J2122A User Guide

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Contents

Foreword

Power Supply Rejection Ratio(PSRR)

Power Supply Rejection Ratio (PSRR) refers to the ability of a power supply to prevent AC noise at the input from appearing at the DC output. To conduct a PSRR test, a scanned sine wave excitation is applied to the input of the power supply.

The J2122A Power Line Signal Injector is a rechargeable professional device with excellent performance and multifunctional features, designed to meet users' high demands for signal injection and measurement. With its wide frequency response, adjustable voltage, high-intensity signal injection, and convenience in eliminating complex power wiring, the J2122A will be a reliable assistant in your signal processing tasks.

In PSRR measurement applications, a DC power supply voltage can be input to the line injector, which is then modulated by the source signal from a Frequency Response Analyzer (FRA). The J2122A allows for modulation of the DC power supply voltage over a wide frequency range, from frequencies lower than those of AC power supplies to higher than most (but not necessarily all) linear regulator bandwidths.

Figure 1 shows the block diagram of the PSRR measurement test setup. This test measures the degree of suppression of various frequency components at the DC input of the device under test (DUT) by power transfer devices such as DC-DC converters or low-dropout regulators (LDOs). In other words, it assesses how much of the interference signal injected at the DC input can reach the regulated DC output.

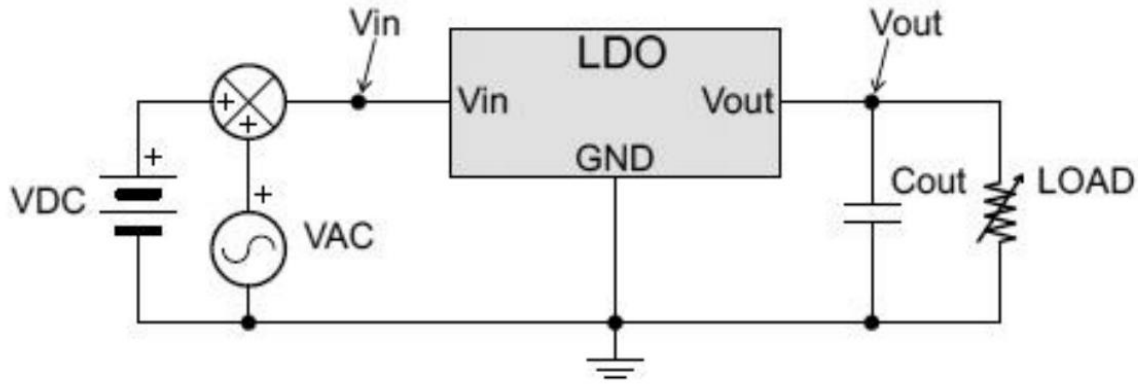


Figure 1: Block Diagram of Power Supply Rejection Ratio (PSRR) Measurement for Low-Dropout Regulators (LDO)

To conduct a PSRR test, a sine wave must be injected at the DC input, sweeping from low frequency to high frequency. This measurement requires a DC + AC summing device, such as the Picotest J2122A line injector. The measurement system simultaneously measures the modulated input and output AC voltage levels, and then calculates the suppression ratio for each frequency within the sweep range using the formula 20Log(Vin/Vout). Some engineers believe that this formula should be 20Log(Vout/Vin). However, this is the formula for gain (A), not for suppression. Suppression is the inverse of gain.

1. Package Contents

The J2122A includes the following accessories as shown as Figure 2.:

1. Banana plug to IC clip *2
2. PWR-OPT05 remote sensing board *1
3. Dual banana plug *4
4. Banana plug to alligator clip *2
5. BNC cable *1
6. Adjustment tool *1

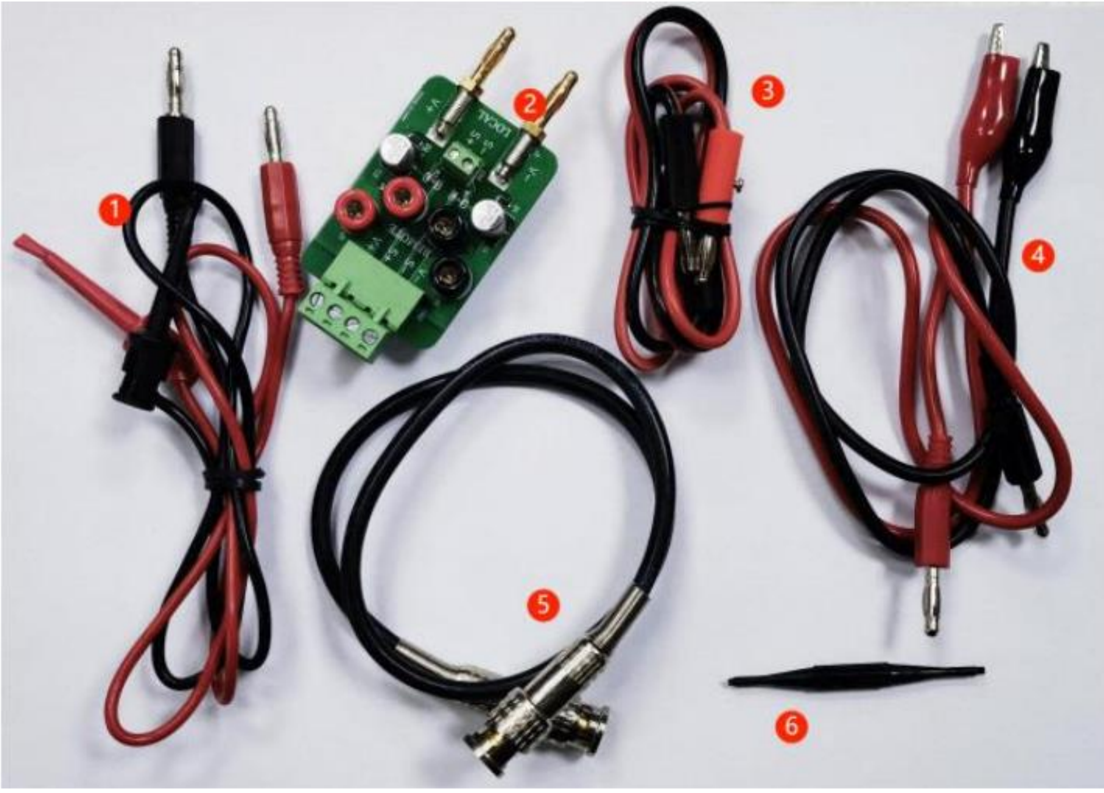


Figure 2: Accessories of J2122A

2. Before Use

Charge is required before use. The charging indicator is red during charging and turns green when fully charged.

Figure 3 : J2122A with red light, during charging

Figure 4: J2122A with green light, fully charged

Figure 3-1: Power Indicator Lights

Figure 3-1 shows the Power indicator lights:

a. Green light constantly on: Power ON indicator light.

b. Green light off: Power OFF state.

c. Flashing orange light: Indicates low battery voltage (automatic power-off after 5-10 minutes).

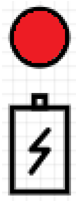


Figure 3-2: Battery Charging Lights

Figure 3-2 shows the Battery charging indicator lights:

a. **Red light steady on:** Fast charging indicator (Battery level < 80%)

b. **Red light steady on + Green light blinking:** Battery level > 80%

c. **Green light steady on:** Charging completed

d. **Red light blinking:** Abnormal battery voltage.

