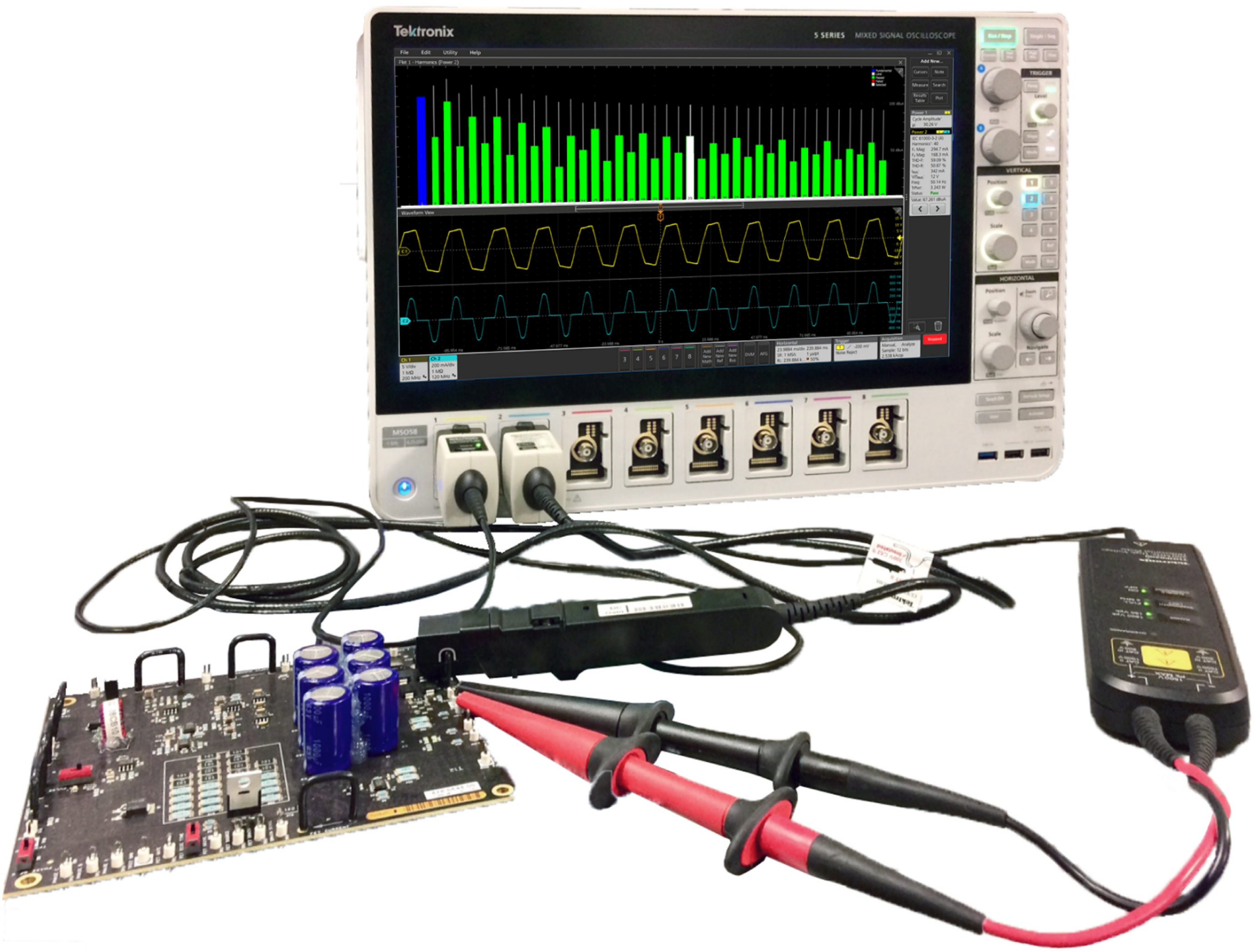
Tektronix®

Advanced Power Measurement and Analysis

4/5/6 Series MSO Option 4-PWR-BAS, 5-PWR and 6-PWR Application Datasheet

Get more visibility into your power supply designs



Get more visibility into your power systems with Advanced Power Measurement and Analysis on the 4/5/6 Series MSO. The combination of the oscilloscope, analysis software, and a wide range of available voltage and current probes, enables you to perform automated, accurate power system measurements even if you are not a power conversion guru. The 12-bit analog-to-digital converters in these oscilloscopes deliver high-precision measurement data, and the pinch/swipe/zoom touch interface makes it easy to manage measurements. A rich set of graphical power analysis tools, high channel-counts, and large HD displays deliver a comprehensive view of your power system. The instruments support a wide range of voltage and current probes, including state-of-the-art IsoVu™ optically isolated voltage probes. The unmatched common mode rejection of IsoVu probes and the automation of Advanced Power Measurement and Analysis make an unbeatable combination for optimizing the latest GaN and SiC designs.

Key measurements

- **Input measurements**
  - **Power** measures true power, apparent power, power factor, and phase angle
  - **Total Harmonic Distortion and Crest Factor measurements**
  - **Harmonics** measurements, bar charts, and tables
  - **Amplitude** provides easy per-cycle measurements of voltage or current, including minimum, maximum, amplitude, and peak-to-peak
  - **Input Capacitance** measures the capacitance value using voltage and current signals
  - **Inrush Current** measures the peak current
- **Switching Device measurements**
  - **Switching Loss** measures turn-on, turn-off, and conduction loss in switching devices
  - **Safe Operating Area (SOA)** provides customizable safe operating area mask testing
  - **Timing Analysis** enables easy analysis of pulse-width-modulated switching signals with cycle-by-cycle plots or histograms of pulse width, duty cycle, frequency, or period
  - **RDS(on)** measures the dynamic resistance of the switching device when it is in the On state
- **Magnetic Analysis measurements (available only in 5/6-PWR)**
  - **Inductance** measures inductance of the core
  - **Magnetic Property** measures and plots the inductor B - H curve.
  - **Magnetic Loss** measures and calculates total magnetic loss
  - **I vs. ∫V** displays the plot of I and ∫V waveforms
- **Output measurements**
  - **Line Ripple** measures the amount of AC signal related to the input line frequency.
  - **Switching Ripple** measures the amount of AC signal related to the switching frequency.
  - **Efficiency** measures the power circuit efficiency by dividing the measured output power by the measured input power
  - **Turn On Time** measures the time delay between the input voltage to the device under test going 'high' to the output voltage reaching its steady state.
  - **Turn Off Time** measures the time delay between the input voltage to the device under test going to zero state, to the output voltage reaching its zero state.
- **Frequency response measurements(available only in 5/6-PWR)**
  - **Control Loop Response (Bode)** plots the frequency and phase response of a closed loop circuit, and automatically calculates the gain and the phase margins.
  - **Power Supply Rejection Ratio (PSRR)** analyzes the ripple rejection capability of a DC-DC converter.
  - **Impedance Analysis** enables 2-port impedance measurement of Power Distribution Networks(PDN) using the oscilloscope.

