Measuring the PSRR of Voltage References

In this article we detail the process of measuring a key performance characteristic of voltage references, power supply rejection ratio or "PSRR", using the Picotest J2120A Line Injector and the Agilent E5061B Network Analyzer.

There are many types of voltage references, including series references, shunt references and several that can perform as either series or parallel devices. The general performance metrics include DC voltage accuracy, temperature coefficient, noise, output impedance, PSRR and stability. The requirements vary greatly from application to application, though the general characteristics remain the same.

PSRR is a significant performance concern as even small amounts of high frequency ripple voltage at the input can significantly degrade the output precision of the device and impact downstream circuitry. The stability of the reference plays a large role in the PSRR and for that reason the measurements in this application note are performed with and without a small ceramic output capacitor across the reference output.

For convenience, we created a PC board that allows both series and shunt references in many common packages to be mounted on the VRTS motherboard[1]. While these measurements can certainly be made without a test fixture, we will use the PCB to keep the measurement setups simple and the parasitics controlled.
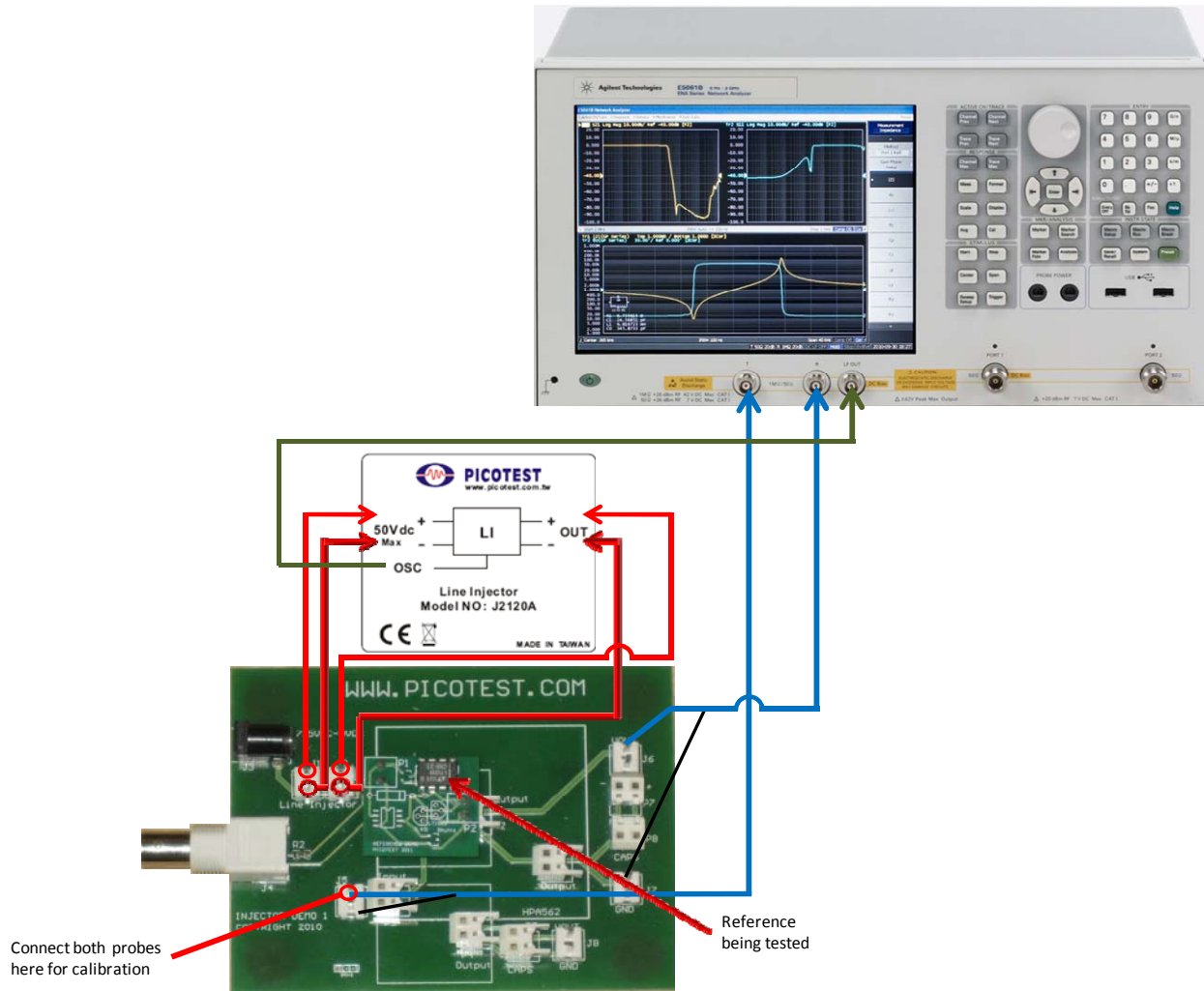
Figure 1 – Connection diagram for the Line Injector, Agilent E5061B network analyzer and voltage reference (center of the VRTS board).
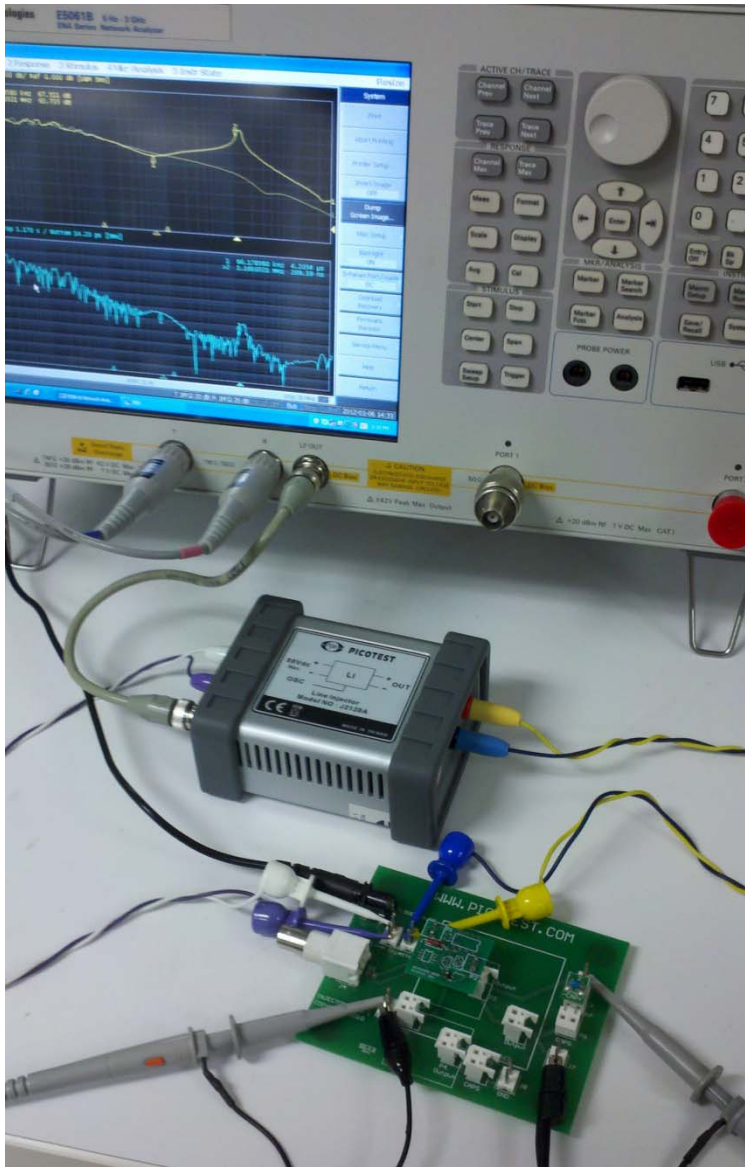
Figure 2 – Injecting AC. Photo showing a LM4040 voltage reference device mounted in a VRTS "daughterboard" for the measurement. The E5061B network analyzer oscillator output is connected to the Line Injector where it combines with a DC input voltage signal. The analyzer and the injector are all you need to measure PSRR.

Calibrating the Measurement

This measurement is made using a frequency sweep and is displayed as a gain curve. With the equipment connected as shown in Figure 1 and power applied, we can connect both probes to the top pin of J5 on the VRTS motherboard.