Battery level control may be affected by variations in the characteristics of individual battery cells, which can result in imbalanced stored energy after usage or over-discharge due to prolonged periods of inactivity. This product is equipped with a self-repair mechanism that automatically balances the battery level or performs trickle charging to rectify abnormal conditions. The charging time varies depending on the actual differences in battery cell characteristics, and in some cases, it may take up to 8 hours for a complete charge. If the situation does not improve after 8 hours of charging,

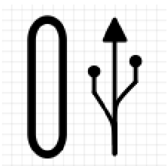


Figure 3-3: USB Type-C Charging Port

The USB Type-C charging port shown on Figure 3-3 is for charging only. When J2122A is being charged, the power switch will automatically turn off and cannot be operated. A 5V, 15W USB charger adapter can be used as the charging power source, **or the included USB to banana adaptor (PWR-OPT03) can be used along with a general desktop DC power supply set to output 5V and limit the current to 3A for charging.**

3. Connection Before Testing

After receiving the product, do not rush to connect it for testing. First, adjust the settings like Figure 5 to ensure that the injector is in the correct working configuration.

Figure 5: Connecting Devices

Verify the test connections as shown above: OSC connects to the signal generator, IN connects to the DC power supply, and OUT connects to the oscilloscope or load.

Turn on the J2122A power supply; the indicator light should be on (green).

Set the power supply to output 3V, set the signal source to 1kHz or 1MHz, 1Vpp, and set the oscilloscope channel to either 1MΩ or 50Ω impedance to observe the waveform on the oscilloscope.

You can also set the signal generator and power supply according to the required injected signal parameters.

In this example as Figure 6, the output impedance of the signal source is set to 50Ω, and the oscilloscope input channel is also set to 50Ω. The DC power supply outputs

3V, and the signal generator outputs 1kHz, 1Vpp.

Figure 6: The Oscilloscope State after the settings are settled down.

If the waveform amplitude appears abnormal, adjust the Vdrop knob with the tool in the package.

Figure 7: The Vdrop adj Location

Adjust the knob to ensure that the waveform is undistorted and has a normal Vdrop. Note: The adjustment of the knob should be moderate; if adjusted improperly, distortion may occur, as shown in Figure 8, where the peaks are clipped.

Figure 8: The distortion waveform that user need to avoid

Readjust to ensure that the waveform is undistorted and that the Vdrop meets the required specifications. As shown in Figure 9, the signal amplitude matches that of the signal source, with a Vdrop of approximately 1V. Subsequent tests can compensate for the corresponding Vdrop by increasing the power supply output.

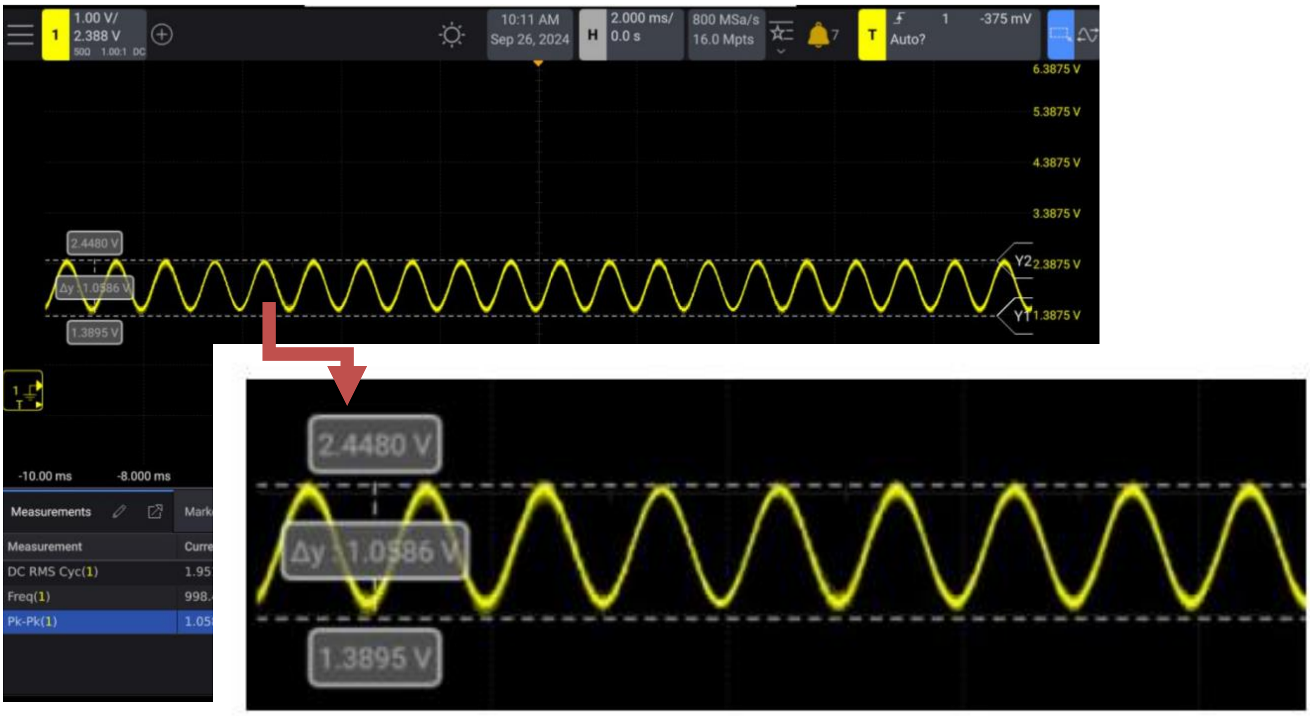


Figure 9: The undistorted waveform

Figure 10 shows the oscilloscope channel impedance set to 1MΩ, with the signal source set to 2Vpp and the signal source output impedance set to high Z, for reference only.

After completing the adjustments to the injector as described above, you can adjust the settings of the signal source and power supply as needed, connect the device under test, and prepare to start testing.

Figure 10: The oscilloscope channel impedance setup

4. About Vdrop and DC Output Adjustment

Due to its operational characteristics, the DC output voltage of the J2122A signal injector will always be less than the input voltage provided by the DC power supply.

Compared to the J2120A, the Vdrop of the J2120A can range from 0.7V to 3.25V, with specific values dependent on the load current size. The J2122A allows for fixed Vdrop adjustments via a knob.

The size of Vdrop affects the actual output amplitude of the AC signal; generally, the amplitude of the AC injected signal will be less than or equal to Vdrop.

Of course, a larger Vdrop results in a greater voltage drop on the DC output. During use, it is necessary to measure the output conditions with a multimeter to adjust the power supply or use a power supply with compensation functions to automatically adjust the output.

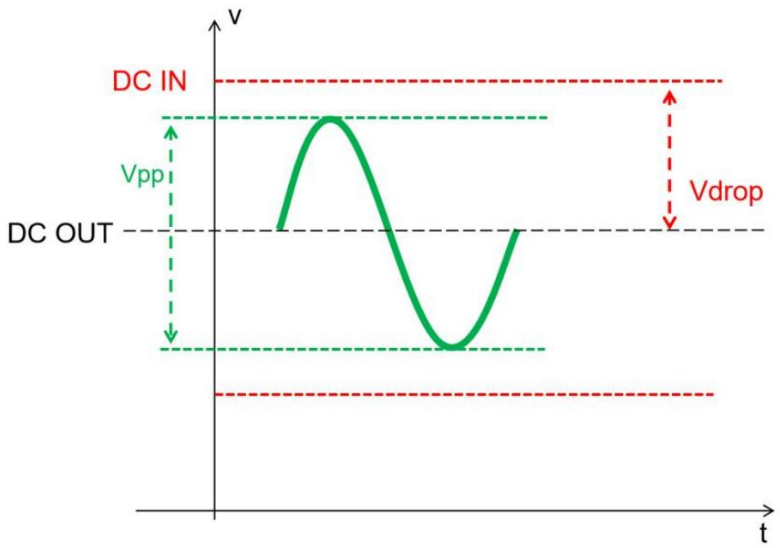


Figure 11: Schematic Diagram of the Relationship Between Vdrop, DC Input/Output, and AC Injected Signals

5. Using the Remote Sensing Compensation Board PWR-OPT05

The PWR-OPT05 remote sensing board works with the remote sensing feature of the power supply (Picotest P9610A) to correct for this voltage drop, eliminating the need for constant adjustments to the benchtop power supply. The Picotest P9610A power supply provides sufficient remote compensation capability for this application. Many other power supplies do not support this feature or have limited compensation capabilities.

