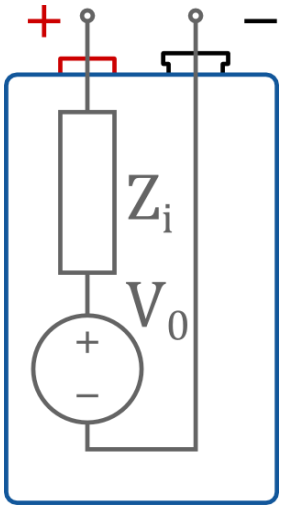
Bode 100 - Application Note

Battery Impedance Measurement



By Florian Hämmerle

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 V2.41 SR1. 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 Executive Summary

Battery impedance includes information about the internal state of a battery. The impedance depends on many factors such as the chemical properties and mechanical design of the battery. Measuring the battery impedance over frequency helps to identify the characteristics of the battery.

The Bode 100 in conjunction with the Picotest J2111A Current Injector offers an easy way to measure the impedance of a battery in the frequency range from 1 Hz to 10 MHz.

This application note shows the connection setup and the device settings of the Bode 100 necessary to perform the impedance measurement.

2 Measurement Task

The impedance of an alkaline 9V block is measured in the frequency range from 1 Hz to 10 MHz. After discharging the battery to a no load voltage of $V_0 = 7.5\ \mathrm{V}$ the impedance spectrum is measured again and compared to the measurement performed on the full charged battery.

Furthermore, the impedance spectrum of a $3.7\ \mathrm{V}$ lithium ion battery is measured to demonstrate that even cells with low output resistance can be measured with the presented method.

3 Measurement Setup & Results

The impedance of a battery, Z_i, can be measured by loading the battery with an AC[1] current and measuring the resulting AC output voltage of the battery. Dividing the AC output voltage v_{out} by the AC output current i_{out} leads to the impedance of the battery.

$$Z_i = \frac{v_{out}}{i_{out}}$$

The output current of the battery is modulated by the J2111A current injector, driven by the output signal of the Bode 100.

The output current is then measured by connecting CH1 of the Bode 100 to the current monitor output of the J2111A. The output voltage of the battery is measured directly using a 1:1 voltage probe connected to CH2.

The connection setup is shown in the figure below:

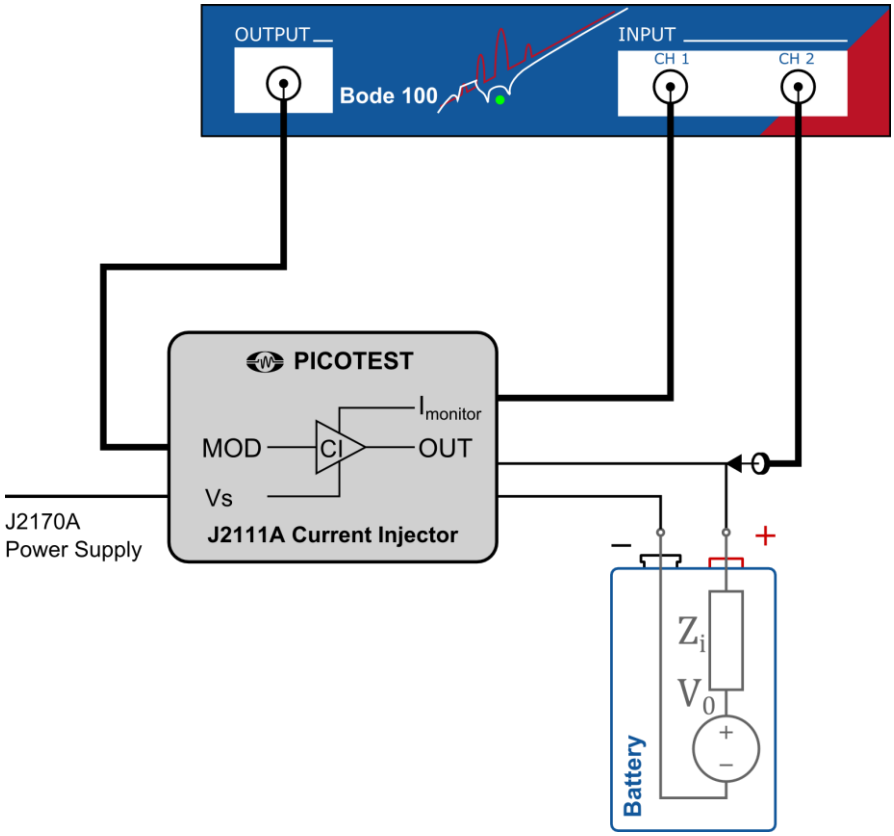


Figure 1: Connection Setup

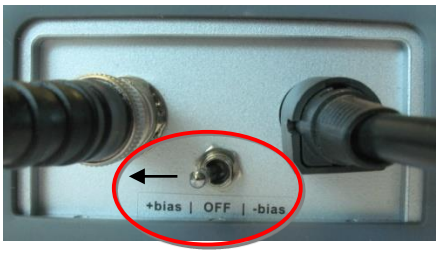
Note: The maximum allowed battery voltage with this setup is $40\ \mathrm{VDC}$!