Key features

- Add, configure, and remove automated measurements using the 4/5/6 Series MSO's pinch/swipe/zoom touch interface
- Easily document test results with automated report generation, including measurements, test results, and plots in a single, editable mht file or pdf file
- Utilizes optional and integrated Arbitrary/Function Generator for frequency response analysis (available only in 5/6-PWR). Also supports external AFG31000 Series function generator.
- Cover diverse applications with a wide range of voltage and current probes, including state-of-the-art IsoVu optically isolated voltage probes
- Configure any measurement and transfer any result via remote interface for automated testing applications

Input analysis

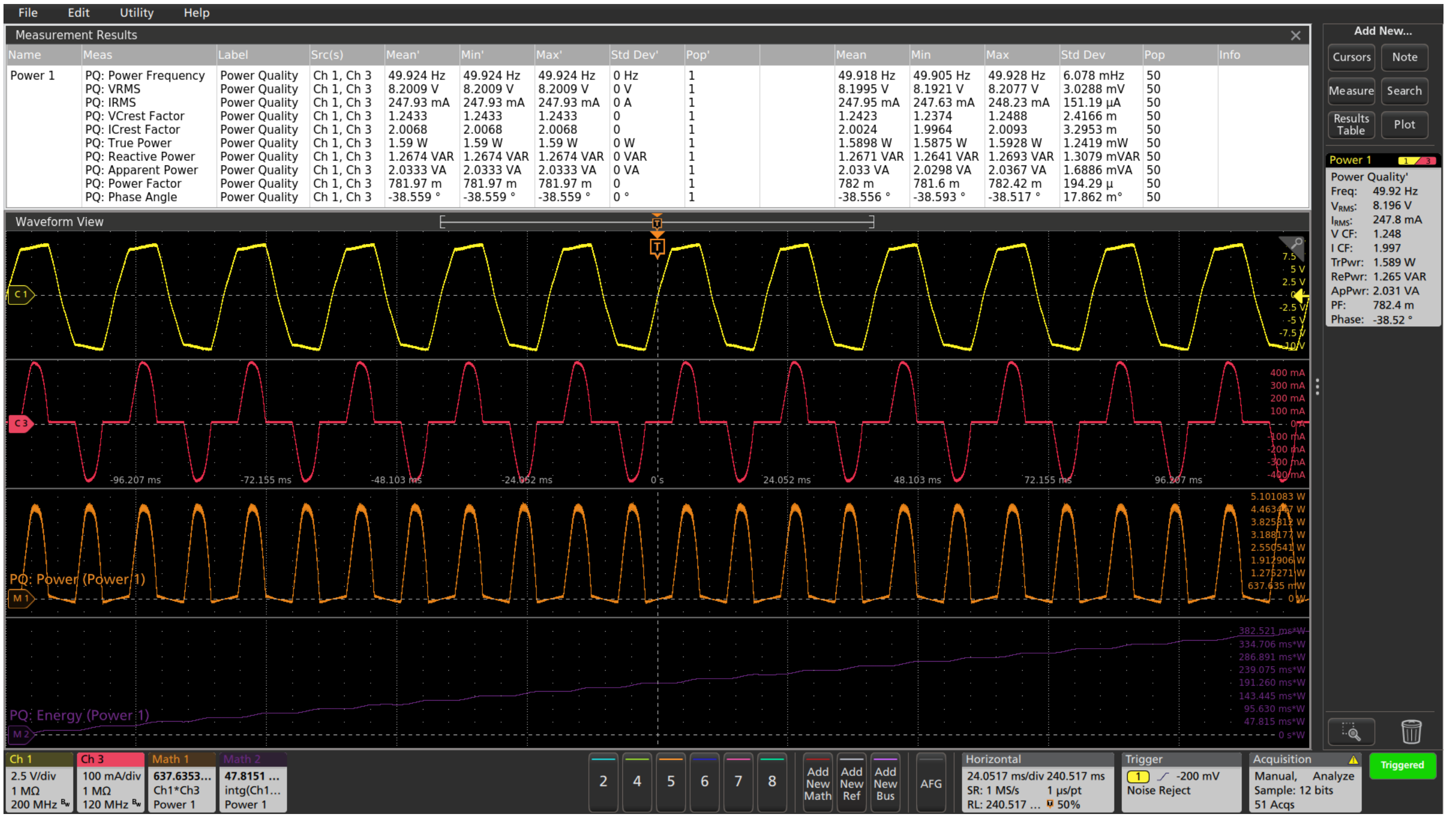
Power quality measurements, Current Harmonics, Input Capacitance, and Inrush Current are the four common sets of measurements made on the input section of a power supply, to analyze the effects of the power supply on the power line and evaluate the performance of the supply under various line conditions.

Power Quality

These measurements are optimized for line frequencies and are commonly performed at the AC line input of the power supply. They provide fast insight into the amount of power and the level of distortion at the input.

