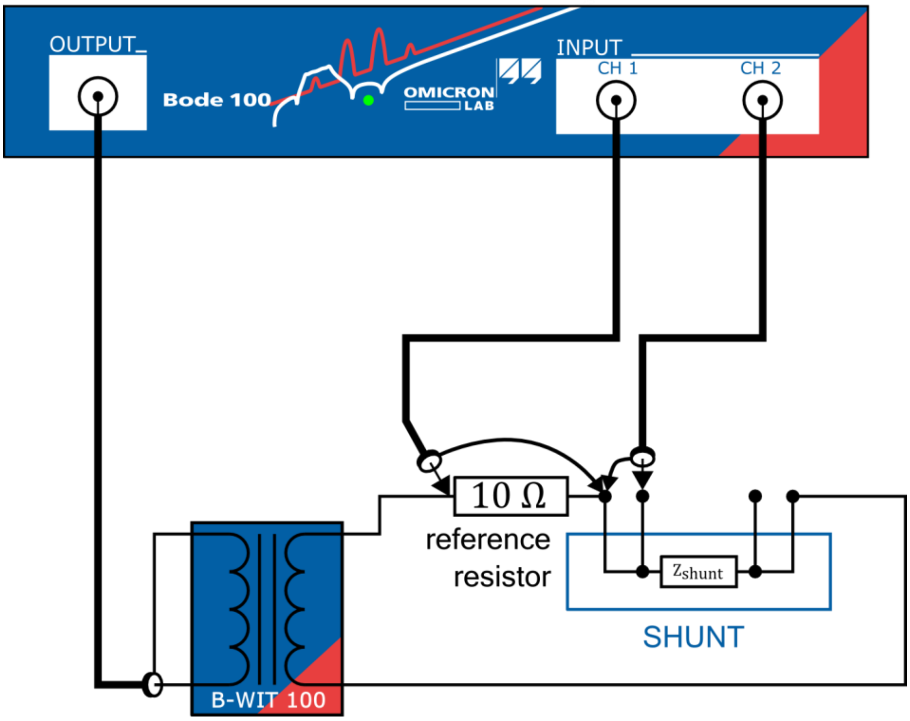
Bode 100 - Application Note

Measure Low Value Impedance
Current Shunt Impedance



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Visit www.omicron-lab.com for more information.
Contact support@omicron-lab.com for technical support.

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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 V3.0. 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 impedances of current sensing devices are generally in the range of several milliohms. Measuring the impedance of such a part can be a challenging task.

This document shows how to use the Bode 100 to measure the impedance of a $20\ \mathrm{m\Omega}$ 4-wire current sense resistor using a test setup with a reference resistor and an isolation transformer.

The DUT[1] resistor is displayed in the picture below.

Figure 1: 20 mΩ ±0.1 % current sense resistor

[1] Device Under Test

2 Measurement

The current sense resistor is a four terminal (Kelvin) resistor. The following figure shows an equivalent circuit model of the current sense (shunt) resistor:

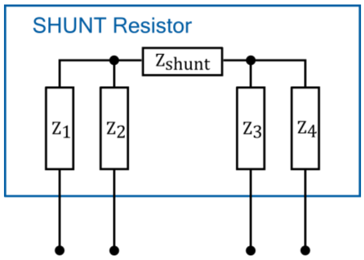

Figure 2: equivalent circuit model

The inner impedance Z_{shunt} cannot be measured with the impedance adapter B-WIC because it is not accessible from the outside. It is therefore necessary to use a different measurement setup.

