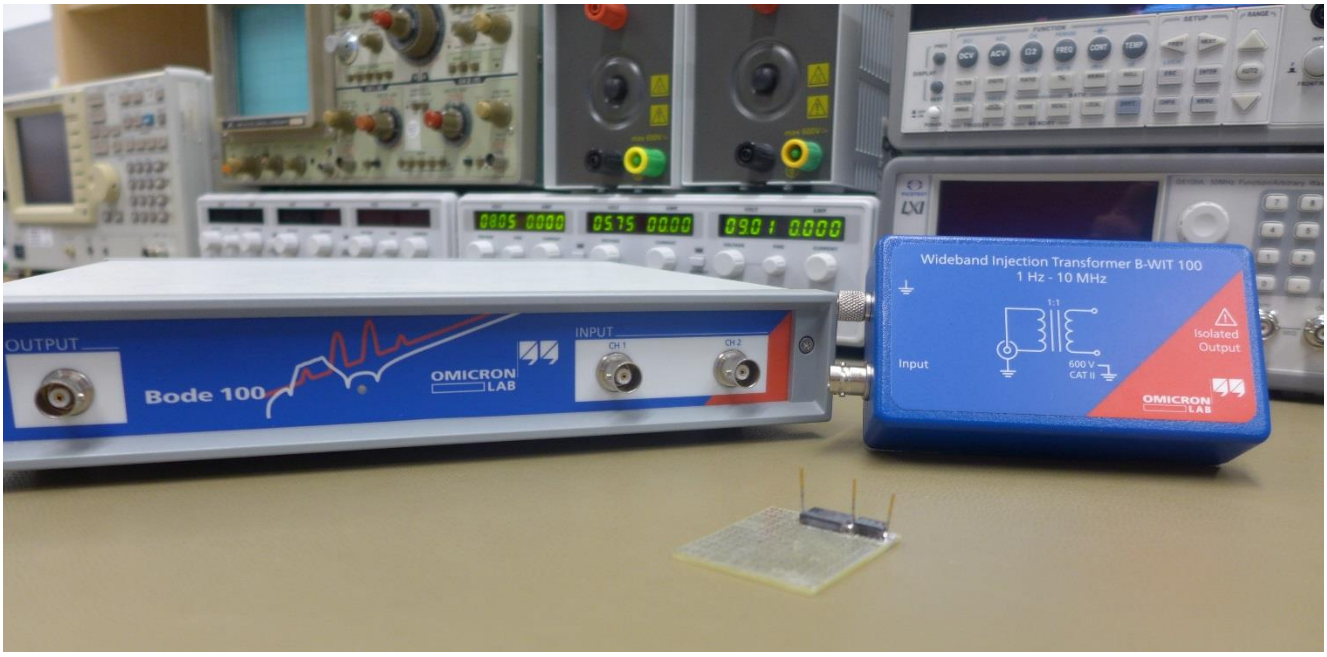
Bode 100 - Application Note

Low Value Impedance Measurement using the Voltage / Current Method



By Florian Hämmerle & Tobias Schuster

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Note: Basic procedures such as setting-up, adjusting and calibrating the Bode 100 are described in the Bode 100 user manual. You can download the Bode 100 user manual at www.omicron-lab.com/bode-100/downloads#3

Note: All measurements in this application note have been performed with the Bode Analyzer Suite V3.00. Use this version or a higher version to perform the measurements shown in this document. You can download the latest version at www.omicron-lab.com/bode-100/downloads

1 Introduction

The impedance of current sensing devices is generally very low, in the range of several milliohms. Measuring the impedance of such a part can be a challenging task.

This document shows how to measure a 20 mΩ SMD resistor, using the *voltage / current* measurement method of Bode 100.

The DUT[1] resistor is displayed in the picture below (resistor in red frame).

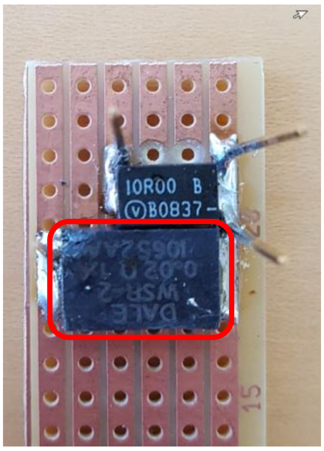

Figure 1: 20 mΩ ± 1 % SMD resistor

The 10 Ω resistor is used as current measurement resistor or reference resistor as explained in the following section.

