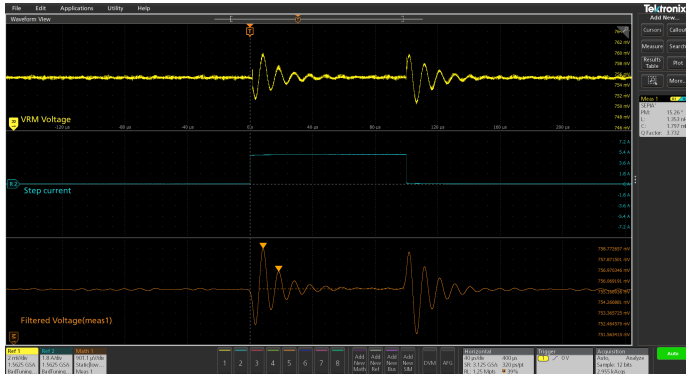


Power Distribution Network Measurement and Stability Analysis

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



Modern Power Distribution Networks (PDNs) demand more than traditional power integrity validation. Engineers must evaluate regulator stability, characterize impedance, analyze dynamic load behavior, and understand how power rail disturbances impact overall system performance. The PDN Analysis Software for Tektronix 4/5/6 Series B MSOs transforms the oscilloscope into a comprehensive power integrity analysis platform, combining frequency-domain, time-domain, and signal correlation techniques within a single workflow.

By integrating Power Integrity (PI), Power Integrity-Signal Integrity (PI-SI), and Large Signal Analysis, the software enables engineers to perform control loop analysis for linear time-invariant systems, apply SEPIA-based stability analysis to non-linear and time-varying power architectures, characterize PDN impedance, evaluate power rail noise coupling into high-speed signals, and correlate measured behavior with simulation models. A unified oscilloscope-based approach accelerates debug, reduces design risk, and provides deeper insight into real-world power delivery performance.

Key measurements

Power Integrity Analysis

- **Control Loop Response (Bode):** Measures gain, phase, and stability margins across frequency for linear, time-invariant control systems, enabling validation of regulator and filter stability using industry-standard frequency-domain analysis.
- **Power Supply Rejection Ratio (PSRR):** Evaluates a regulator's ability to reject input ripple and noise across frequency.
- **2-Port Impedance:** Characterizes PDN impedance, verifies target impedance compliance, and identifies resonances across the frequency spectrum.
- **SEPIA (Scope Embedded Power Integrity Analysis):** Uses time-domain load-step response to assess stability in non-linear, time-varying, and high-power PDNs where traditional Bode analysis may be impractical or less representative of

real operating conditions. Estimates phase margin, Q factor, and generates equivalent SPICE models for simulation and correlation.

Large Signal Analysis

- **d/dt:** Measures voltage and current slew rates to characterize transient behavior, switching events, and large-signal dynamic responses.

Power Integrity – Signal Integrity Analysis

- **Power Supply Induced Jitter (PSIJ):** Correlates power rail noise with jitter in high-speed signals, helping engineers understand and quantify the impact of power integrity on signal performance.

Key Features

- Supports for Math waveforms in FRA measurements, enabling analysis of de-embedded, differential, filtered, and custom-derived signals.
- Integrated Spectrum View for improved frequency resolution and visibility into noise and resonance behavior.
- Multi-channel, multi-domain analysis for correlated power, signal, and transient measurements.
- Exports measurement results and SEPIA-derived models for reporting, simulation, and design validation workflows.

