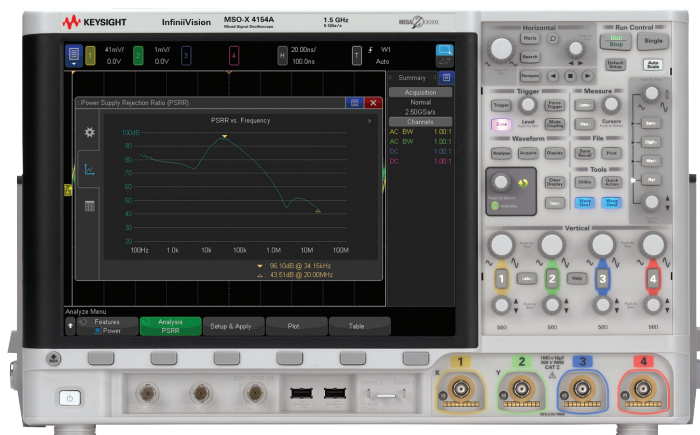


Keysight Technologies

Power Supply Rejection Ratio (PSRR) Measurements

Using Keysight InfiniiVision X-Series Oscilloscopes

Application Note



Introduction

The primary measurement tool used to test and characterize power supplies is an oscilloscope. Many of today's scopes, including the Keysight Technologies, Inc. InfiniiVision X-Series, offer special power measurement options that can help automate many of the most important measurements. Figure 1 shows a list of the power supply characterization measurements that are available on Keysight's InfiniiVision 3000T and 4000 X-Series oscilloscopes with the power measurements option (DSOX3PWR or DSOX4PWR). Unique to Keysight's portfolio of measurements are frequency response measurements including power supply rejection ratio (PSRR) and control loop response (Bode). These particular stimulus-response type measurements are typically performed using low-frequency network analyzers. But since Keysight's InfiniiVision X-Series oscilloscopes come with a built-in function/arbitrary waveform generator, they can also be performed using these scopes.



Figure 1. Power supply characterization measurements available in Keysight's InfiniiVision X-Series oscilloscopes.

Power Supply Rejection Ratio (PSRR)

Figure 2 shows a block diagram of a PSRR measurement test setup. This test provides a measure of how well a power delivery device, such as a DC-to-DC converter or a low-voltage drop-out regulator (LDO), rejects various frequency components injected at the DC input of the device-under-test. In other words, how much of a disturbance signal injected at the DC input reaches the regulated DC output.

To perform a PSRR test, a sine wave must be injected at the DC input and then swept from a low frequency to a high frequency. A DC + AC network summing device, such as Picotest's J2120A line injector, is required for this measurement. The measurement system measures both the modulated input and output AC voltage levels and then computes the rejection ratio as $20\text{Log}(V_{in}/V_{out})$ at each frequency within the swept band. Some engineers argue that the formula should be $20\text{Log}(V_{out}/V_{in})$. But this is the formula for gain (A), not rejection. Rejection is the inverse of gain. The built-in waveform generator along with the Power Measurements option in Keysight's InfiniiVision X-Series oscilloscopes makes this frequency response measurement possible for the first time in an oscilloscope.

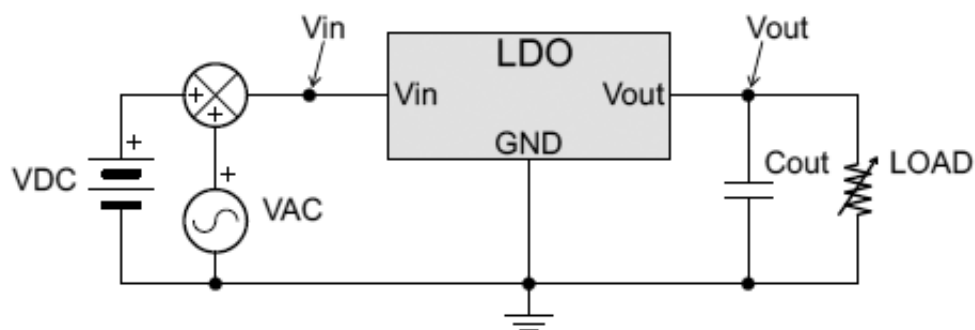


Figure 2. Block diagram of a power supply rejection ratio (PSRR) measurement on a low-voltage drop out regulator.

