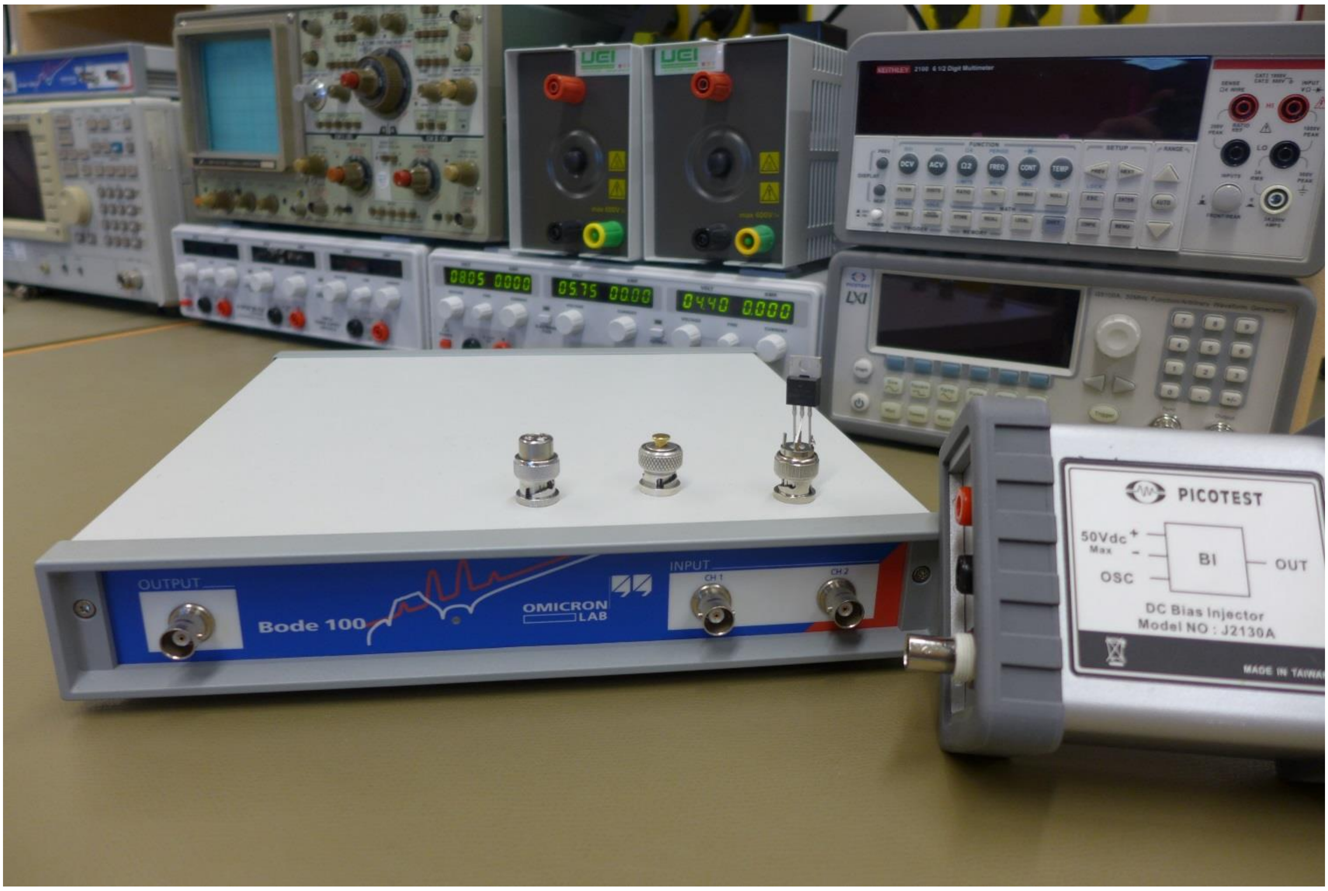
Bode 100 - Application Note

DC Biased Impedance Measurements
MOSFET



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Visit www.omicron-lab.com for more information.
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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

You can download the latest Picotest Injector manual at http://www.picotest.com/products_injectors.html.

1 Executive Summary

Measuring the impedance of electronic parts or devices can be a challenging task as the impedance often depends on many external parameters.

One of these parameters is the DC Bias or DC offset. The Bode 100 generally measures impedances using an AC signal with zero DC offset.

But in this application note we show how the Bode 100 impedance measurement capabilities are extended with the Picotest J2130A DC Bias Injector.

One measurement task is performed where the DC offset has a strong influence on the measurement results:

- The Gate Resistance of a MOSFET, depending on the operation point.