Principle of Remote Compensation with PWR-OPT05

If the output of the J2122A is fed back directly without filtering, the power supply's remote sensing function will adjust away the modulated signal. The output of the J2122A is filtered and sensed through an RC network to adjust for voltage drops caused by load current. The cutoff frequency of the RC filter is set to $1/(2\pi R*C)$, which is 6.4 Hz. This ensures that we only correct for the DC component of the voltage drop, while the modulated signal does not enter the detection loop.

Figure 10 shows the connection diagram for measuring the input impedance of a DC-DC converter using remote sensing functionality. The input impedance is measured as the ratio of input voltage to input current. FRA CH1 uses a current probe to measure input current, while FRA CH2 measures input voltage. The input impedance of the DC-DC converter is measured as the ratio of CH2 to CH1. Figure 11 shows the connection diagram for measuring PSRR using remote sensing functionality. CH1 measures input voltage, and CH2 measures output voltage. PSRR is the ratio of CH1 to CH2.

The capacitor in the RC filter provides local detection for AC signals by bypassing the remote sensing line, while the resistor provides remote sensing for DC and low-frequency signals. A 24.9 Ω detection resistor becomes part of the source power supply's voltage divider, producing a fixed 75 mV voltage drop, thus avoiding the need for manual adjustment of the source power supply. The 75 mV offset is due to the series connection of the 24.9 Ω filter resistor with the internal power supply divider resistor. This remote sensing filter can be used for all measurements performed with the J2122A.

Figure 12 shows the connection diagram for measuring input impedance using remote sensing to compensate for voltage drops caused by the J2122A. Due to the series connection of the 24.9 Ω filter resistor with the internal power supply divider resistor, a fixed offset of 75 mV is generated.

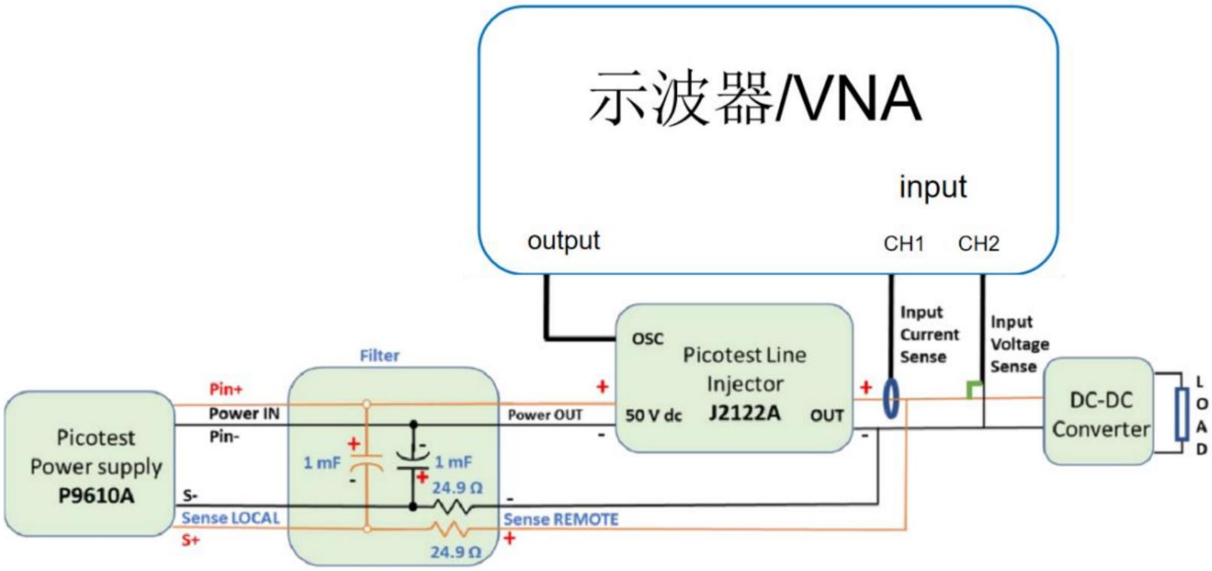


Figure 12: The connection diagram for measuring input impedance using remote sensing

Figure 13 shows the connection diagram for measuring PSRR using remote sensing to compensate for voltage drops induced by the J2122A. Again, a fixed offset of 75 mV is generated due to the series connection of the 24.9 Ω filter resistor with the internal power supply divider resistor.

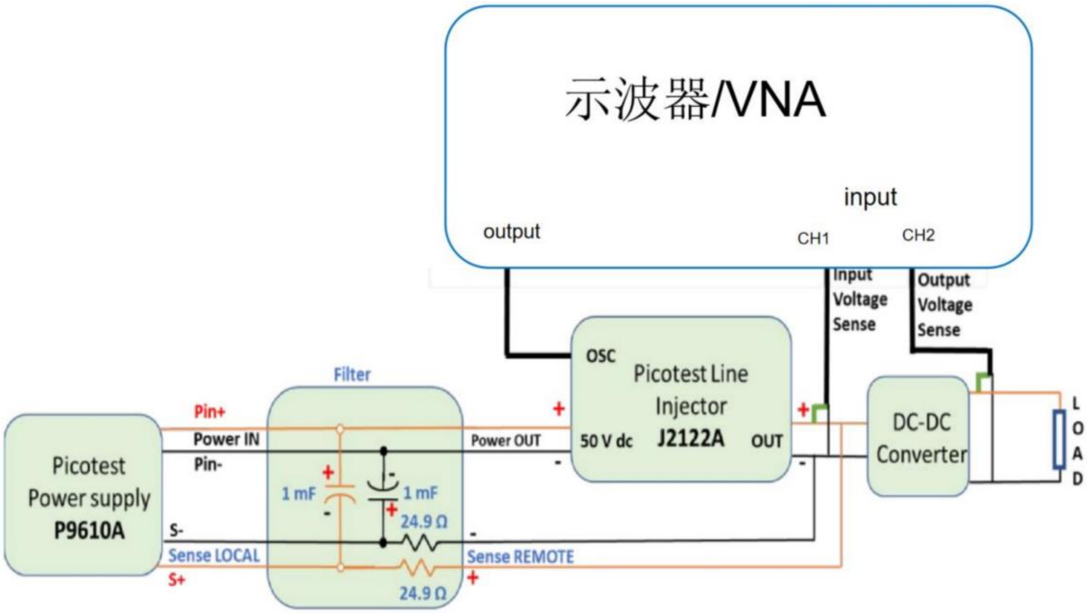


Figure 13: the connection diagram for measuring PSRR using remote sensing to compensate

