PICOTEST

Remote Sensing to Remove Non-linear DC Drop Due to Line Injector J2120A

While the injection transformer is a very wideband adapter, it is not useful for measuring PSRR of a power supply or even an opamp. This is because the attributes that make the injection transformer perform so well also results in a transformer that is intolerant of DC current. Even very small DC currents (5 mA or less) can greatly reduce the signal capacity which causes transformer saturation and higher currents can potentially result in permanent damage to the injection transformer.

The Picotest J2120A line injector is designed to support power supply rejection ratio (PSRR) and DC-DC converter input impedance measurements. The J2120A is a wideband, passive injector with very low noise density. One byproduct of this design approach is that the J2120A presents a load current dependent voltage drop. This means that each time the load current is adjusted the source power supply must also be adjusted to maintain a constant DC output voltage at the J2120A terminals.

Figure 1 shows the resistance and voltage drop of the J2120A as a function of load current. The maximum voltage drop is approximately 3.25 V at the maximum 5 A load current. The voltage drop is a non-linear function of output current. It does not impact the measurement results; however, this requires the constant adjustment of the benchtop power supply which is cumbersome and tiring to the designer.

This application note explains how to use the remote sense feature in the Picotest P9610A power supply to correct for this voltage drop, eliminating the need to constantly adjust the benchtop power supply. The Picotest P9610A power supply offers sufficient remote sense compliance for this application. Many other power supplies do not support this feature.
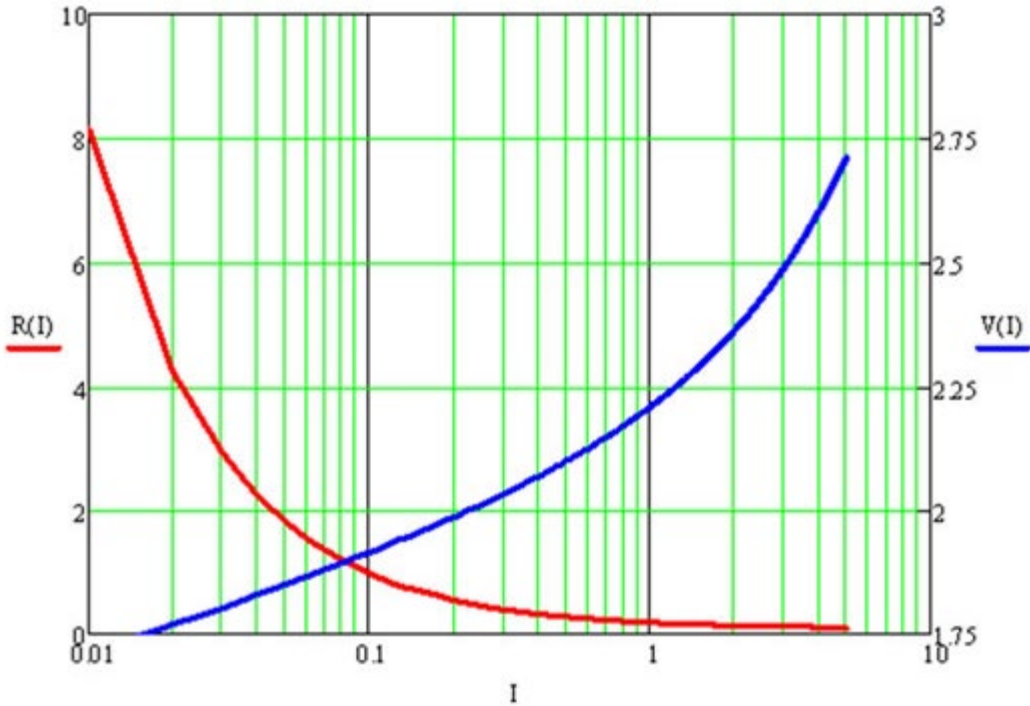
Figure 1: J2120A resistance (in Ω) and voltage drop (in V) versus output current (in A). Please note the non-linear voltage drop due to load current which makes PSRR and input impedance measurements difficult.

