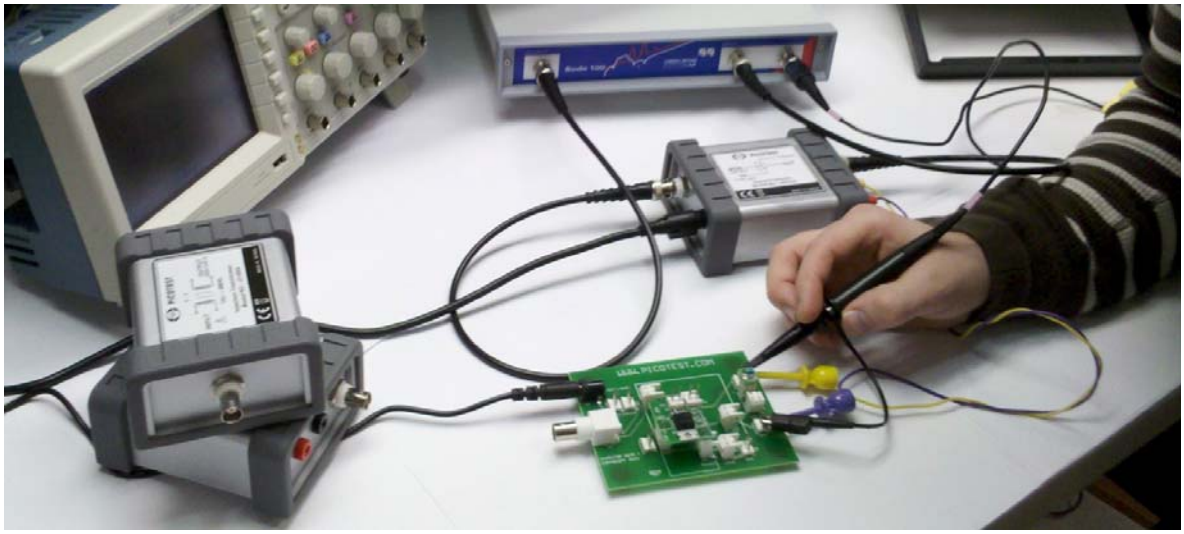
Power Supply Rejection Ratio Measurement

Using the Bode 100 and the Picotest J2120A Line Injector



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Notes: Basic procedures such as setting-up, adjusting and calibrating the Bode 100 are described in the Bode 100 user manual.

The Picoest J2120A Line Injector does not require calibration.

All measurements in this application note have been performed with the OMICRON Lab Bode 100 Analyzer Suite V2.31. Use this version or a higher version to perform the measurements detailed in this application note.

You can download the latest version at http://www.omicron-lab.com/downloads.html.

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

1 Executive Summary

This application note shows how the Power Supply Rejection Ratio, or PSRR, of a linear voltage regulator (LM317) can be measured using the Picotest J2120A Line Injector and the OMICRON Lab Bode 100.

The same techniques can be used to measure switching regulators as well.

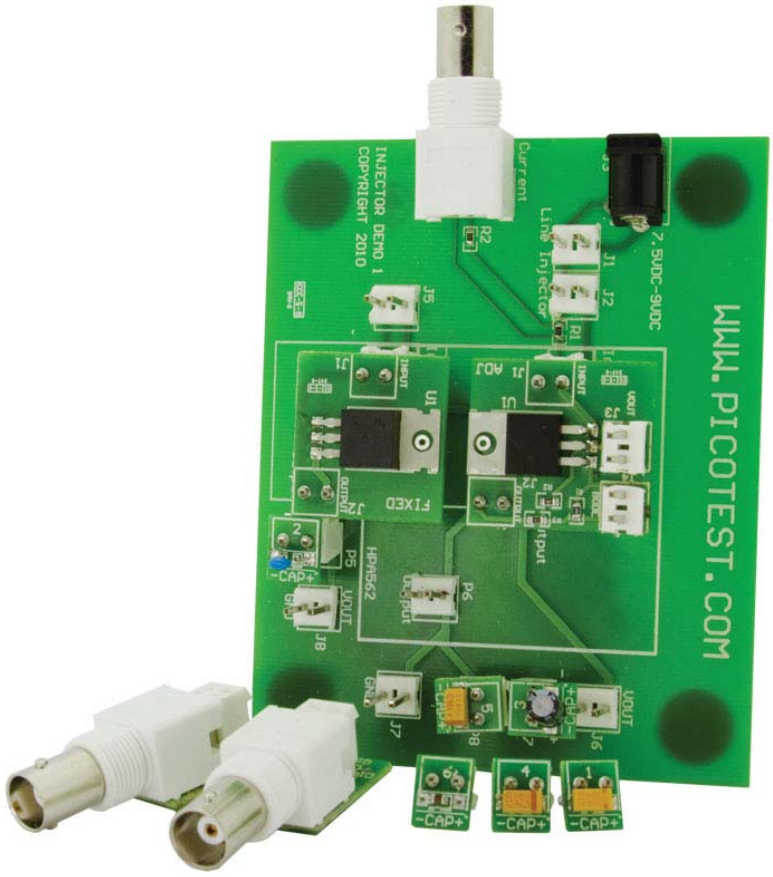
The measurements in this application note are performed using the Picotest Voltage Regulator Test Standard (VRTS) testing board[1].