Measurements include:

- RMS voltage and current
- Frequency
- True, apparent, and reactive power
- Power factor
- THD and crest factor

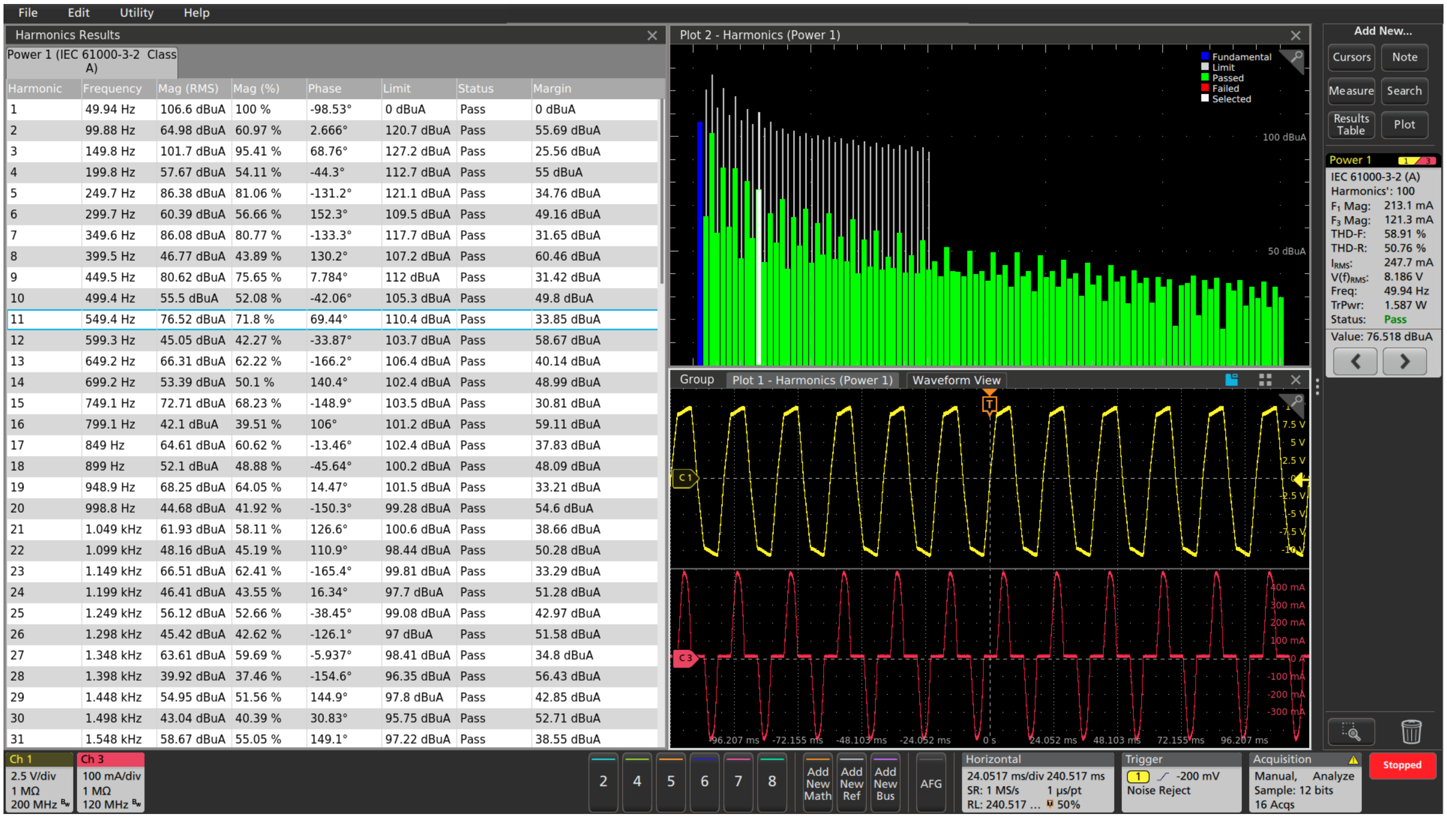


Power Quality measurements deliver information in multiple formats. Numerical results (upper right), tables (upper), and instantaneous power waveform and energy plots (lower)

Harmonics

Any power supply with a non-linear device on its input (e.g. a rectifier) presents a nonlinear load to the AC line. Unless mitigated, excessive harmonic energy can affect the operation of other equipment connected to the power line and increase the cost of delivering the electric power. This has resulted in standards limiting harmonics generated by line-powered devices.

Advanced Power Measurement and Analysis includes test limits for the IEC61000-3-2, AM 14, and MIL- STD-1399 standards to help you perform pre-compliance testing before investing in official compliance testing. It presents up to 100 harmonics in graphical and tabular formats, and lets you easily traverse though the list to get details on any individual harmonic.