Probing the Input and Output

Although a standard 10:1 passive probe can be used to probe the modulated DC input, a 1:1 passive probe, such as the Keysight Technologies, Inc. N2870A, is recommended to probe the output. Assuming that the DC-to-DC converter under test has lots of rejection, the amplitude of output will be very small (sub millivolts). In addition, properly grounding the probe near the DC output test point is important. If you use the standard ground lead that comes with your 1:1 passive probe, it will act as an antenna and pick up a significant amount of noise in the air and thereby reduce the dynamic range of your measurement. A short spring clip ground adapter (usually shipped as an accessory with the probe and shown in the inset image of Figure 3), or better yet, a soldered-in probe socket will provide the best low-noise signal fidelity.

Figure 3 shows a photo of actual test set up of a PSRR measurement on a Picotest 3.3V linear regulator evaluation board using a Picotest J2120A line injector as the input summing device. Note the probe socket used on the output probing point for a solid ground connection (no antenna).

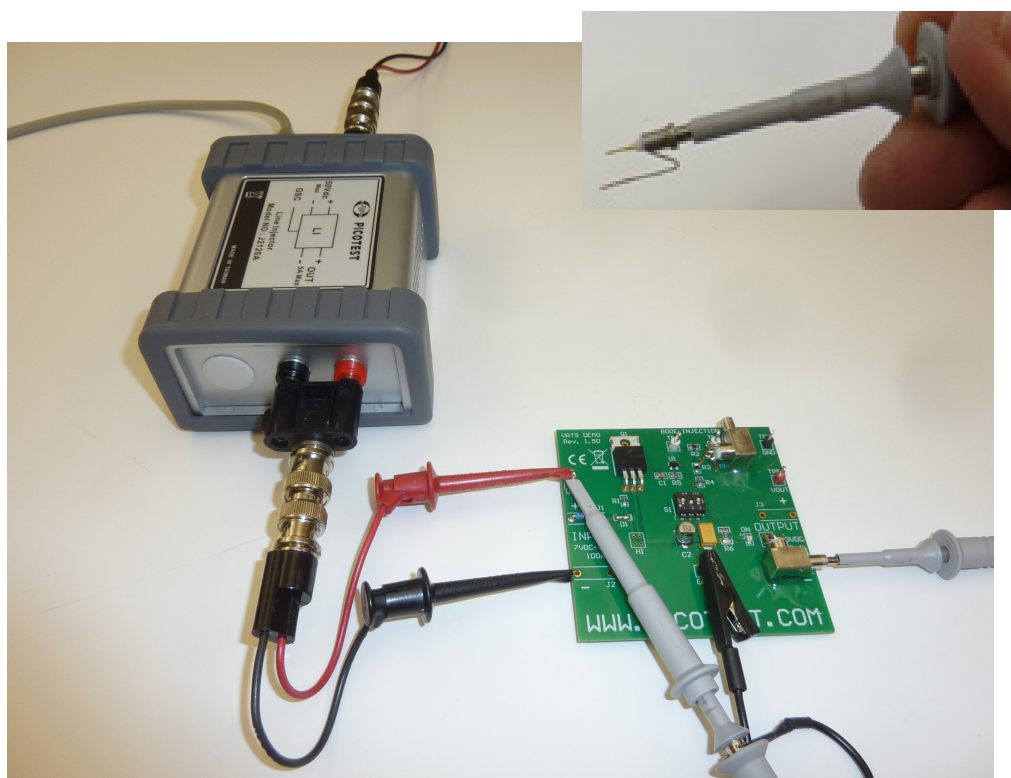


Figure 3. Probing the DC-to-DC converter using two channels of the oscilloscope.

Performing the PSRR Measurement

To perform this PSRR test using an InfiniiVision X-Series oscilloscope with the power measurements option, first select the PSRR measurement from the list of possible power supply related measurements, and then select the Setup & Apply menu shown in Figure 4. We will begin this measurement using a fixed test amplitude of 130 mVpp to modulate the DC input as shown in Figure 4. Next, press Apply to begin the test.



Figure 4. Establishing the PSSR test parameters.

Performing the PSRR Measurement (Continued)

Figure 5 shows the plot of rejection after the completion of the test. In this plot of results we can see what appears to be chatter at the lower test frequencies. This chatter is evidence that our SNR may be too low at some test frequencies. One method of improving SNR is to simply increase the test amplitude at all frequencies. However, increased test amplitudes can sometimes induce distortion as some test frequencies.

