Bode 100 - Application Note

Power Supply Reverse Transfer Measurement

Using the Bode 100 and the Picotest J2111A Current Injector

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Table of Contents

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

1 Executive Summary

This application note shows how the reverse transfer characteristic of a linear voltage regulator (TIP120) can be measured using the OMICRON Lab Bode 100 and the Picotest J2111A Current Injector. The same technique can be used to measure switching regulators as well.

The measurements are performed on the Picotest Voltage Regulator Test Standard testing board Rev. 1.5 (VRTS 1.5).
The VRTS 1.5 board can be used to perform many voltage regulator measurements using the Bode 100 in conjunction with the Picotest Signal Injectors. The PCB features a linear voltage regulator and two different output caps and a load resistor which can be activated or not.

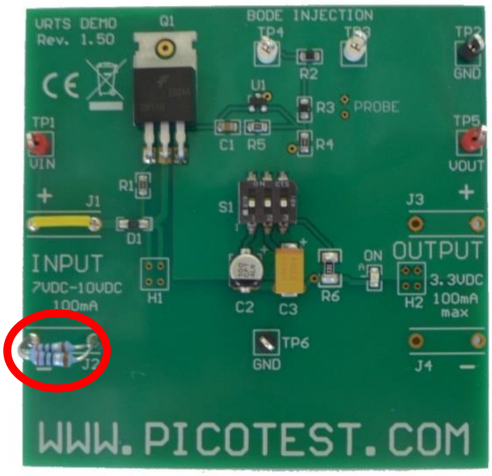


Figure 1: Voltage Regulator Test Standard board 1.5 including 1 Ω shunt resistor

Note: The outlined 1 Ω shunt resistor is additionally soldered on the board to measure the input current.

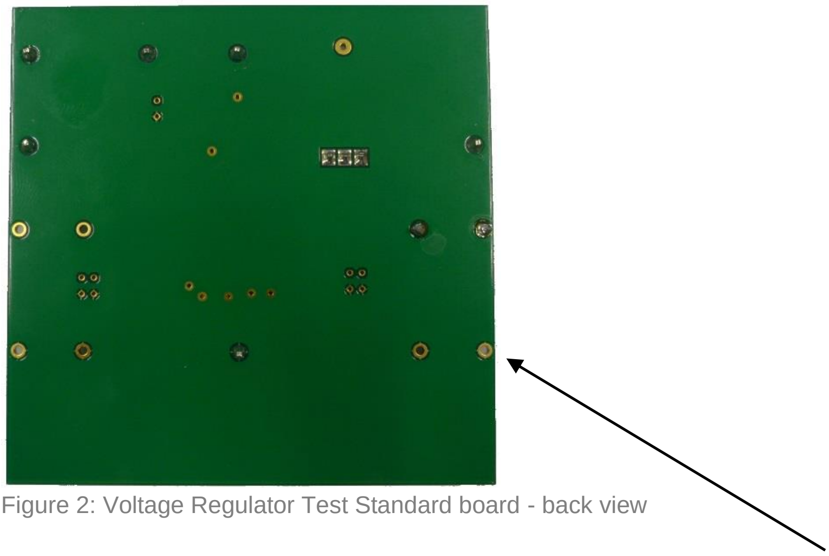


Figure 2: Voltage Regulator Test Standard board - back view

Note: We cut the connections to the ground, to do not short the shunt resistor (also see Figure 4).

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

2 Measurement Setup & Results

The Reverse Transfer characteristic describes how a change in the output current (load current) passes through the voltage regulator to the supply side. We define the reverse transfer to be measured in dB and therefore:

$$RT = 20 \cdot \log \frac{i_{IN}}{i_{OUT}}$$

where i_{OUT} and i_{IN} are the AC ripple of the input current I_{IN} and output current I_{OUT}, respectively.