2 Measurement Task

2.1 MOSFET Gate Resistance

The Bode 100, used in conjunction with the Picotest J2130A DC Bias Injector, is a perfect combination for measuring the internal gate resistance of a MOSFET. The Bias Injector allows the resistance to be measured with a DC voltage applied from the gate to the source of a MOSFET while leaving the drain floating or connected to the source.
The Bode 100 then measures the vector impedance of the junction. This measurement is very sensitive, since the resistance is very small compared with the capacitive impedance. This measurement requires a very low noise floor and exceptional resolution, both of which are provided by the Bode 100.
We measure the gate resistance of an N-MOSFET, Type: IRLZ24N.

3 Measurement Setup

The measurement setup for the DC biased impedance measurement is simple when using the Bode 100 in combination with the Picotest J2130A. The following figure shows the connection setup for the MOSFET Gate Resistance measurement.

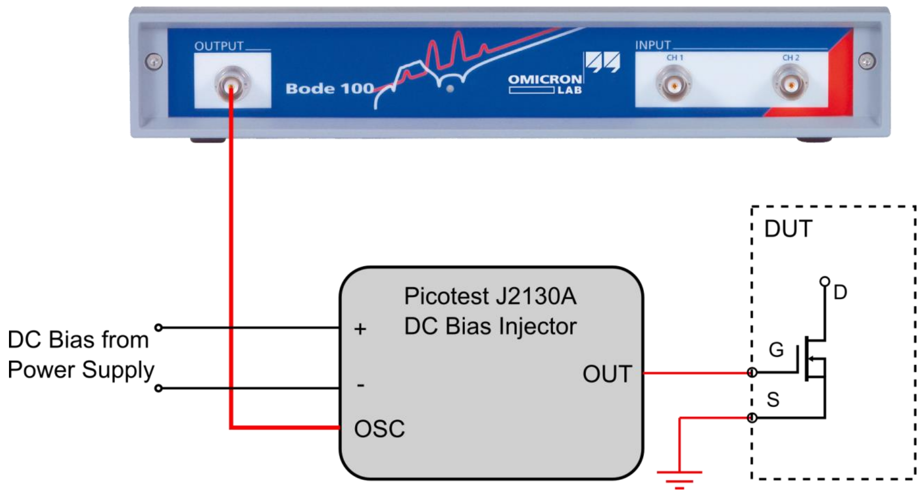


Figure 1: Gate Resistance Connection Diagram

The simplicity of the measurement setup can be seen in the picture below. The J2130A DC Bias Injector is connected to the Bode 100 using a BNC cable. The DC Bias voltage is supplied by a regulated DC power supply. The DUT is soldered to a BNC connector which is a preferable method to keep the connections short and ensure low contact resistance.