[1] Alternating Current (sine-waveform)

3.1 Device Setup

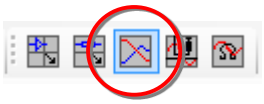
Current Injector J2111A:

The positive bias of the Current Injector must be switched on (+bias) since the Bode 100 output voltage does not have an offset. The positive bias provides a 25 mA offset current, allowing the current injector to operate in class "A" mode. For the best performance, the output wires from the J2111A should be twisted or be coaxial.



Bode 100:

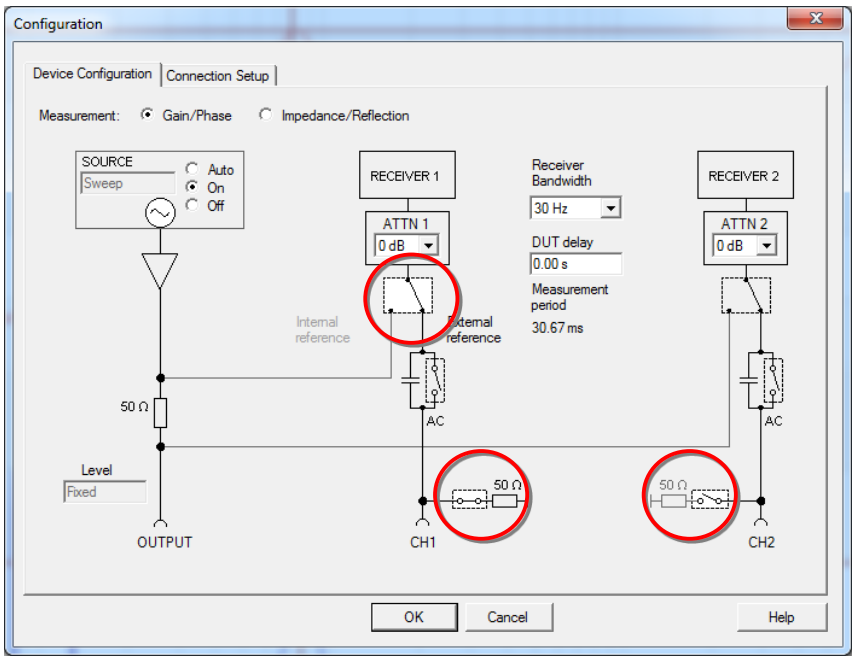
The battery impedance measurement can be performed directly with the Bode 100 using the external reference function. The Bode 100 is set up as follows:



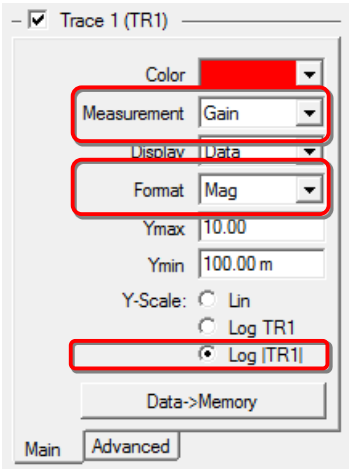
Measurement Mode:	Frequency Sweep Mode
Start Frequency:	1 Hz
Stop Frequency:	10 MHz
Sweep Mode:	Logarithmic
Number of Points:	201 or more
Receiver Bandwidth:	100 Hz
Attenuator 1 &2:	0 dB
Level:	0 dBm

To switch on the external reference start the device configuration window and click on the external reference switch symbol:

In addition, the input impedance of channel 1 must be set to 50Ω, while channel 2 need to remain in high impedance mode:



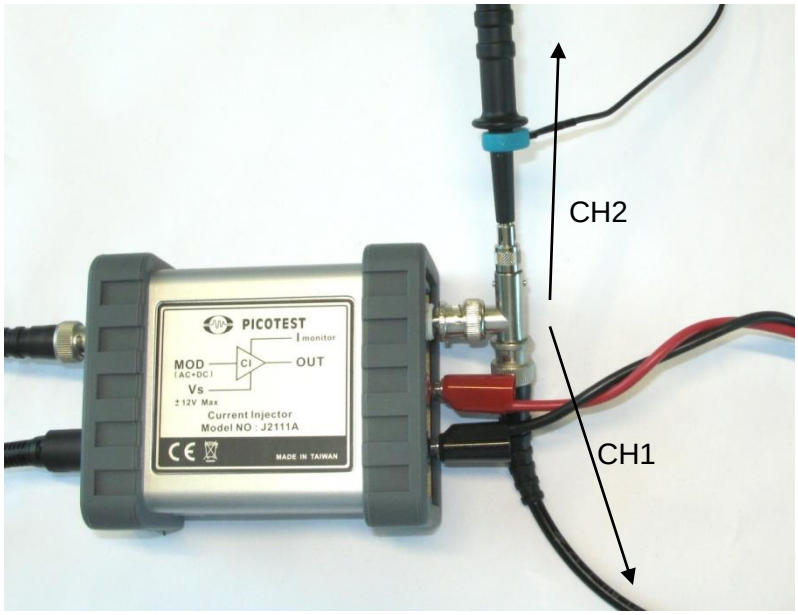
Trace 1 settings:



It is advisable to activate the Full Speed Mode to achieve a higher measurement speed since we are measuring over a low frequency range.

3.2 Calibration

To remove the influence of the voltage probe, we recommended calibrating the setup. To do this the voltage probe at CH2 is connected to the current monitor output of the current injector and a THRU calibration is performed.



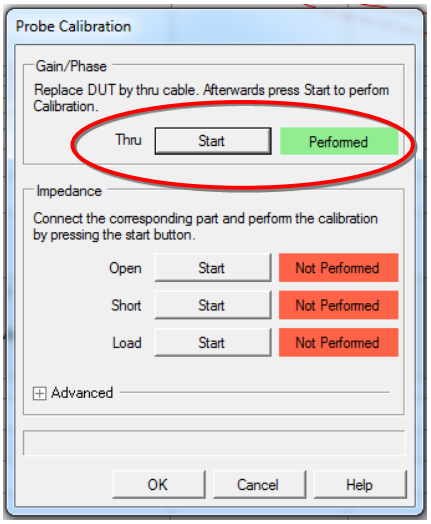


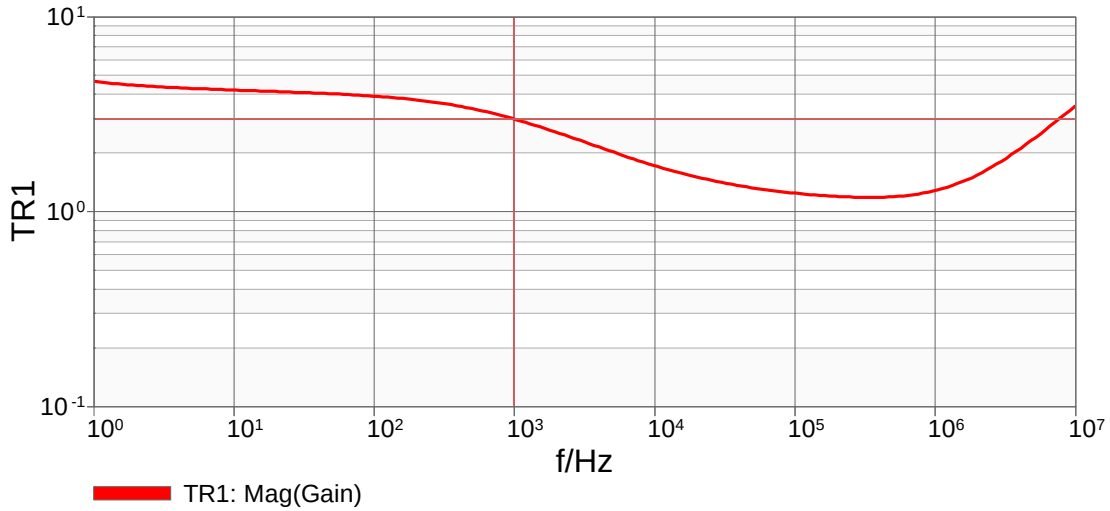
Figure 2: Connection during THRU calibration

3.3 Measurement

For the measurement of the battery impedance, the battery under test is connected as shown in the picture below.