[1] Device Under Test

2 Measurement

2.1 Measurement Setup

The following measurement setup uses a reference resistor to measure the impedance of the DUT.

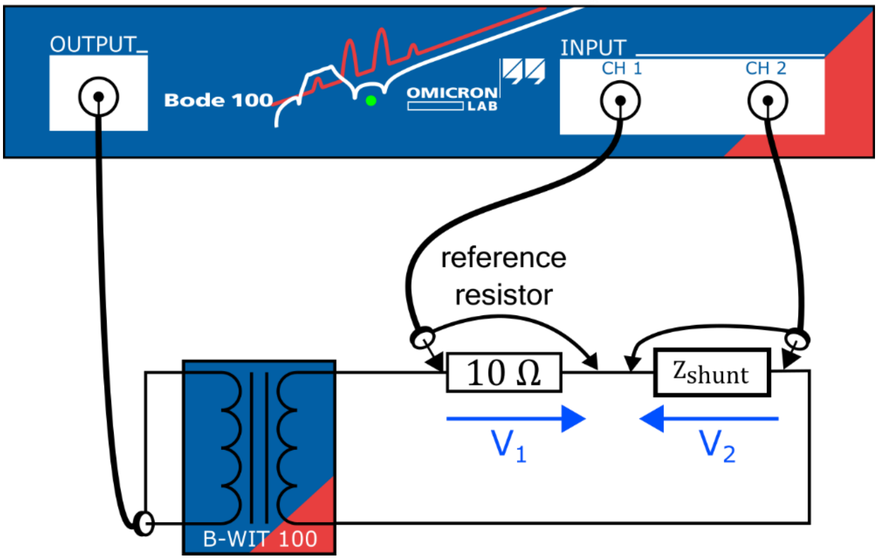

Figure 2: Measurement setup

Channel 1 measures the voltage drop V_1 along the reference resistor which is proportional to the current flowing through the reference resistor. The same current also flows through the DUT. The second input channel measures the voltage drop at the DUT (V_2). The impedance Z_{shunt} of the device under test then equals the measured gain.

$$Gain = \frac{CH2}{CH1} = \frac{V_2}{V_1} = \frac{V_2}{I \cdot 10\Omega} = \frac{Z_{shunt}}{10} \quad (1)$$

Note: The ground path resistance of the channel 1 and 2 connections should be as low as possible to achieve accurate results! To do so, the test pins and the connections itself are soldered together in this measurement example.

Note: The 10 Ω reference resistor was chosen because it shows resistive behavior up to a frequency of 1 MHz. When using a smaller value resistors the parasitic inductance lowers the usable frequency range.

The following pictures show the used measurement setup. The reference resistor is directly soldered to the pin of the shunt. This point is the common ground point for the two input channels. Soldered test pins enable the use of clips for the connection of the Bode 100.

The B-WIT and the Bode 100 are connected using short BNC to clip leads as shown in the picture below.