Remote Sense Principle

Remote sensing directly would try to regulate out the modulation signal if the output of J2120A is fed back without a filter. The output of J2120A is sensed and filtered with an RC network to set the voltage to compensate for the output load current drop. The RC filter knee frequency is set at $1/(2*\pi*R*C)$ which is 6.4 Hz. This ensures that we are correcting only the DC part of the voltage drop and the modulation signal is not in the remote sense loop.

Figure 2 shows the connection diagram for measuring DC-DC converter input impedance with remote sense. Input impedance is measured as the ratio of input voltage to input current. CH1 of the Bode 100 vector network analyzer (VNA) measures the input current using current probe. CH2 of the VNA measures the input voltage. Bode 100 measures the input impedance of the DC-DC converter as the ratio of CH2 to CH1. Figure 3 shows the connection diagram to

measure PSRR with remote sense. CH1 measures the input voltage and CH2 measures the output voltage. The PSRR is obtained as the ratio of CH1 to CH2.

The capacitors in the RC filters provide LOCAL sense for AC signals, by bypassing the remote sense lines, while the resistors provide remote sensing for DC and low frequencies. The 24.9 Ω sense resistors become part of the source power supply voltage sensing divider, resulting in a **fixed**, 75 mV voltage drop avoiding the need to adjust the source power supply manually. 75 mV offset is due to the 24.9 Ω filter resistors being in series with the internal power supply voltage divider resistors. This remote sense filter can be used in all measurement using the J2120A.
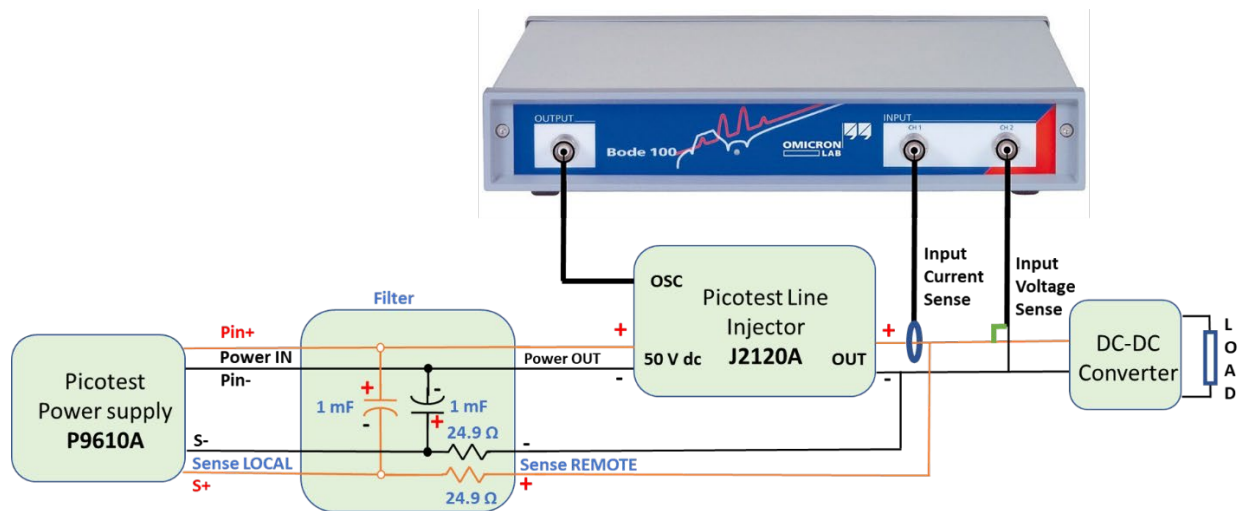

