# DC-DC Converter Input Impedance Measurement

A switching regulator has negative input impedance which needs to be measured to design an input electromagnetic interference (EMI) filter. The system can become unstable if the input impedance is not measured accurately during the converter design. The J2121A High Power Line Injector with a vector network analyzer (VNA)/frequency response analyzer (FRA) like Bode 100 makes this challenging measurement easy.

## Measurement Principle

The J2121A uses the VNA's oscillator signal to modulate the input voltage (output of the J2121A) while accommodating a wide range of voltage and current conditions. The input voltage at the converter and the input current taken from the J2121A's current sense monitor are divided in the VNA displaying input impedance. Please note that this measurement is **NOT** in 2-port shunt-through configuration. A simple through calibration corrects for the scaling of the current monitor and the probe connections.

Figure 1 shows the setup diagram to measure input impedance of a DC-DC converter. OUTPUT pin in Bode 100 is connected to the OSC pin in J2121A line injector. J2121A requires +/-12 V power supply, which is provided by J2171A power supply. The input supply to the DC-DC converter is provided at the + and - pins (400 VDC) in the J2121A. Imon pin is connnected to Bode 100's CH1 which measures the input current. Input voltage is directly measured using a probe through CH1. The input impedance is measured as the ratio of CH2 to CH1.

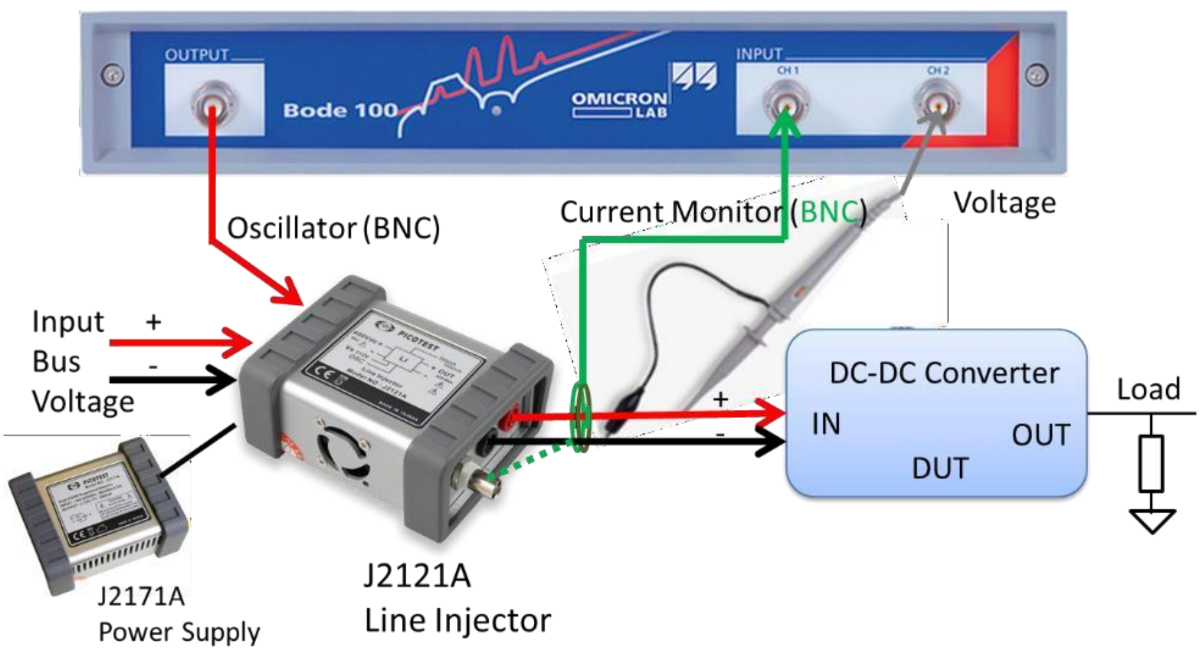


 