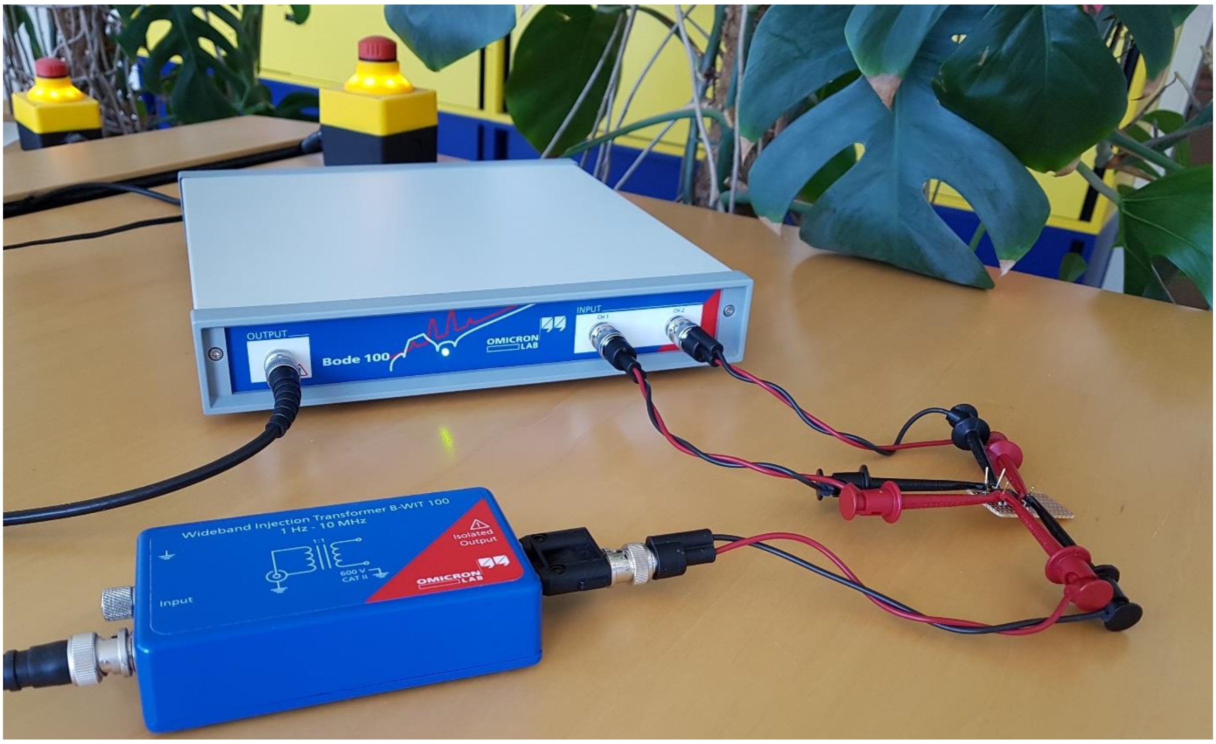

Figure 3: Measurement Setup

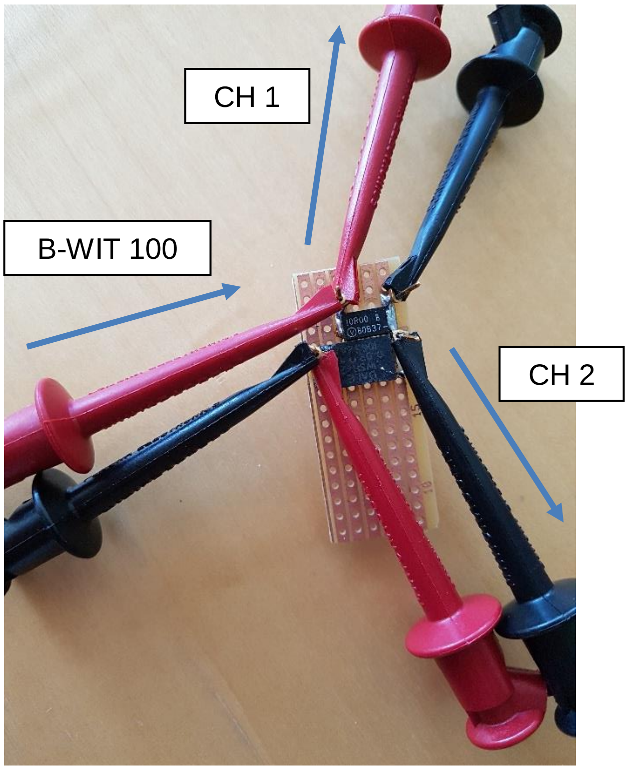

Figure 4: DUT and reference resistor with connections

2.2 Device Configuration

The measurement is performed as a Voltage/Current measurement type.