Figure 2: Connection diagram to measure input impedance with remote sense to compensate the non-linear voltage drop due to J2120A. 75 mV fixed offset is introduced by the 24.9 Ω filter resistors being in series with the internal power supply voltage divider resistors.
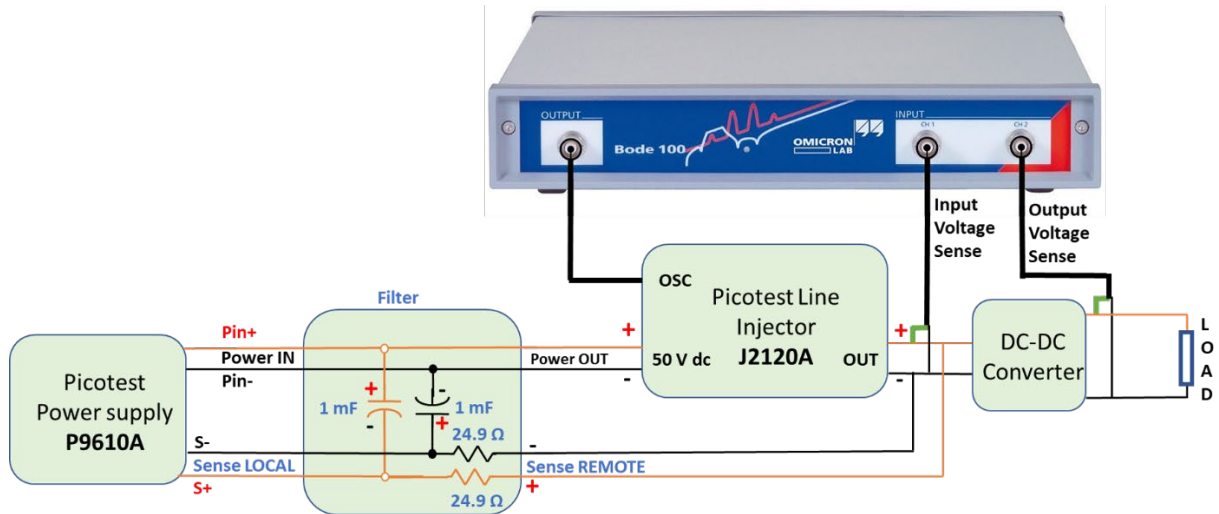
Figure 3: Connection diagram to measure PSRR with remote sense to compensate the non-linear voltage drop due to J2120A. 75 mV fixed offset is introduced by the 24.9 Ω filter resistors being in series with the internal power supply voltage divider resistors.

Measuring J2120A Transfer Function with the Remote Sense Filter

Figure 4 shows the connection diagram to measure the J2120A transfer function with the filter included. The input to the J2120A OSC pin is capacitive, the bandwidth is impacted by the source impedance. Without a 50 Ω terminator at the OSC input the J2120A bandwidth is 5 MHz. Adding a 50 Ω terminator doubles the bandwidth to 10MHz. Figure 5 shows the measurement set-up based on the connection diagram, while the measurement is shown in Figure 6.