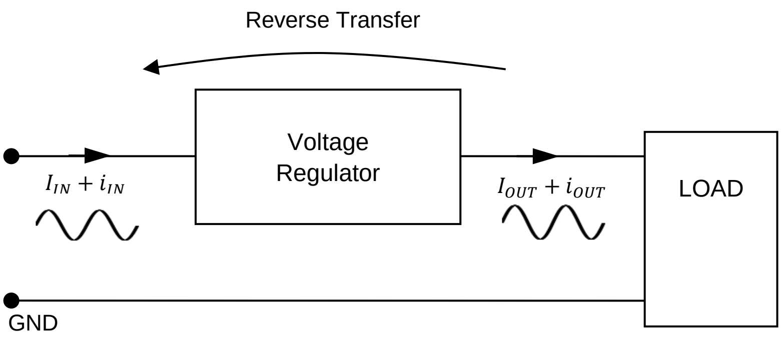


Figure 3: Setup principle

In general, the low frequency reverse transfer of a series voltage regulator will be 0 dB as the current that flows out of the output also flows into the input. This result is impacted by the stability of the regulator.

2.1 Measurement Setup

The Reverse Transfer can be measured by applying a sinusoidal ripple on the load current and measuring the gain factor between output current and input current of the regulator.
The Picotest J2111A Current Injector adds a modulated output current, in parallel to any other particular loading that is applied. The added current is modulated according to the sinusoidal output voltage of the Bode 100. The Reverse Transfer is then measured by comparing the output current with the input current of the voltage regulator.

The following figure shows the reverse transfer measurement setup:

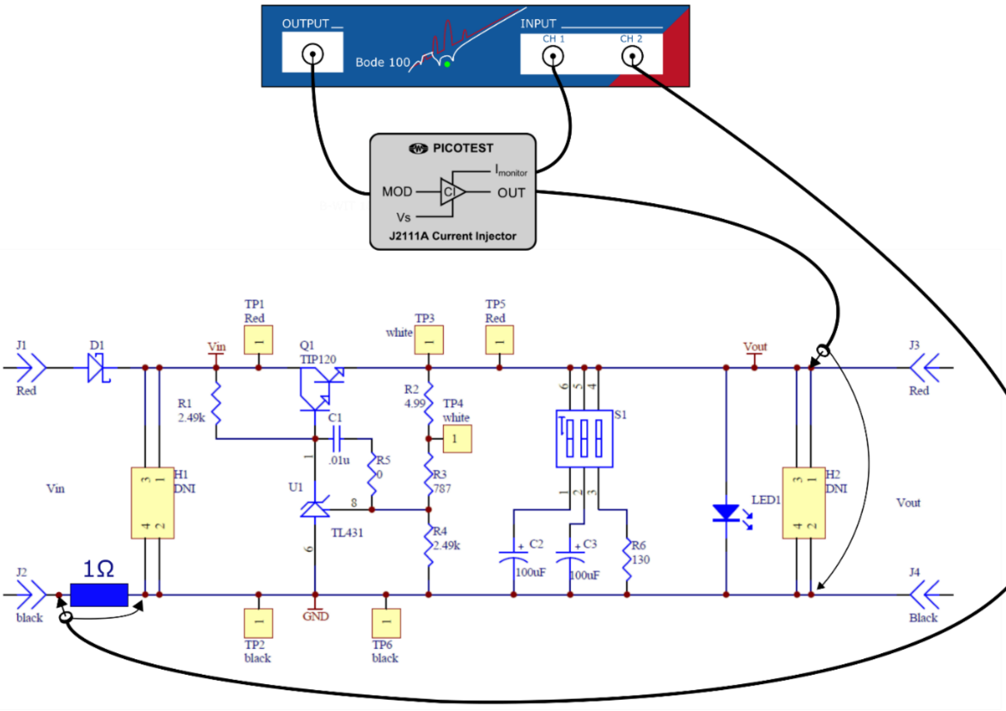


Figure 4: Reverse Transfer measurement setup

The J2111A Current Injector can also act as a load for the voltage regulator. To achieve this, switch on the +bias of the J2111A resulting in a constant current load of $25\ \mathrm{mA}$. The Bode 100 and the Current Injector are connected to the VRTS 1.5 board as shown in the following pictures:

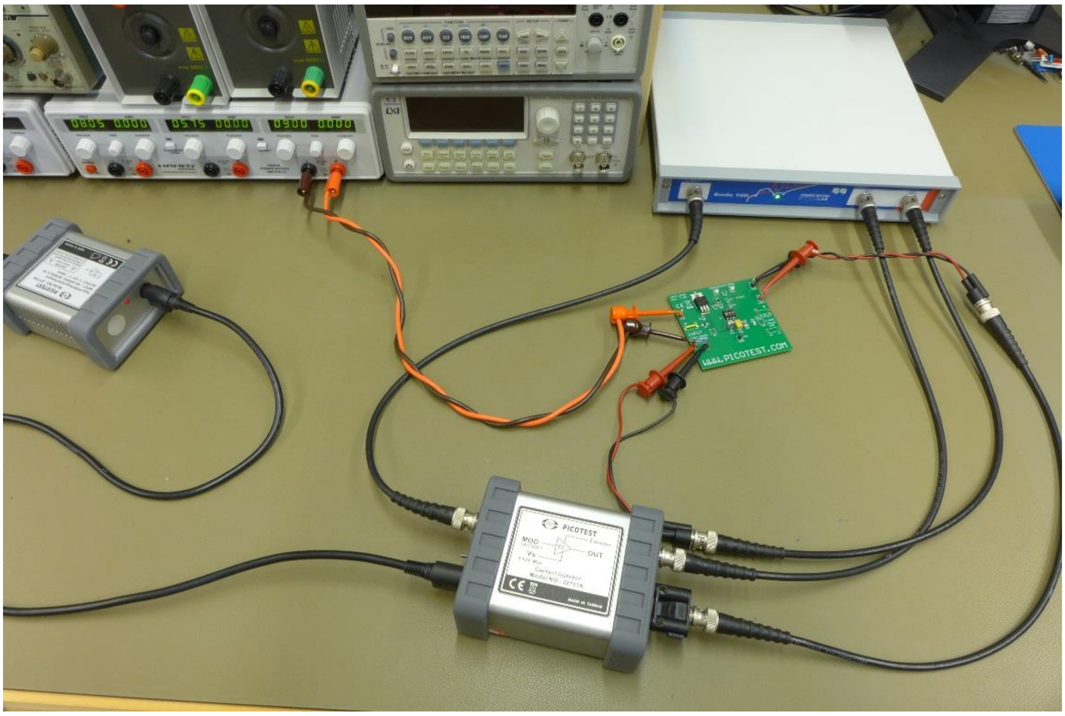


Figure 5: Reverse Transfer measurement setup example

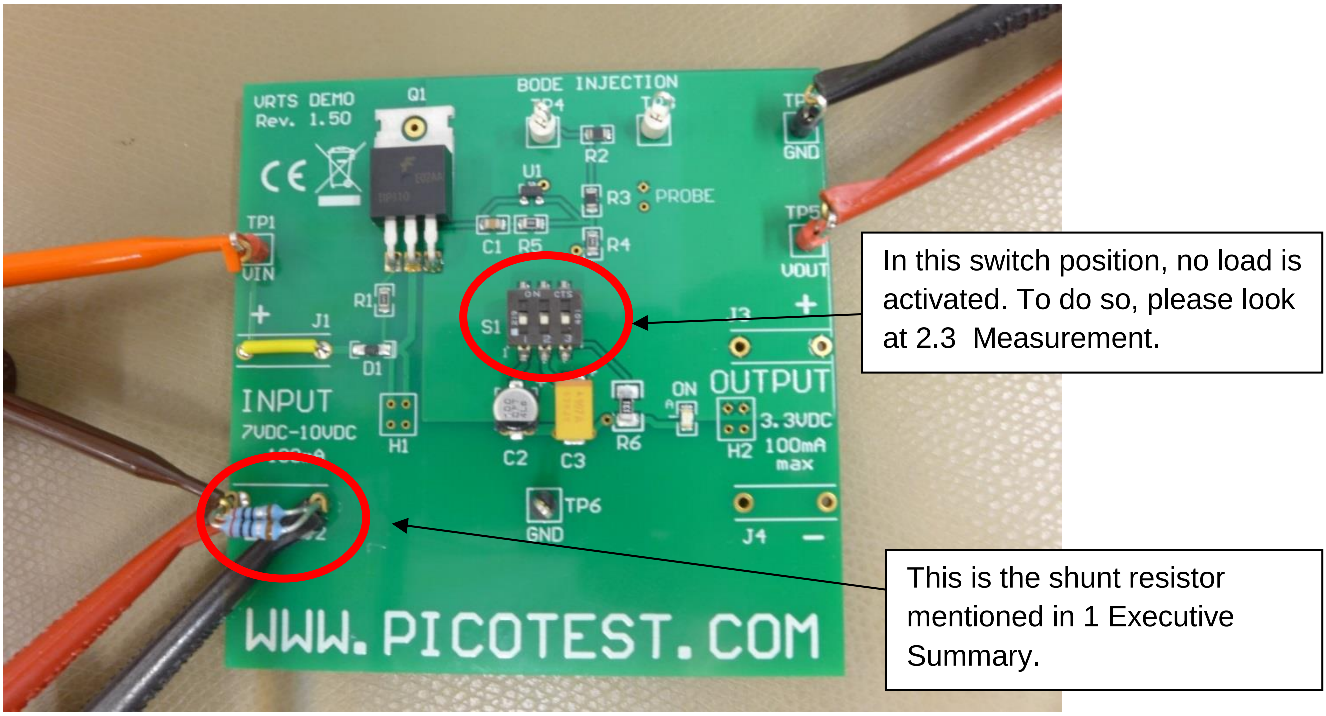


Figure 6: Reverse Transfer measurement setup example – VRTS 1.5

2.2 Device Setup

The reverse transfer measurement can be performed directly with the Bode 100 using the external reference function which is selected by starting a “Gain / Phase” measurement.