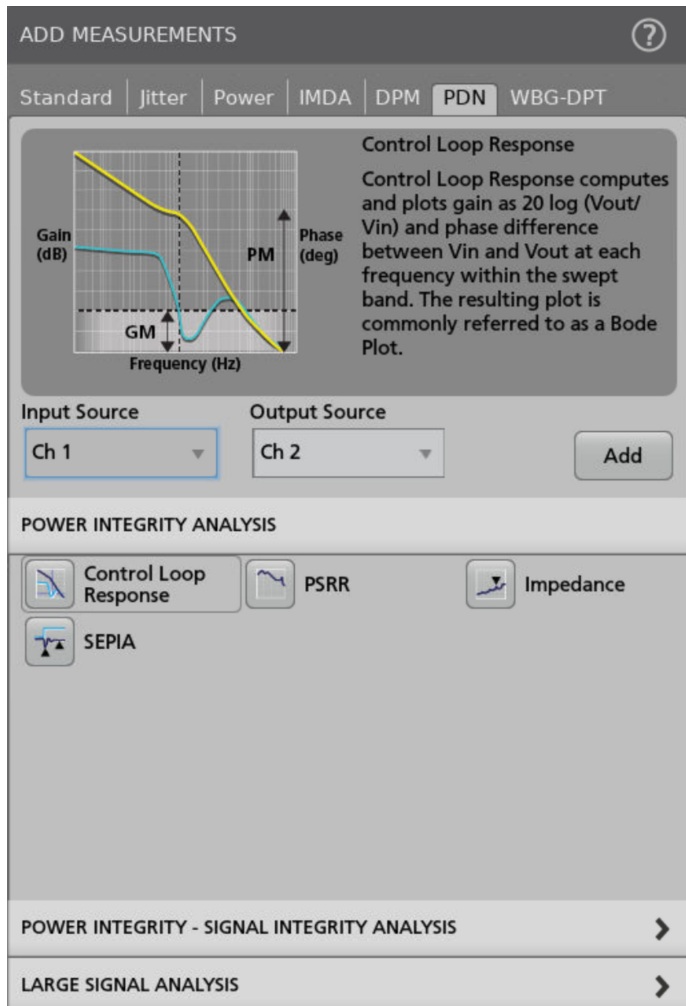
Key applications

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



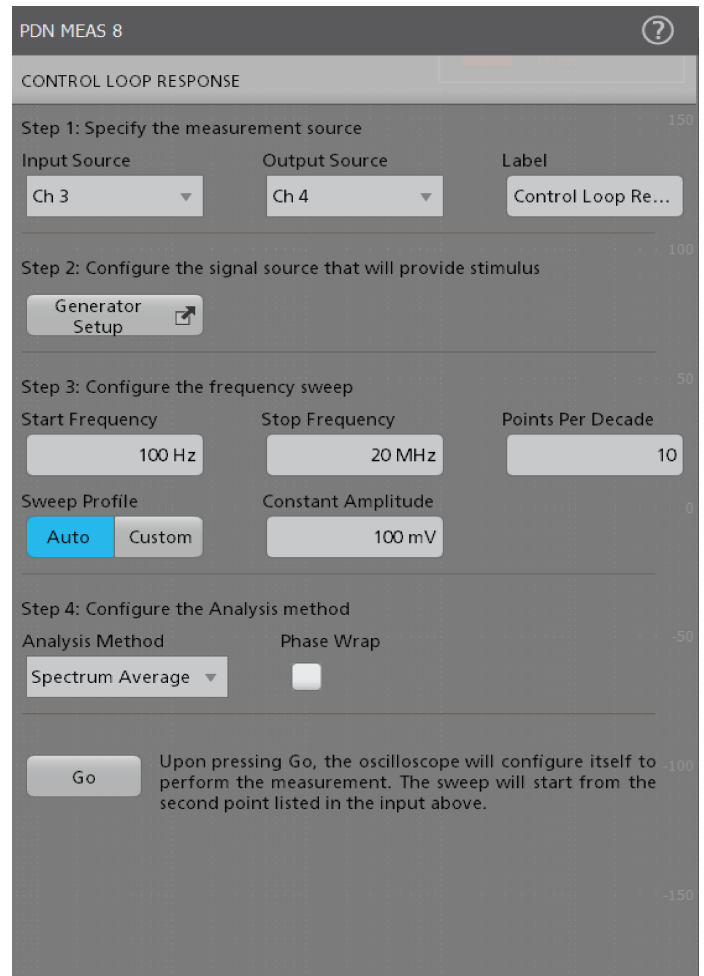
Control Loop Response (Bode plot)

Bode plot 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.

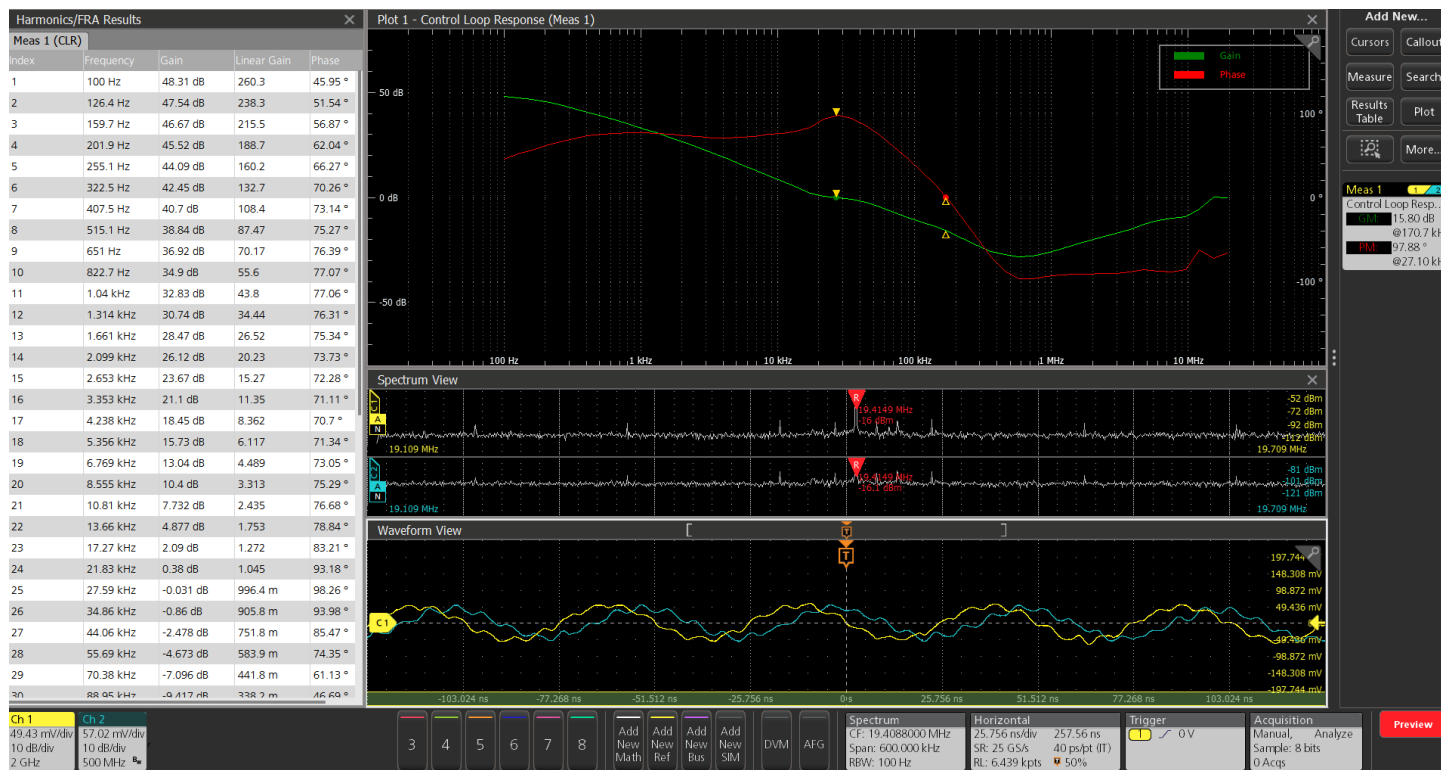
Automated Control Loop Response measurements use the built-in AFG of the oscilloscope or Tektronix AFG31000 series function generator to provide a signal source to sweep through a specified frequency range, plotting amplitude and phase at each point. Signals are introduced into the control loop using 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 $20\text{Log}(V_{in}/V_{out})$ at each frequency within the swept band, and plots the result.