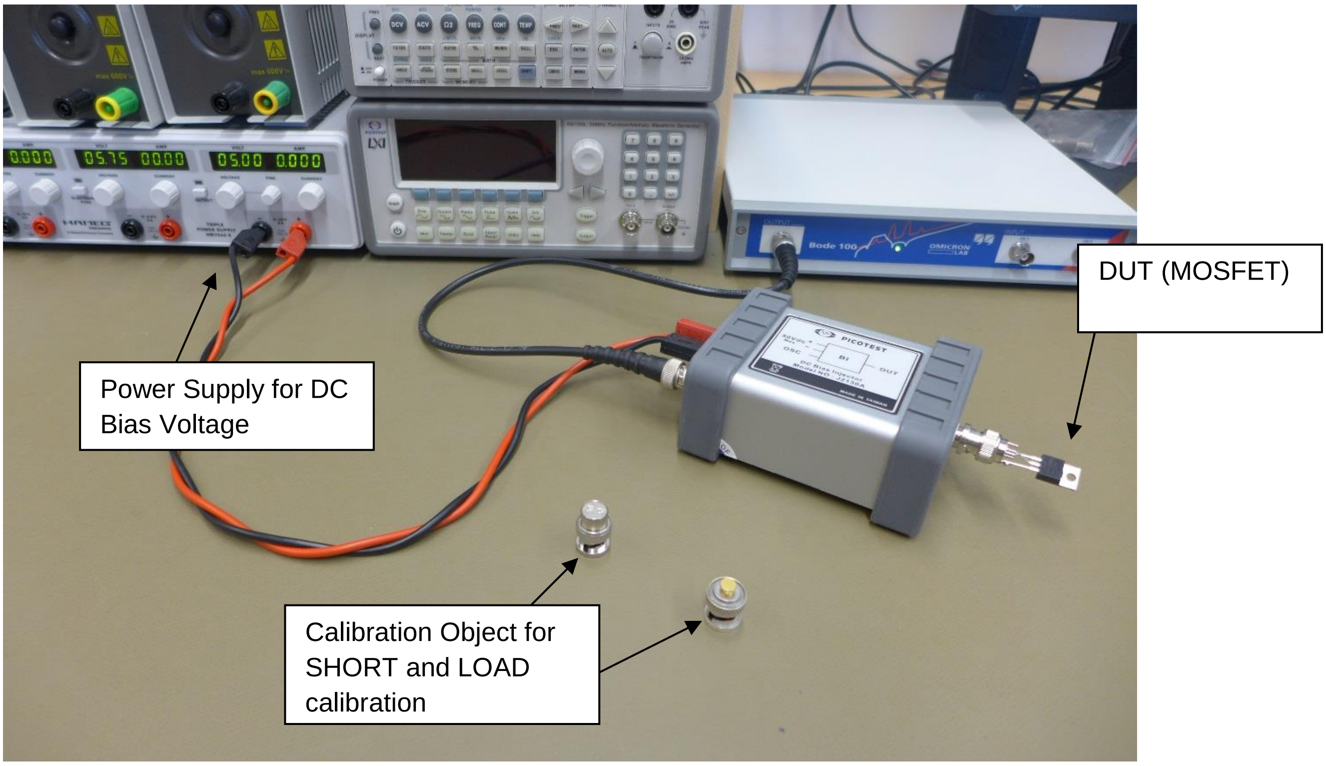


Figure 2: Measurement Setup Example

4 Device Setup and Calibration

4.1 Device Setup

The gate resistance of the MOSFET at a frequency of 1 MHz wants to be measured. Therefore, the gate has to be biased with a voltage of 10 VDC and the Bode 100 settings are as follows:

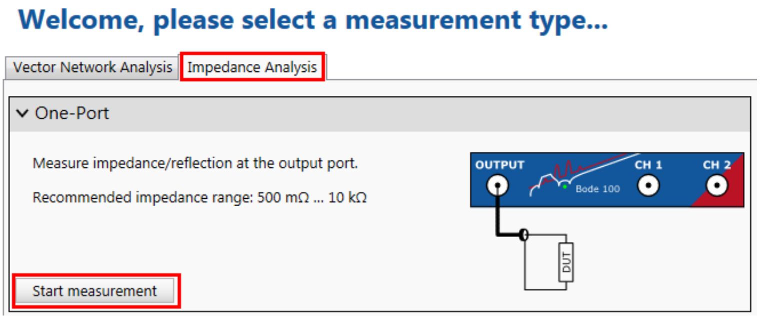


Figure 3: select measurement type one-port

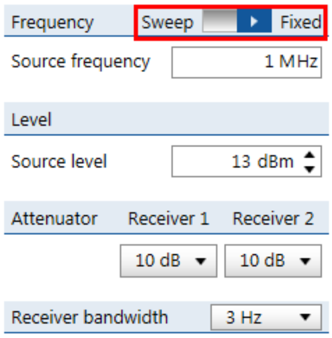


Figure 4: measurement settings

4.2 Calibration

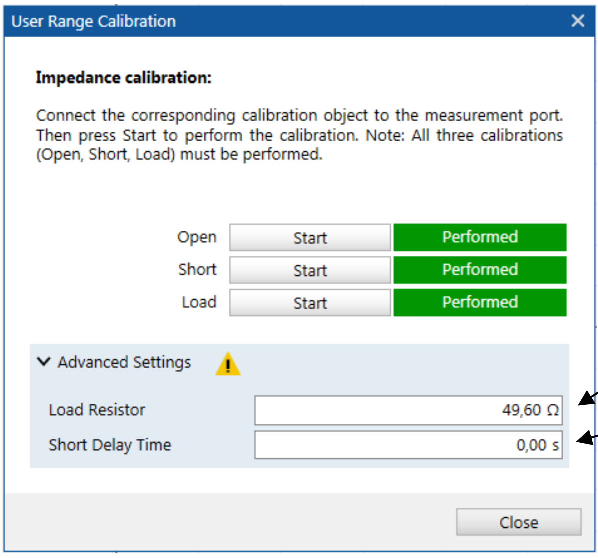
One of the most critical aspects of the measurement is calibrating out the parasitics from the cables and the Bias Injector. Open, Short and Load calibration has to be performed to ensure measurement accuracy. For this measurement, we are using 3 BNC connectors with the leads shorted, open and with a 50 Ω resistor to calibrate the Bode 100. The DUT is soldered to the same BNC connector in order to minimize parasitics outside of the calibration. In this case, the calibration and measurements are all referenced to the BNC connector leads.