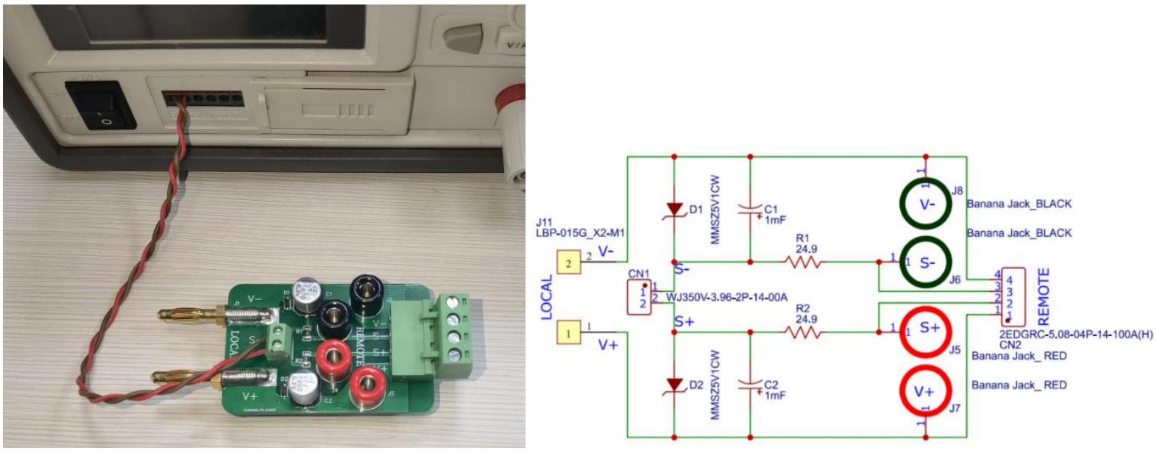


Figure 14: Schematic Diagram of the Remote Sensing Filter and PWR-OPT05

According to the parameters set in Figure 9, the oscilloscope channel impedance is 50Ω, the power supply outputs 3V DC, the remote sensing feature of the power supply is enabled, and the signal generator is set to 1kHz, 1Vpp with an output impedance of 50Ω. The test connection is as shown in Figure 15.

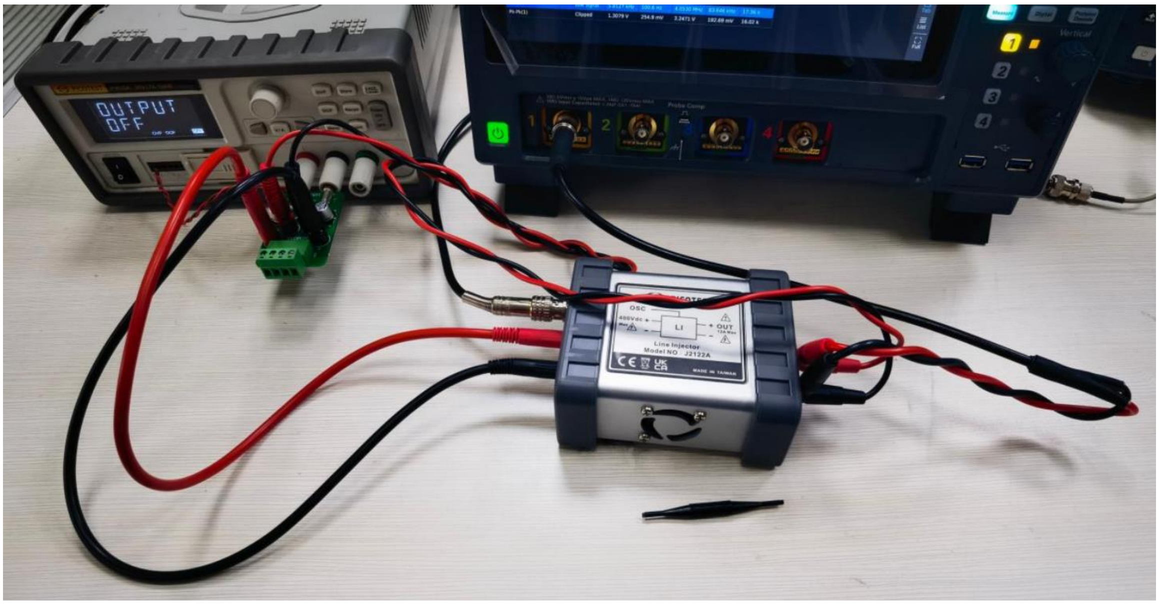
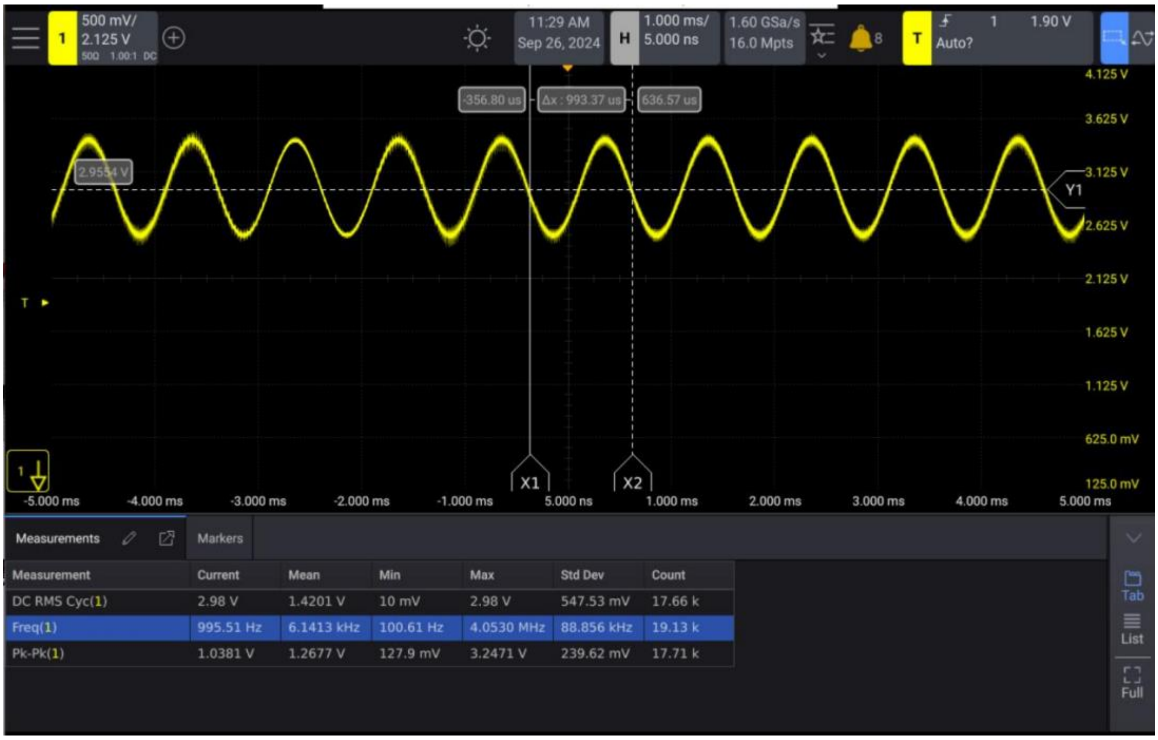


Figure 15: Connection Diagram Using OPT05

When using OPT05 and enabling the remote sensing feature of the power supply, the power supply can automatically readjust the DC voltage drop caused by Vdrop to the actual required output level.

Note: The specific amount that can be automatically adjusted depends on the compensation capability of the power supply.



Measurement	Current	Mean	Min	Max	Std Dev	Count
DC RMS Cyc(1)	2.98 V	1.4201 V	10 mV	2.98 V	547.53 mV	17.66 k
Freq(1)	995.51 Hz	6.1413 kHz	100.61 Hz	4.0530 MHz	88.856 kHz	19.13 k
Pk-Pk(1)	1.0381 V	1.2677 V	127.9 mV	3.2471 V	239.62 mV	17.71 k

Figure 16: the power supply can automatically readjust the DC voltage drop

6. PSRR Connection Testing

- **Using E5061B for PSRR testing.** The connection method is shown in the following figure.