PDN MEAS 9

PSRR

Step 1: Specify the measurement source

Input Source	Output Source	Label
Ch 3	Ch 4	PSRR

Step 2: Configure the signal source that will provide stimulus

Generator Setup

Step 3: Configure the frequency sweep

Start Frequency	Stop Frequency	Points Per Decade
100 Hz	20 MHz	10

Sweep Profile: Auto Custom

Constant Amplitude: 100 mV

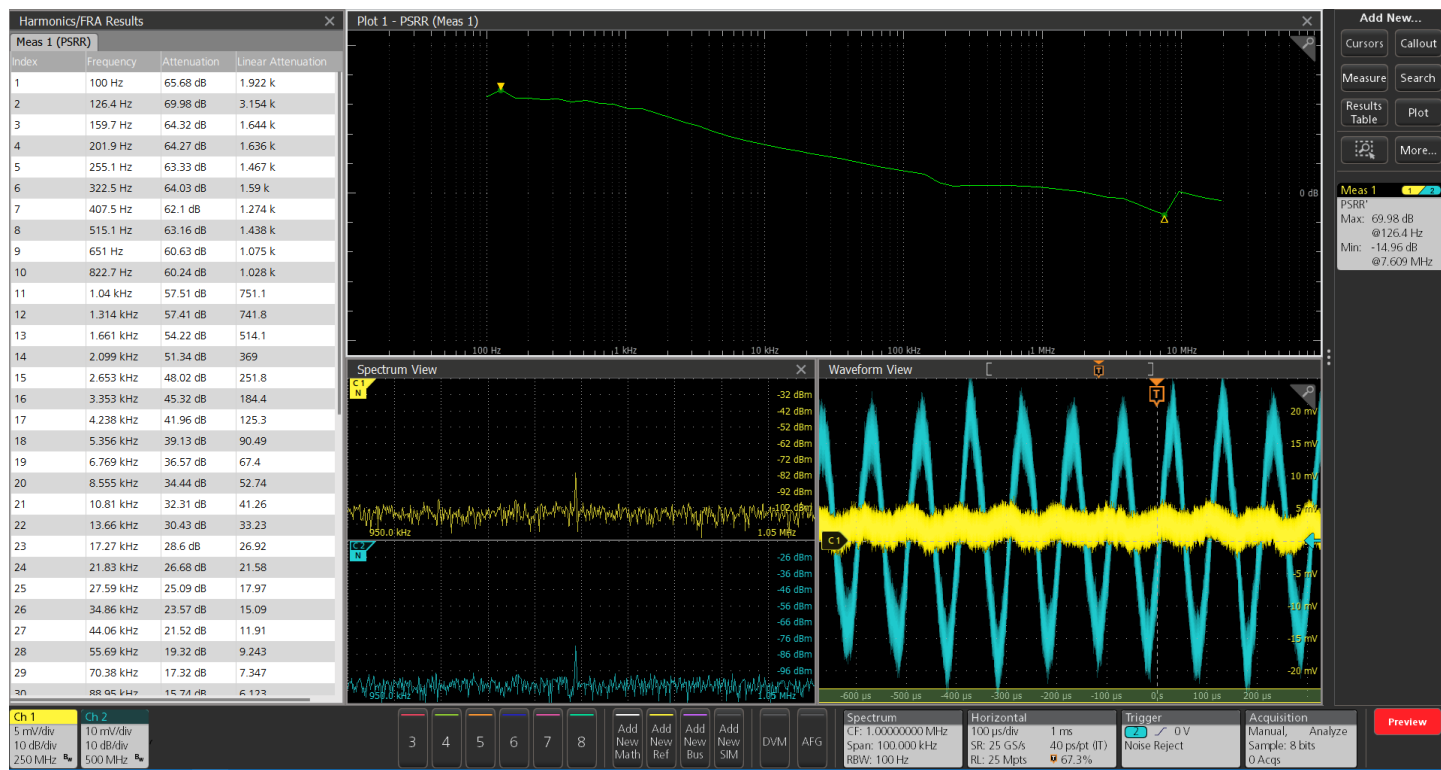
Step 4: Configure the Analysis method

Analysis Method: Spectrum Average

Go

Upon pressing Go, the oscilloscope will configure itself to perform the measurement. The sweep will start from the second point listed in the input above.

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

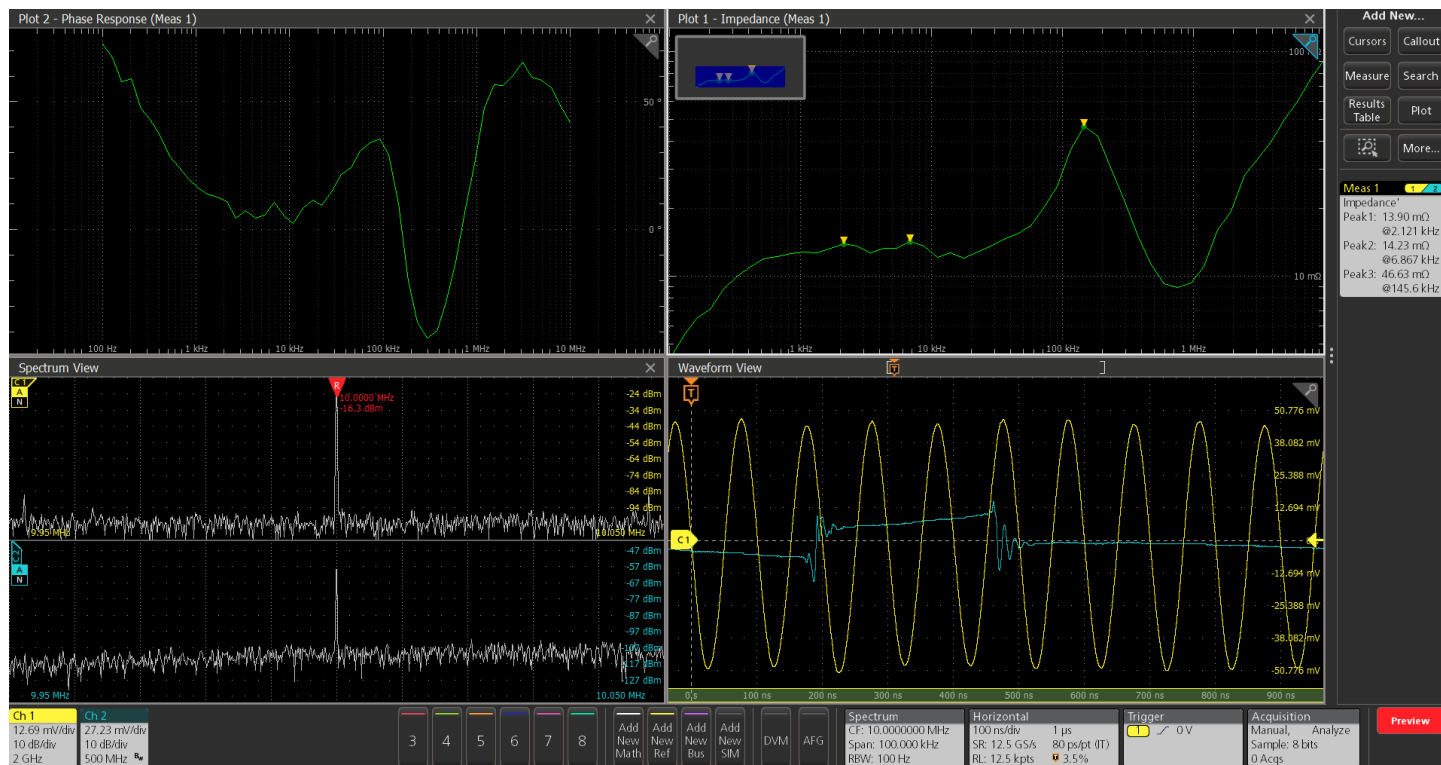
The 2-port impedance measurement enables designers to verify the impedance of their Power Distribution Network (PDN) over a specified frequency range. The test uses the optional built-in function generator of 4/5/6 Series B MSO or an external Tektronix AFG31000 Series function generator, along with an active splitter J2161A (requires power supply J2170B) and 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.