We recommend performing a User Calibration for this measurement setup.

Note: The DC Bias voltage should be applied **prior to** the calibration!

Note: When connecting a DC-conductive DUT, the 10 kΩ injection resistor of the J2130A and the DC-resistance of the DUT form a voltage divider! The DC voltage at the DUT can be checked using a standard voltmeter.

After applying the DC Bias voltage (we use 10 VDC for our measurement) the calibration can be started.



Note:

- For precise measurements enter the measured value of the load resistor in the advanced section
- Set the short delay time to 0s

Figure 5: User Range Calibration Window

After calibrating the setup it is advisable to check the calibration points to verify that the calibration points were measured successfully.

Short

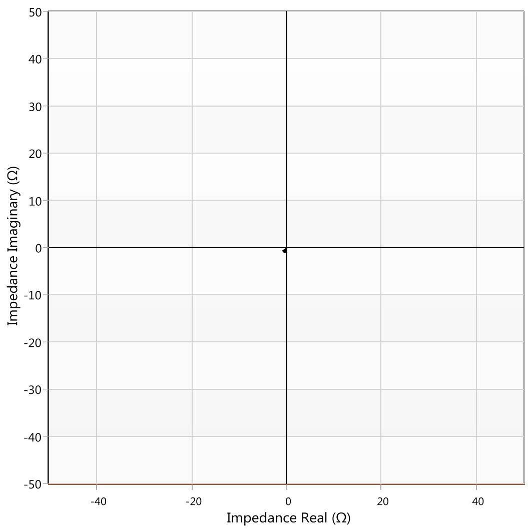


Figure 6:calibration check short

Impedance @ 1.000 MHz:

Real 33.421 µΩ

Imag 72.222 µΩ

Load

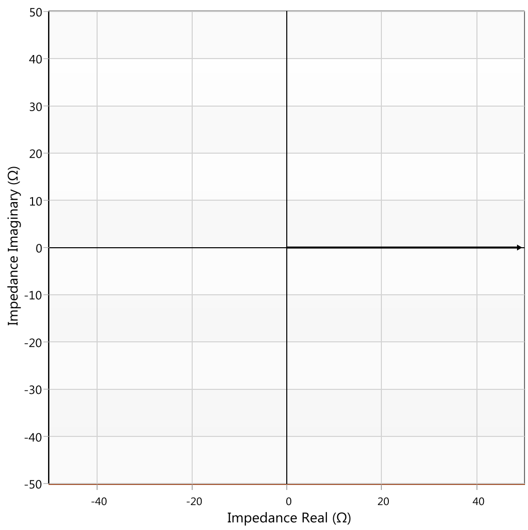


Figure 7: calibration check load

Impedance @ 1.000 MHz:

Real 49.599 Ω

Imag -343.963 µΩ

5 Measuring the Gate Resistance

Once the setup is calibrated the impedance of the MOSFET can be measured. We measure the impedance of an IRLZ24N N-type MOSFET. The gate is biased with a voltage of 10 VDC.
We are measuring the resistance of the gate at 1 MHz. This frequency has been chosen because it is an industry standard, though the measurement setup described here works for any frequency from 1 Hz to 50 MHz. One thing to keep in mind, however, is that at lower frequencies the X_P portion of the impedance will increase and the real portion will remain the same. This means Q will be significantly higher at lower frequencies, making the measurement much more difficult. Conversely, making the measurement at a higher frequency reduces the Q making the measurement less sensitive.
Keeping the injection signal close to full scale will help to reduce the noise of the measurement, resulting in optimum dynamic range and noise floor.

Connecting the MOSFET to the DC Bias Injector leads to the following measurement result:

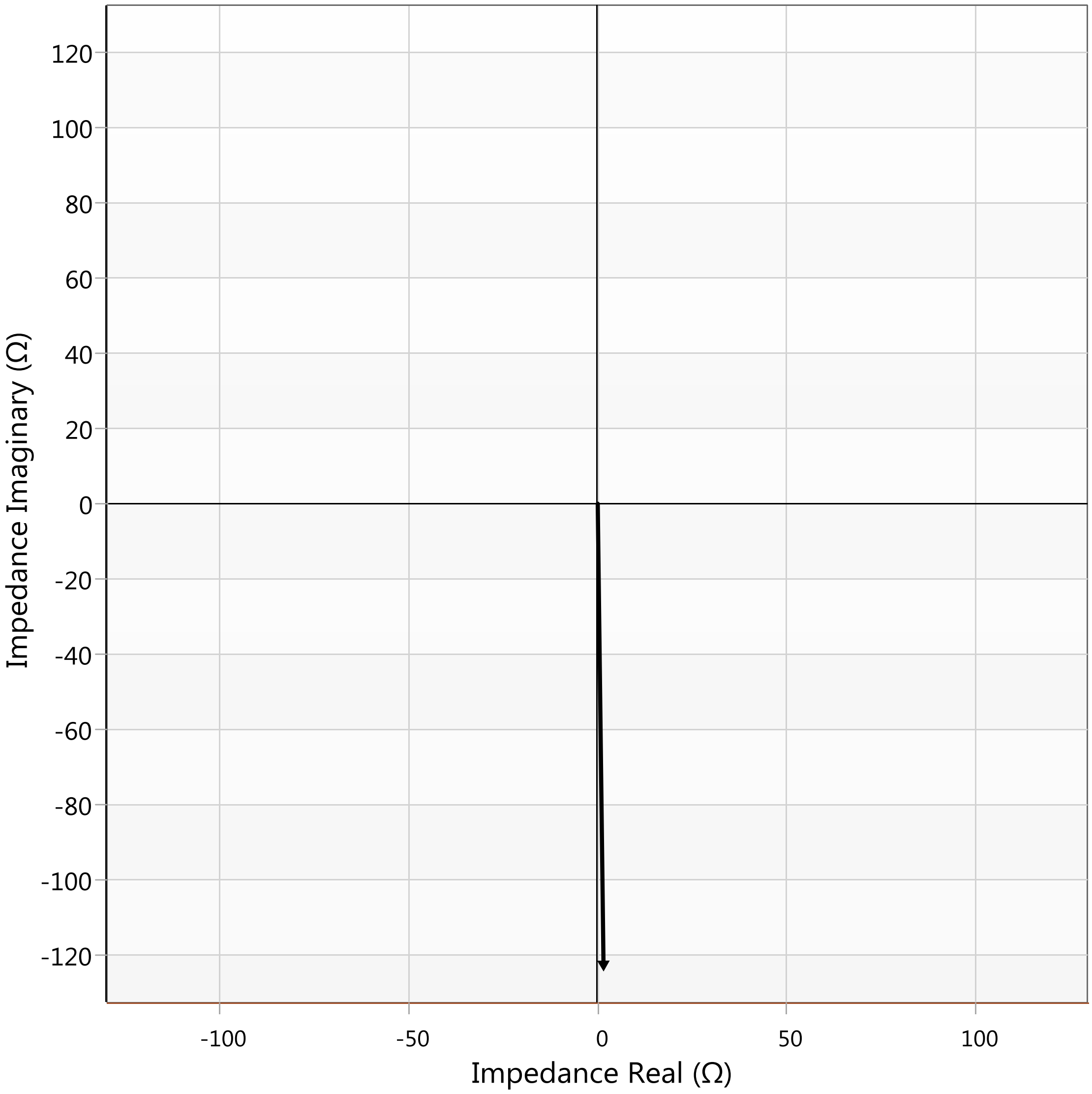


Figure 8: measurement result

Format	Value
Real	1,548 Ω
Imaginary	-124,352 Ω
Magnitude	124,362 Ω
Magnitude (dB)	41,894 dB Ω
Phase (°)	-89,287 °
Phase (rad)	-1,558 rad

Figure 9: measurement values

From the data we can see that the IRLZ24N MOSFET has an internal gate resistance of $\approx 1.55\ \Omega$ and we can also see the gate-source capacitance of the device simultaneously.

The Bode Analyzer Suite directly displays the equivalent circuits and its calculated values:

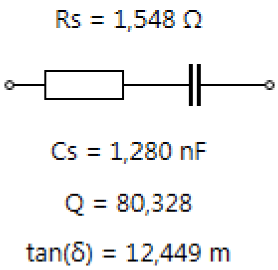


Figure 10: series equivalent circuit

6 Conclusion

We have demonstrated how you can measure the gate resistance of a MOSFET quickly and accurately using the Bode100 and the Picotest J2130A Bias Injector. A proper fixture should be made to house the MOSFET while keeping cable lengths short and signal levels as low possible. With proper calibration of your equipment this measurement will be repeatable for various MOSFETs and allow production testing to be a simple one-step process.

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