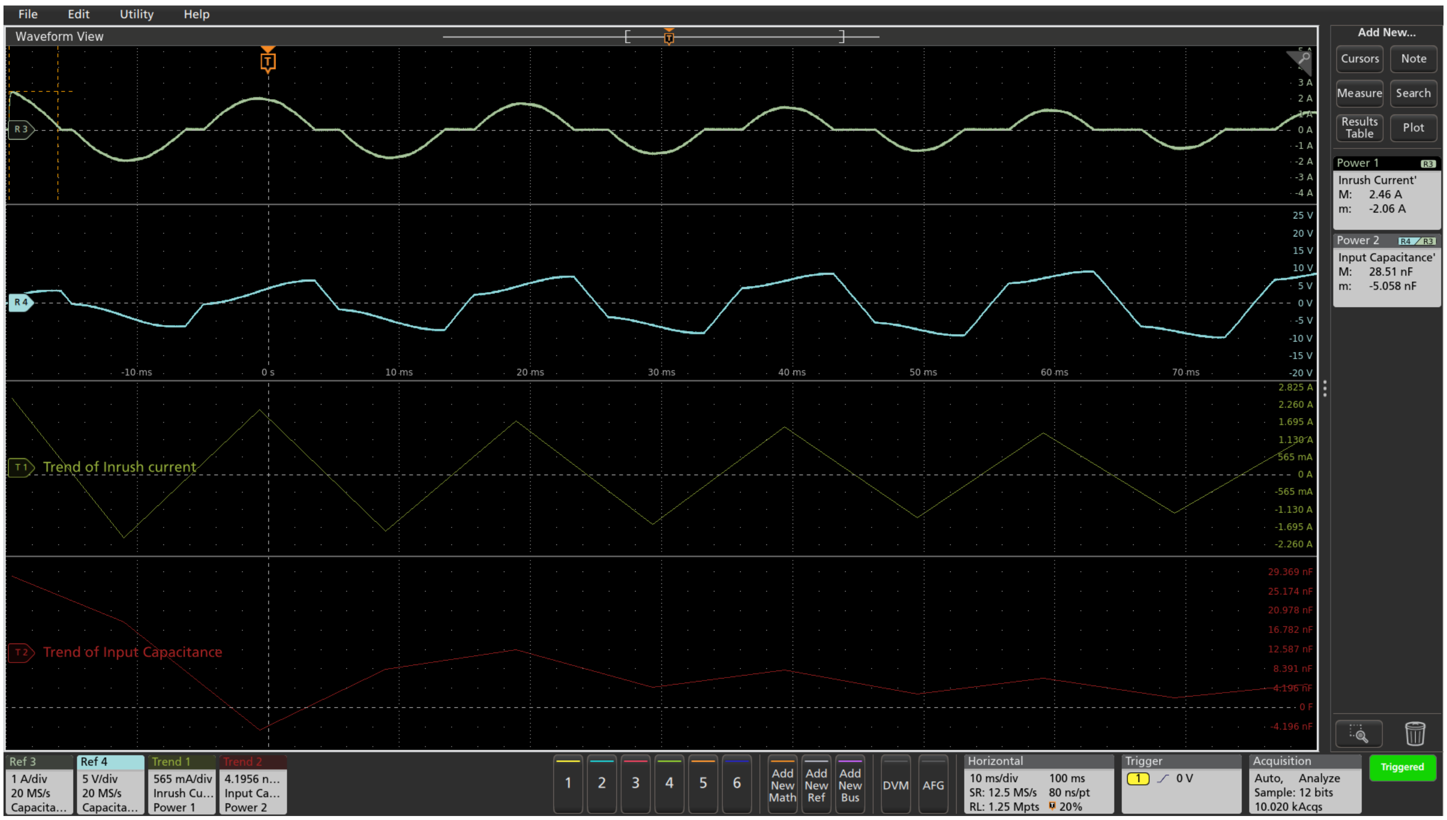


Harmonics bar graph, harmonics results table, and traverse capability via the results bar (upper right)

Input capacitance and Inrush current measurement

4-PWR-BAS, 5-PWR and 6-PWR provides peak inrush current and capacitance measurements for testing switching power supplies during operation.

Inrush current, input surge current or switch-on surge is the maximum, instantaneous input current drawn by an electrical device when first turned on. Power converters have inrush current that is more than their steady state current due to the charging current of input capacitance. Measuring inrush current and input capacitance is important to ensure the design works effectively.



Input capacitance and inrush current measurement with traverse capability

Switching component analysis

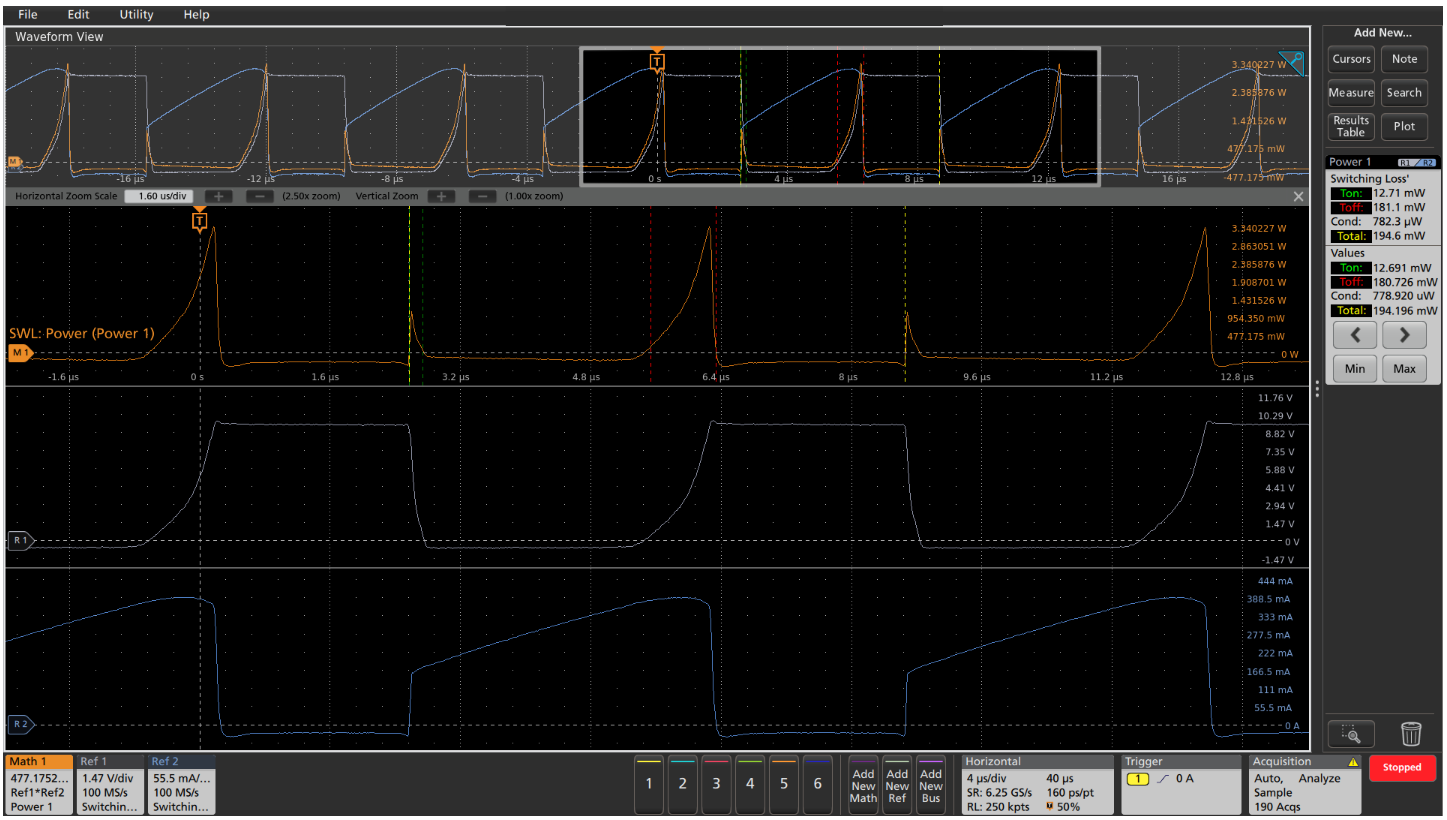
The accurate calculation and evaluation of energy loss in power supplies has become even more critical with the drive toward higher power conversion efficiency and greater reliability.