The screenshot shows the 'PDN MEAS 7' configuration window with a help icon in the top right. The window is titled 'IMPEDANCE' and is divided into four steps:

- Step 1: Specify the measurement source**
 - Input Source:** Ch 3 (dropdown)
 - Output Source:** Ch 4 (dropdown)
 - Label:** Impedance (text field)
 - Splitter:** Active (selected button), Passive (button)
- Step 2: Configure the signal source that will provide stimulus**
 - Generator Setup:** (button with icon)
- Step 3: Configure the frequency sweep**
 - Start Frequency:** 100 Hz (text field)
 - Stop Frequency:** 20 MHz (text field)
 - Points Per Decade:** 10 (text field)
 - Sweep Profile:** Auto (selected button), Custom (button)
 - Constant Amplitude:** 100 mV (text field)
- Step 4: Configure the Analysis method**
 - Analysis Method:** Spectrum Average (dropdown)
 - Phase Wrap:** (checkbox, currently unchecked)

At the bottom, there is a **Go** button and a text box explaining: 'Upon pressing Go, the oscilloscope will configure itself to perform the measurement. The sweep will start from the second point listed in the input above.' Below this is a **Plots :** section with a small waveform icon.

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 impedance 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 PROFILE

Step	Start Frequency	Stop Frequency	Amplitude
1	1 kHz	10 kHz	100 mV
2	10 kHz	300 kHz	250 mV
3	300 kHz	1 MHz	100 mV
4	1 MHz	5 MHz	50 mV
5	5 MHz	10 MHz	80 mV

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

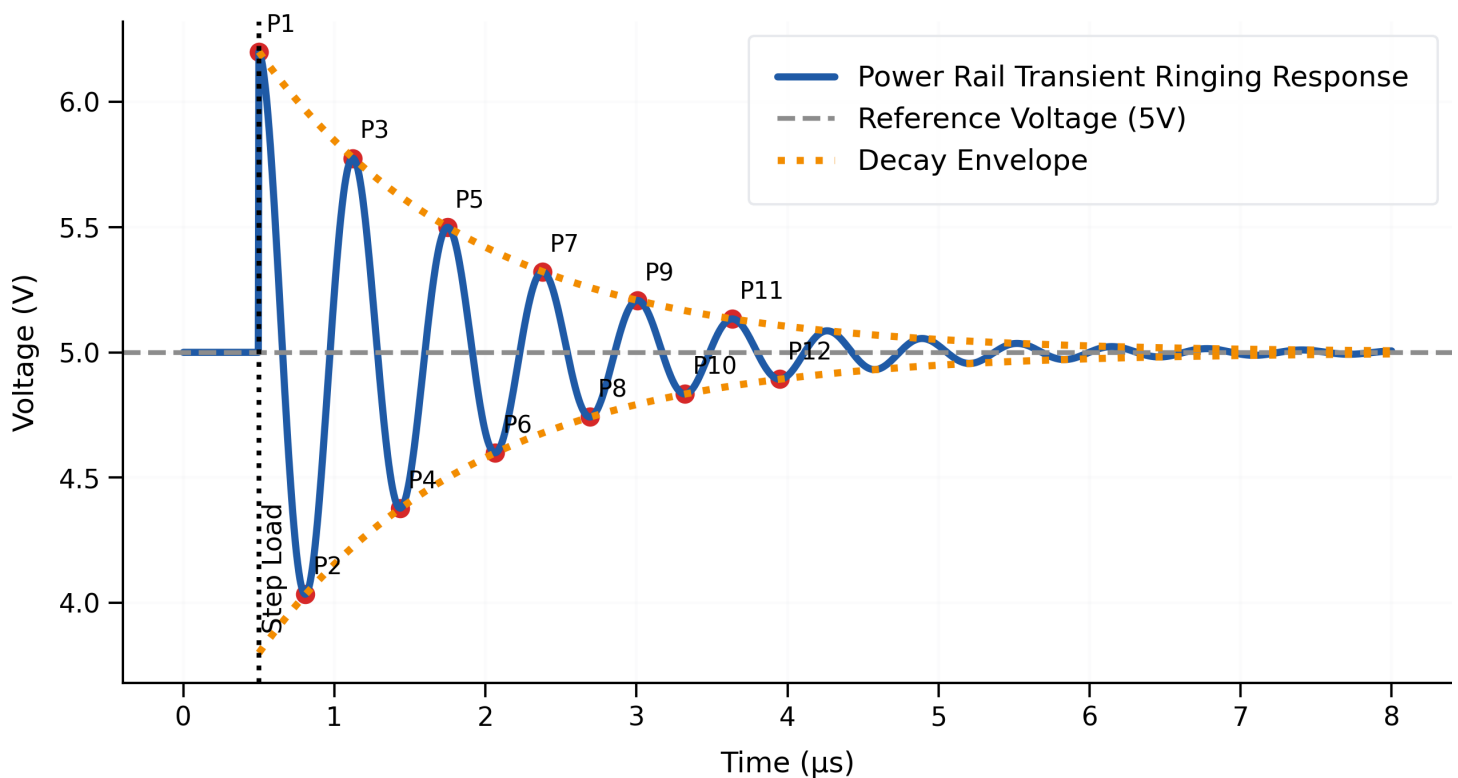
SEPIA -Stability Evaluation for Power Integrity Analysis

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.