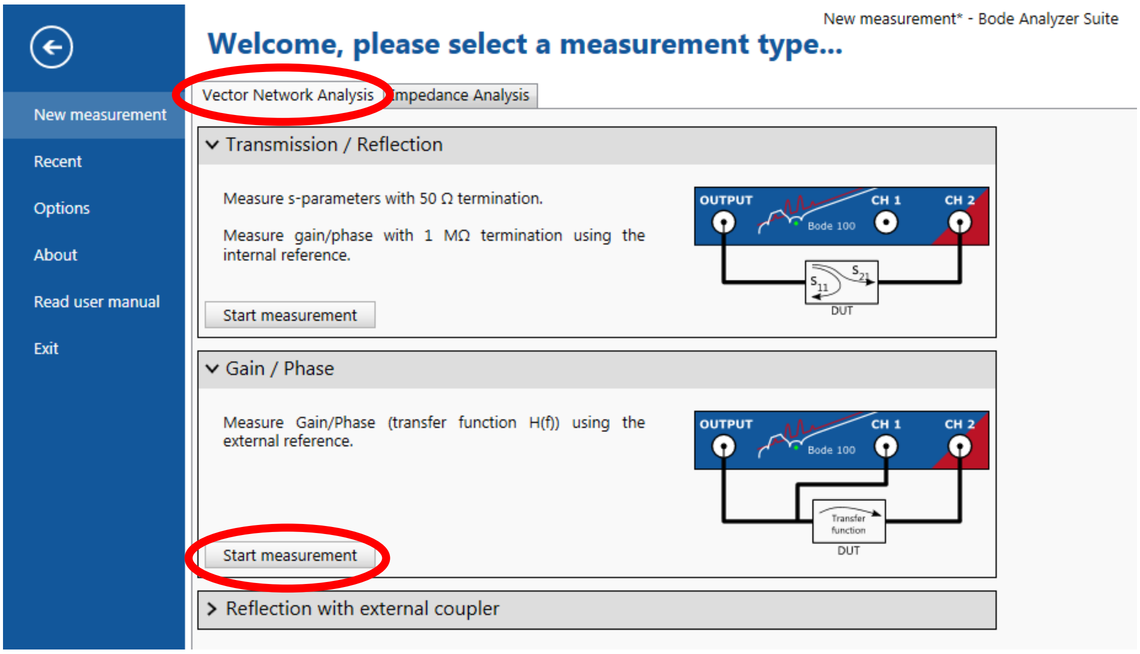


Figure 7: Start menu

The Bode 100 is set up as follows:

Start Frequency:	10 Hz
Stop Frequency:	10 MHz
Sweep Mode:	Logarithmic
Number of Points:	201 or more
Level:	13 dBm
Attenuator 1 & 2:	0 dB
Receiver Bandwidth:	100 Hz

To edit the internal settings click on the Hardware Setup - Transmission / Gain button. This will lead to the following window.