2 Measurement Task

The PSRR of the LM317 linear voltage regulator is measured with and without a capacitor on the output of the regulator.

The PSRR is measured from 10 Hz to 10 MHz.

The Picotest VRTS kit is used as the basis for the testing. The VRTS helps alleviate the intricacies of regulator testing and can perform most of the common voltage regulator measurements using the Bode 100 in conjunction with the Picotest Signal Injectors. The VRTS kit includes the regulators and capacitors used for the measurements in this application note.



Voltage Regulator Test Standard board, Source (1)

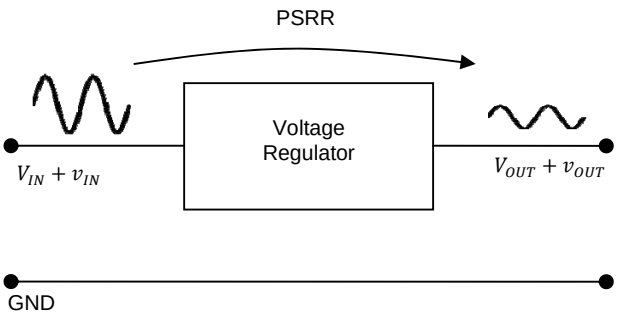
[1] See: http://www.picotest.com/products_injectors.html

3 Measurement Setup & Results

The PSRR describes how a signal on the DC input voltage of the regulator system is transmitted to the regulated output. The PSRR is generally measured in dB and defined to be:

$$PSRR \equiv 20 \log \frac{v_{OUT}}{v_{IN}}$$

Where v_{OUT} and v_{IN} are the AC ripple of the output and input voltage, respectively.



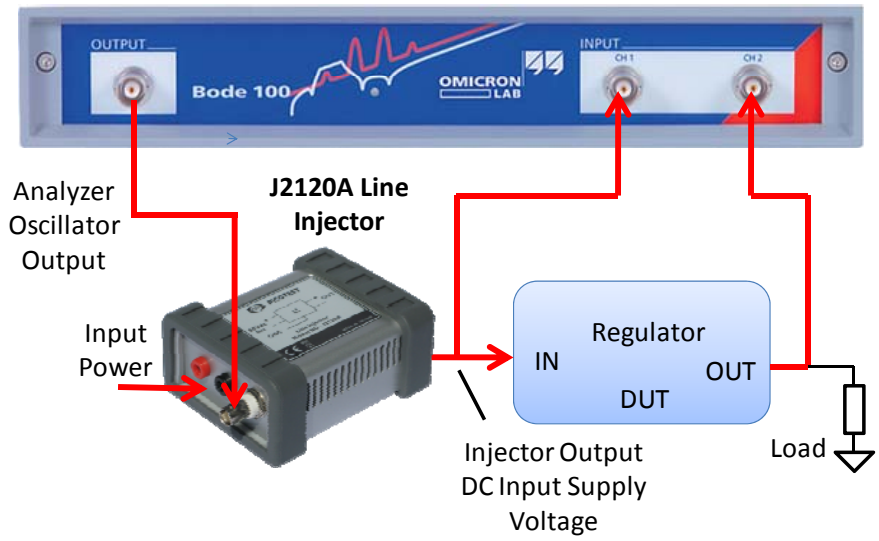
Depending on the definition the PSRR can be a negative or positive number. Using the above definition, negative PSRR values indicate signal attenuation from input to output, and positive numbers represent signal gain.

