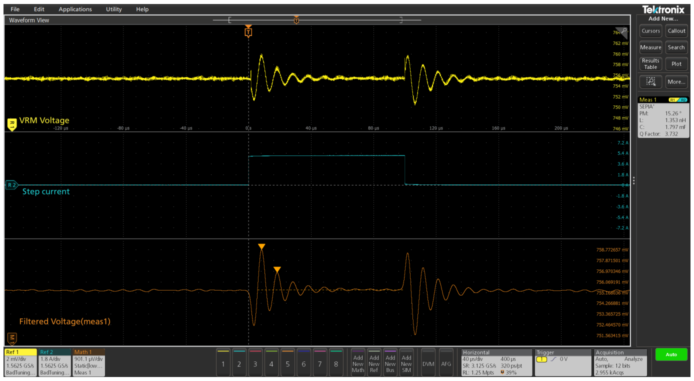
# Power Distribution Network Measurement and Stability Analysis

## 4/5/6 Series B MSO Option 4/5/6-PDN Application Datasheet




Modern electronic systems rely on complex Power Distribution Networks (PDNs), where stability, impedance, and power rail noise directly impact system's performance. Ensuring robust power distribution is critical for reliable operation, especially in designs with tightly regulated voltage rails and fast dynamic load conditions.

The PDN Analysis Software option for the 4/5/6 Series B MSO provides a comprehensive, oscilloscope-based solution for power integrity validation and debugging. It enables engineers to quickly evaluate control loop stability, characterize impedance, and analyze power rail behavior without breaking the loop or requiring a dedicated external instrumentation like Vector Network Analyzer (VNA) or Frequency Response Analyzer.

At its core, the solution focuses on Power Integrity (PI) analysis, combining automated measurements such as:

- Control Loop Response (Bode)
- Power Supply Rejection Ratio (PSRR)
- 2-port Impedance
- Stability Evaluation for Power Integrity Analysis (SEPIA)

These measurements provide both frequency-domain and time-domain insights into PDN performance using multi-channel and multi-domain signal views, helping engineers identify resonances, evaluate transient response, and ensure stable regulator operation under real-world conditions.

In addition to PI analysis, the software extends into system-level validation by correlating power rail behavior with signal performance using Power Supply Induced Jitter (PSIJ). This enables engineers to understand how power noise propagates into high-speed signals and impacts overall system integrity.

By integrating these capabilities within a single oscilloscope platform with multi-channel and multi-domain analysis, this solution provides intuitive workflows, and advanced analysis tools for PDN engineers, which simplifies measurement setup, accelerates debug cycles, and provides a unified view of both power performance and its impact on system behavior.

## Key measurements and Features

### Power Integrity Analysis

- **Control Loop Response (Bode):**
  Measures gain and phase across frequency to evaluate loop stability and automatically calculate gain and phase margins. The measurement runs directly on the oscilloscope using internal or external stimulus, eliminating the need for a separate frequency response analyzer and simplifying setup.
- **Power Supply Rejection Ratio (PSRR):**
  Quantifies how effectively a regulator attenuates input ripple across frequency. Automated sweep and analysis allow quick evaluation of ripple rejection performance.
- **2-port Impedance:**
  Characterizes PDN impedance over frequency to verify target impedance and identify resonances. Integrated frequency sweep and multi-channel acquisition provide accurate measurement of low-impedance networks directly on the board.
- **SEPIA (Stability Evaluation for Power Integrity Analysis):**
  Uses time-domain load step response to extract stability metrics and estimate phase margin, Q factor, and derive an equivalent RLC model for netlist export. This approach simplifies stability analysis under real operating conditions without breaking the control loop or injecting signals, which is critical for datacenter PDNs.

### Signal Integrity-Power Integrity (SI/PI) Analysis

- **Power Supply Induced Jitter (PSIJ):**
  Correlates power rail noise with jitter in high-speed signals, enabling analysis of how power integrity impacts signal integrity. Built-in jitter correlation and filtering techniques help isolate the contribution of noise from power rails into overall signal degradation.

These measurements leverage the integrated Spectrum View of the MSO oscilloscopes to provide fine frequency resolution across user-configurable bands, improving visibility into noise and resonance behavior and enhancing overall measurement accuracy.

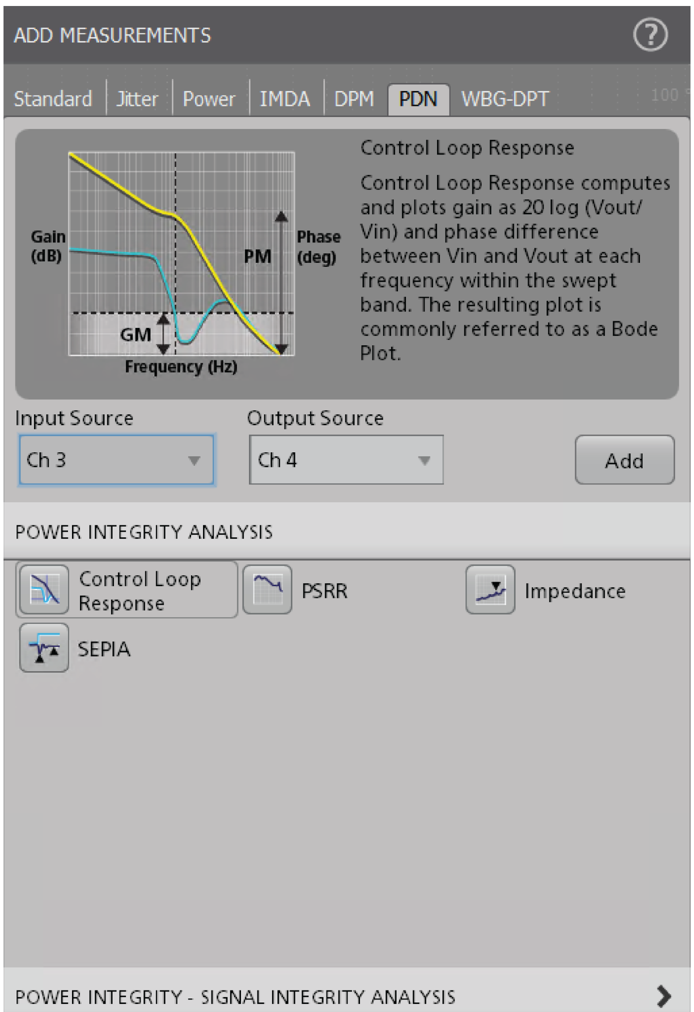
## Key applications

Power integrity analysis is critical in modern system-on-chip (SoC) and high-performance microprocessor designs, where multiple voltage rails and tightly coupled subsystems must operate reliably under dynamic load conditions. Ensuring that each power rail meets target impedance and stability requirements is essential to maintain proper VRM operation and overall system performance, especially under fast transient loads.