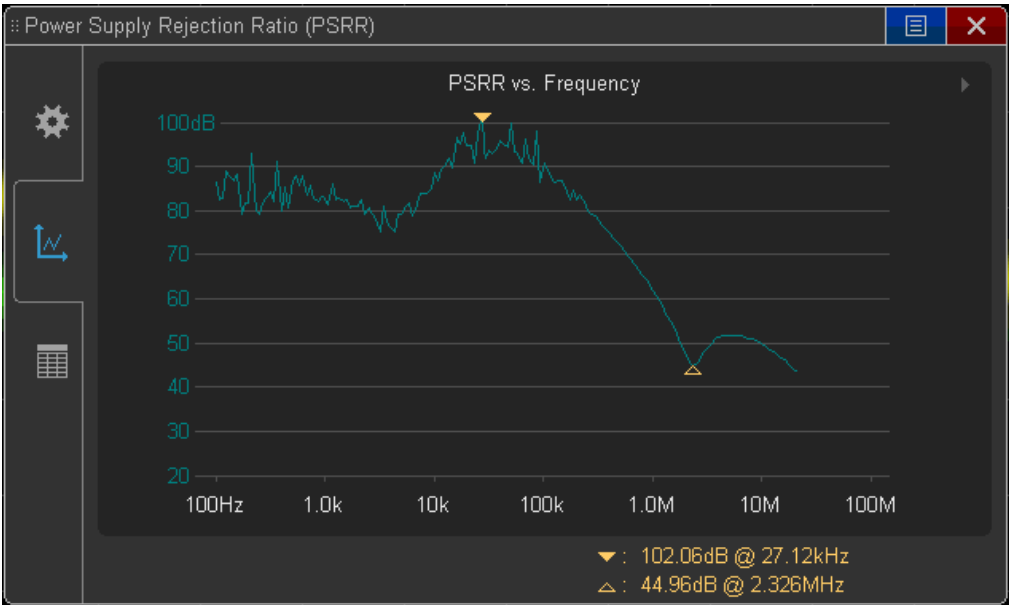


Figure 5. Initial PSRR test shows chatter using a fixed test amplitude of 130 mVpp.

Performing the PSRR Measurement (Continued)

A better solution to improve SNR is to customize test amplitudes using the amplitude profile capability of this measurement tool shown in Figure 7. With amplitude profiling, you can test at lower amplitudes at frequencies where the DUT is sensitive and test at higher amplitudes where it is less sensitive to distortion.



Figure 6. Using amplitude profiling to optimize signal-to-noise ratio.

Performing the PSRR Measurement (Continued)

Figure 8 shows the PSRR measurement based on the use of a customized test amplitude. Notice that the chatter due to insufficient signal-to-noise ratio has been significantly minimized. Using the cursors after the completion of the test, we measure a maximum rejection of 95 dB at 34.15 kHz and a minimum rejection of 43.5 dB at 20 MHz (final test frequency).

So how do you determine optimum test amplitudes? One advantage of Keysight's scope-based solution is that you often can observe distortion in the time-domain waveform during the test. If the output sine wave begins to look loop-sided, clipped, or somewhat triangular in shape (non-sinusoidal), then you are probably encountering distortion due to overdriving your DUT. Optimizing test amplitudes to achieve the best dynamic range measurements often is an iterative process of running your frequency response measurements multiple times. With Keysight's oscilloscope-based frequency response measurements, you typically will go through fewer iterations.

Note that you also can perform a PSRR measurement at a single frequency using Keysight's oscilloscope-based solution. This allows you to run a test a single frequency and then make manual amplitude and frequency adjustments within the scope's WaveGen setup menu while visually monitoring repetitive time-domain waveforms on the oscilloscope's display.