3.1 Measurement Setup

The PSRR can be measured by applying a sinusoidal ripple on the supply voltage and measuring the gain from the input to output of the regulator.

The Picotest J2120A Line Injector allows you to add the sinusoidal output voltage of the Bode 100 or other analyzer or signal source to the DC input supply voltage of the regulator. The PSRR is then measured by connecting two voltage probes to the input and output of the regulator. In this case, two 1:1 voltage probes are used.

The following figure shows the principle measurement setup:

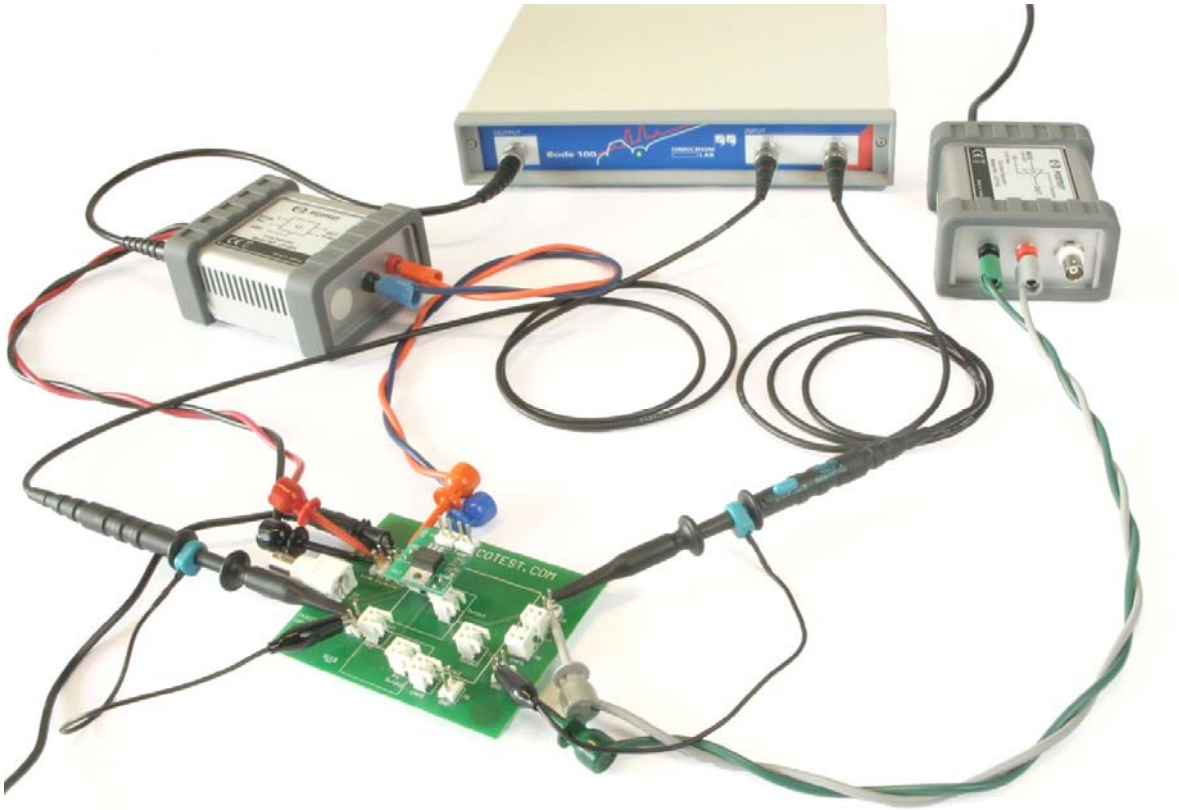


PSRR measurement setup, Source (1)

Note: The output impedance of the J2120A is slightly resistive. An input capacitor on the regulator would, therefore, create a low pass network reducing the bandwidth of the injector. Many regulator manufacturers remove the input capacitor for this measurement. The measurements shown in this application note are performed without an input capacitor.

The Picotest J2111A Current Injector acts as a load for the voltage regulator though the regulator can be loaded as normal. The +bias of the J2111A is switched on resulting in a constant current load of 25 mA.

The voltage probes and injectors are connected to the Bode 100 and the VRTS board as shown in the following picture:



PSRR example measurement setup (Vout/Vin).