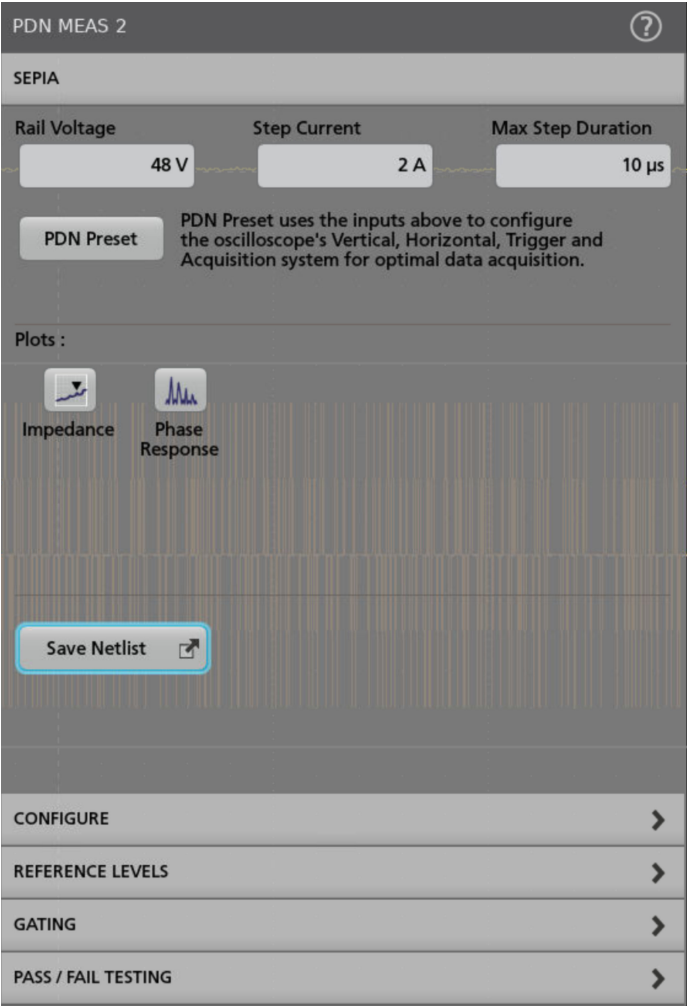
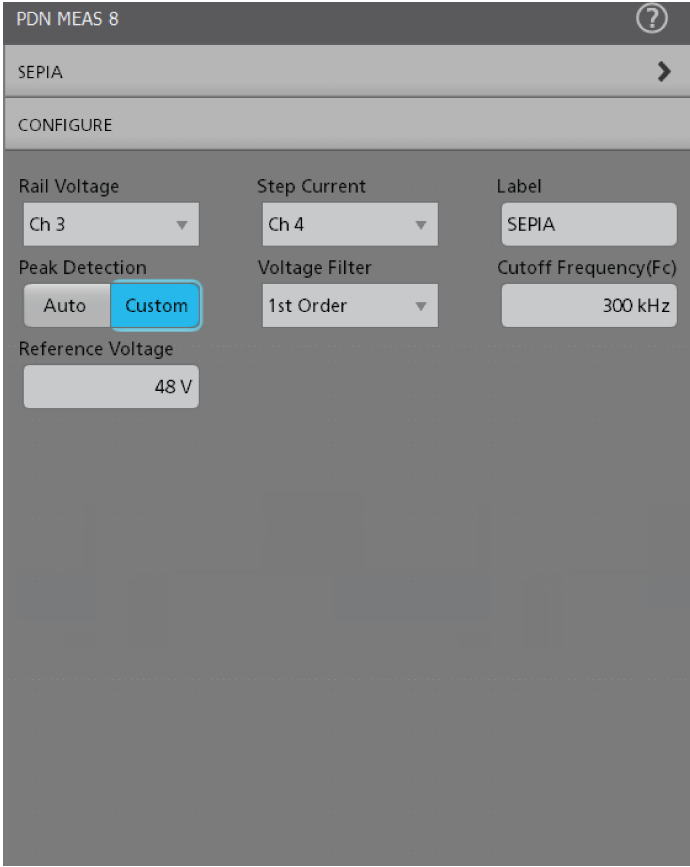
Because VRM voltage outputs contain ripple and noise, an IIR filter is used to isolate valid peaks and valleys. The transient regions are identified from voltage edges. In Auto mode, peaks and valleys are detected statistically using an algorithm-derived

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.

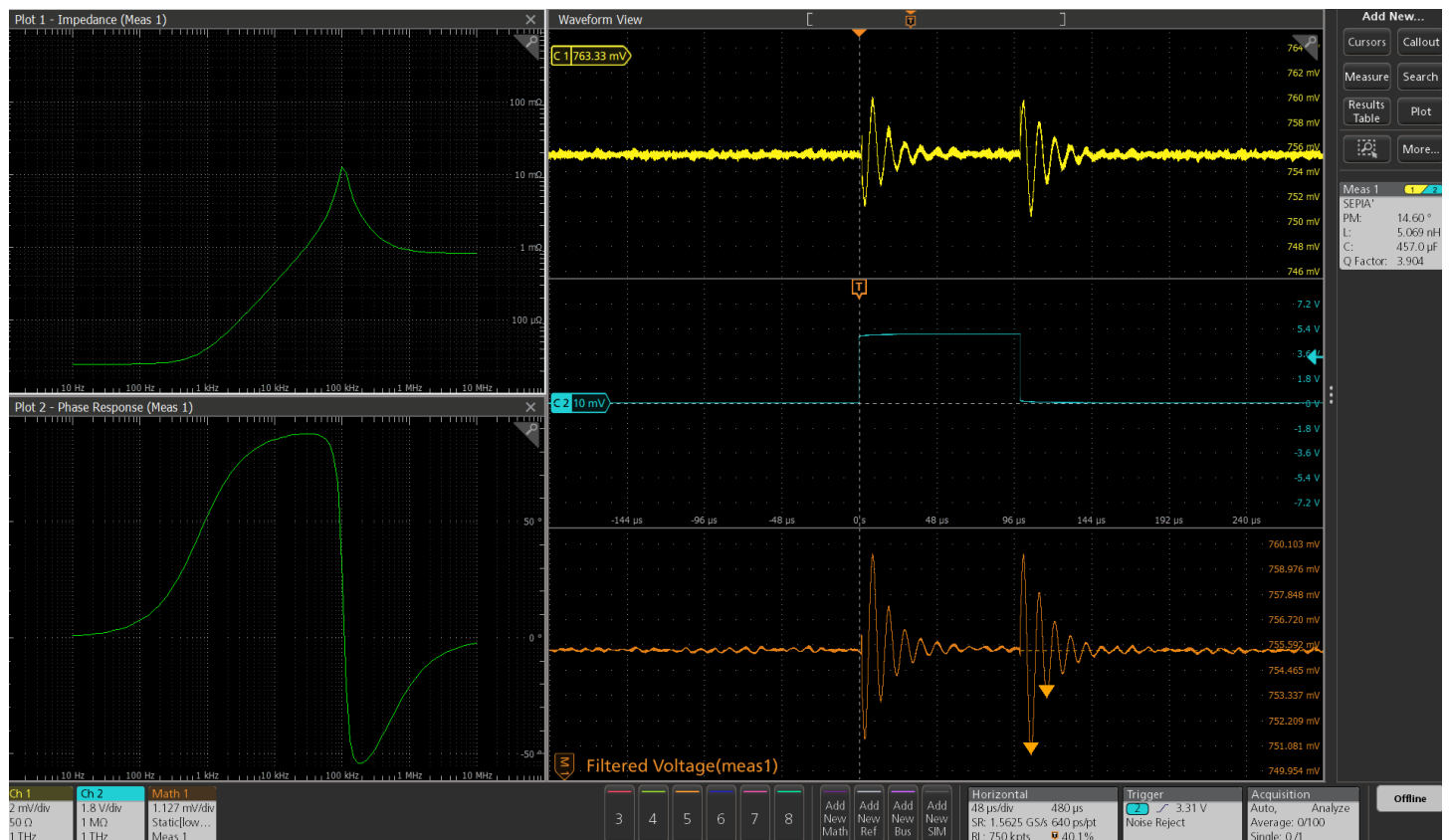
SEPIA measurement outputs impedance and phase response plots across the entire frequency band which can be used to analyze behavior of the PDN at different frequencies.