PDN characterization is increasingly important across applications that demand high-current delivery, low impedance, and tight transient response, including:

- Data center and AI infrastructure (CPU, GPU, ASIC power delivery)
- Computing platforms (servers, laptops, and high-performance systems)
- Automotive electronics (ECUs, ADAS, EV power systems)
- Industrial and embedded systems

## Measurement overview



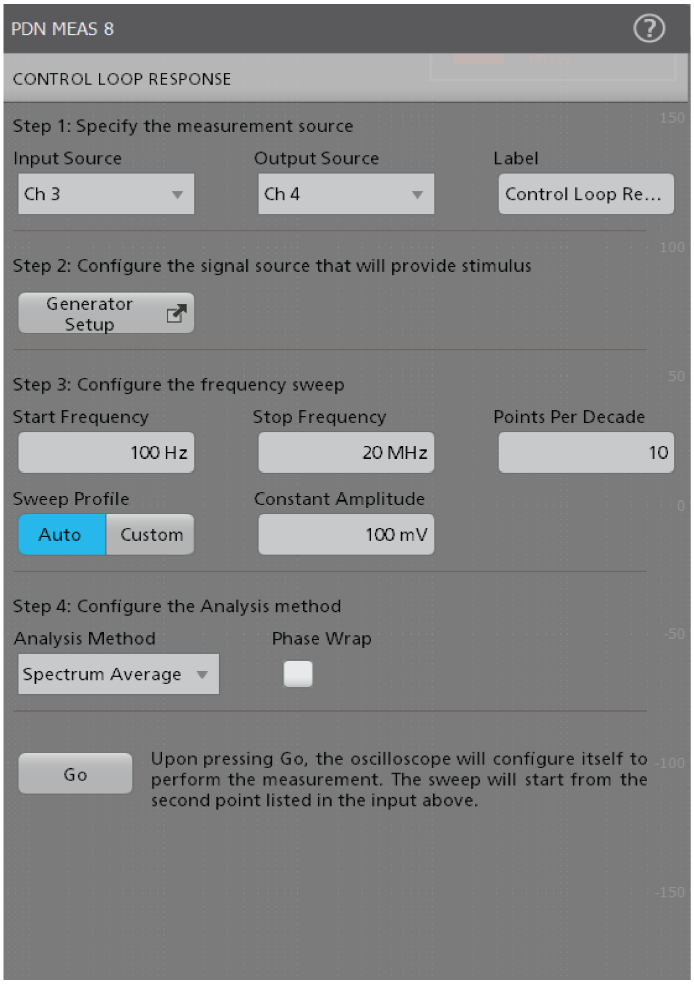
## Control Loop Response (Bode plots)

Bode plots and gain/phase margin measurements enable designers to determine the stability of a power supply control loop. Unstable control loops lead to oscillations and inefficient performance. Filter designers also use amplitude and phase plots to test filter designs.

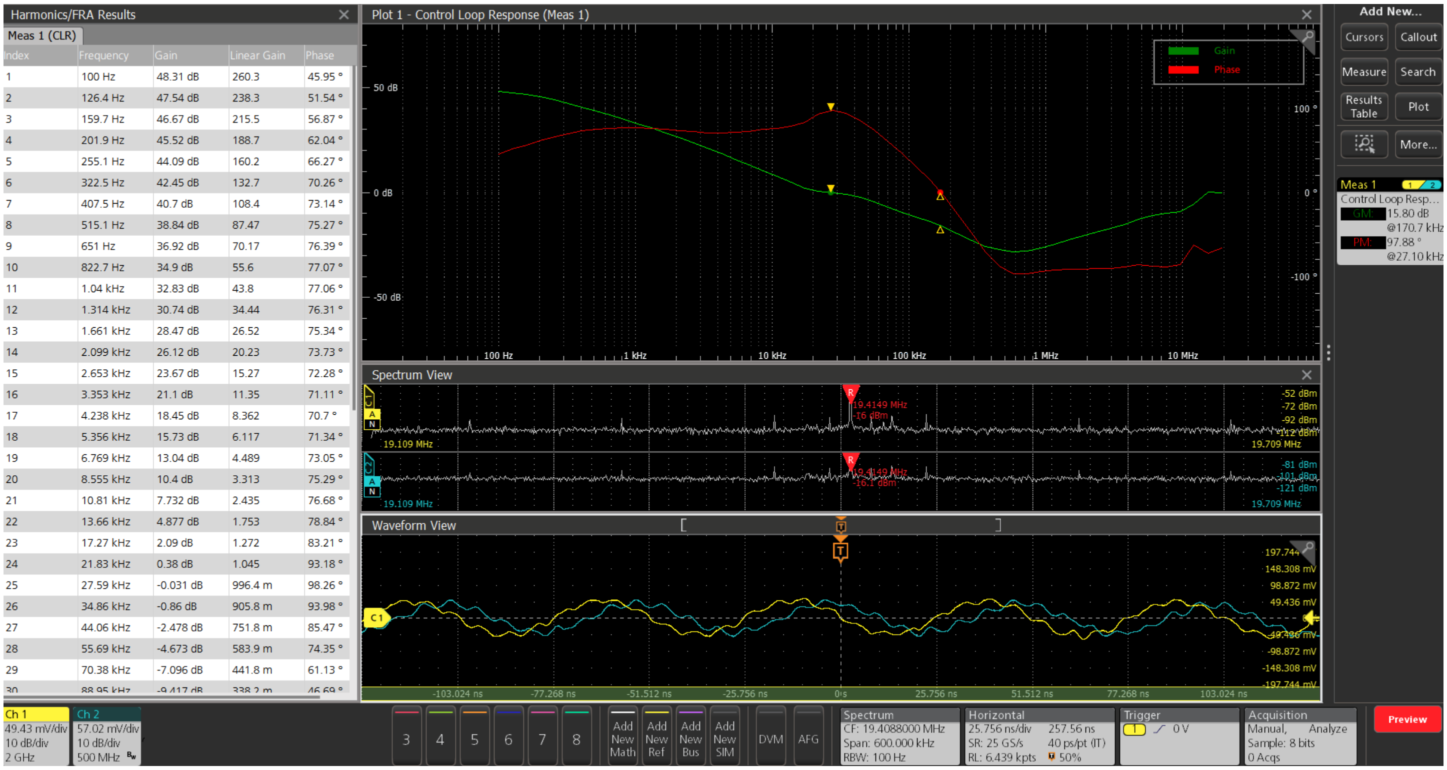
Automated Control Loop Response measurements use the built-in AFG of the oscilloscope or Tektronix AFG31000 series function generator to provide a signal source to sweep through a specified frequency range, plotting amplitude and phase at each point. Signals are introduced into the control loop using an injection transformer, such as the J21xxA models from Picotest. The resulting gain and phase plots (Bode plots) are used to automatically calculate gain and phase margins. Cursors allow you to view gain and phase values at any frequency on the curves.

Control loop response measurement configuration allows you to set START and STOP frequencies, select constant/amplitude profile, impedance, phase wrap, analysis method as FFT, Spectrum Average, and Spectrum Normal, and points per decade for better plot rendering.

Phase wrap configuration allows you to unwrap the phase trace where it jumps more than the number of degrees set in the adjacent field. The default phase is set to 180°.



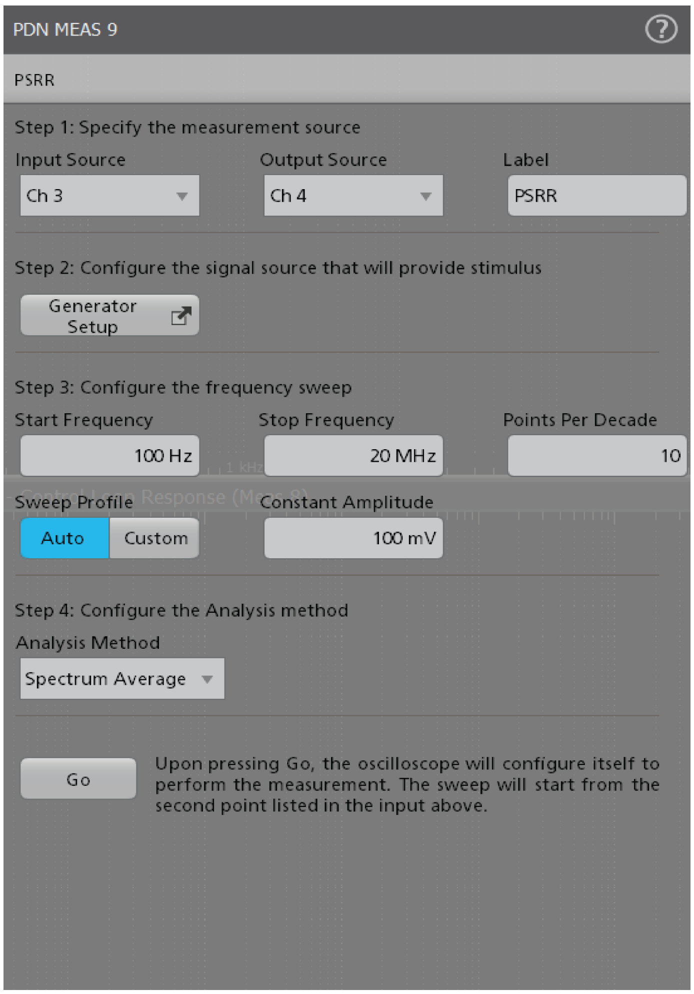

***Bode plot measurement allows you to set START and STOP frequencies, supporting both oscilloscope internal and external function generators, select amplitude profile, phase wrap, different analysis methods and choose ppd for better plot rendering.***