3.2 Device Setup

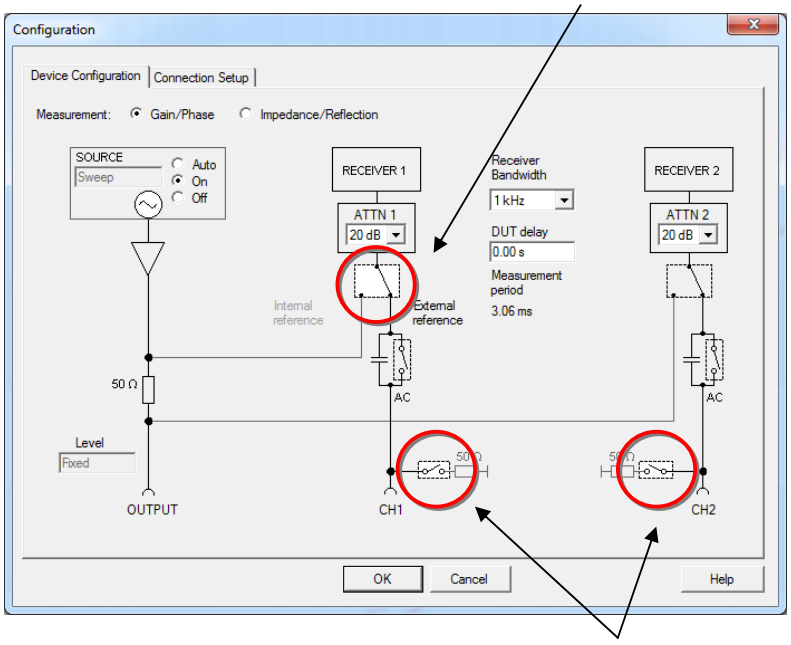
The PSRR measurement can be performed directly with the Bode 100 using the external reference. The Bode 100 is set up as follows:

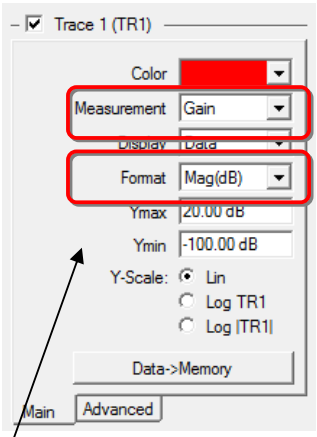
Measurement Mode:	Frequency Sweep Mode
Start Frequency:	10 Hz
Stop Frequency:	10 MHz
Sweep Mode:	Logarithmic
Number of Points:	401 or more
Receiver Bandwidth:	100 Hz
Attenuator 1 &2:	10 dB
Level:	-10 dBm

Note: When the Bode 100 is used with the J2120A the output level should be set in the range from -20 to 10 dBm. The PSRR measurement is a small signal measurement and so the goal is only to maintain a level above the noise floor.

Note:
Use of the full speed mode is **not** recommended for measurements with the J2120A.

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



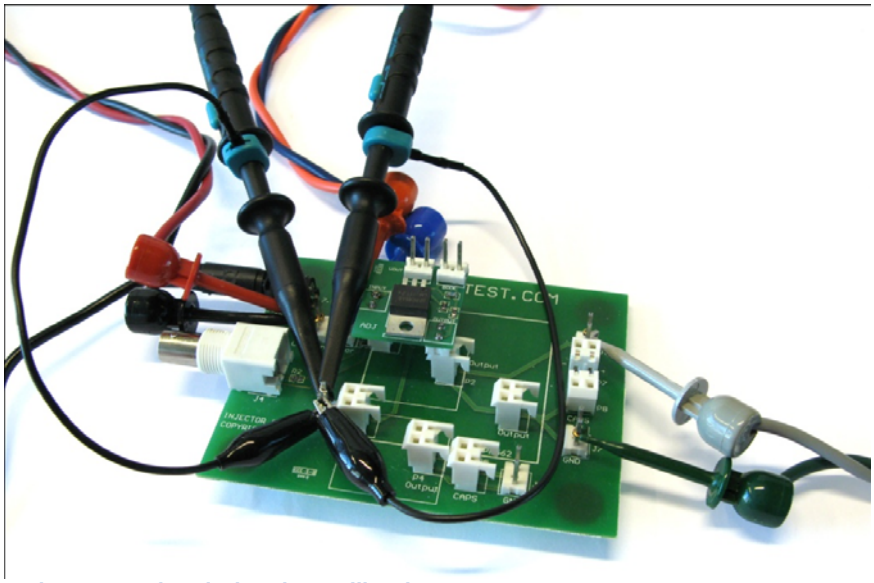


Both channels are set to high input impedance.