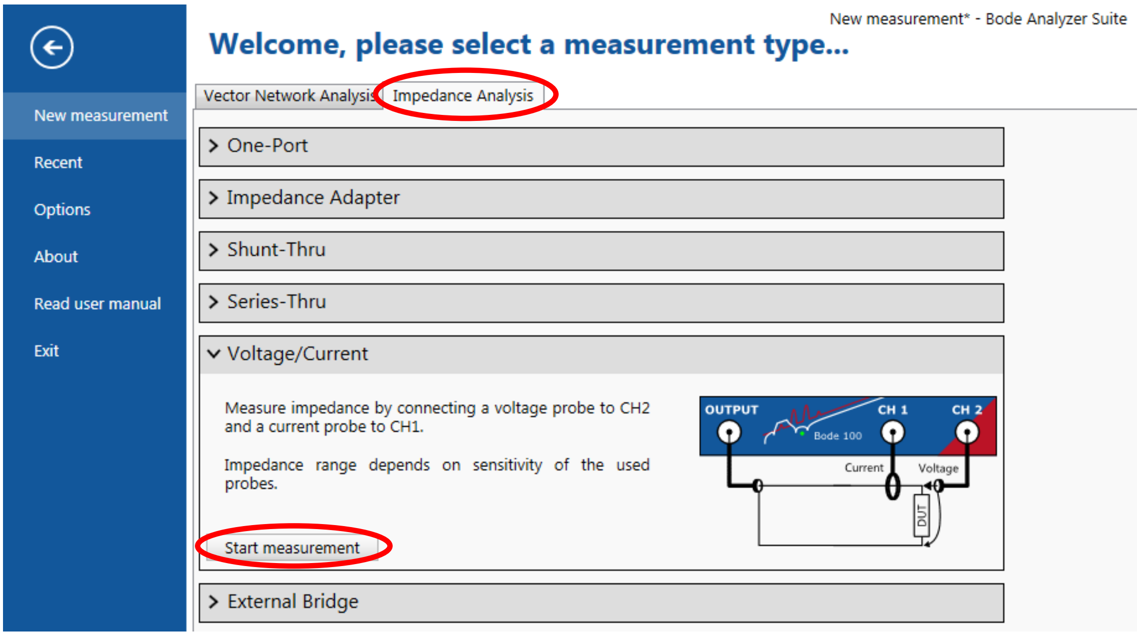

Figure 5: Start menu

The following settings are applied:

Start Frequency:	10 Hz
Stop Frequency:	1 MHz
Sweep Mode:	Logarithmic
Number of Points:	201 or more
Level:	13 dBm
Attenuator 1:	10 dB
Attenuator 2:	0 dB
Receiver Bandwidth:	10 Hz

Since a 10 Ω current sense resistor is used, which delivers 10 V / 1 A, the Probe 1 ratio has to be set to 1:-10 to get a correct impedance and inductance reading.
1:-10 instead of 1:+10 has to be set since we measure the current in the opposite direction. If this setting is positive, the inductance measurement would be negative.

The probe ratio can be set in the Hardware Setup window.