The transfer characteristics are the same as without remote sense, illustrating that the remote sense does not affect the J2120A bandwidth performance due to the insertion of the remote sense circuit.
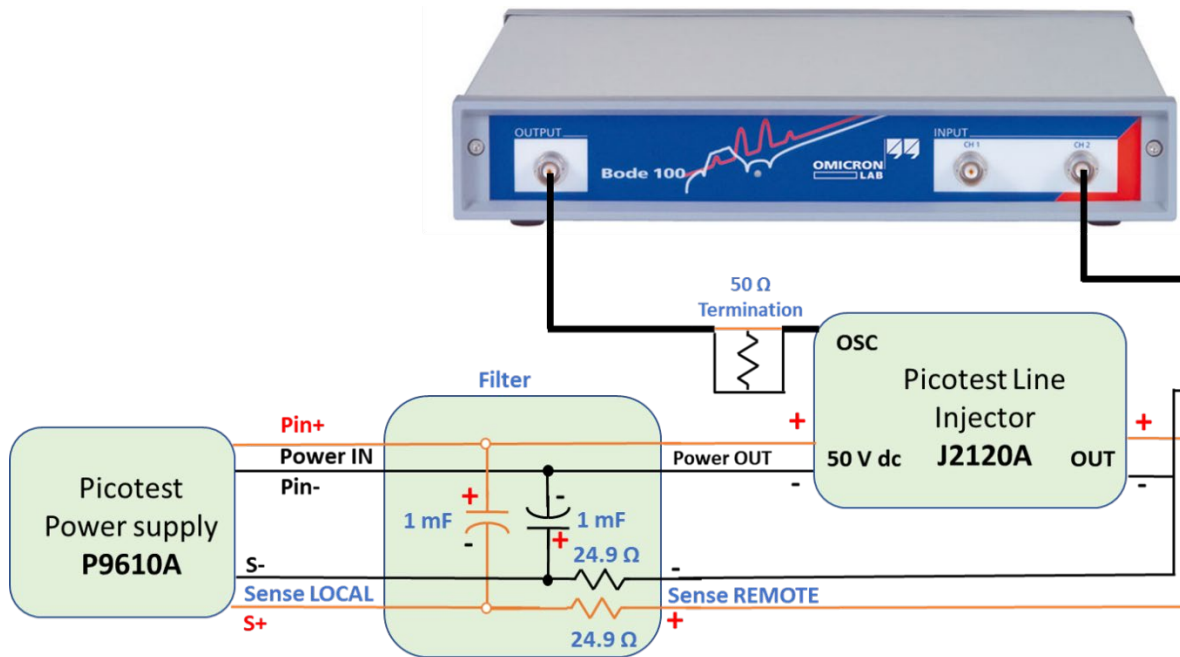
Figure 4: Connection diagram to measure J2120A with remote sense filter. 50 Ω termination is used to extend the frequency limit to 10 MHz. Without the termination, the bandwidth is only 5 MHz.
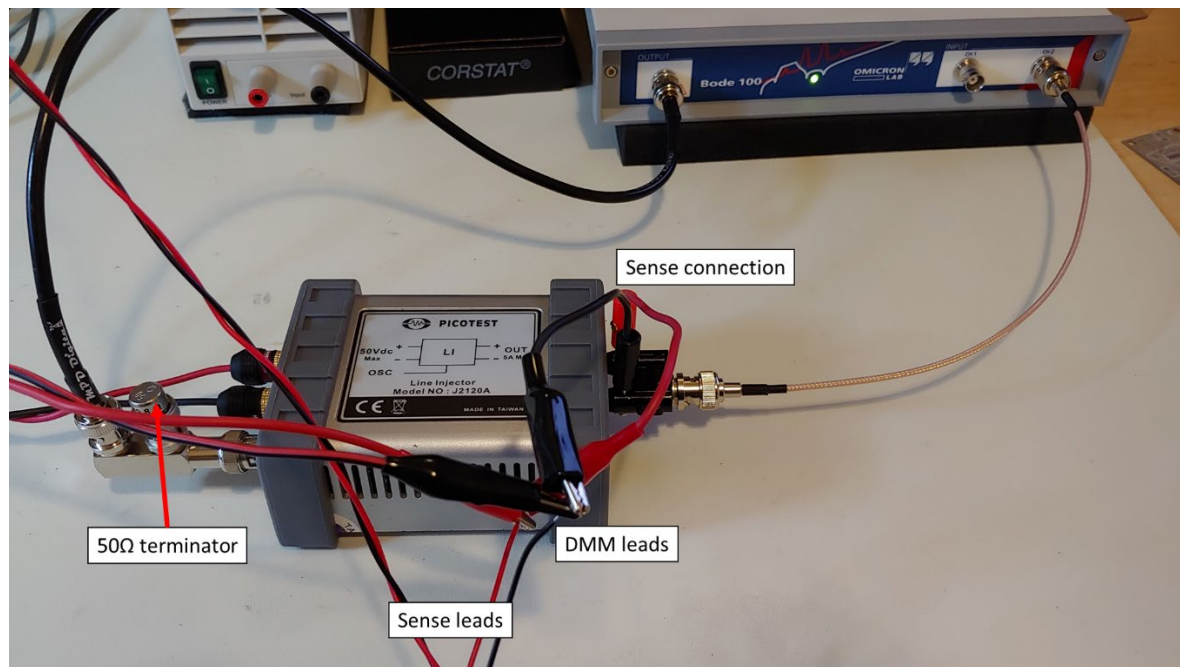