Switching loss measurements

Although almost all components of a power supply contribute to energy losses, a significant portion of energy losses in a switch-mode power supply (SMPS) occur when the switching transistor transitions from a Turn-off (T_{off}) to a Turn-on (T_{on}) state and vice versa (Turn-off loss). By measuring the voltage drop across the switching device and the current flowing through the switching device, Advance Power Analysis automatically calculates switching loss measurement parameters for each cycle.

Until recently, taking switching measurements on the high side of half-bridge switching stages were almost impossible. Any measurement relative to the switching node, including high-side V_{DS} and voltages across current shunts, suffered from distortion due to the significant common-mode voltage signal impinging on the differential signal. This problem is worse with wide bandgap devices, such as GaN and SiC transistors, as switching frequencies increase and the need to optimize new designs becomes imperative.

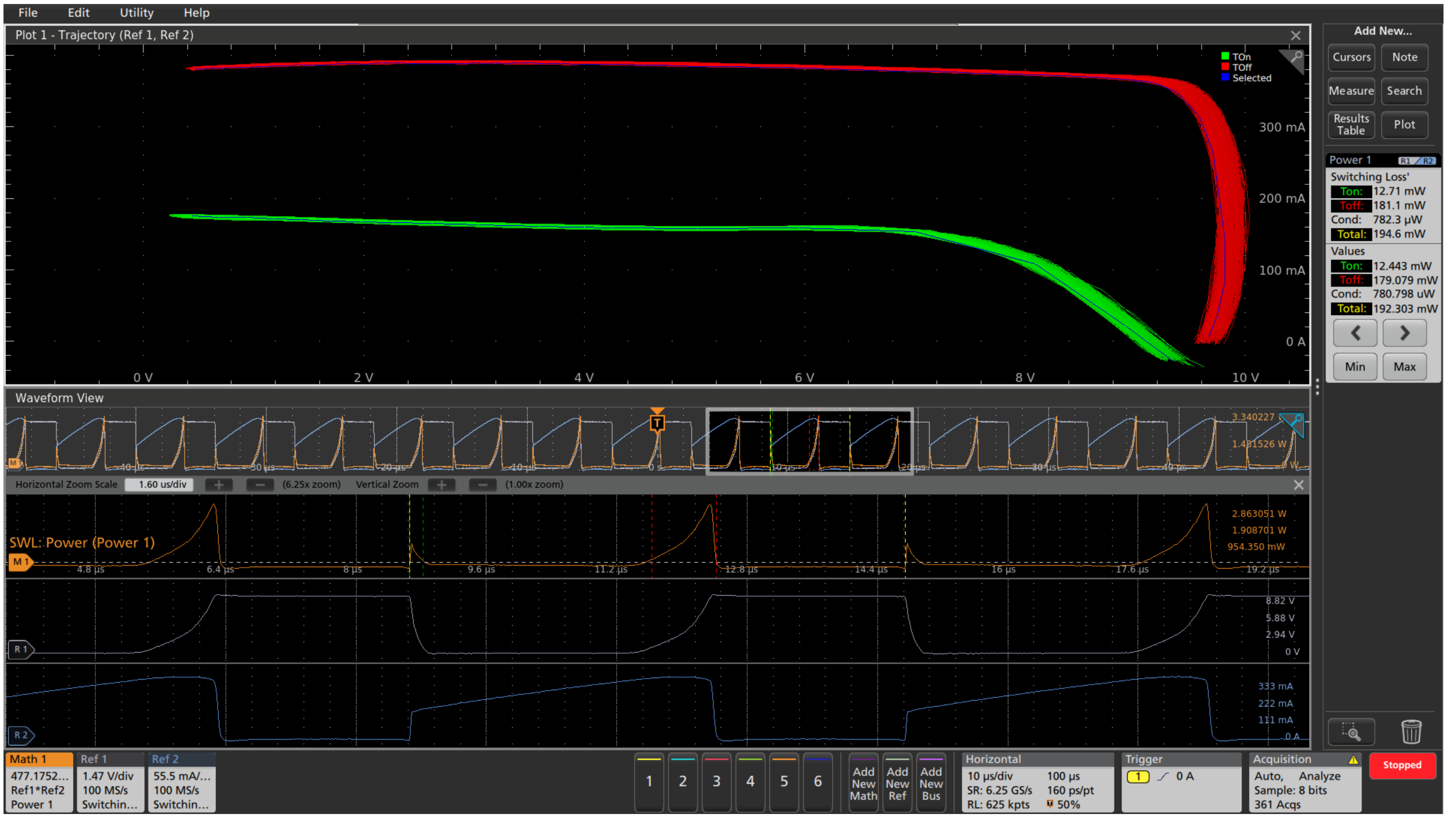
The 4/5/6 Series MSO is designed to work with IsoVu optically isolated probes, enabling designers to perform accurate switching measurements even in the presence of high common mode signals.



Switching Loss shows power dissipation in a FET. Waveforms are annotated with color-coded markers showing the measurement regions for T_{on}, T_{off}, and Total cycle, corresponding to values in the results badge. Controls in the results badge let you easily traverse from cycle to cycle.

Switching loss measurements include special settings to produce stable, repeatable measurements on active power factor correction stages, and flyback converters.