Figure 6: hardware setup button

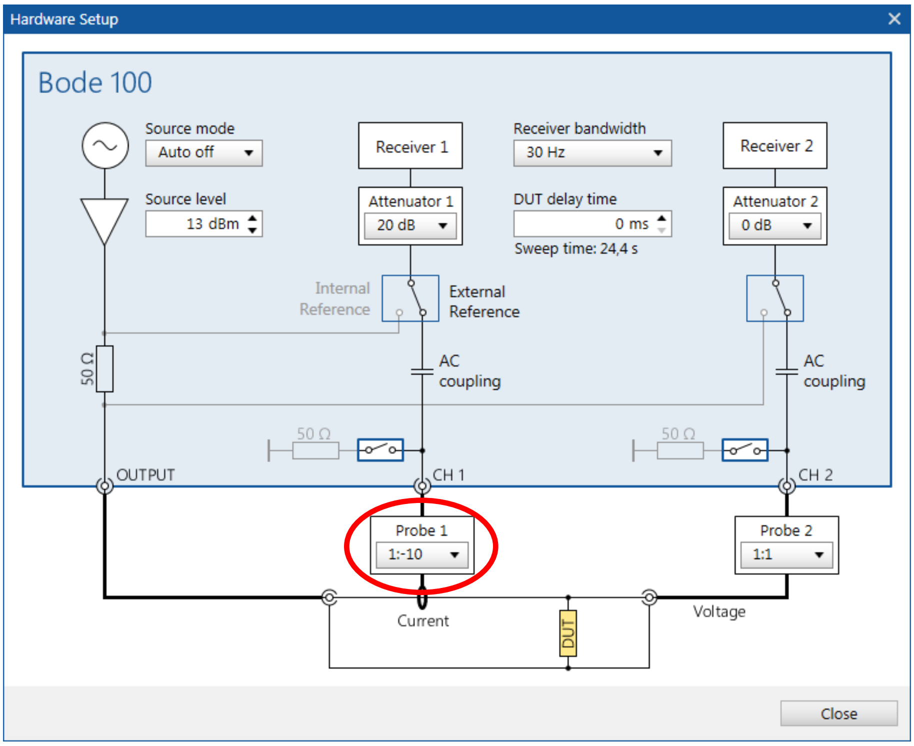

Figure 7: Hardware setup window

2.3 Calibration

In this measurement, a calibration is not mandatory. If we set up the measurement like shown in Figure 8, we can check if a calibration is required. Both probes are applied to the current sense resistor and pick up the same signal. The result must be a flat line at 10 Ω since we have set the probe of CH1 to 1:-10 and a 10 Ω resistor is measured.

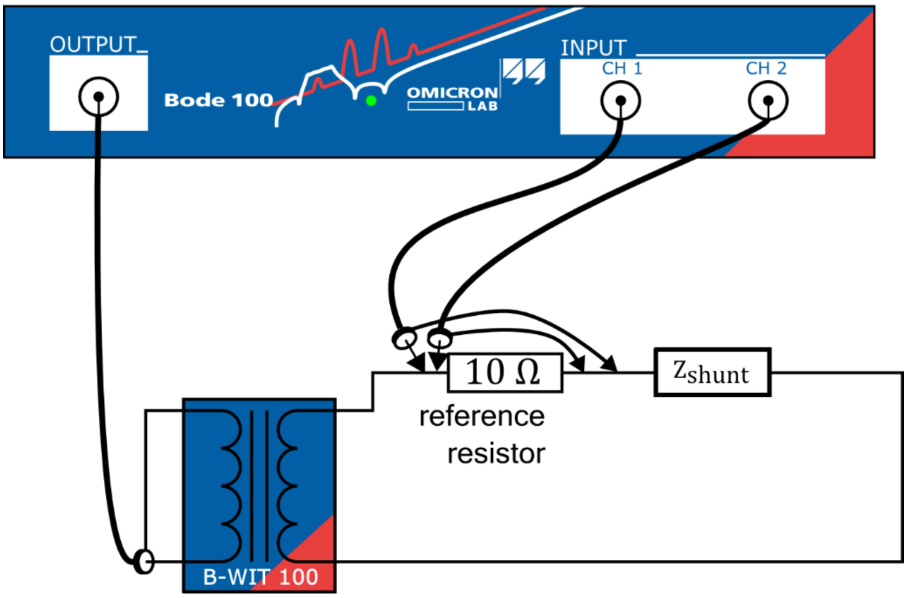

Figure 8: Connection during THRU calibration & for calibration check

2.4 Measurement Result

After applying the settings and connecting the probes like in Figure 2, the measurement can be started by clicking on the single sweep button.

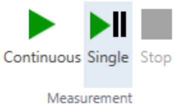

Figure 9: measurement buttons

The following graph shows the measurement results.