Trace 1 measurement is set to gain and the format to Mag(dB).

3.3 Calibration

If two dissimilar probes are used for the measurements a “thru calibration” has to be performed before the measurement is carried out. During the thru calibration both probes have to be connected to the input point as shown on the following picture:

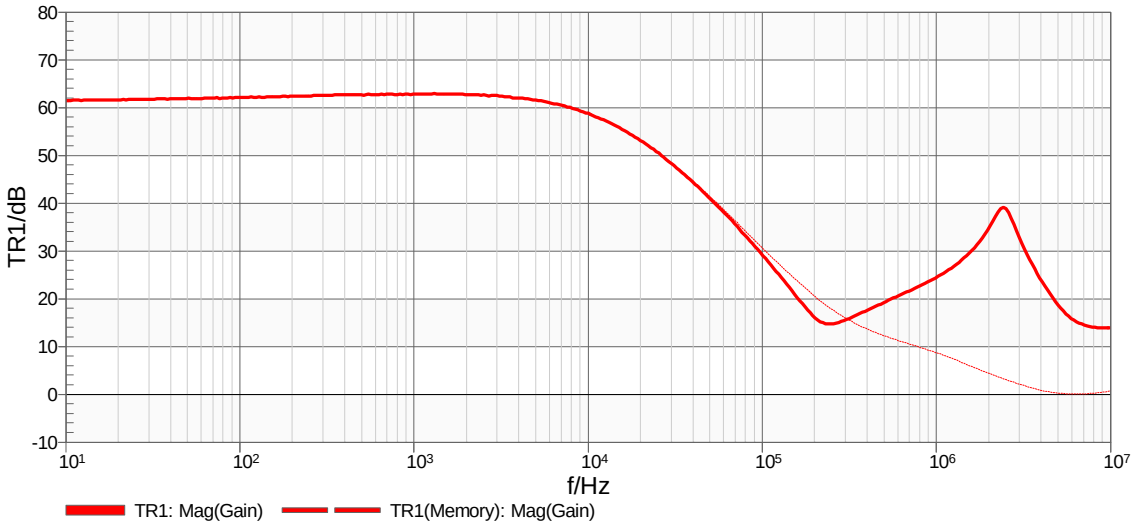


Probe connection during thru calibration

3.4 Measurement

You can get started using the settings and setup from above the measurement. However, for this measurement we connect the input voltage to Ch.2 of the Bode100 and the output voltage to Ch.1. This allows us to measure the PSRR of the regulator using the convention most widely seen across IC vendors’ datasheets (susceptibility vs. attenutation).

Two single sweeps lead to the following PSRR curves:



LM317 PSRR measurement with and without (dashed) an output capacitor

The dashed curve represents the PSRR of the LM317 without an output capacitor. The solid trace is with a 0.1uF capacitor at the output of the regulator. At low frequencies the PSRR is very high which results in high suppression of disturbances from the supply line. In the higher frequency area (> 1 MHz) the PSRR gets very small and even reaches 0 dB at 6 MHz. This means that a 6 MHz signal would pass through the regulator without attenuation.

To see the influence of an output capacitor on the PSRR the VRTS No.2 capacitor is connected to the regulator output. This 0.1 µF ceramic capacitor changes the PSRR curve (solid trace).

The PSRR does not drop below an attenuation of about 10 dB; however, there is less signal attenuation in the 200-300 kHz range than without the output capacitor.

4 Conclusion

The Bode 100 in combination with the J2120A Line Injector offers a test set that enables simple and fast PSRR measurements in a wide frequency range starting at 10 Hz and reaching 10 MHz.

No injection transformer is necessary for the test set. This setup allows you to measure the PSRR even in systems with high DC currents up to 5 A without the danger of destroying an expensive transformer.

References:

1. Picotest. Voltage Regulator Test Standard. *Version 1.0d.* 2010.
2. Signal Injector Documentation. *Version 1.0d.* 2010.