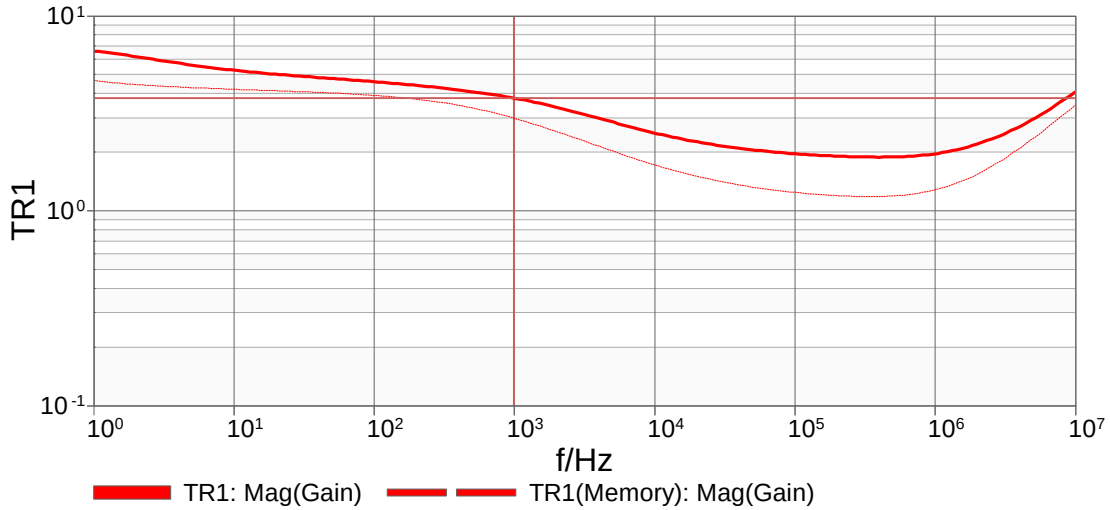
Figure 3: Measurement Setup Example

First, we measure impedance of the fully charged battery. Starting a single sweep leads to the following impedance spectrum:



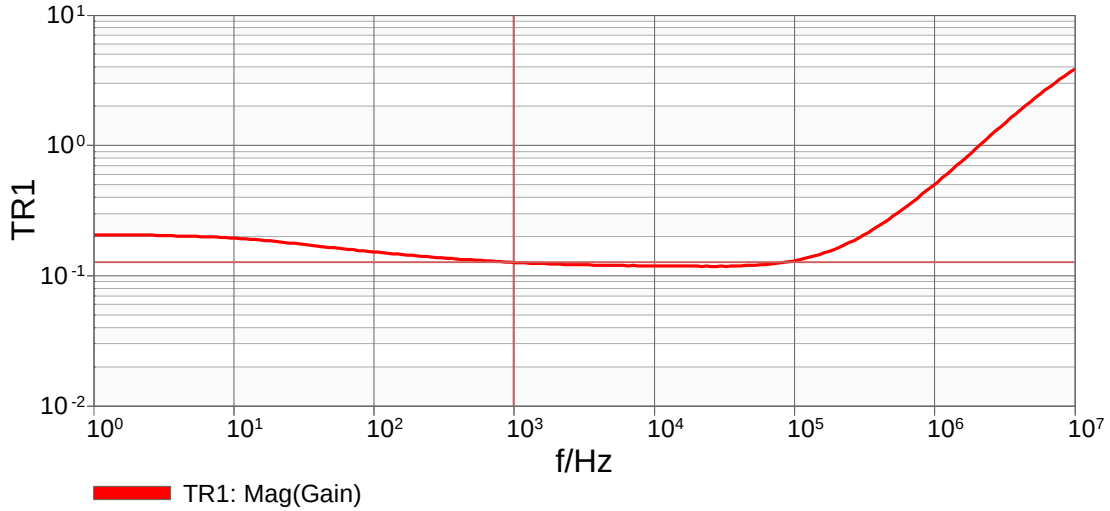
The Gain magnitude in this case equals the impedance magnitude in Ohm. At $1\ \mathrm{kHz}$ the impedance shows a value of $2.9\ \Omega$.

Now the battery is discharged to a no load voltage of $V_0 = 7.5\ \mathrm{V}$ and a second sweep is performed. This results in a different impedance spectrum (see solid line in the graph below).



The battery impedance at $1\ \mathrm{kHz}$ did increase to $\approx 3.8\ \Omega$.

The same measurement setup can be used to measure all types of batteries. As an example we measured the impedance of a $1000\ \mathrm{mAh}$, $3.7\ \mathrm{V}$ lithium ion cell. The impedance of this cell is shown in the graph below:



At $1\ \mathrm{kHz}$ the lithium ion cell shows an impedance of $126\ \mathrm{m\Omega}$ which is much lower than the impedance of the alkaline battery.

4 Conclusion

The Bode 100 in conjunction with the Picotest J2111A Current Injector offers a test set that enables simple and fast measurement of the battery impedance. The impedance of low and high impedance batteries can be evaluated over the frequency range from 1 Hz to 10 MHz.

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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