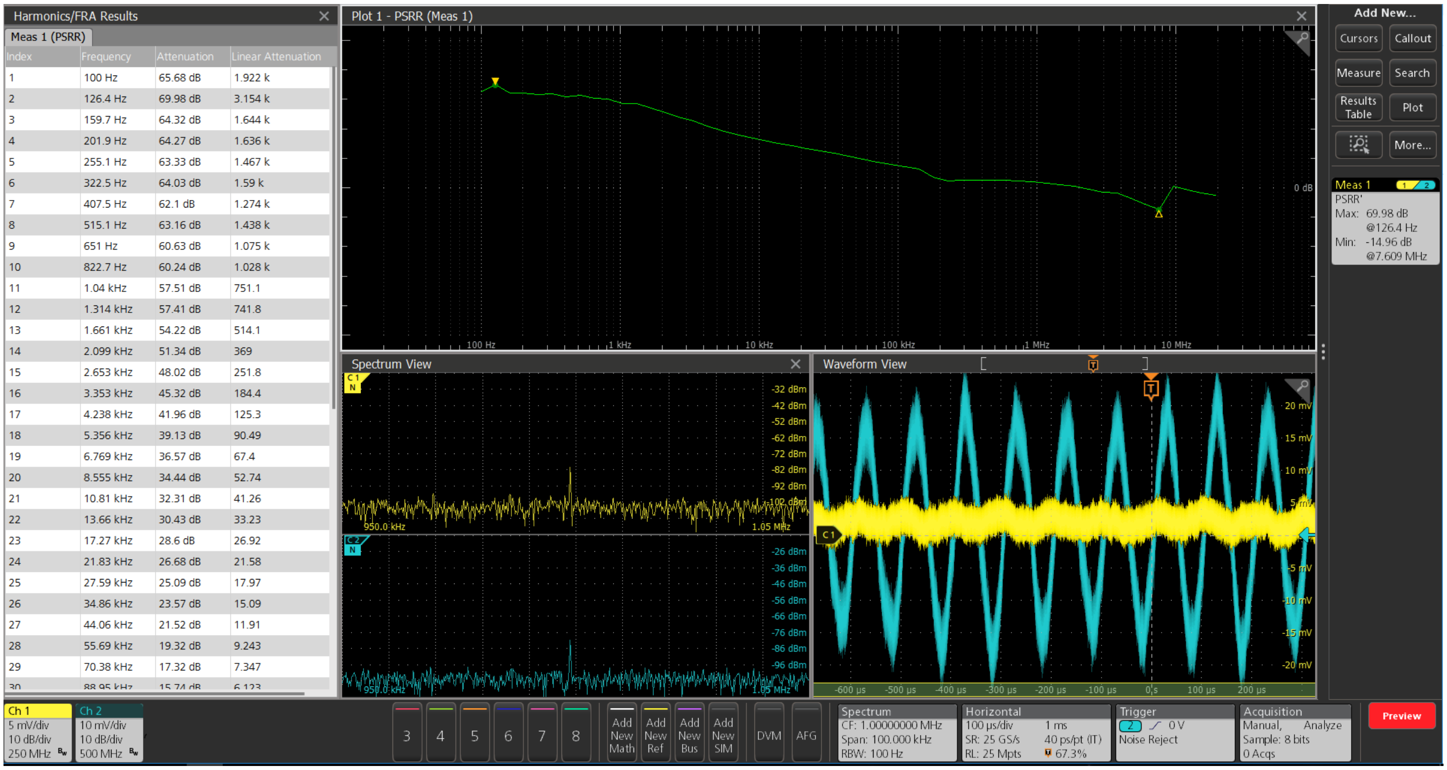

***Control Loop Response (Bode plot) plots gain and phase versus frequency and calculates the gain margin and phase margin.***

## Power Supply Rejection Ratio(PSRR)

The PSRR measurement enables designers of DC-DC converters and regulators to quantify the ability of devices to attenuate AC over a specified frequency range. The test uses the optional, built in function generator of the 4/5/6 Series B MSO or an external Tektronix AFG31000 function generator, along with an injection transformer (such as the Picotest J2120A Line Injector), to modulate the input to the regulator. The system automatically measures the AC voltage at both the modulated input and output. It calculates the rejection ratio as 20Log (Vin/Vout) at each frequency within the swept band, and plots the result.



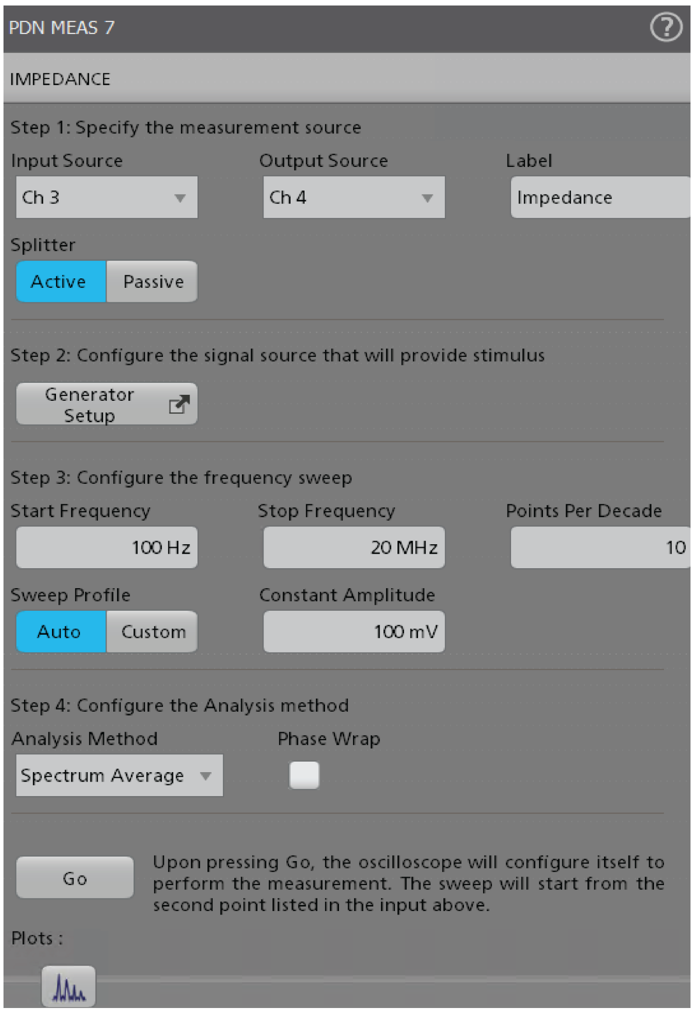

***PSRR measurement allows you to set START and STOP frequencies of internal or external generator, select constant amplitude profile, impedance, analysis method as spectrum view or FFT, and points per decade for better plot rendering.***