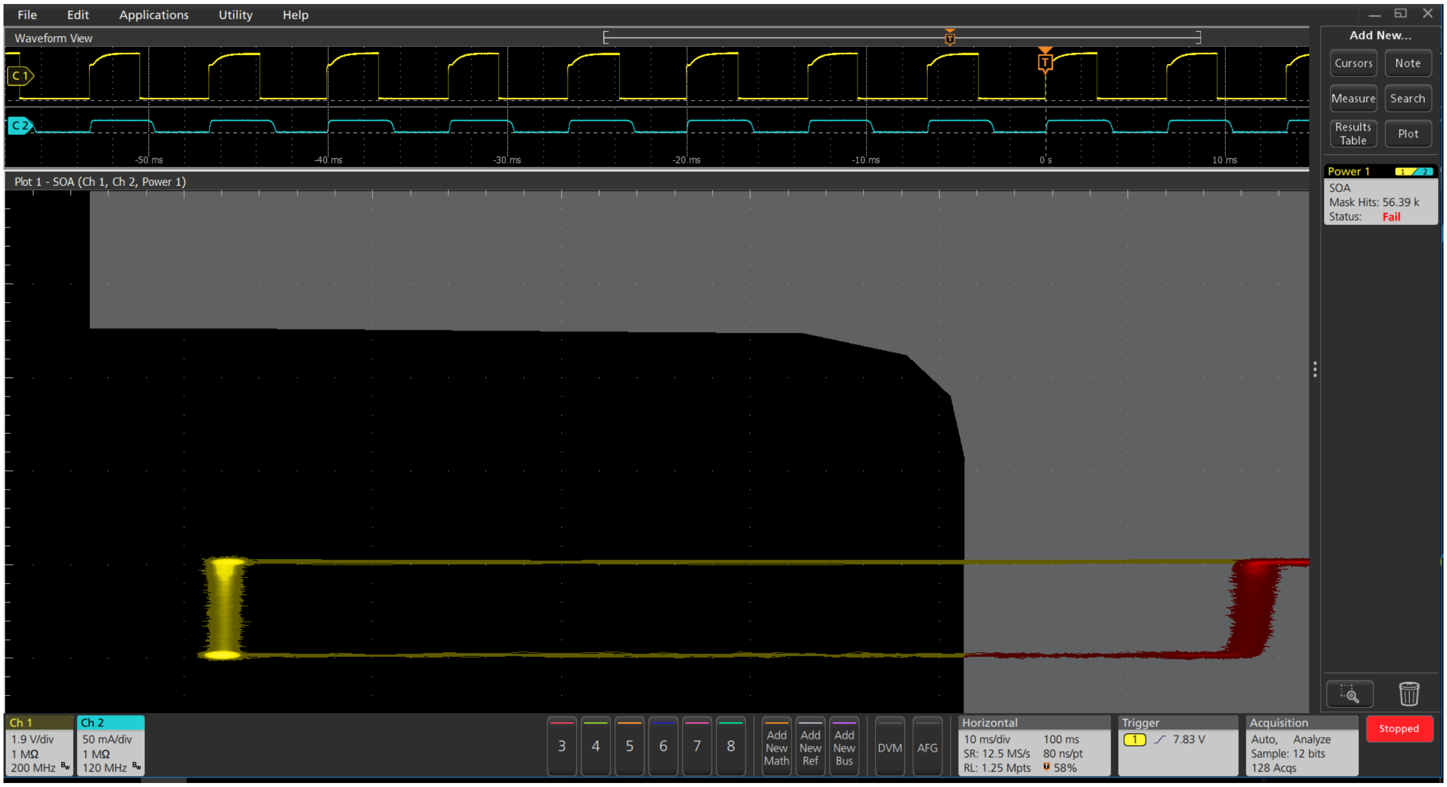
To get an overview of the switching loss for all captured cycles, you can use the trajectory plot. It automatically plots the voltage across the switch versus current through the switch during turn-on and turn-off, letting you judge the range of switching loss for all cycles at a glance.



Switching Loss Trajectory Plots (upper window) show the T_{on} loss, and T_{off} loss for all switching cycles in a single plot.

Safe operating area

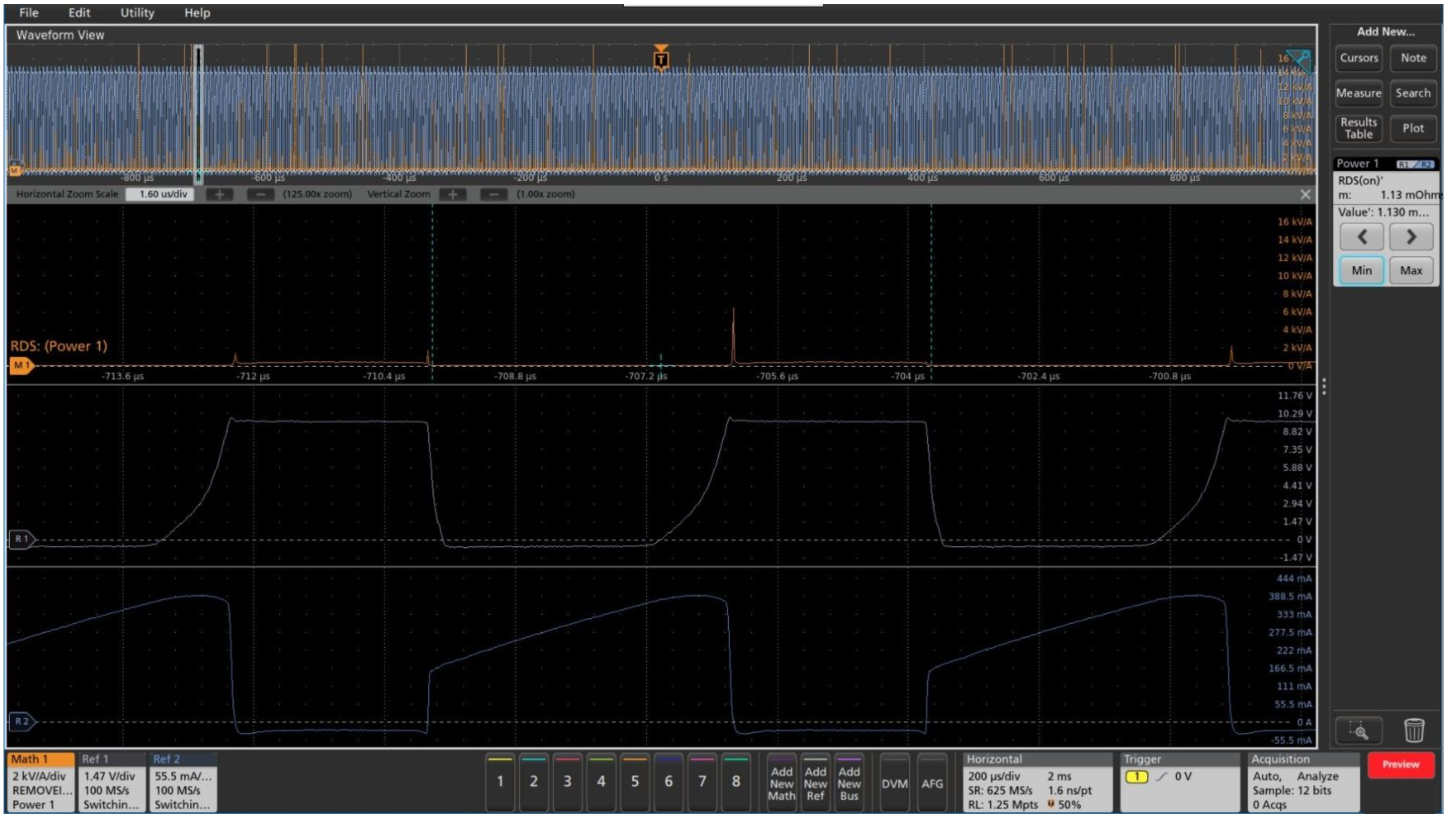
The Safe Operating Area (SOA) plot is a graphical technique for evaluating a switching device to ensure that it is not being stressed beyond its maximum specifications. SOA testing can be used to validate performance over a range of operating conditions, including load variations, temperature changes, and variations in input voltages. Mask testing can also be used with SOA plots to automate validation.