2.1 Measurement Setup

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

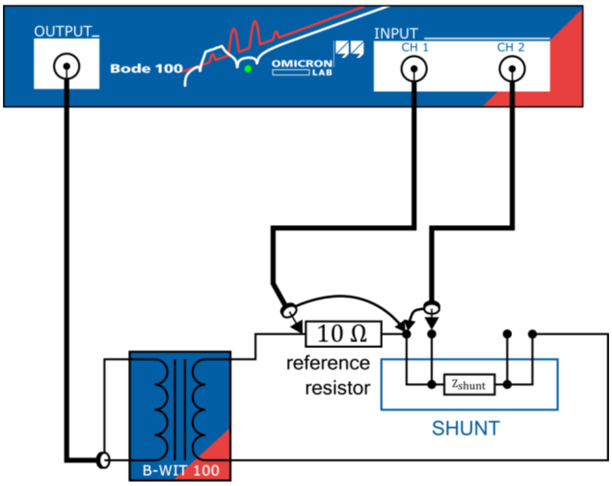

Figure 3: Measuring Z1

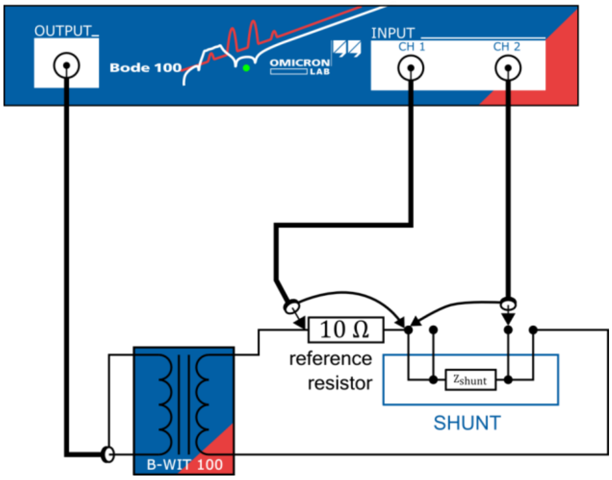

Figure 4: Measuring Z1+Zshunt

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.

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

The setup in Figure 3 measures the impedance Z_1. The influence of Z_2 is negligible because the current flowing to the input is very low (Bode 100 input impedance $= 1\ \mathrm{M\Omega}$). The measurement shown on the right side results in $Z_1 + Z_{shunt}$. The inner impedance Z_{shunt} can then be calculated by subtracting the first from the second measurement result.

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 $10\ \Omega$ reference resistor was chosen because it shows resistive behavior up to a frequency of $1\ \mathrm{MHz}$. Smaller value resistors generally have higher parasitic inductance which lowers the usable frequency range.

The following pictures show the used measurement setup. Note that the connections were soldered when possible and kept short to minimize errors introduced by interconnection parasitics. 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.