**Figure 1: Setup to measure input impedance of a DC-DC converter. OUTPUT pin in Bode 100 is connected to the OSC pin in J2121A line injector. J2121A requires +/-12 V power supply, which is provided by J2171A power supply. The input supply to the DC-DC converter is provided at the + and - pins (400 VDC) in the J2121A. Imon pin is connnected to Bode 100's CH1 which measures the input current. Input voltage is directly measured using a probe through CH1. The input impedance is measured as the ratio of CH2 to CH1.**

## Examples

Two examples are shown in this application note. The first measures the input impedance of LM20143 3 A synchronous buck converter. The test setup is shown in Figure 2. The measurement results are shown in Figure 3. This also shows the 1 Ω calibration standard. Output is 0.9 V at 14 A. The input is set at 4.5V, 5.0V and 5.5V. The results are shown with and without input capacitors. The negative input impedances are shown clearly in the figure.

The second example is shown in Figure 4. This measures the input impedance of TPS544B25 SWIFT™ synchronous buck converter. The output is 0.9 V at 14 A. Figure 2 shows the impedances at input voltages 9 V, 12 V, and 15 V. Real impedances are plotted on the right axis, which shows negative values. Magnitudes are plotted on the left axis.

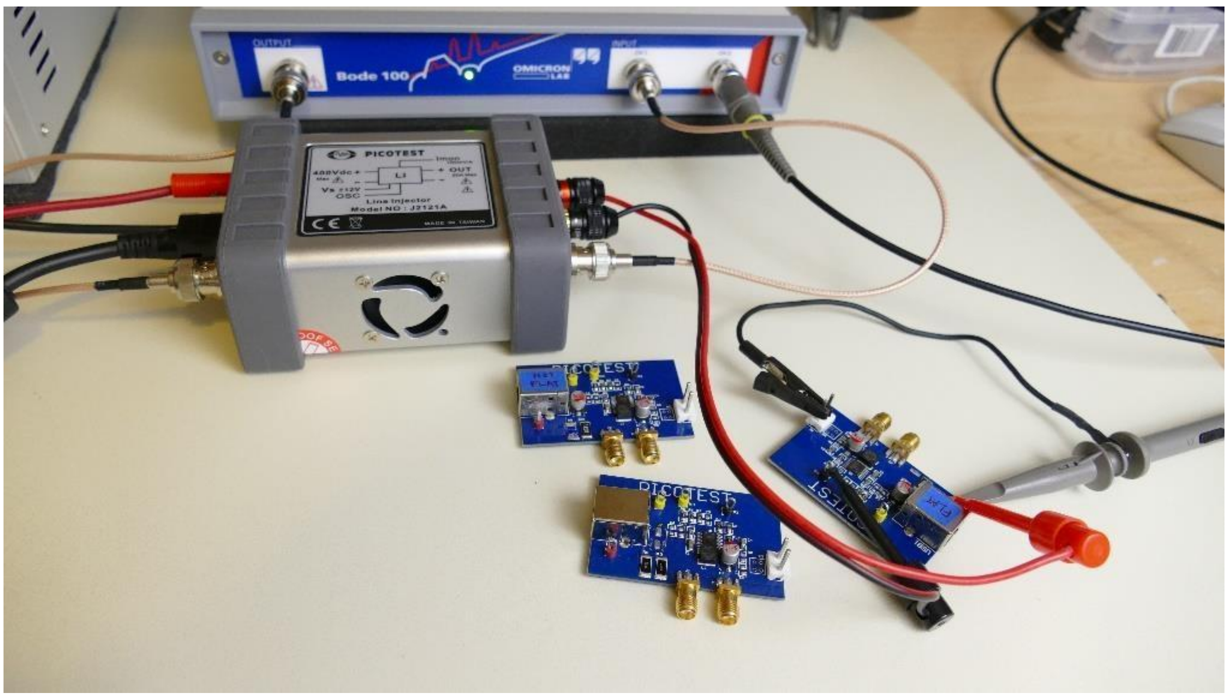


**Figure 2: Test setup for measuring input impedance of LM20143 3 A synchronous buck converter with 0.9 V at 14 A output.**