Safe Operating Area (SOA) plot with mask helps verify the switching devices are staying within their SOA envelope under changing operating conditions.

RDS$_{(on)}$

This measurement characterizes the resistance of the switching device during the conduction cycle, when the device is ON and conducting current. The dynamic-on-resistance is the ratio of the voltage across the device when it is turned ON to the current flowing through the device. The software ensures that the minimum RDS$_{on}$ value in the acquisition is highlighted and zoomed in for easy viewing. In addition, the traverse capability helps to move from cycle to cycle to the respective RDS$_{on}$ values.



RDS$_{(on)}$ measurement

Magnetic analysis (available only in 5/6-PWR)

Supports the following measurements:

- Inductance
- Magnetic property including BH curve
- Magnetic loss
- I vs. ∫V

Magnetic components are an important part of any power supply system. Inductors and transformers are used as energy storage devices in both switch-mode and linear power supplies. Some power supplies also use Inductors in filters at their output stage. Given their important role in the system, it is essential to characterize these magnetic components to determine the stability and overall efficiency of the power supply.

Inductance

Inductors exhibit increasing impedance as frequency increases, impeding higher frequencies more than lower frequencies. This behavior is known as inductance and is measured in units of Henries. The inductance can be measured automatically with Advanced Power Measurement and Analysis software.

Magnetic loss

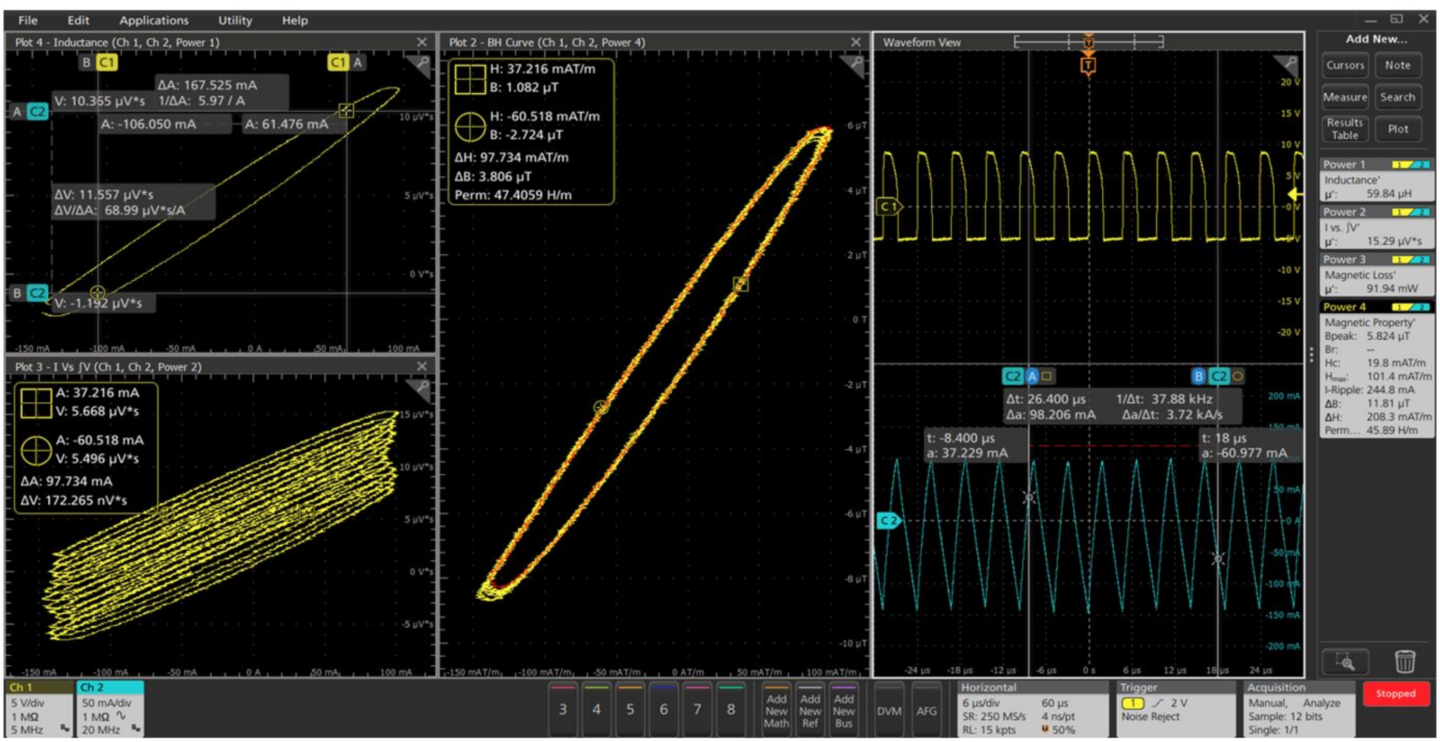
An analysis of magnetic power losses is essential to accurately characterize the efficiency, reliability, and performance of a switching power supply. Advanced Power Measurement and Analysis software measures the inductive total magnetic power loss, as shown in the following figure.