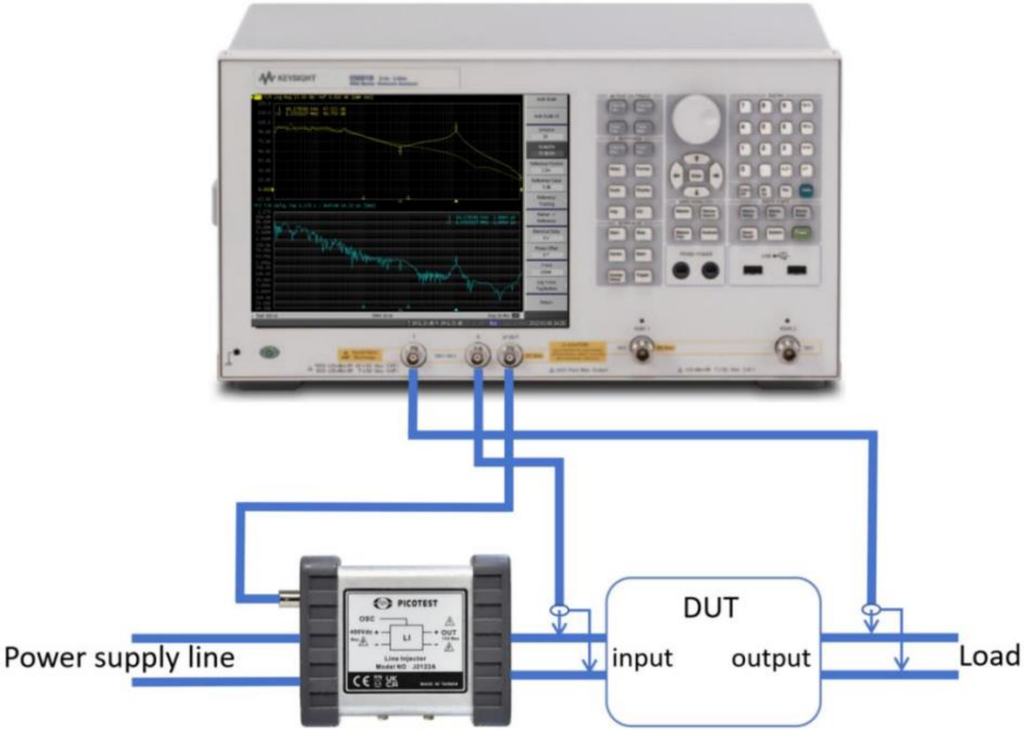


Figure 17: PSRR Connection

The test results are similar to the following figure.

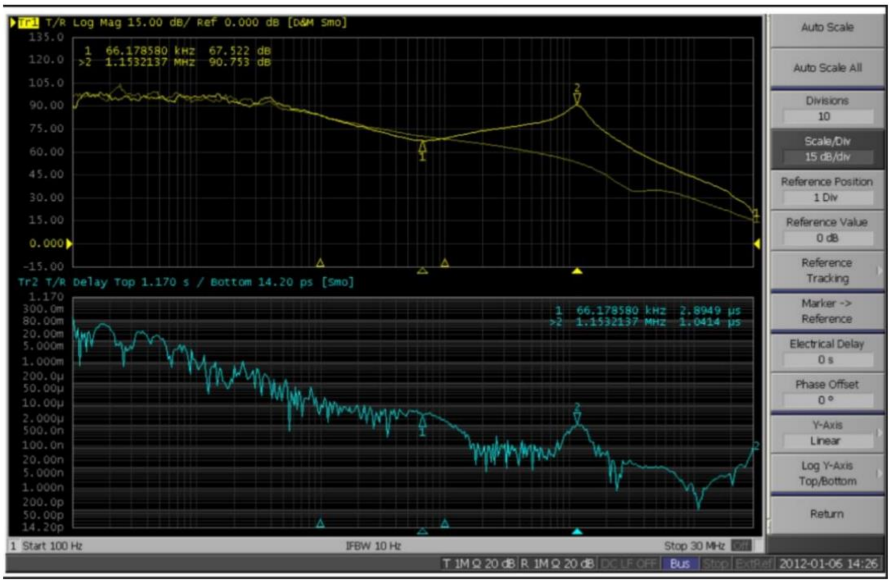


Figure 18: The PSRR Test Result

- **Using an oscilloscope for PSRR testing**

Taking Keysight's HD304MSO as an example, the connection method is shown in the following figure.

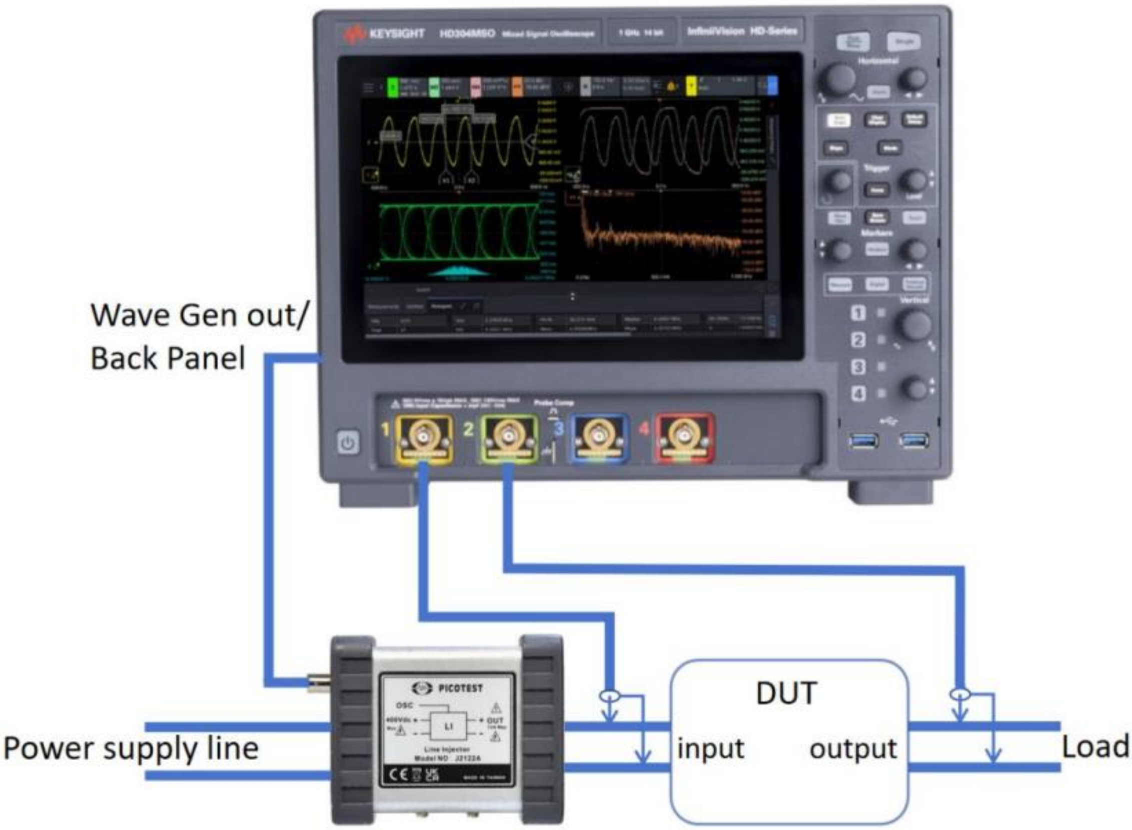


Figure 19: The PSRR Test via Keysight's HD304MSO

*Before using the oscilloscope, probe calibration is required. After connecting as shown in the figure:

1. Press the Analyze button.
2. Select Frequency Response.
3. In the dialog box that appears, select Enable to activate the frequency response testing function.
4. On the settings page below, set the frequency range and signal source amplitude according to the required testing parameters.