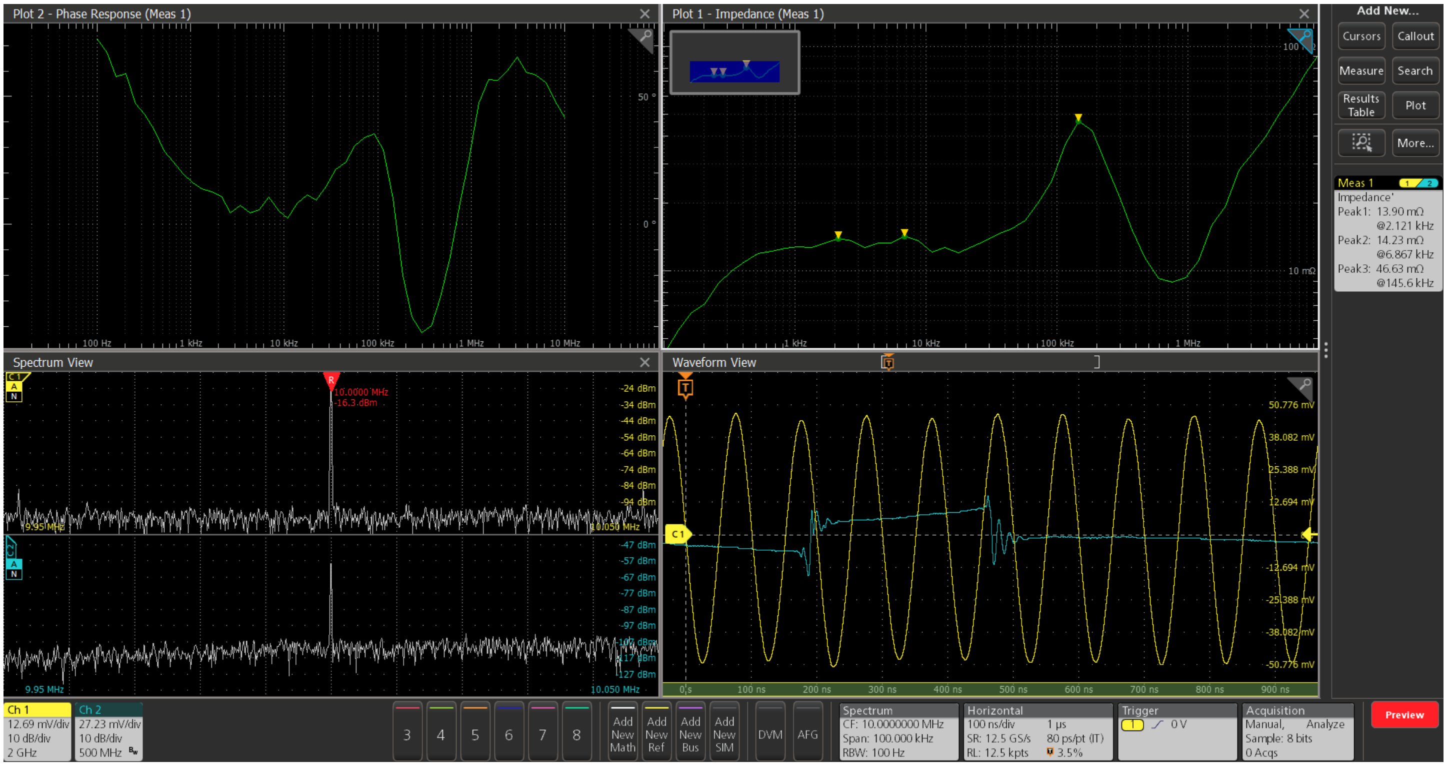
***Power Supply Rejection Ratio (PSRR) plots the rejection ratio over frequencies and annotates the min and max values.***

## Impedance measurement

The 2-port impedance measurement enables designers to verify the impedance of their Power Distribution Network (PDN) over a specified frequency range. The test uses the optional built-in function generator of 4/5/6 Series B MSO or an external Tektronix AFG31000 Series function generator, along with an active splitter J2161A (needs power supply J2170B) an injection transformer (such as the Picotest J2102B or J2113A line injector) to measure the impedance of the PDN network. The system automatically calculates the impedance at each frequency of the swept band, and plots the results. BNC or a direct SMA connection is recommended.



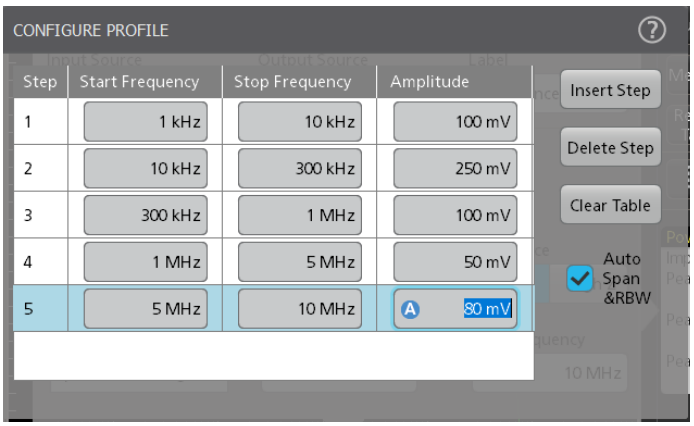

***2-port Impedance measurement allows you to set START and STOP frequencies of internal or external generator, select constant/amplitude profile, phase wrap, analysis method as spectrum view or FFT, and points per decade for better plot rendering.***




***Impedance measurement with results table and results badge displaying values for the peak impedance points. Corresponding impedence plot, Group Delay plot, and Phase plot are also shown.***

## Amplitude Profile configuration for Control Loop Response, PSRR, and Impedance Measurements

The configure profile menu enables precise amplitude profiling for Power Supply Rejection Ratio (PSRR), Control Loop Response (Bode), and Impedance measurements. Customize the internal or external generator's amplitude across frequency ranges to match DUT sensitivity at lower amplitudes near critical crossover points and higher amplitudes elsewhere. This is beneficial especially for power supplies, which are highly sensitive near the zero-degree crossover frequency. Profiling ensures minimal distortion and optimized measurement accuracy compared to constant amplitude signals.