Under the E5061B Calibration menu, select the "THRU" calibration. This calibration will adjust for the differences in frequency response of the two probes.
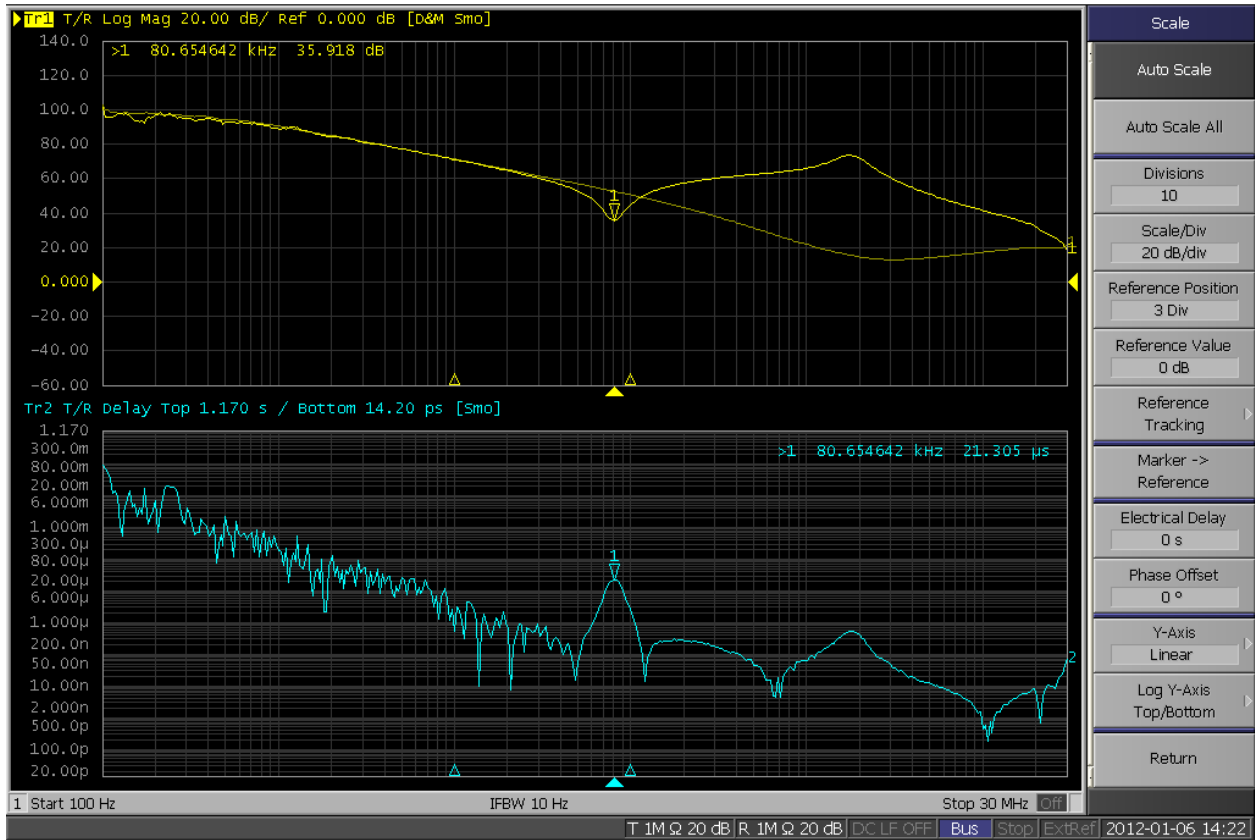
Making the Measurement