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.

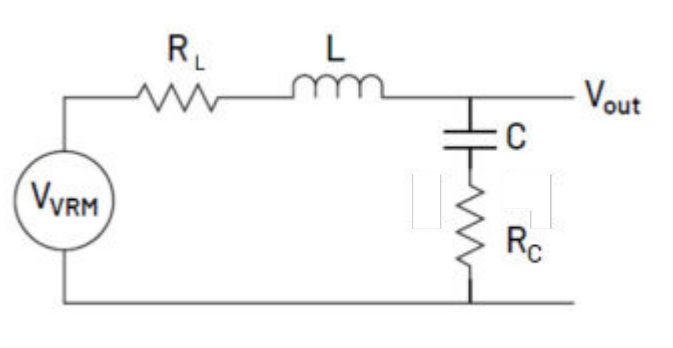


SEPIA measurement with results table and results badge displaying values for the PM, L, C and Q. Corresponding Impedance plot and Phase plot are also shown.

SEPIA generates an equivalent second-order circuit model from the measured load-step response and enables export of the model as a SPICE netlist (.sp) or CSV (.csv) file. This allows engineers to reuse measured PDN data in simulation environments, validate designs, and compare real-world performance against modeled behavior.

```
* Tektronix
* SEPIA PDN SPICE netlist
* Measurement: Meas 1
* Phase Margin: 1.45958468e+01 deg
* Quality Factor: 3.90370820e+00
*
* ===== AC Impedance Testbench =====
* 1 A AC current injected at VOUT.
* V(VOUT) = PDN impedance |Z(f)| in ohms.
* Plot V(VOUT) after simulation to view impedance and phase.
* Open in HSPICE/PSpice; plot V(vout) vs frequency from the .ac0/.dat output.
I1 0 VOUT AC 1
X1 VOUT 0 PDN_SEPIA
.ac dec 200 1 1G
*
* ===== Auto-measure PDN parameters =====
.meas AC RL_lowF FIND V(vout) AT=1
.meas AC Rcap_highF FIND V(vout) AT=1G
*
* ===== PDN subcircuit =====
.SUBCKT PDN_SEPIA VOUT GND
* Inductive branch (RL1 + L)
L1 VOUT N1 5.06942162e-09
RL1 N1 GND 2.44745565e-05
* Capacitive branch (Rcap + C)
C1 VOUT N2 4.56979689e-04
RC1 N2 GND 8.28730480e-04
.ENDS PDN_SEPIA
.end
```

An example net list for an RLC equivalent circuit based on a SEPIA analysis.



An equivalent series RLC circuit

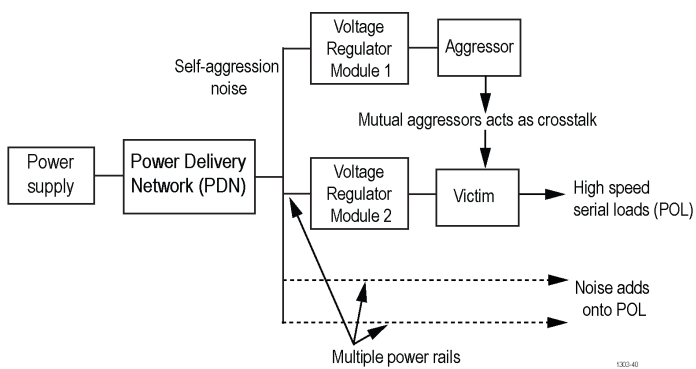
Power Integrity and Signal Integrity Analysis

Power Supply Induced Jitter (PSIJ)

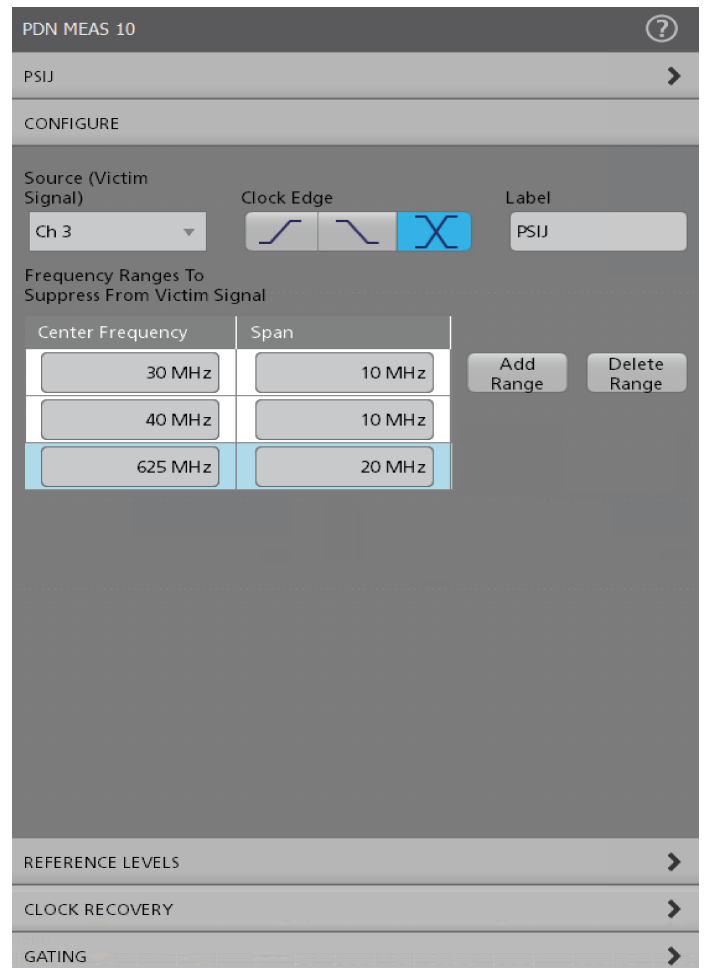
The PSIJ (Power Supply Induced Jitter) is the key SI/PI measurement that acts as a tool that gives insights and confidence to High Speed Serial (HSS) design engineers to improve designs before making any power related (hardware) changes during the prototyping phase.