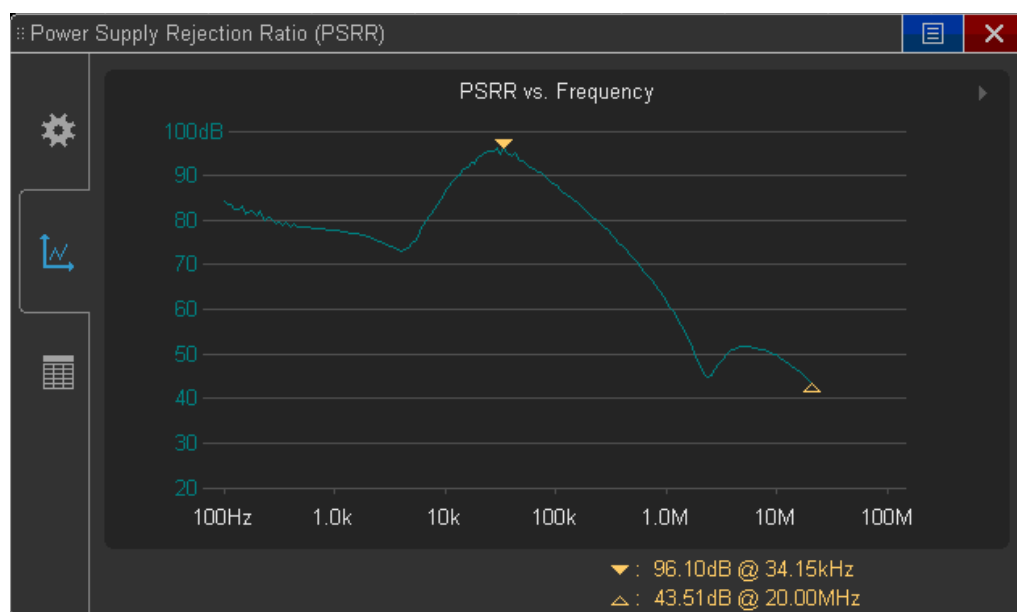


Figure 7. PSRR measurement using optimized test amplitudes.

Summary

Oscilloscopes are the primary measurement tools used today by engineers to test and characterize their power supply designs. But most scopes have significant limitations when it comes to performing frequency response measurements such as power supply rejection ratio (PSRR). Keysight's InfiniiVision X-Series oscilloscopes are the first scopes on the market that can perform PSRR measurements automatically.

System Requirements

A PSRR test on a Keysight InfiniiVision 3000T, 4000, or 6000 X-Series oscilloscope requires that the scope be licensed with the power measurements option (DSOX3PWR, DSOX4PWR, or DSOX6PWR). The WaveGen option is not required. The scope will automatically turn on the WaveGen for the one-time PSRR measurement. A 1:1 passive probe, such as the N2870A, is recommended for probing the low-level output signal. Coupling the input disturbance signal from the scope's WaveGen output into the DC input requires a network summing device such as Picotest's J2120A Line Injector. For more information about this product, contact Picotest at www.picotest.com

In addition to the above listed minimum system requirements, it is recommended that your 3000T or 4000 X-Series oscilloscope be running on firmware version 4.08 or greater.

Related Literature

Publication title	Publication number
<i>InfiniiVision 3000T X-Series Oscilloscopes - Data Sheet</i>	5992-0140EN
<i>InfiniiVision 4000 X-Series Oscilloscopes - Data Sheet</i>	5991-1103EN
<i>InfiniiVision 6000 X-Series Oscilloscopes - Data Sheet</i>	5991-4087EN
<i>InfiniiVision Oscilloscope Probes and Accessories - Selection Guide</i>	5968-8153EN
<i>Power Supply Control Loop Response (Bode Plot) Measurements - Application Note</i>	5992-0593EN
<i>Switch Mode Power Supply Measurements - Application Note</i>	5991-1117EN
<i>Making Your Best Power Integrity Measurements - Application Note</i>	5992-0493EN
<i>Tips and Techniques for Making Power Supply Noise Measurements with an Oscilloscope - Application Note</i>	5989-6755EN
<i>Evaluating Oscilloscopes for Low-Power Measurements - Application Note</i>	5991-4268EN
<i>New Probing Technology Enables High Sensitivity, Wide Dynamic Range Current Measurement - Application Note</i>	5991-1951EN



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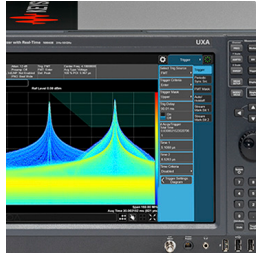
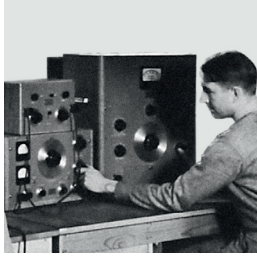
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