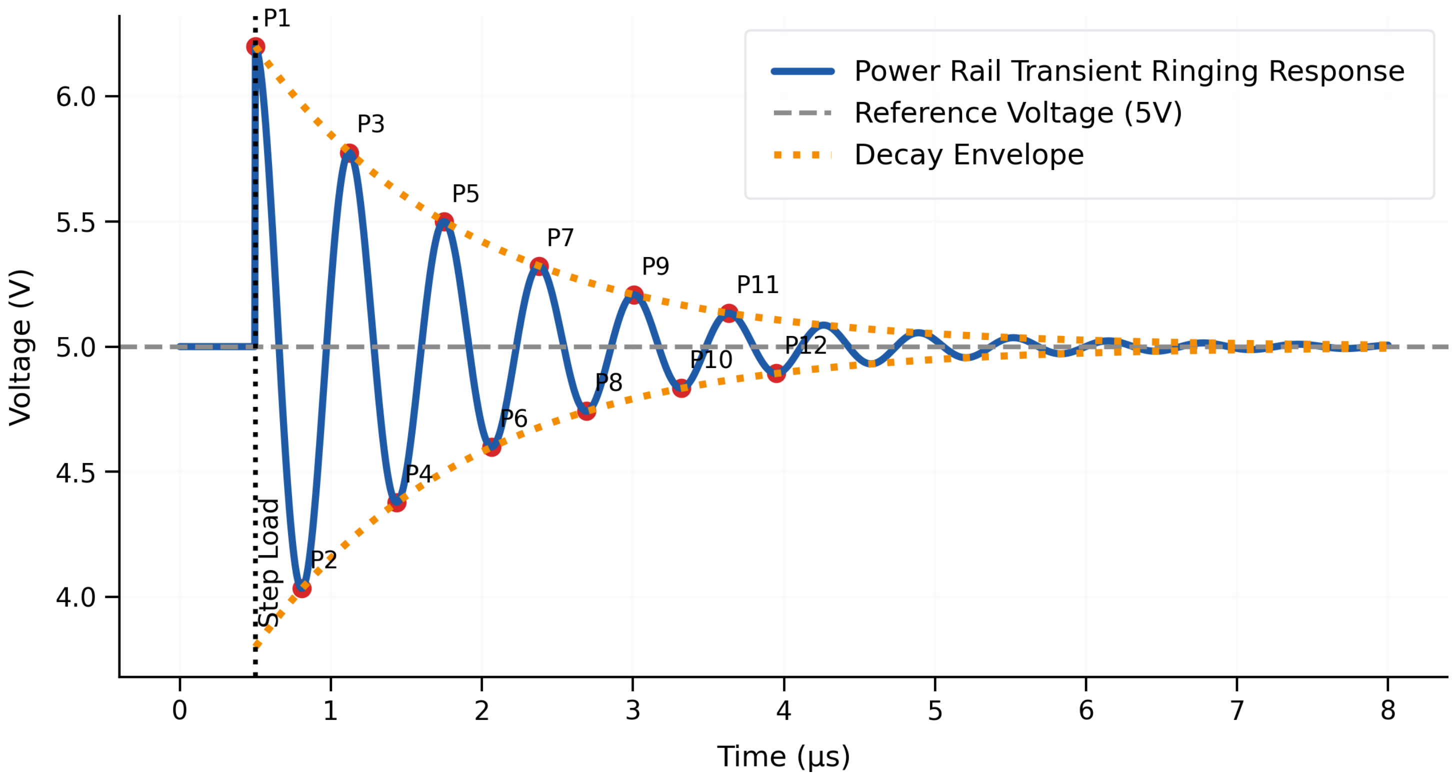

***Configure amplitude at required start and stop frequencies. Span and RBW can be configured in spectrum view analysis method.***

## SEPIA -Stability Evaluation for Power Integrity Analysis

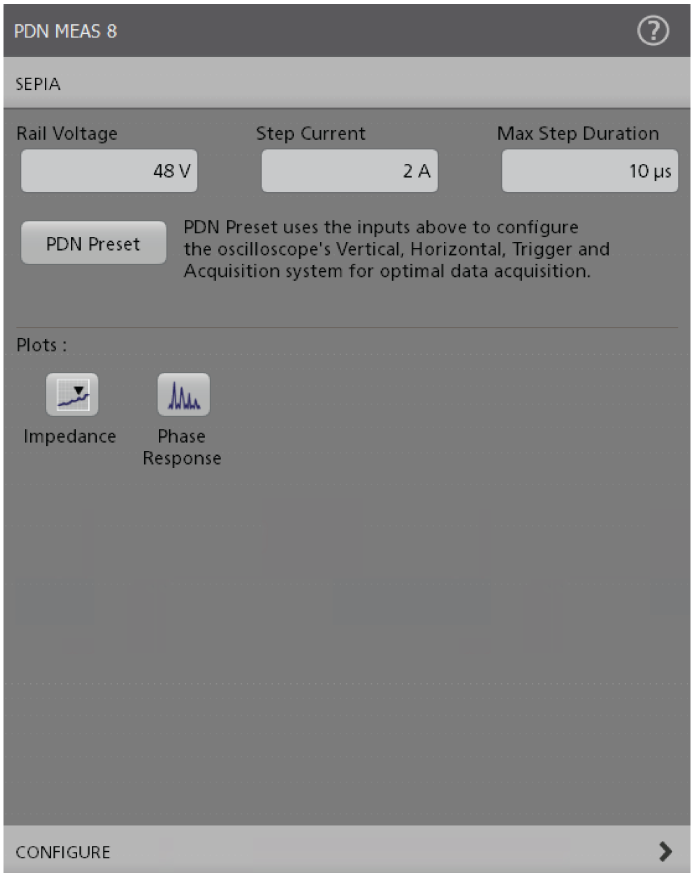
SEPIA by Picotest is a time-domain technique that extracts stability metrics and a compact R-L-C equivalent model from a measured step-load response. A second-order dominant system produces a ringing waveform, whose decay rate and number of peaks are determined by the quality factor Q. Accordingly, Q is estimated from the damped transient response. This makes SEPIA, also called Scope Embedded Power Integrity Analysis, well suited for non-linear, time-variant VRMs where Bode analysis is no longer reliable.

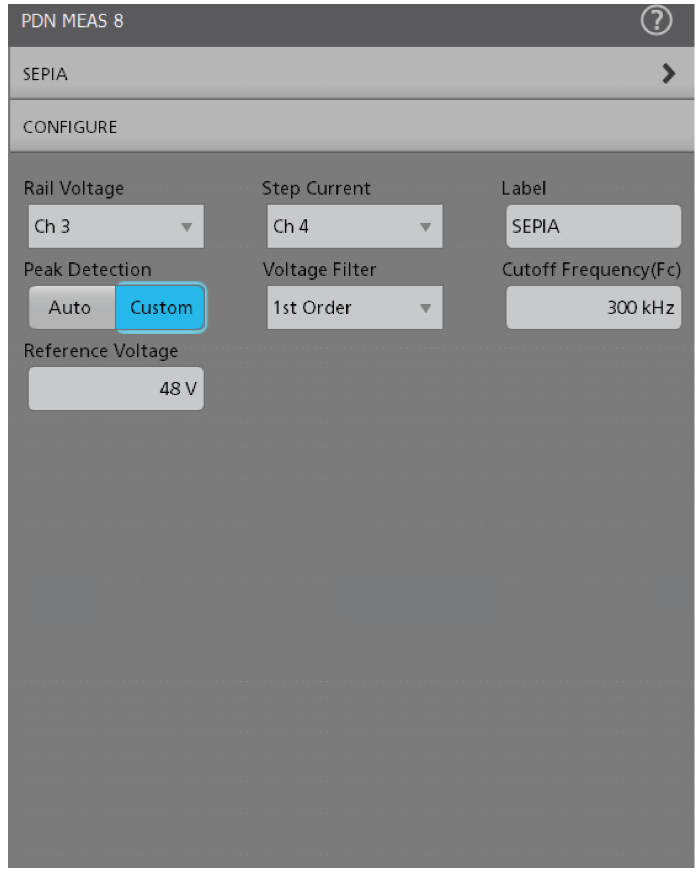
Because VRM voltage outputs contain ripple and noise, an IIR filter is used to isolate valid peaks and valleys. The Transient regions are identified from voltage edges. In Auto mode, peaks and valleys are detected statistically using an algorithm-derived reference voltage. Higher order behavior is identified from ringing characteristics and compensated accordingly, with only dominant peaks retained. In custom mode, you must select consecutive peaks or valleys consistently; a user-defined reference voltage is then used to determine relative amplitudes.

SEPIA measurement outputs impedance and phase response plots across the entire frequency band which can be used to analyze behavior of the PDN at different frequencies.