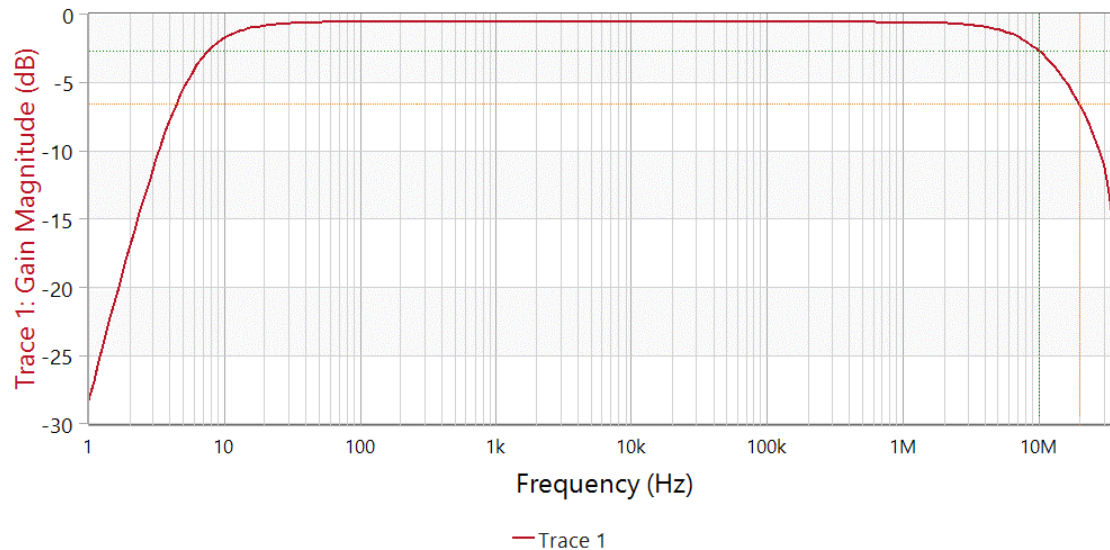**Figure 5: Set-up to measure J2120A characteristics with remote sense feature.**

Figure 6: Measured J2120A characteristics with remote sense feature using the set-up shown in .

shows the inherent 75 mV fixed DC drop introduced in the circuit by the filter.

However, this value is independent of the load current which is not an issue in measurements.
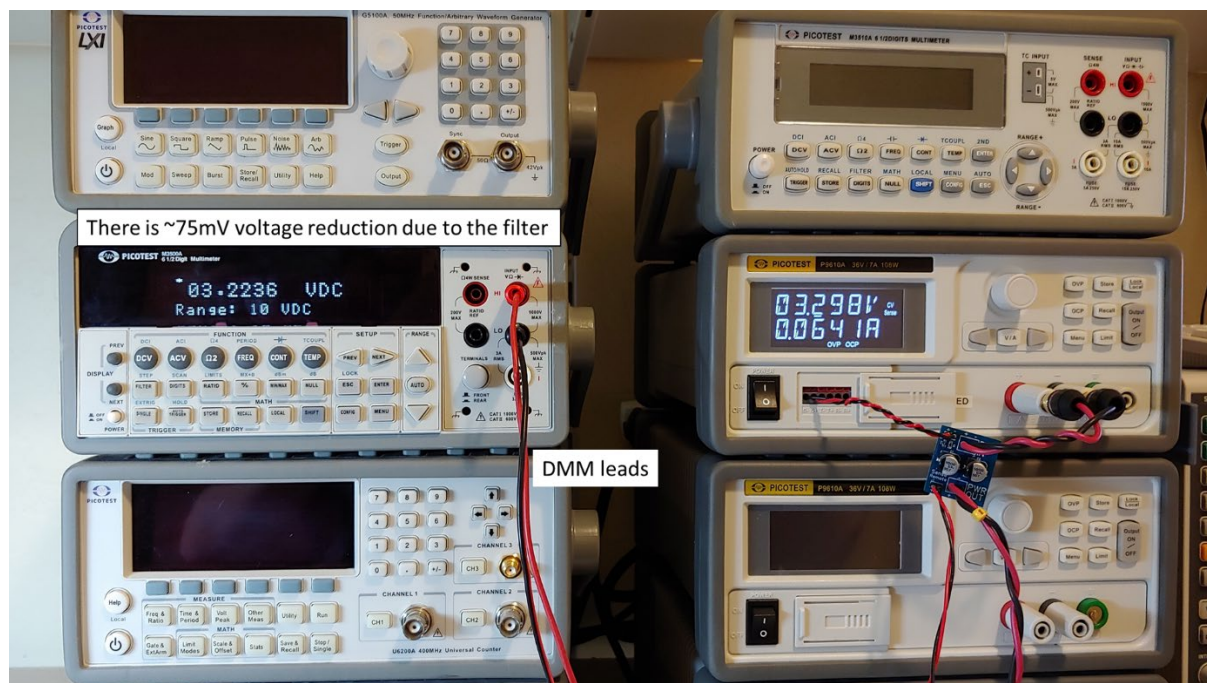