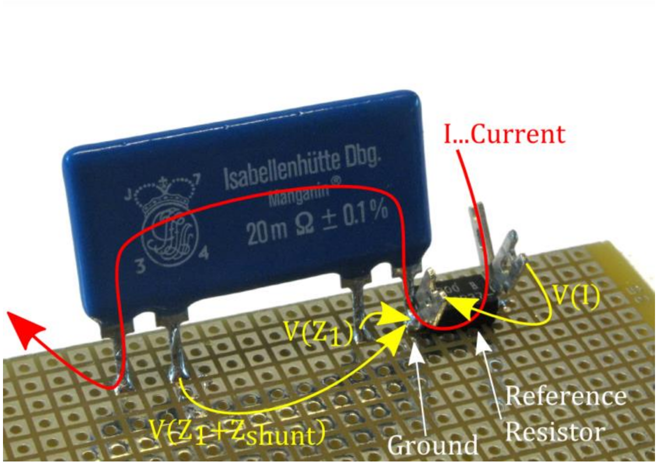

Figure 5: DUT and reference resistor

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

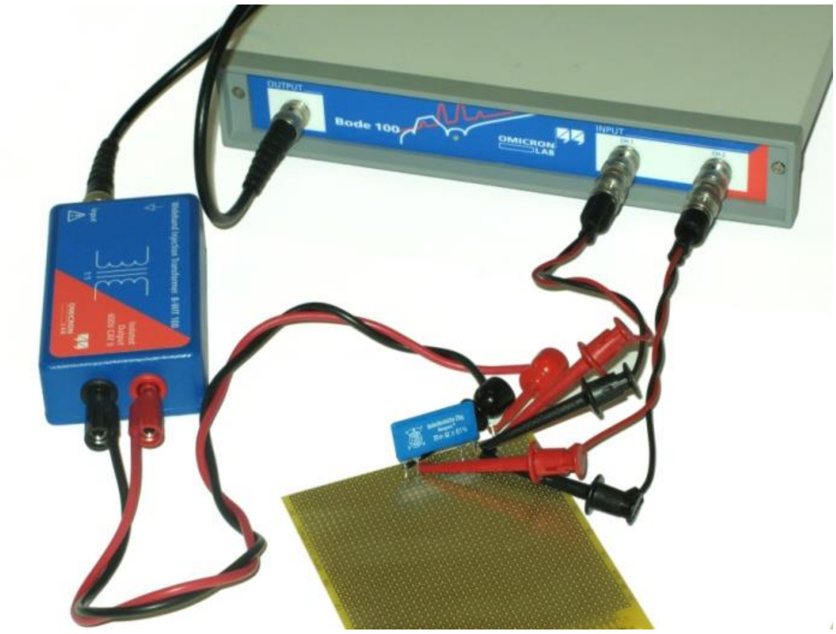

Figure 6: Measurement Setup

2.2 Device Configuration

The measurement is performed in the Voltage/Current measurement type.

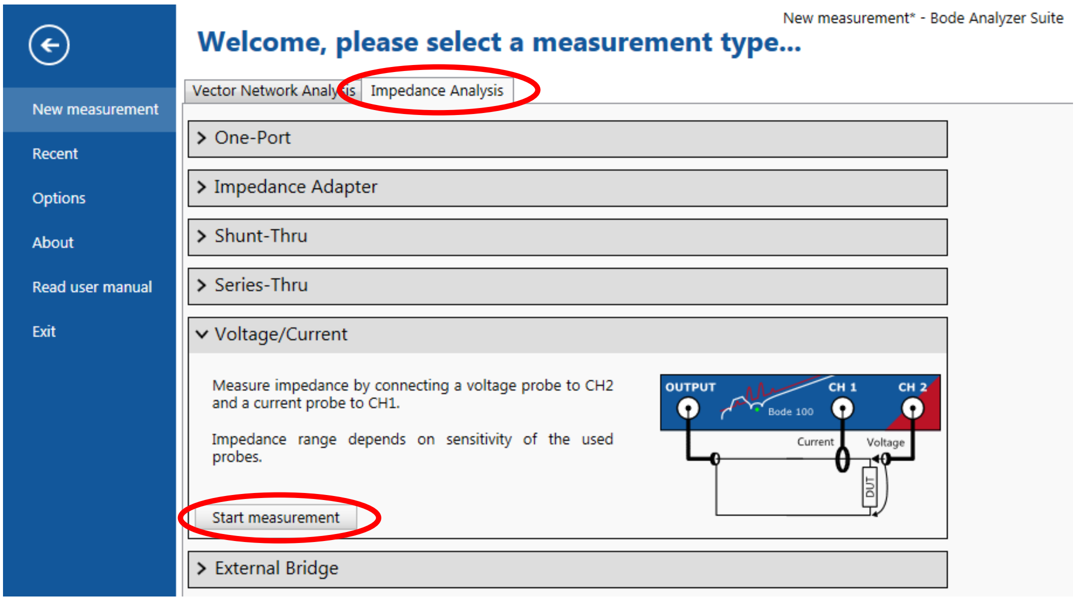

Figure 7: Start menu

The following settings are applied:

Start Frequency:	10 Hz
Stop Frequency:	1 MHz
Sweep Mode:	Logarithmic
Number of Points:	201 or more
Level:	0 dBm
Attenuator 1 &2:	0 dB
Receiver Bandwidth:	30 Hz

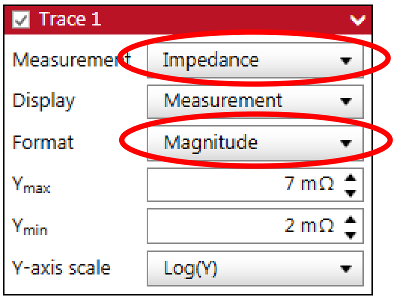

Figure 8: Settings Trace 1

2.3 Measurement Result

After applying the settings, the measurement can be started by clicking on the single sweep button.

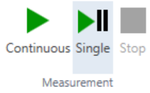

Figure 9: measurement buttons

The following graph shows the measurement results. Two different measurements were performed to identify the lead parasitics. Note that the result values (y-axis) have to be multiplied by a factor of 10 because we used a $10\ \Omega$ reference resistor. The displayed gain magnitude then equals the measured impedance magnitude.

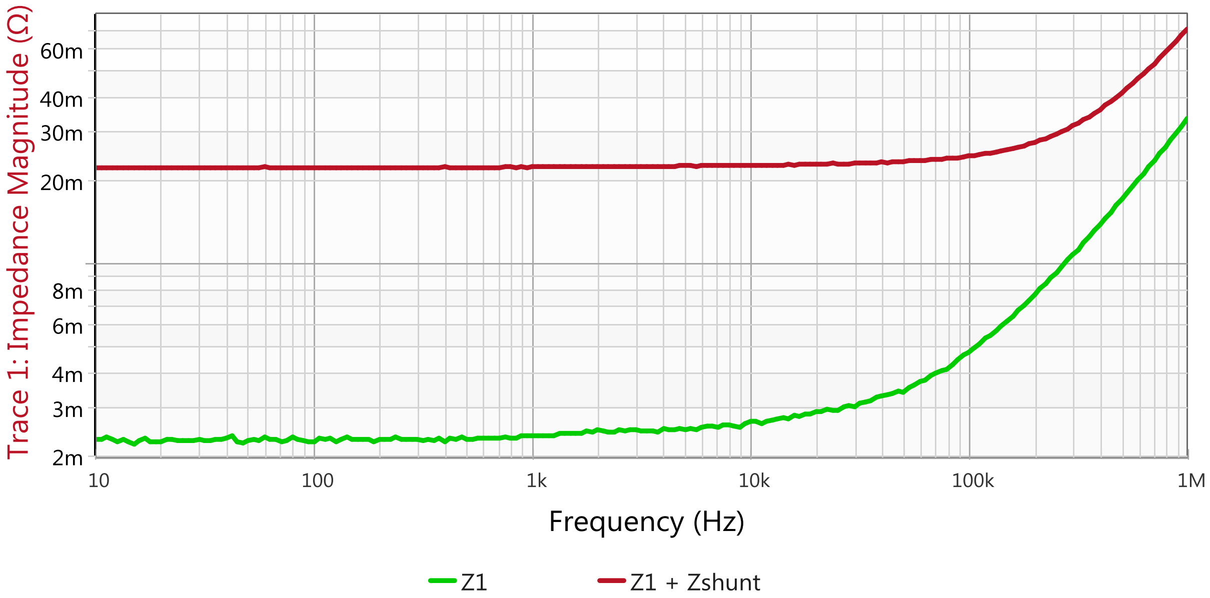

Figure 10: Shunt impedance curves

The red line equals the impedance $Z_1 + Z_{shunt}$. The other measurement (green line) equals Z_1. The inner impedance Z_{shunt} can then be calculated by subtracting Z1 from the Z1 + Zshunt measurement curve.
This can be done directly in the Bode Analyzer Suite by setting the display to “math” as shown below.