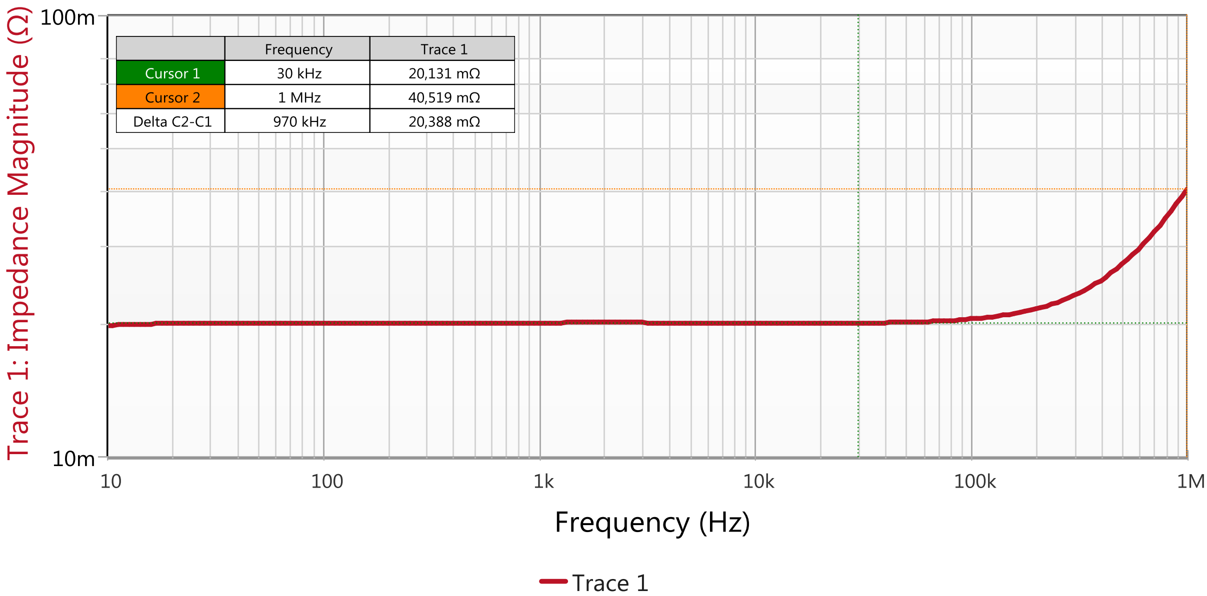

Figure 10: Shunt impedance

The impedance of the measured current sense resistor equals 20.1 mΩ below a frequency of approximately 30 kHz.
Above this frequency, the self-inductance of the shunt starts to influence the impedance magnitude. At 1 MHz, the impedance equals $|Z| \approx 40.5\ \mathrm{m\Omega}$.

The inductance can be directly measured with the Bode 100. For this, we change the Trace 1 setting "Format" from Magnitude to Ls.

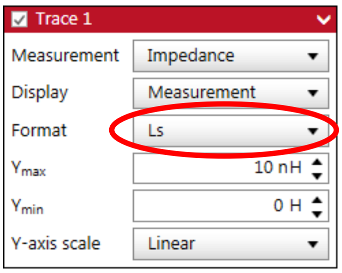

Figure 11: Settings Trace 1

The inductance can also be calculated with the imaginary value (Trace 1 set to Imaginary and Cursor on 1 MHz = 37,09 mΩ) which leads with the equation below, to the following result: L = 5,9 nH

$$L = \frac{Imag(Z)}{2 \cdot \pi \cdot f} \qquad (2)$$

This result equals the measurement as can be seen below where the cursor is set to 1 MHz.