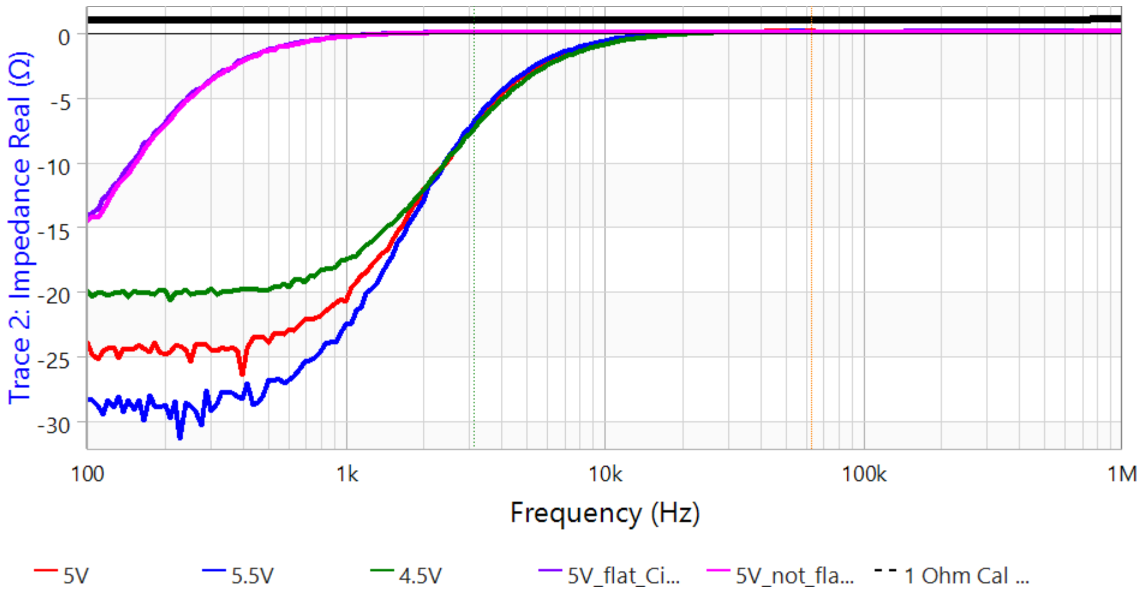


**Figure 3: Measured real impedance of LM20143 using the test setup shown in Figure 2. Blue/Red/Green = Vin 4.5V, 5.0V and 5.5V no input cap, Purple with an input capacitor, Black - 1ohm calibration. Note the negative impedances.**