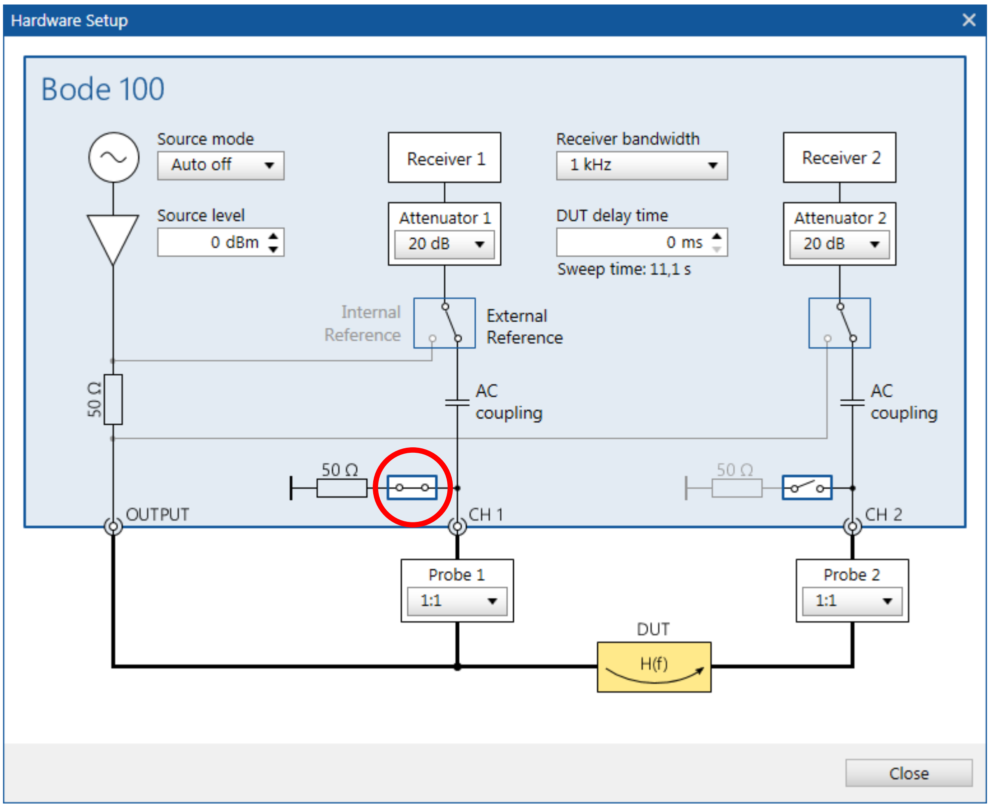


Figure 8: Hardware Setup Window

Channel 1 has to be set to 50 Ω since the Picotest current injector J2111A needs a 50 Ω impedance at its output.

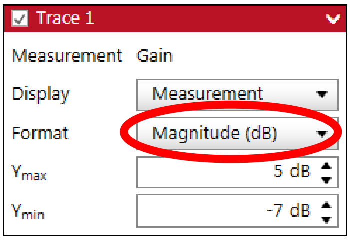
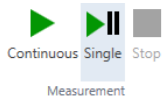


Figure 9: Settings Trace 1

2.3 Measurement

Performing a single sweep leads to the following Reverse Transfer:



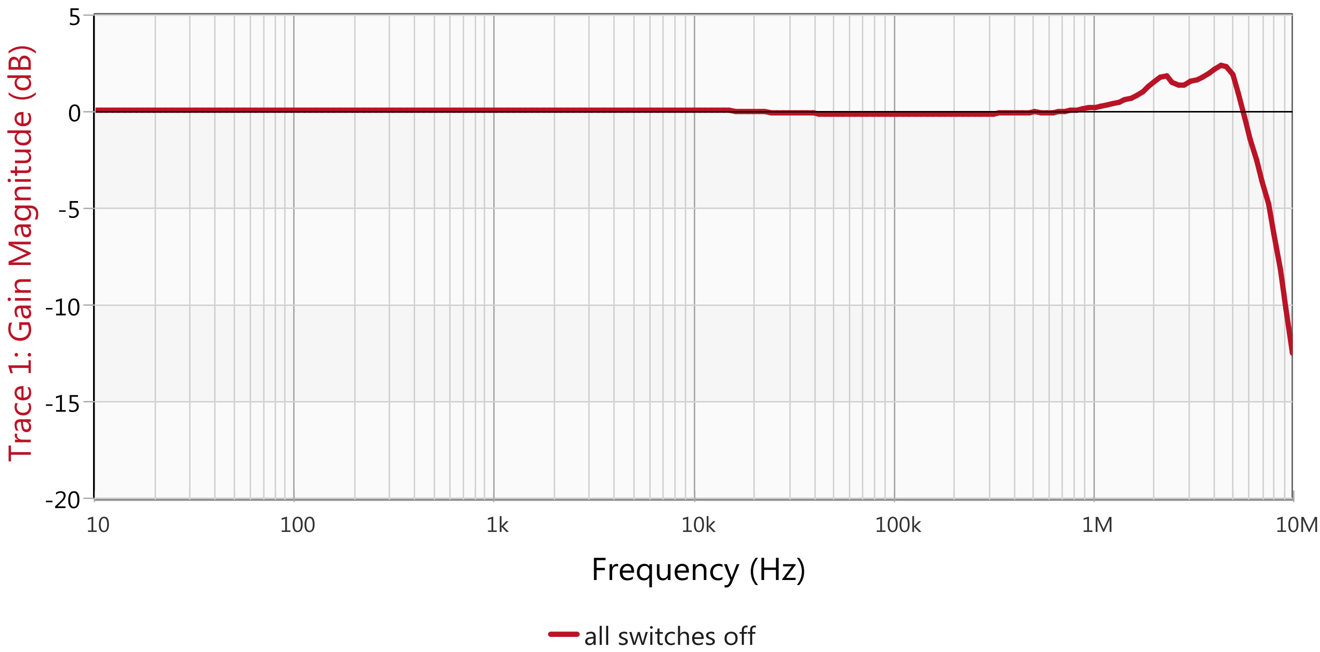


Figure 10: Reverse Transfer

As mentioned in the beginning, the Reverse Transfer of the TIP120 at low frequencies equals nearly 0 dB.

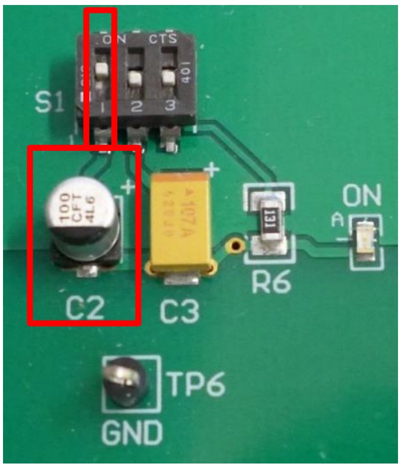


Figure 11: Capacitor C2 (aluminum)

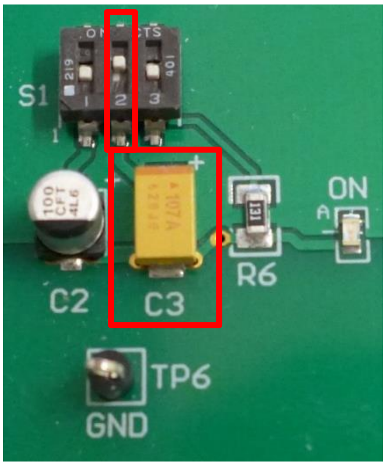


Figure 12: Capacitor C3 (tantalum)