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

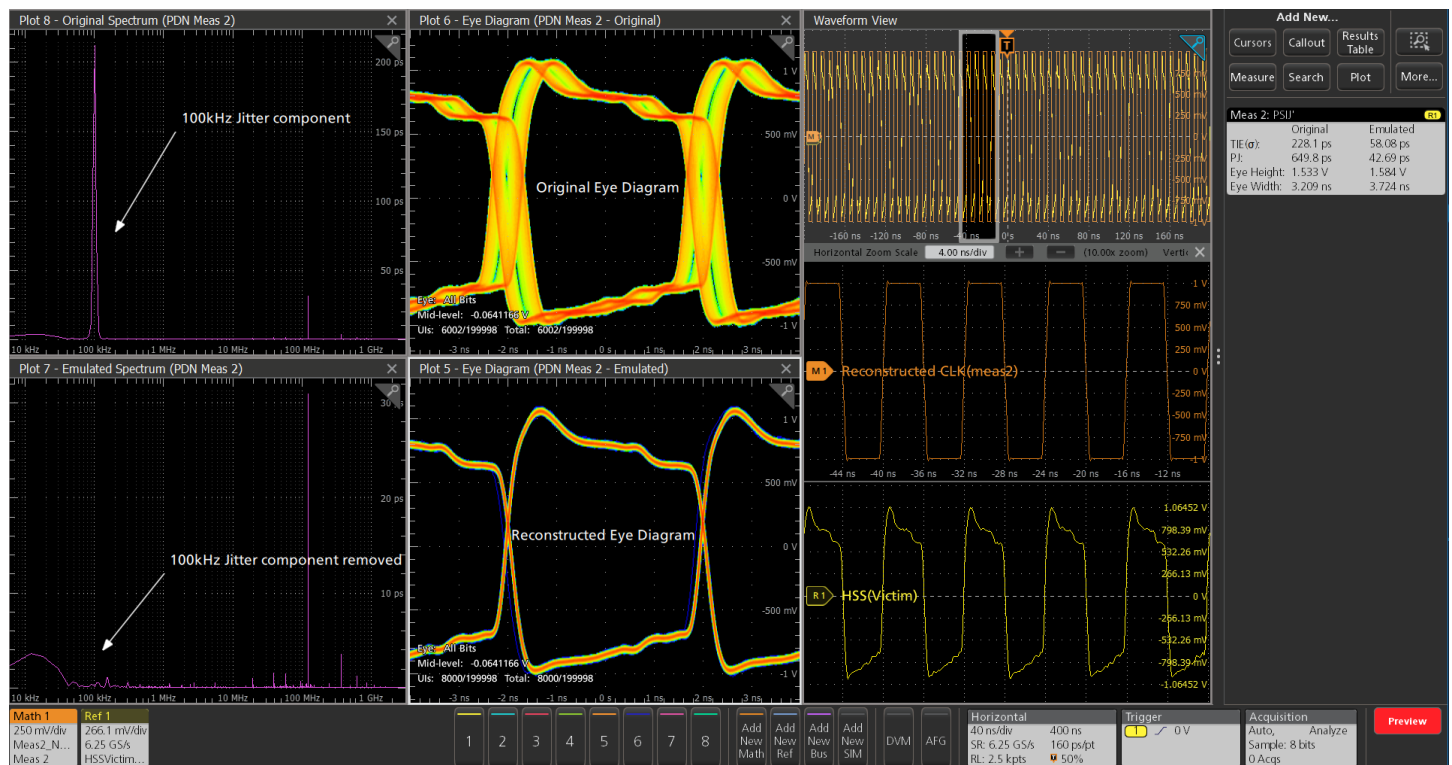


The image shows a multi-rail example of the effect of noise with various points of load (POL) such as DDR memory, PCIe, etc.



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 the spread of the 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 provides essential results such as eye height, eye width, PJ, and TIE of the original and emulated signals.