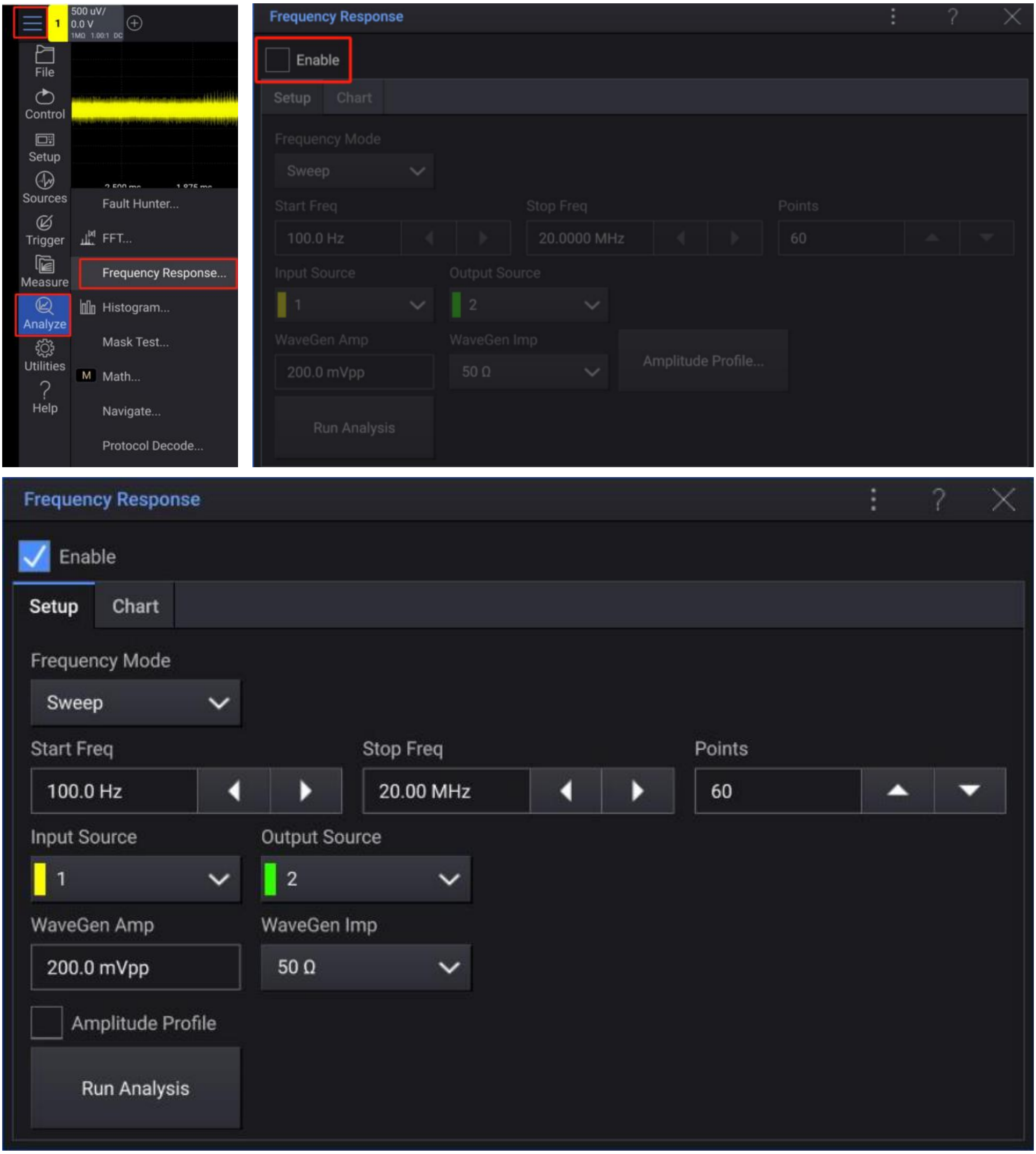


Figure 20: Set the frequency range and signal source amplitude

Frequency Mode: You can scan the entire frequency range or perform analysis at a single frequency. Single frequency point mode is very useful for evaluating amplitude at a single frequency. After running tests at a single frequency, you can manually adjust (increase) the waveform generator's amplitude until you observe waveform distortion on the oscilloscope display. You can then use this amplitude in scan mode for all frequencies or evaluate amplitudes at other frequencies to determine an optimized amplitude profile.

Start Freq: Set the starting frequency value for scanning.

Stop Freq: Set the stopping frequency value for scanning.
Measurement values are displayed on a logarithmic scale, so in addition to a maximum frequency of 20 MHz, you can also select starting and stopping frequencies from decade values.

Points: Number of points per decade.
Select the number of frequency test points per decade (on a logarithmic scale).
Input source: Select the input channel of the device under test (DUT) and corresponding probe.

Output source: Select the output channel of the DUT and corresponding probe.

WaveGenAmp: Set the waveform generator amplitude value and expected output load impedance. The rated output impedance of Gen Out signals is 50 ohms. However, selecting an output load allows the waveform generator to display the correct amplitude and offset level for the expected output load. If the actual load impedance differs from the selected value, the displayed amplitude and offset level will be incorrect.

Amplitude Profile: Checking this box allows you to specify an initial waveform generator amplitude for each frequency range. With amplitude analysis, you can use lower amplitudes at frequencies where the DUT is sensitive to distortion and higher amplitudes at frequencies where it is less sensitive to distortion. Distortion is typically observed during testing; if the input test sine wave begins to lean to one side, gets clipped, or resembles a triangle (non-sinusoidal), it indicates potential distortion due to DUT overspeed. Usually, optimizing test amplitude is an iterative process involving multiple runs of frequency response measurements to achieve optimal dynamic range measurements.

To set different amplitudes for different frequency points, please select Amplitude Profile.

5. Click Run Analysis to run the test.

6. Wait for the program to finish and check the test results.

Figure 21: The Test Result

Note: If the test results show negative values, you need to switch the input and output channel settings in the channel setup. The oscilloscope's frequency response analysis function defaults to Gain, which is 20Log(Vout/Vin).

Switch the channel settings and rerun the test to obtain the results shown below.

Figure 22: Switch the channel to rerun the test

We can optimize the display curve by turning off the displays of channels 1 and 2 and adjusting the channel display coordinates.

You can drag the marker arrow to the point you want to observe to see the corresponding test results (upper right corner of the screen). Using an external mouse will make operation more convenient.