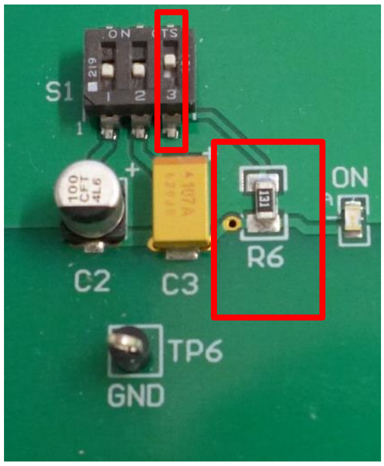


Figure 13: Resistor R6 (load)

In the next measurement we will use the switch to enable and disable C2, C3 and R6, as can be seen above.

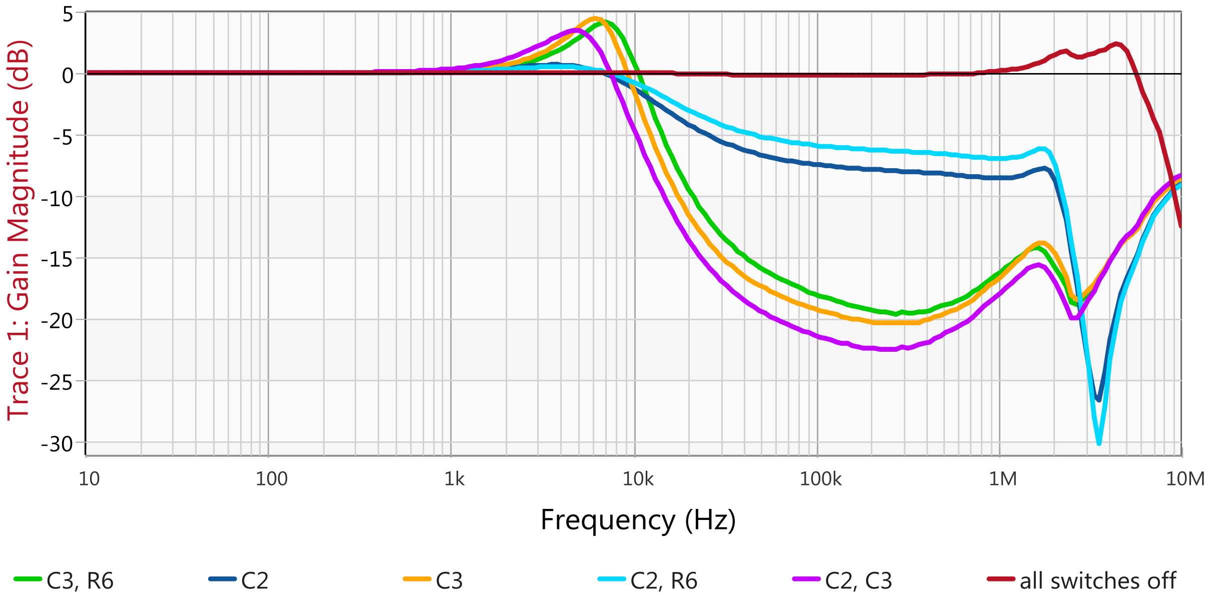


Figure 14: Reverse Transfer – Output C & R comparison

In the chart above, the influence of the different output capacitors and the load on the reverse transfer can be seen. The original Trace 1 line (R6 – red) equals the former result for comparison. The settings of the switch for each measurement is shown in the chart legend below the lines (labeled resistor or capacitors are activated).

3 Conclusion

Reverse transfer is an unappreciated and rarely discussed characteristic, defining the attenuation of the load current perturbations at the regulator input. When multiple regulators are connected to the same input bus, poor reverse transfer of one regulator could potentially cause noise or oscillations at the output of another. This effect is particularly damaging if a regulator has poor Power Supply Rejection Ratio (PSRR) performance.

The Bode 100 in combination with the J2111A Current Injector offers a test set that enables simple and fast reverse transfer measurements in a wide frequency range.

4 References

1 **Picotest.** Voltage Regulator Test Standard. *Version 1.5*.
2 —. Signal Injector Documentation. *Version 1.0c.* 2010.

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