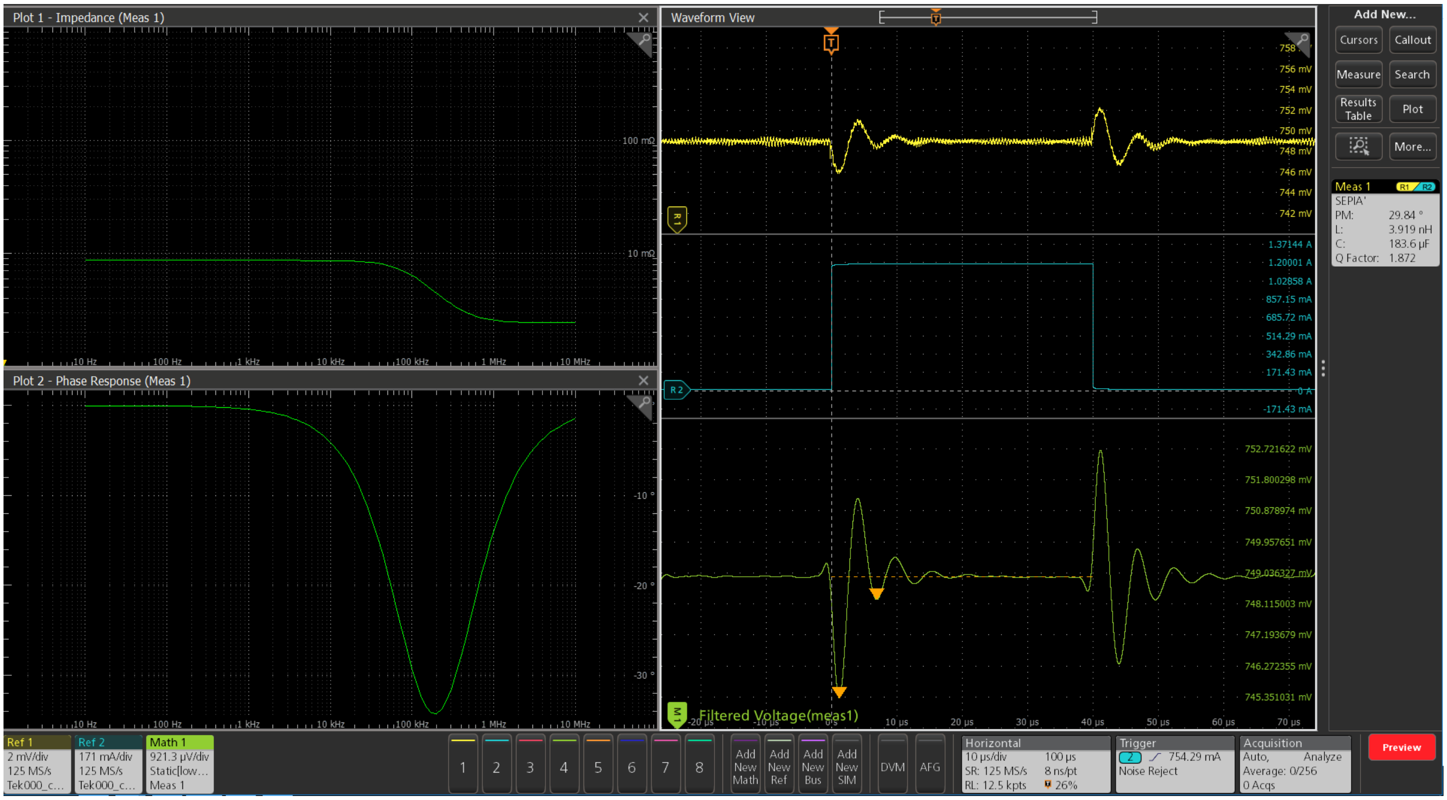



*Example of 5V power rail (VRM) output transient ringing response.*




***SEPIA measurement setup with rail voltage and step current inputs, displaying selectable impedance and phase response plots for transient stability analysis.***




***SEPIA measurement with results table and results badge displaying values for the PM, L, C and Q. Corresponding Impedence plot and Phase plot are also shown.***

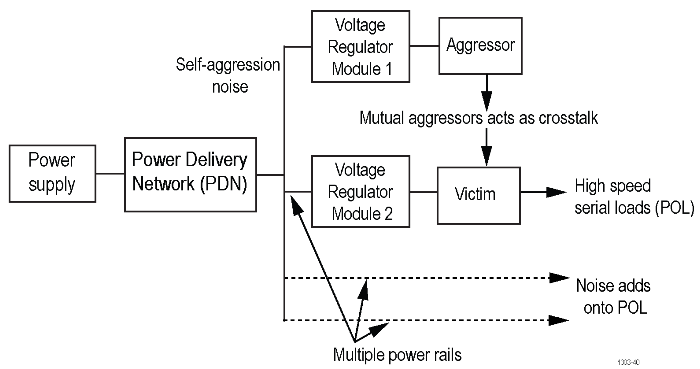
## Power Integrity and Signal Integrity Analysis

### Power Supply Induced Jitter(PSIJ)

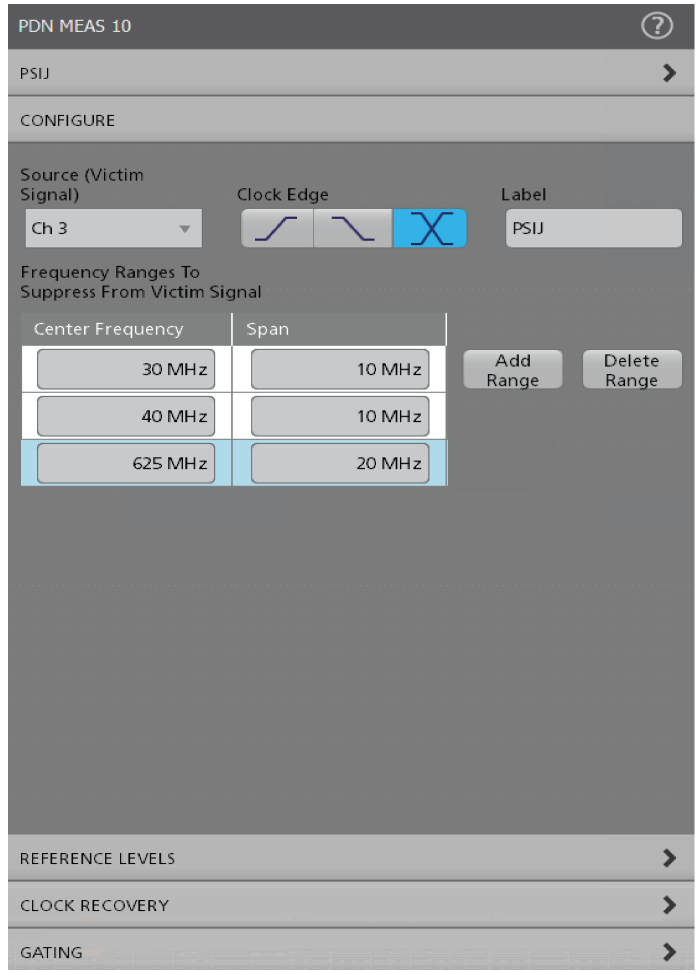
The PSIJ (Power Supply Induced Jitter) is the key SI/PI measurement that acts as a tool that gives insights and confidence to High Speed Serial (HSS) design engineers to improve designs before making any power related (hardware) changes during the prototyping phase.

This measurement has two goals:

- To identify jitter caused by the power rail noise
- To suppress jitter on HSS waveform and see the improvement in the signal quality