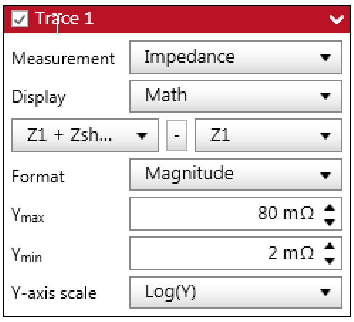

Figure 11: Settings Trace 1

The Math feature calculates every single point at the same frequency trough the full frequency range with the other list of points.

Subtracting the Z1 curve from the Measurement curve (both shown in Figure 10) leads to the impedance of the shunt shown in the graph below:

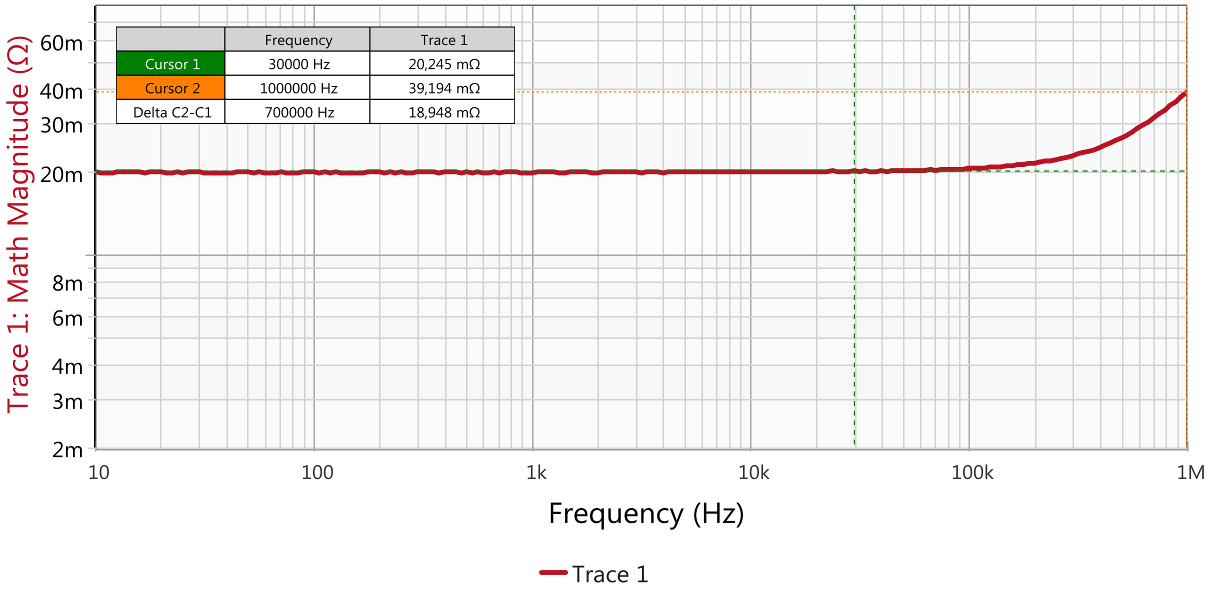

Figure 12: Inner shunt impedance

The impedance of the measured current sense resistor equals $20\ \mathrm{m\Omega}$ below a frequency of approximately $30\ \mathrm{kHz}$.
Above this frequency the self-inductance of the shunt starts to influence the impedance magnitude. At $1\ \mathrm{MHz}$ the impedance equals $|Z| \approx 39.2\ \mathrm{m\Omega}$.

Additionally we can measure the existing inductance near $1\ \mathrm{MHz}$ by switching the format in the Bode Analyzer Suite to Ls. By setting a cursor on $1\ \mathrm{MHz}$, we can see the inductance of 5.22 nH.

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 to estimate in example the self-inductance of a current sense resistor or the self-inductance of chip capacitors at high frequencies.

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