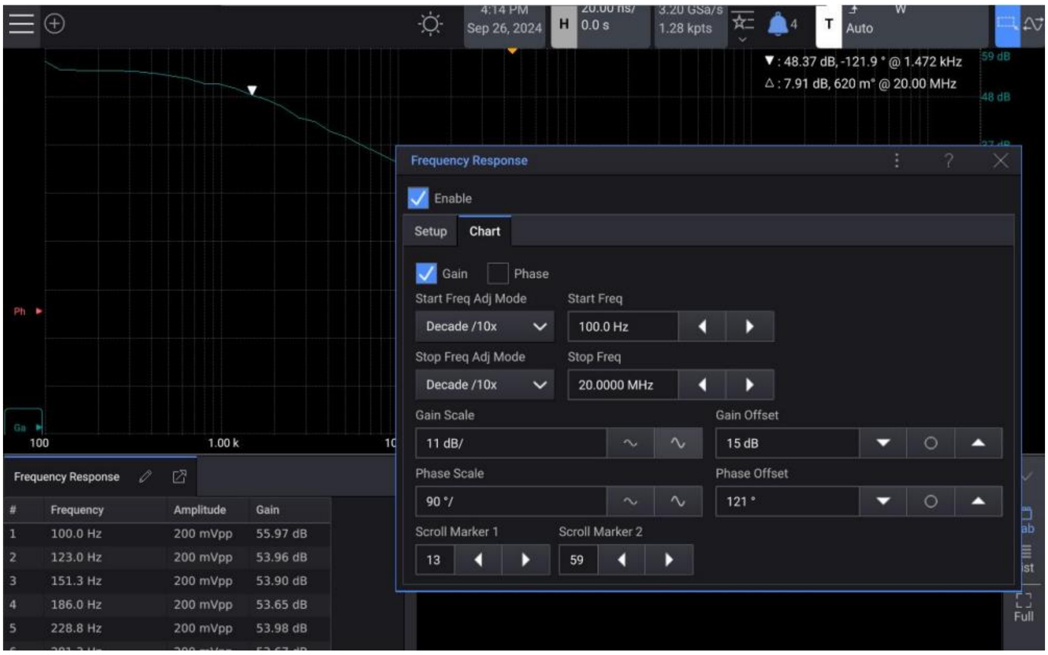


Figure 23: Drag the marker arrow to see the corresponding test results.

A better way to improve the signal-to-noise ratio is to use the amplitude curve function of the measurement tool shown in the figure to customize the test amplitude. With the amplitude curve, you can test at a lower amplitude at frequencies where the DUT is sensitive and at a higher amplitude at frequencies where the DUT is less sensitive to distortion.

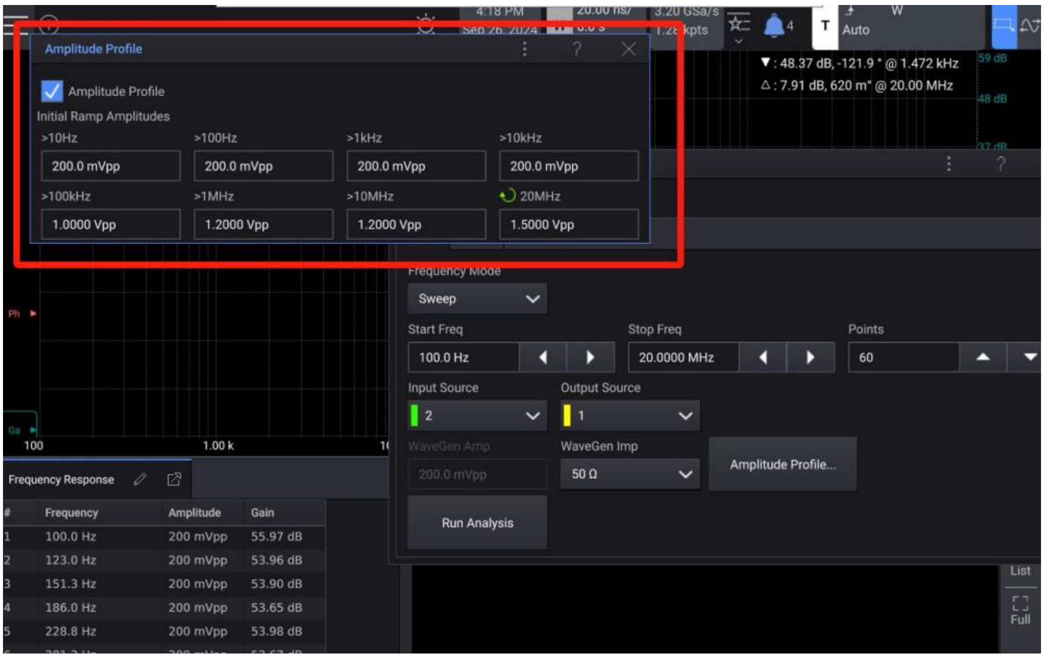


Figure 24: Use the amplitude curve function to improve the signal-to-noise ratio

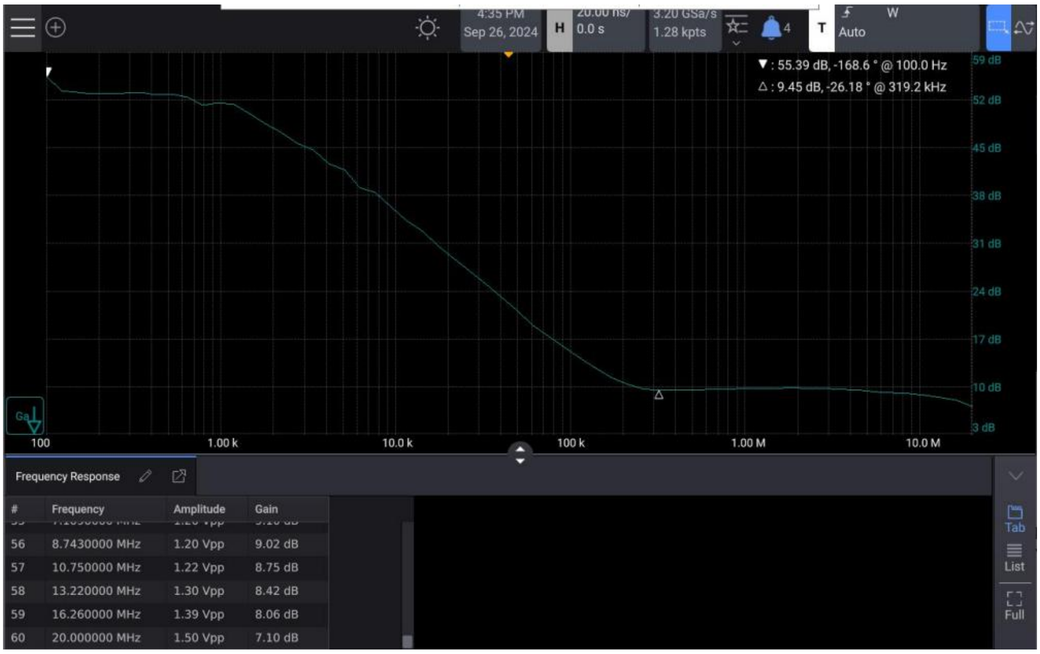


Figure 25: Show the PSRR measurement results based on custom test amplitudes

After completing the test, using the cursor, we measured a maximum suppression of 55 dB at 100Hz and a minimum suppression of 7 dB at 20 MHz (the final test frequency), with insufficient suppression above 319 kHz.

So, how do you determine the optimal test amplitude? One advantage of Keysight's oscilloscope solution is that you can often observe distortion in the time-domain waveform during testing. If the output sine wave begins to show ringing, clipping, or triangular (non-sinusoidal) shapes, you are likely encountering distortion caused by DUT overload. Optimizing the test amplitude for best dynamic range measurements is usually an iterative process involving multiple runs of frequency response measurements. Using Keysight's oscilloscope-based frequency response measurements can typically reduce the number of iterations.

Additionally, with Keysight's oscilloscope-based solution, you can also perform PSRR measurements at a single frequency. As shown in Figure 26, long-pressing on the required frequency point will pop up a single-frequency test button.