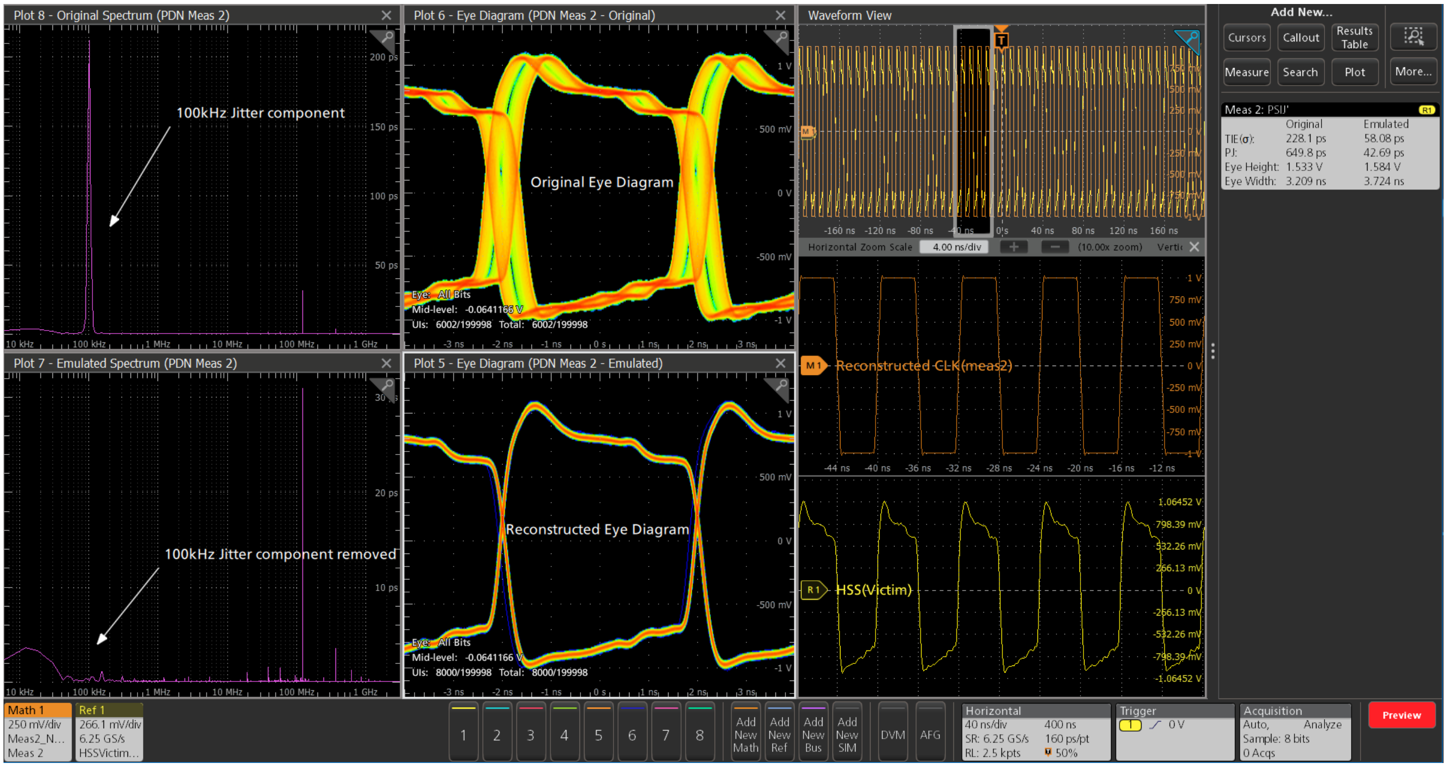



***The image shows a multi-rail example of the effect of noise with various points of loads (POL) such as DDR memory, PCIe, etc.***




The PSIJ measurement correlates periodic jitter (PJ) component in high-speed signals (victim) with the power supply (aggressor) rail noise using the jitter suppression technique. The jitter suppression algorithm filters out the specified frequencies from the victim signal which were induced from the power rail source. Configure the notch filter with the center frequency that needs to be suppressed from the victim signal. The span of notch filter is an absolute value which specifies spread of notch filter around the center frequency and span. Up to 12 notch filter settings can be configured. It is recommended to run the PSIJ measurement with a constant clock recovery method. The spectrum plots of the HSS before and after filtering out the power rail noise helps to validate the improvement in signal quality. This can also be verified by adding eye diagram plot on the HSS signals.

The measurement gives out essential results such as eye height, eye width, PJ, and TIE of the original and emulated signals.




***The image shows improvement in PSIJ results after removing the jitter which was added by the power rail source.***

## Report generation

Data collection, archiving, and documentation can be tedious, but they are critical in the design and development process. 4-PDN, 5-PDN, and 6-PDN analysis software includes an automated report generator to facilitate communication and record-keeping. Press a few buttons and generate a report showing all active measurements. Add plots or append additional tests to customize your reports. Reports are available as editable .mht files, or .pdf files. A sample report is shown below.

**Measurement Report**

2026-06-26T12:26:20+05:30

**Setup Configuration**

| Scope Details | | | |
|---|---|---|---|
| **Scope Model Number** | **Scope Serial Number** | **TekScope Version** | **Scope Calibration Status** |
| MSO58 | Q100086 | 2.26.13 | Pass |

| Probe Details - CH1 | | |
|---|---|---|
| **Probe Type** | **Probe Serial Number** | **Probe Cal Status** |
| TPR4000 | D011787 | Default |

| Probe Details - CH3 | | |
|---|---|---|
| **Probe Type** | **Probe Serial Number** | **Probe Cal Status** |
| TPP1000 | C006938 | Default |

| Probe Details - CH4 | | |
|---|---|---|
| **Probe Type** | **Probe Serial Number** | **Probe Cal Status** |
| TPP1000 | QU00246 | Default |

**Waveform Histogram Results**

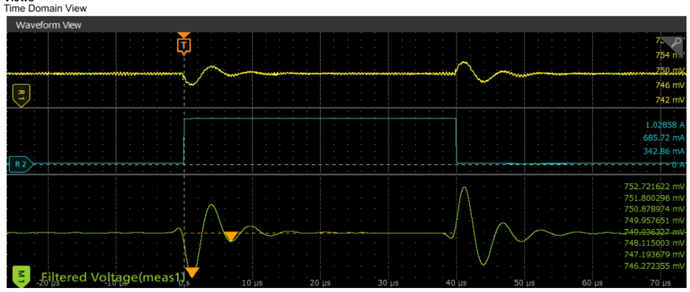
No Waveform Histogram Results Available

**Measurement Results**

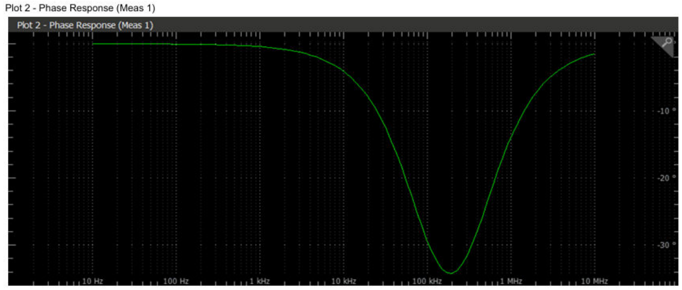
| Name | Measurement | Src(s) | Mean' | Min' | Max' | Pk-Pk' | Std Dev' | Population' | Accum Mean | Accum Min | Accum Max | Accum Pk-Pk | Accum Std Dev | Accum Pop |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PDN Meas 1 - SEPIA | Phase Margin | Ref 1,Ref 2 | 29.836 Degrees | 29.836 Degrees | 29.836 Degrees | 0.0000 Degrees | 0.0000 Degrees | 1 | 29.836 Degrees | 29.836 Degrees | 29.836 Degrees | 0.0000 Degrees | 0.0000 Degrees | 1 |
| | L | | 3.9190 nH | 3.9190 nH | 3.9190 nH | 0.0000 H | 0.0000 H | 1 | 3.9190 nH | 3.9190 nH | 3.9190 nH | 0.0000 H | 0.0000 H | 1 |
| | C | | 183.56 uF | 183.56 uF | 183.56 uF | 0.0000 F | 0.0000 F | 1 | 183.56 uF | 183.56 uF | 183.56 uF | 0.0000 F | 0.0000 F | 1 |
| | Q Factor | | 1.8720 | 1.8720 | 1.8720 | 0.0000 | 0.0000 | 1 | 1.8720 | 1.8720 | 1.8720 | 0.0000 | 0.0000 | 1 |

**Views**

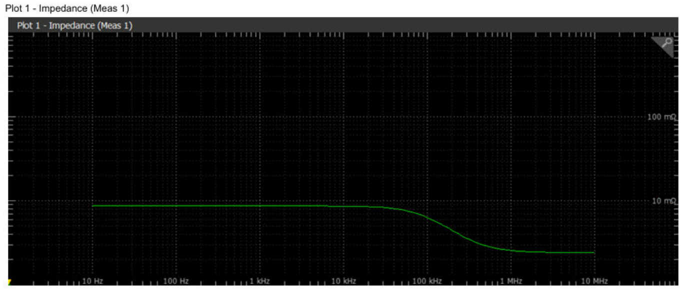
Time Domain View




Plot 2 - Phase Response (Meas 1)