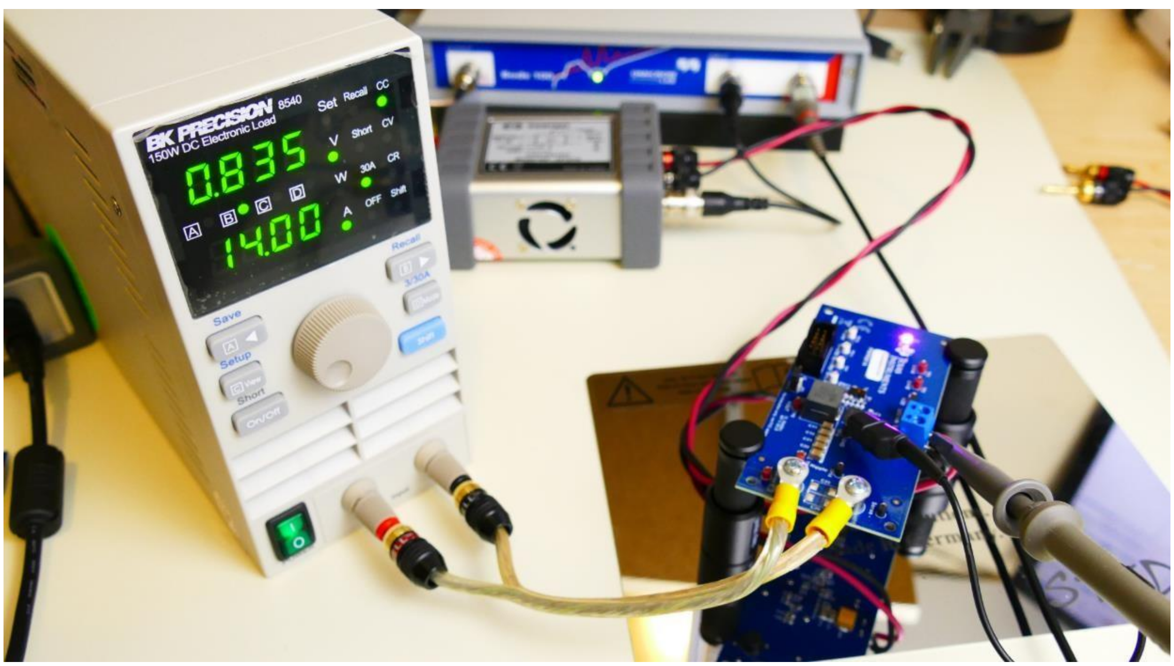


**Figure 4: Test setup for measuring input impedance of TPS544B25 SWIFT$^{TM}$ synchronous buck converter with 0.9 V at 14 A output.**

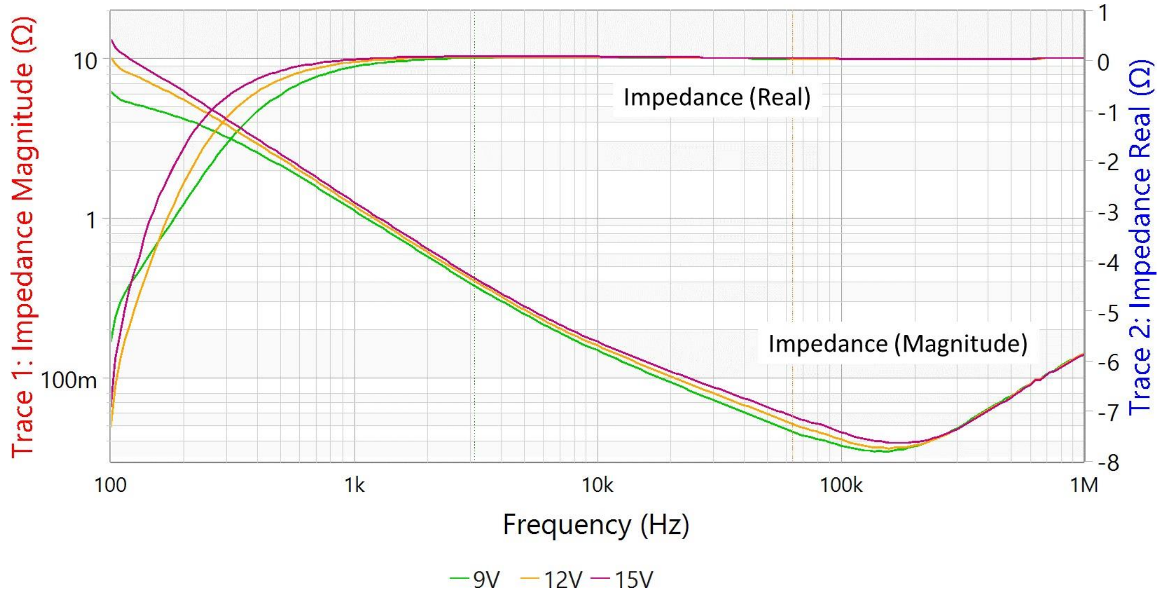


**Figure 5: Measurement results of the test setup in Figure 4 are shown as magnitude and real impedances at 9 V, 12 V, and 15 V. Note the negative impedances on the right axis.**

## Conclusion

This application note studied the procedure to measure input impedance of DC-DC converters using the Picotest J2121A line injector and Bode 100 VNA/FRA. Two measurement examples are shown to obtain the negative input impedance of the buck converters. Obtaining this measurement is an important step in input filter design to keep the DC-DC converter stable with the filter.