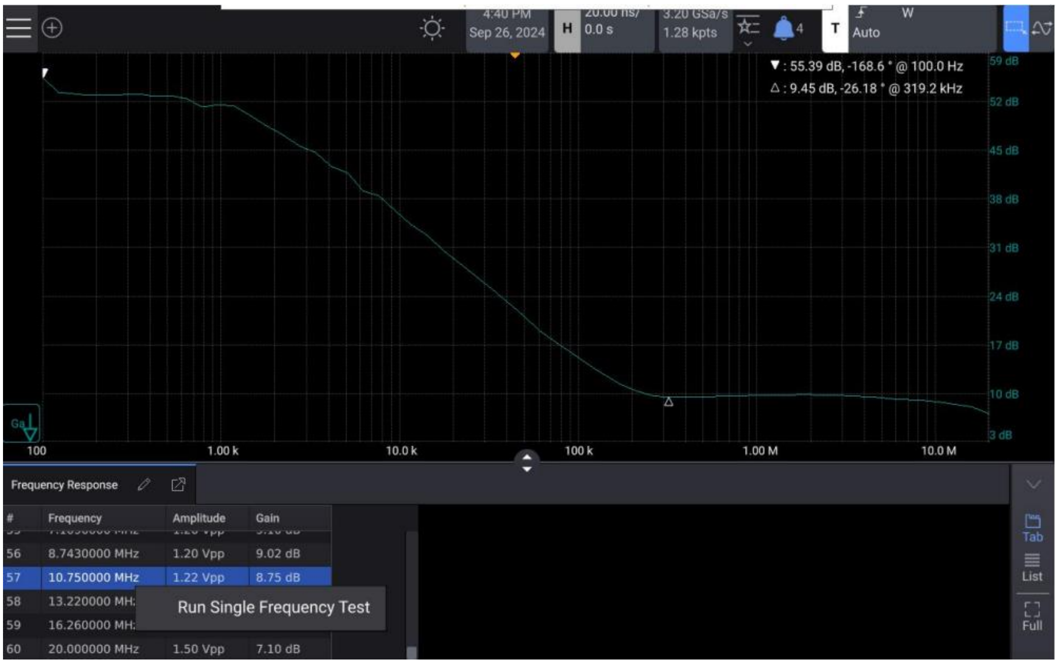


Figure 26: The PSRR measurements via Keysight's Oscilloscope

Alternatively, as shown in Figure 27, in the frequency response test dialog box, select single-frequency testing, input the required frequency point and amplitude value, and click run.

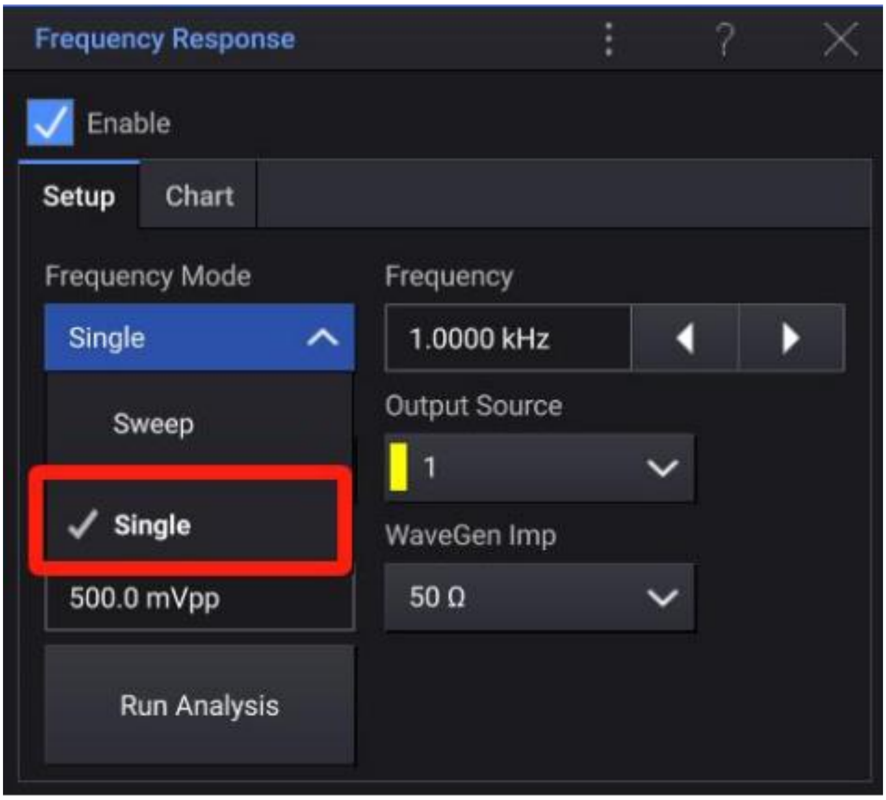


Figure 27: The frequency response test dialog box

This way, you can run single-frequency tests while manually adjusting amplitude and frequency in the oscilloscope's WaveGen settings menu, simultaneously monitoring repeated time-domain waveforms visually on the oscilloscope display.

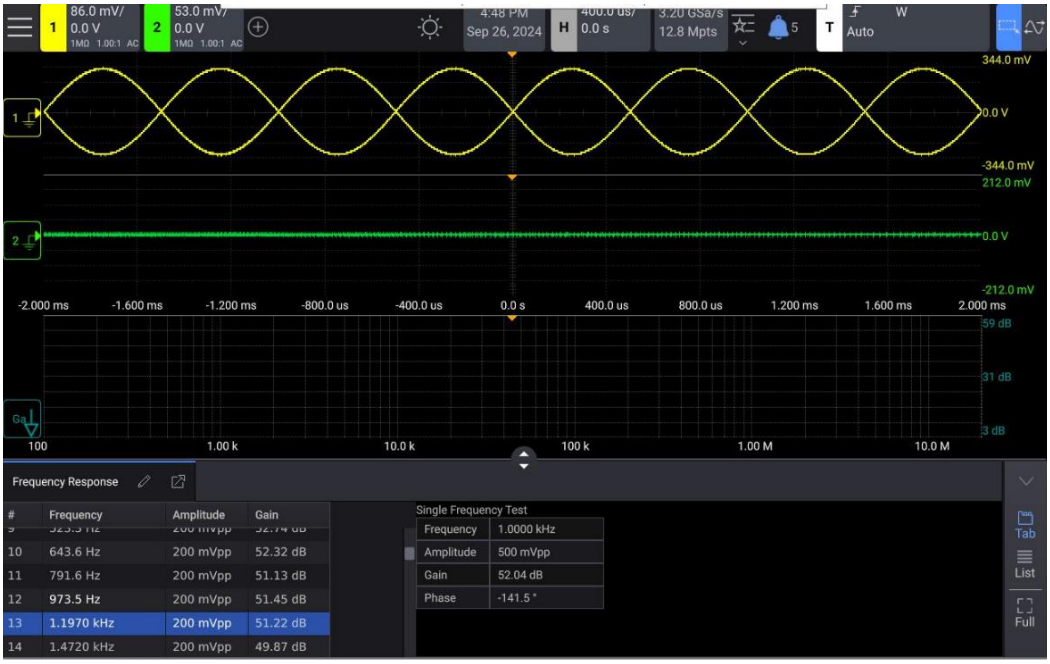


Figure 28: Run single-frequency tests while manually adjusting amplitude and frequency in the oscilloscope's WaveGen settings menu

7. Summary:

We have demonstrated a simple method for measuring LDOs using the Picotest signal injector and Keysight's HD304MSO InfiniiVision.

Using Keysight's HD304MSO InfiniiVision oscilloscope makes it easier to test the PSRR of devices, allowing you to see distortion in input and output signals during testing, facilitating adjustments to testing parameters for more accurate test results.