Plot 1 - Impedance (Meas 1)




**Global Configuration**

| Standard Configuration | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Gating** | **Display Unit Type** | **Standard Reference Levels** | **Jitter Separation Model** | **Dual Dirac Model** | **Jitter Reference Levels** | **Lock RJ** | **Jitter Analysis Method** | **DDJ Separation Method** |
| None | Seconds | Every Acquisition | SpectralOnly | PCIExpress | First Acquisition | False | JitterOnly | SpectralDomain |

**Reference Levels Configuration**

| Ref Levels | Ref 1, Ref 2 |
|---|---|
| Ref Level Type | Global |
| Base Top Method | Automatic |
| RiseHigh | 90% |
| RiseMid | 50% |
| RiseLow | 10% |
| FallHigh | 90% |
| FallMid | 50% |
| FallLow | 10% |
| Hysteresis | 5% |

| PDN Meas 1 - SEPIA | | | | | |
|---|---|---|---|---|---|
| Ref Levels | | Configurations | | Gating | |
| Ref Level Type | Global | Custom Measurement Name | SEPIA | Gating Type | None |
| Source(s) | Ref 1,Ref 2 | Peak Detection | Custom | | |
| | | Voltage Filter | Second | | |
| | | Cutoff Frequency(Fc) | 500.00 kHz | | |
| | | Reference Voltage | 748.90 mV | | |

# Specifications

## Measurements

| Measurement | Description |
|---|---|
| Control Loop Response | Measures gain (20 log(Vout/Vin)) and phase versus frequency across the swept range.<br>Frequency sweep: 10 Hz to 50 MHz using the oscilloscope's internal AFG, 10 Hz to the maximum frequency of an external AFG31000 Series generator.<br>Dynamic range: typically 55 dB.<br>Probes supported: single-ended measurements with TPP0502 probes (recommended) and differential measurements using TDP Series differential probes.<br>Signal source: oscilloscope's internal AFG (up to 5 V) or an external AFG 31000 Series generator (up to 10 Vpp).<br>Requires Picotest isolation and injector transformers. |
| PSRR | Measures both the modulated input and output AC voltage levels and plots the rejection ratio as 20 log (Vin/Vout) at each frequency within the specified band.<br>PSRR dynamic range is typically 85 dB. |
| Impedance | Measures and plots the two-port impedance at each frequency within the swept band.<br>2-port Impedance requires a BNC or Direct SMA cable with DC block.<br>Frequency: 10 Hz to 50 MHz for internal AFG and 10 Hz to maximum frequency of AFG31000 Series in case of external.<br>Minimum impedance can be measured is 10 mΩ and maximum is 47 Ω. |
| SEPIA | SEPIA evaluates power supply and VRM stability by extracting frequency-domain information from a time-domain voltage response to a step load.<br>It analyzes transient ringing to estimate an equivalent RLC model, providing insight into damping, resonance, and control-loop stability without breaking the loop. |
| PSIJ | PSIJ measurement to identify the periodic jitter introduced on the high-speed serial data due to the power rail noise. |

# Ordering information

## Models

| Product | Options | Supported instruments |
|---|---|---|
| New instrument order option | 4-PDN<br>5-PDN<br>6-PDN | 4 Series B MSO (MSO44B, MSO46B)<br>5 Series B MSO (MSO54B, MSO56B, MSO58B, MSO58LP)<br>6 Series B MSO (MSO64B, MSO66B, MSO68B) |
| Product upgrade option | SUP4-PDN<br>SUP5-PDN<br>SUP6-PDN | |
| Floating license | SUP4-PDN-FL<br>SUP5-PDN-FL<br>SUP6-PDN-FL | 4 Series B MSO (MSO44B, MSO46B) Floating licenses are transferrable from any 4 Series oscilloscope to any other 4 Series oscilloscope, for use of one instrument at a time.<br><br>5 Series B MSO (MSO54B, MSO56B, MSO58B, MSO58LP) Floating licenses are transferrable from any 5 Series oscilloscope to any other 5 Series oscilloscope, for use of one instrument at a time.<br><br>6 Series B MSO (MSO64B, MSO66B, MSO68B) Floating licenses are transferrable from any 6 Series oscilloscope to any other 6 Series oscilloscope, for use of one instrument at a time. |

## Software bundles

| Bundle options | Supported instruments | Description |
|---|---|---|
| 4-PRO-POWER-1Y | 4 Series B MSO | 1 Year License Pro Power Bundle |
| 4-PRO-POWER-PER | | Perpetual License Pro Power Bundle |
| 4-ULTIMATE-1Y | | 1 Year License Ultimate Bundle |
| 4-ULTIMATE-PER | | Perpetual License Ultimate Bundle |
| 5-PRO-POWER-1Y | 5 Series B MSO | 1 Year License Pro Power Bundle |
| 5-PRO-POWER-PER | | Perpetual License Pro Power Bundle |
| 5-ULTIMATE-1Y | | 1 Year License Ultimate Bundle |
| 5-ULTIMATE-PER | | Perpetual License Ultimate Bundle |
| 6-PRO-POWER-1Y | 6 Series B MSO | 1 Year License Pro Power Bundle |
| 6-PRO-POWER-PER | | Perpetual License Pro Power Bundle |
| 6-ULTIMATE-1Y | | 1 Year License Ultimate Bundle |
| 6-ULTIMATE-PER | | Perpetual License Ultimate Bundle |

## Recommended probes and accessories

| **Measurement** | **Required accessories** | |
|---|---|---|
| | From Tektronix | From Picotest ([https://www.picotest.com/](https://www.picotest.com/)) |
| Control loop response (Bode plot) | TPP0502 passive probes – 2 Qty<br>Internal AFG option/AFG31000(for frequencies up to 250 MHz) | Isolation transformers<br>J2100A (for 1 Hz to 5 MHz operation)<br>J2101A (for 10 Hz to 45 MHz operation)<br>J2110A Solid State Injector (for DC to 45 MHz operation) |
| Power supply rejection ratio (PSRR) | TPP0502 passive probes – 2 Qty<br>Internal AFG option/AFG31000(for frequencies up to 250 MHz) | Line injector J2120A (for 10 Hz to 10 MHz operation) |
| 2-port Impedance | Internal AFG option/AFG31000(for frequencies up to 250 MHz) | P2102A-1X 2-Port PDN Probe, 1X Attenuation<br>J2102B Common Mode Transformer<br>J2161A 2-Way Wideband Active Splitter<br>PDN Cables: 2 – 1m SMA-Mini SMP (included with P2102A), 2 – 24" BNC-SMA (used for J2161A OUT2 to DUT and DUT to J2102B), 2 – 12" BNC-BNC (one cable goes from OUT1 of J2161A to oscilloscope input, the other goes from J2102B output to oscilloscope input), 1 – 1m BNC-BNC (goes from the AFG output to the J2161A input)<br>Port Saver DC Block – 2 Qty (required if the device is active and above 2 volts) |
| SEPIA | AFG31000 series/equivalent signal generator for load step generation<br>Tektronix Power rail probe (TPR1000/TPR4000)<br>Tektronix isolated current probe (TICP series) – optional | P2105A (S10 version) with load step head (choose load step head from 50 mΩ to 47 Ω range depending on test voltage and desired load current)<br>P2104A or P2105A for use with TICP Differential Probe: 1 Qty (Need 2 Qty if TICP probe is used for power rail voltage measurement)<br>J2115A Ground Loop Isolator: 1 Qty (mandatory with TPR probes, optional for TICP probes) |

## Certifications

Tektronix is registered to ISO 9001:2015 and ISO 14001:2015.

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