Figure 7: J2120A with remote sense feature showing a fixed 75 mV voltage drop. This voltage drop is fixed and NOT load current dependent. 75 mV offset is due to the 24.9 Ω filter resistors being in series with the internal power supply voltage divider resistors.
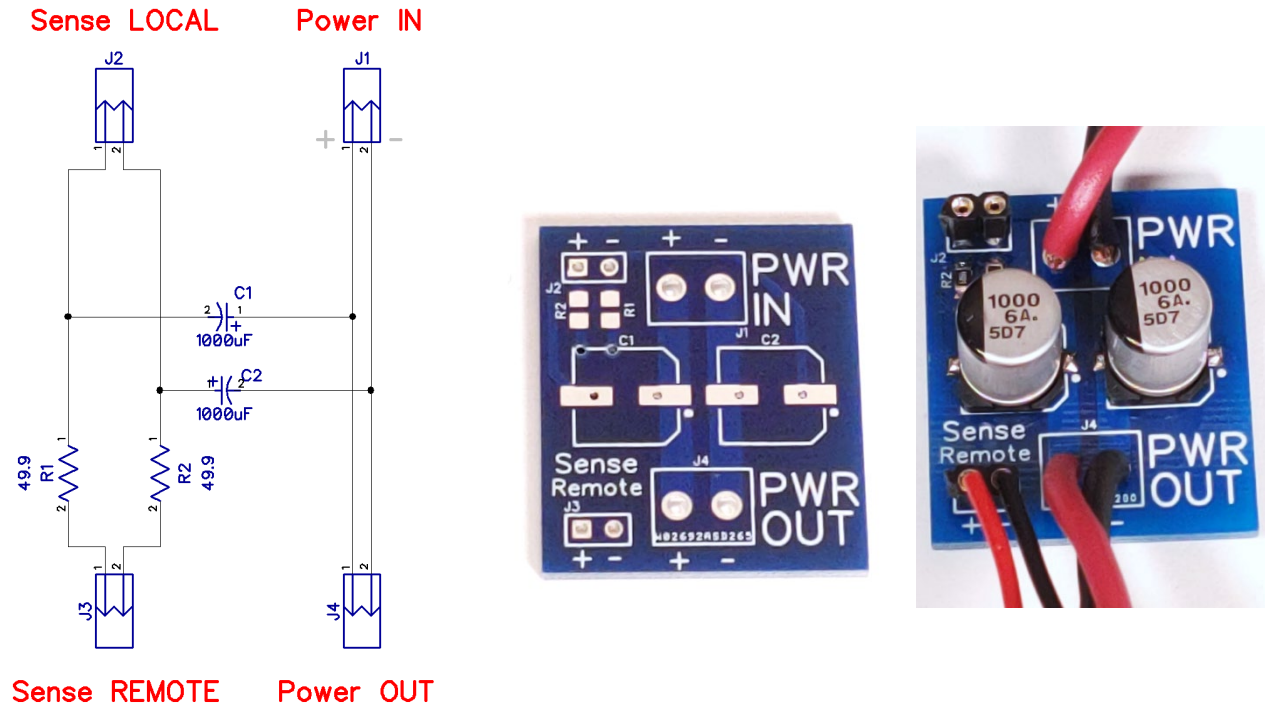
Figure 8: Sample remote sense filter along with the blank and populated boards.

Conclusion

The J2120A line injector introduces non-linear DC voltage drop which requires adjustment of the source power supply any time the load current is changed. The high compliance remote sense feature of the P9610A power supply is used to mitigate this problem. The RC filter shown in this application note corrects the DC voltage without compromising the J2120A bandwidth. The addition of the filter resistor does add a **fixed** 75 mV DC drop. Since it is a fixed voltage drop, it does not have to be corrected for each load current and does not affect measurements.

References

1. https://www.picotest.com/products_J2120A.html

2. https://www.picotest.com/products_P9610A_11A.html

3. P9610A/11A Mixed mode DC power supply, User's manual. Download at
   https://www.picotest.com/support.html