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

Large Signal Analysis

d/dt Measurement

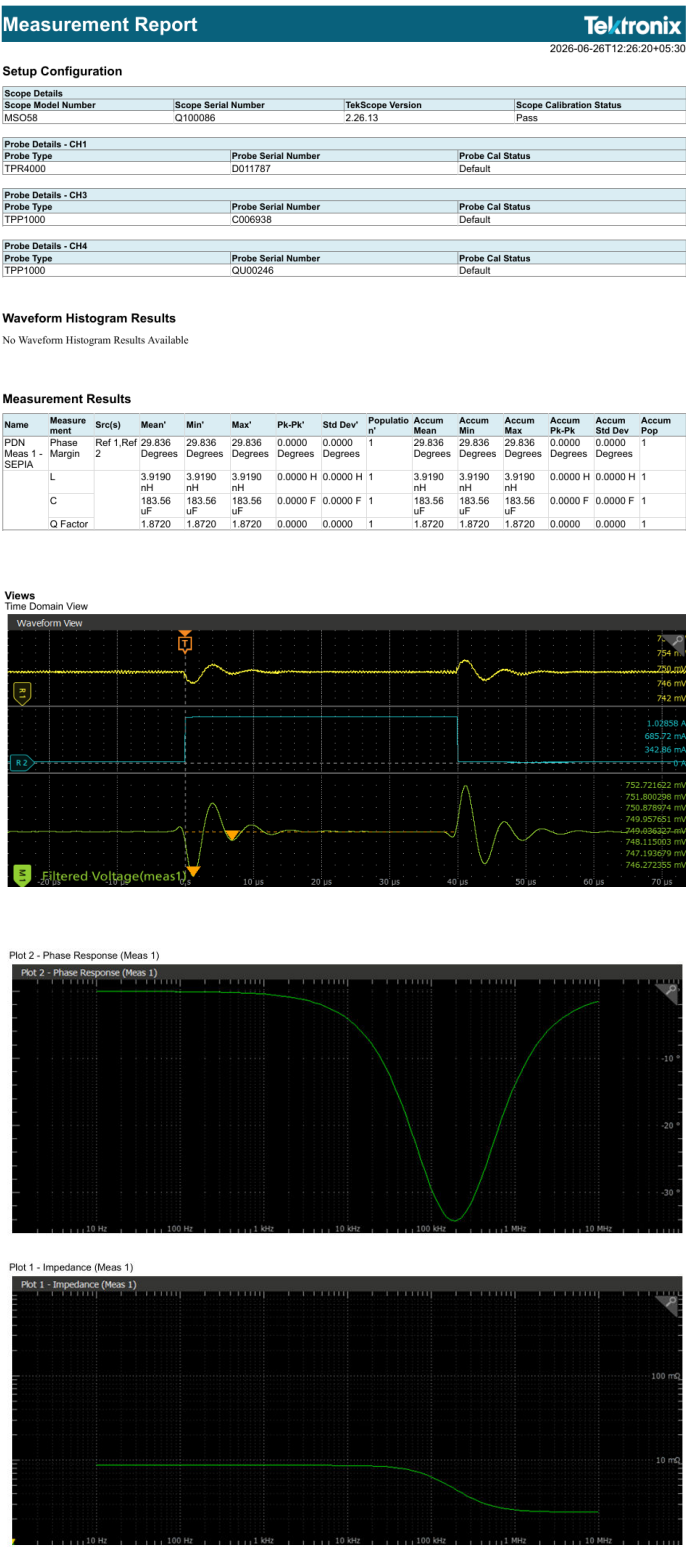
The d/dt measurement quantifies the rate of change (slew rate) of a waveform between user-defined reference levels. Measurements can be performed on rising or falling edges using configurable top and base reference thresholds.

The measurement is useful for analyzing power rail startup behavior, load transients, switching events, regulator responses, and general large-signal performance. By measuring the slope of voltage transitions, engineers can quickly evaluate transient response characteristics and compare system behavior under different operating conditions.



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.



Power Distribution Network Measurement and Stability Analysis 4/5/6 Series B MSO Option 4/5/6-PDN Application Datasheet

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	<p>Measures gain ($20 \log(V_{out}/V_{in})$) and phase versus frequency across the swept range.</p> <p>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.</p> <p>Dynamic range: typically 55 dB.</p> <p>Probes supported: single-ended measurements with TPP0502 probes (recommended) and differential measurements using TDP Series differential probes.</p> <p>Signal source: oscilloscope's internal AFG (up to 5 V) or an external AFG 31000 Series generator (up to 10 Vpp).</p> <p>Requires Picotest isolation and injector transformers.</p>
PSRR	<p>Measures both the modulated input and output AC voltage levels and plots the rejection ratio as $20 \log(V_{in}/V_{out})$ at each frequency within the specified band.</p> <p>PSRR dynamic range is typically 85 dB.</p>
Impedance	<p>Measures and plots the two-port impedance at each frequency within the swept band.</p> <p>2-port Impedance requires a BNC or Direct SMA cable with DC block.</p> <p>Frequency: 10 Hz to 50 MHz for internal AFG and 10 Hz to maximum frequency of AFG31000 Series in case of external.</p> <p>The Minimum impedance that can be measured is 10 mΩ and the maximum is 47 Ω.</p>
SEPIA	<p>SEPIA evaluates power supply and VRM stability by extracting frequency-domain information from a time-domain voltage response to a step load. It analyzes transient ringing to estimate an equivalent second-order RLC model and provides phase margin, Q factor, and impedance response characteristics. Derived models can be exported as SPICE netlists (.sp or .csv format) files for simulation and validation workflows.</p> <p>Provides insight into damping, resonance, and control-loop stability without breaking the loop.</p>
d/dt	<p>Measures waveform slew rate between configurable top and base reference levels. Provides rate-of-change analysis for rising and falling waveform transitions.</p>
PSIJ	<p>PSIJ measurement to identify the periodic jitter introduced on the high-speed serial data due to the power rail noise.</p>

Ordering information

Models

Product	Options	Supported instruments
New instrument order option	4-PDN 5-PDN 6-PDN	4 Series B MSO (MSO44B, MSO46B) 5 Series B MSO (MSO54B, MSO56B, MSO58B, MSO58LP) 6 Series B MSO (MSO64B, MSO66B, MSO68B)
Product upgrade option	SUP4-PDN SUP5-PDN SUP6-PDN	
Floating license	SUP4-PDN-FL SUP5-PDN-FL SUP6-PDN-FL	<p>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.</p> <p>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.</p> <p>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.</p>

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/)
Control loop response (Bode plot)	TPP0502 passive probes – 2 Qty Scope built-in AFG (optional 4-AFG/5-AFG/6-AFG license) or AFG31000 Series (up to 250 MHz)	Isolation transformers J2100A (for 1 Hz to 5 MHz operation) J2101A (for 10 Hz to 45 MHz operation) J2110A Solid State Injector (for DC to 45 MHz operation)
Power supply rejection ratio (PSRR)	TPP0502 passive probes – 2 Qty Scope built-in AFG (optional 4-AFG/5-AFG/6-AFG license) or AFG31000 Series (up to 250 MHz)	Line injector J2120A (for 10 Hz to 10 MHz operation)
2-port Impedance	Scope built-in AFG (optional 4-AFG/5-AFG/6-AFG license) or AFG31000 Series (up to 250 MHz)	P2102A-1X 2-Port PDN Probe, 1X Attenuation J2102B Common Mode Transformer J2161A 2-Way Wideband Active Splitter 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) 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 Tektronix Power rail probe (TPR1000/TPR4000) Tektronix isolated current probe (TICP series) – optional	P2105A (S10 version) with load step head from 50 mΩ to any custom resistor range depending on test voltage and desired load current P2104A or P2105A for use with TICP Differential Probe: 1 Qty (Need 2 Qty if TICP probe is used for power rail voltage measurement) 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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