Figure 3 – The REF03 PSRR with (thick trace) and without (thin trace) a 0.1uF ceramic capacitor. Note the high Q due to the 0.1uF capacitor which results in a 15dB PSRR degradation at 80 kHz. The non-invasive (meaning this measurement can be made "in-circuit") calculation method for the phase margin of the reference control loop is 10 Deg with the 0.1uF ceramic capacitor installed.
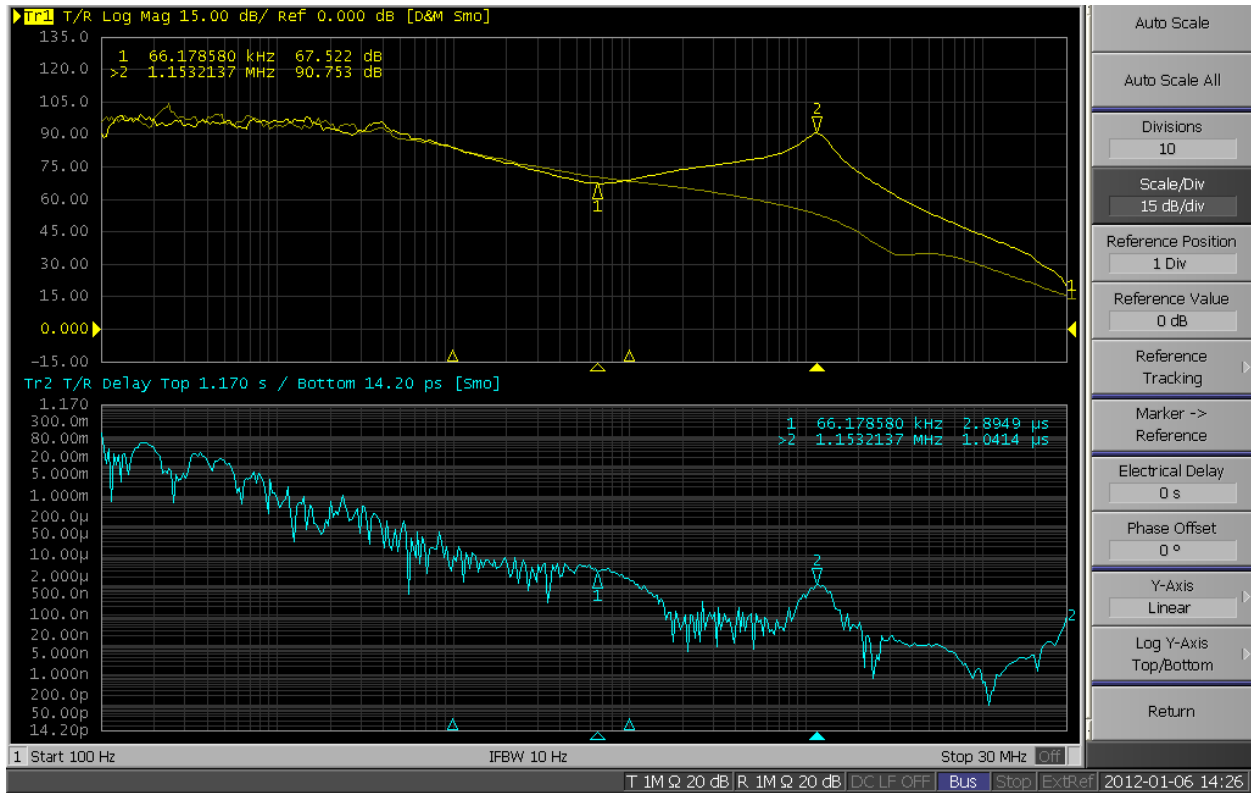
Figure 4 – LM4040 PSRR with (thick trace) and without (thin trace) a 0.1uF ceramic capacitor. Note the similar high Q due to the 0.1uF capacitor and the nearly 8dB PSRR degradation at 66 kHz.

Conclusion

The Agilent E5061B Network Analyzer, combined with the Picotest J2120A Line Injector, makes accurately measuring the PSRR of reference devices simple. This measurement clearly shows how the addition of a capacitor degrades the PSRR at the bandwidth of the device. Similar to the output impedance measurement, the non-invasive phase margin indicator also works in this PSRR measurement, directly providing the regulator phase margin and system Q.

Using the methods in the Power Electronics article on regulator ESR determination[2], the ESR or series resistance required for stable performance can easily be determined for any operating current, thereby improving the dynamic performance of the reference.

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[1] VRTS, Voltage Regulator Test Standard Manual, v1.0d

[2] Simple Method to Determine ESR Requirements for Stable Regulators, Steven M. Sandler, Power Electronics Technology, Aug 2011