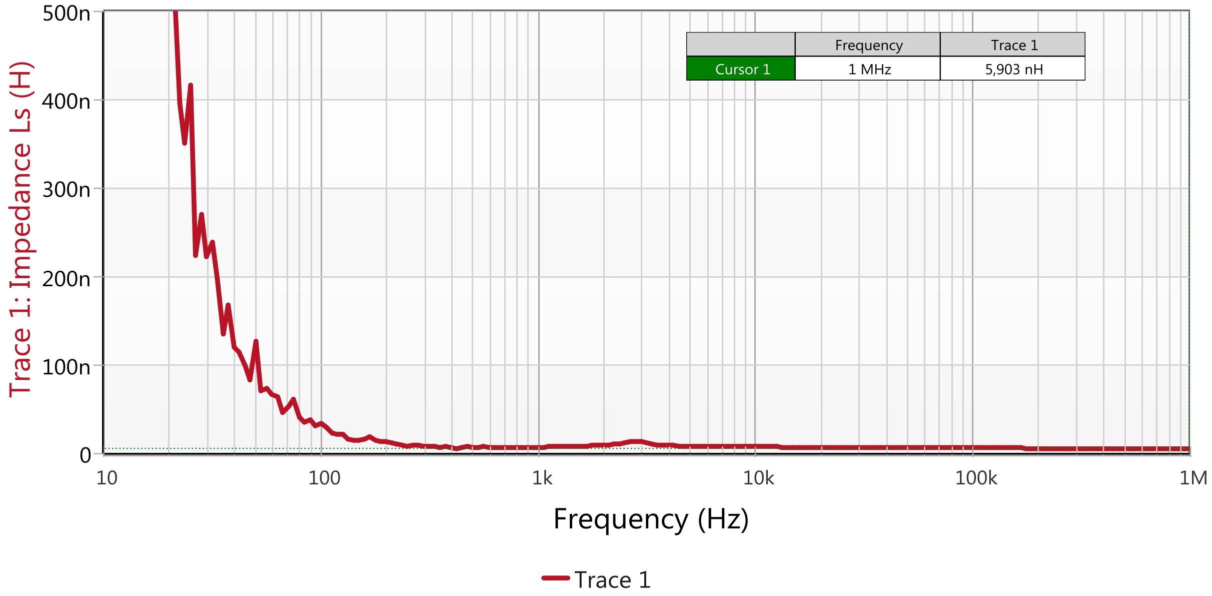

Figure 12: Measurement result

2.5 Result Verification

To verify the measurement results, we perform a measurement without the Bode 100 by using standard multi-meters. Therefore, the DUT must be connected to two multi-meters and one power supply as shown below. The power supply is configured to drive 1 A thru the device under test. By measuring the voltage and current, we can calculate the DC value of the resistor as shown below:

$$R = \frac{U}{I} = \frac{21.67mV}{1A} = 21.67\ m\Omega \qquad (3)$$

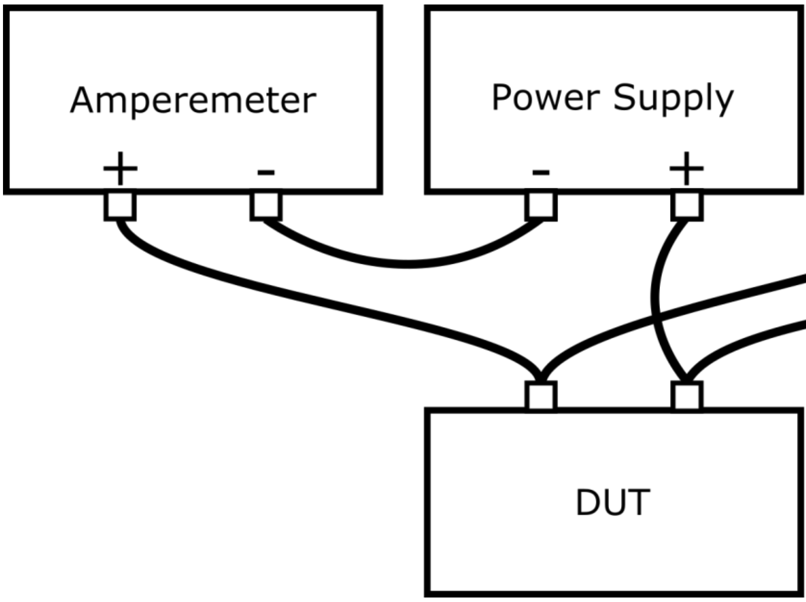

Figure 13: Measurement Setup – Multi-meter

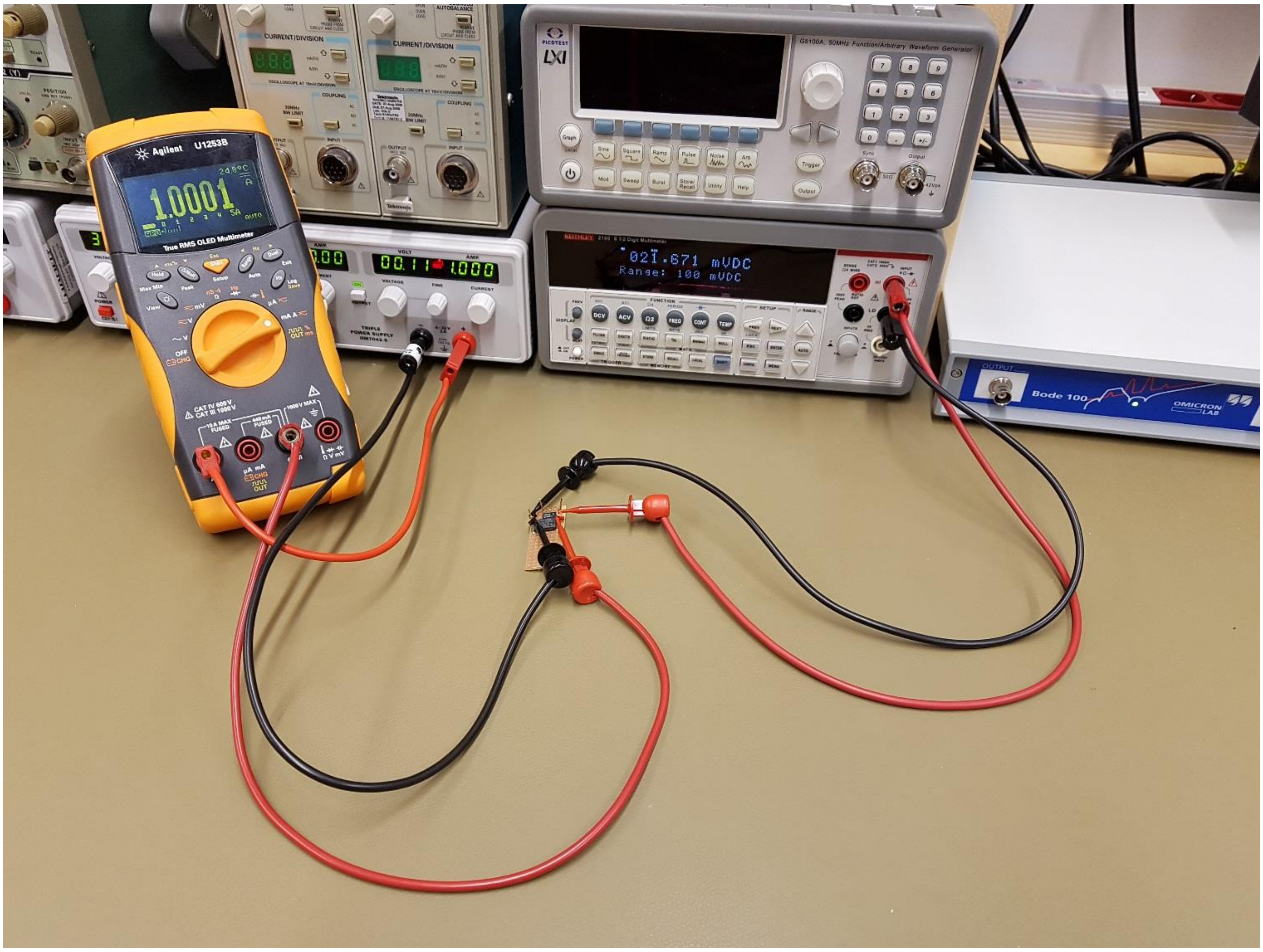

Figure 14: Multi-meter measurement setup (from left: Ampere-meter, Power Supply and Voltmeter)

3 Conclusion

We have demonstrated how very low impedance values can be measured using the Bode 100 and additional accessories like the B-WIT 100 injection transformer.
Impedance values down to several milliohms can be measured over a wide frequency range. This enables an easy way to estimate e.g. the self-inductance of a current sense resistor or the self-inductance of chip capacitors at high frequencies.

If you need to measure low value impedance at higher frequencies, we recommend using the Shunt-Thru method.

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Europe, Middle East, Africa
OMICRON electronics GmbH
Phone: +43 59495
Fax: +43 59495 9999

Asia Pacific
OMICRON electronics Asia Limited
Phone: +852 3767 5500
Fax: +852 3767 5400

Americas
OMICRON electronics Corp. USA
Phone: +1 713 830-4660
Fax: +1 713 830-4661

info@omicron-lab.com • www.omicron-lab.com