B-H plots

The properties of magnetic materials are described by the magnetic flux density (B), magnetic field intensity strength (H), and the magnetic permeability of a material (μ). B-H plots are often used to verify the saturation (or lack thereof) of the magnetic elements in a switching supply and provide a measure of the energy lost per cycle in a unit volume of core material. Advanced Power Measurement and Analysis software measures the voltage across the magnetic element and the current flowing through it, and plots B versus H, as shown in the following figure. You can test multiple secondary windings of a transformer simultaneously, thereby ensuring faster validation/testing times leading to faster time to market.

I vs. ∫V plot

I vs. ∫V plot provides insight to the B and H values, proportional to the voltage and current. This is the integral of the voltage and current waveforms in X-Y plot format as shown in the following figure.



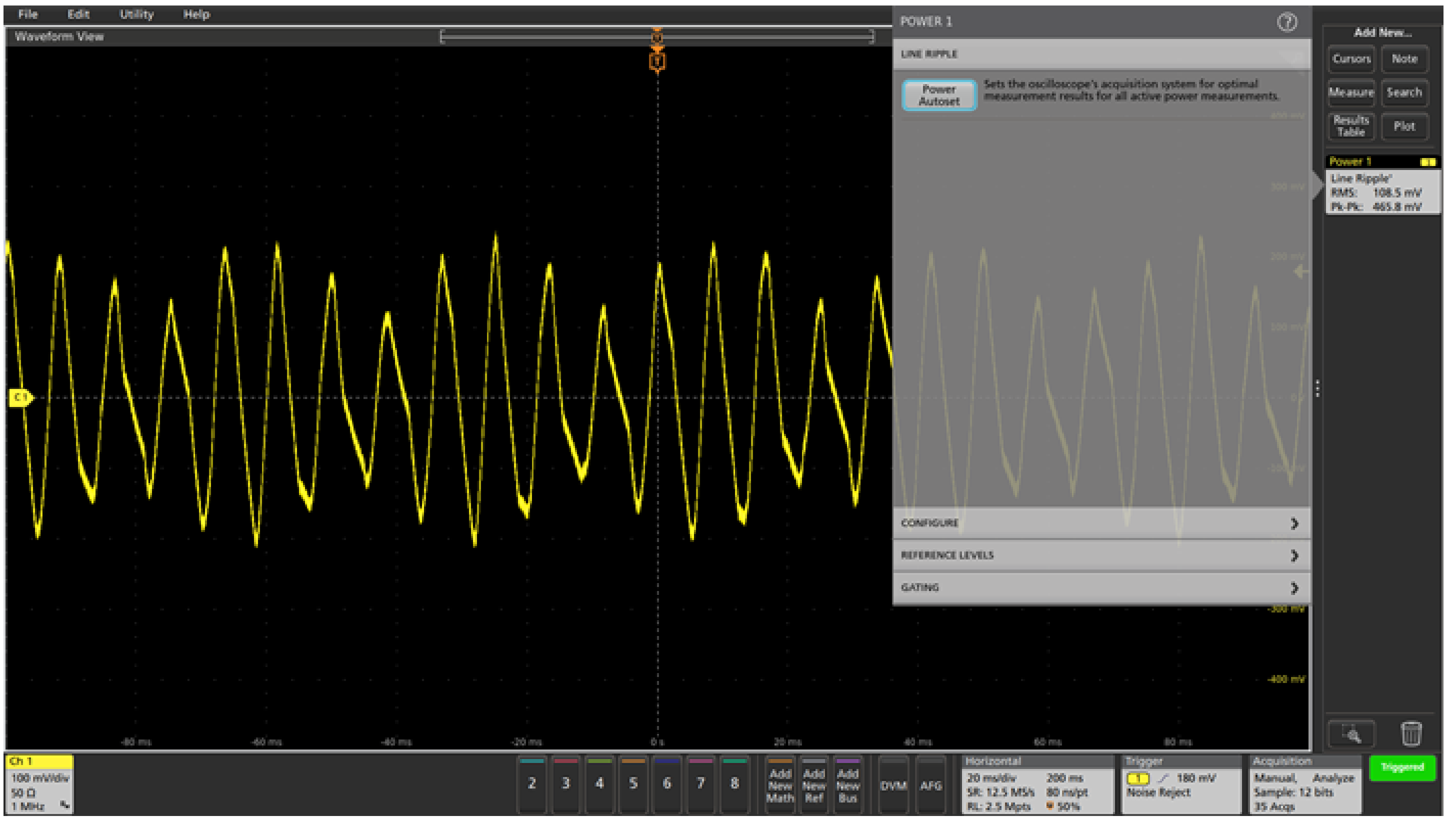
Magnetic Analysis measurement with B-H curve, I vs. ∫V, and Inductance plots

Output analysis

The ultimate goal of a DC-output power supply is to transform input power into one or more DC output voltages. The most important output measurements for switching power supplies are line ripple and switching ripple.

Line and switching ripple

The quality of a power supply's DC output should be clean, with minimal AC noise and ripple. Advanced Power Measurements and Analysis software measures ripple to help you isolate the cause. Line ripple measurements indicate the amount of AC signal related to the input line frequency (since the input is rectified, line ripple is usually twice the frequency of the AC line). Switching ripple measures the amount of AC signal related to the switching frequency.

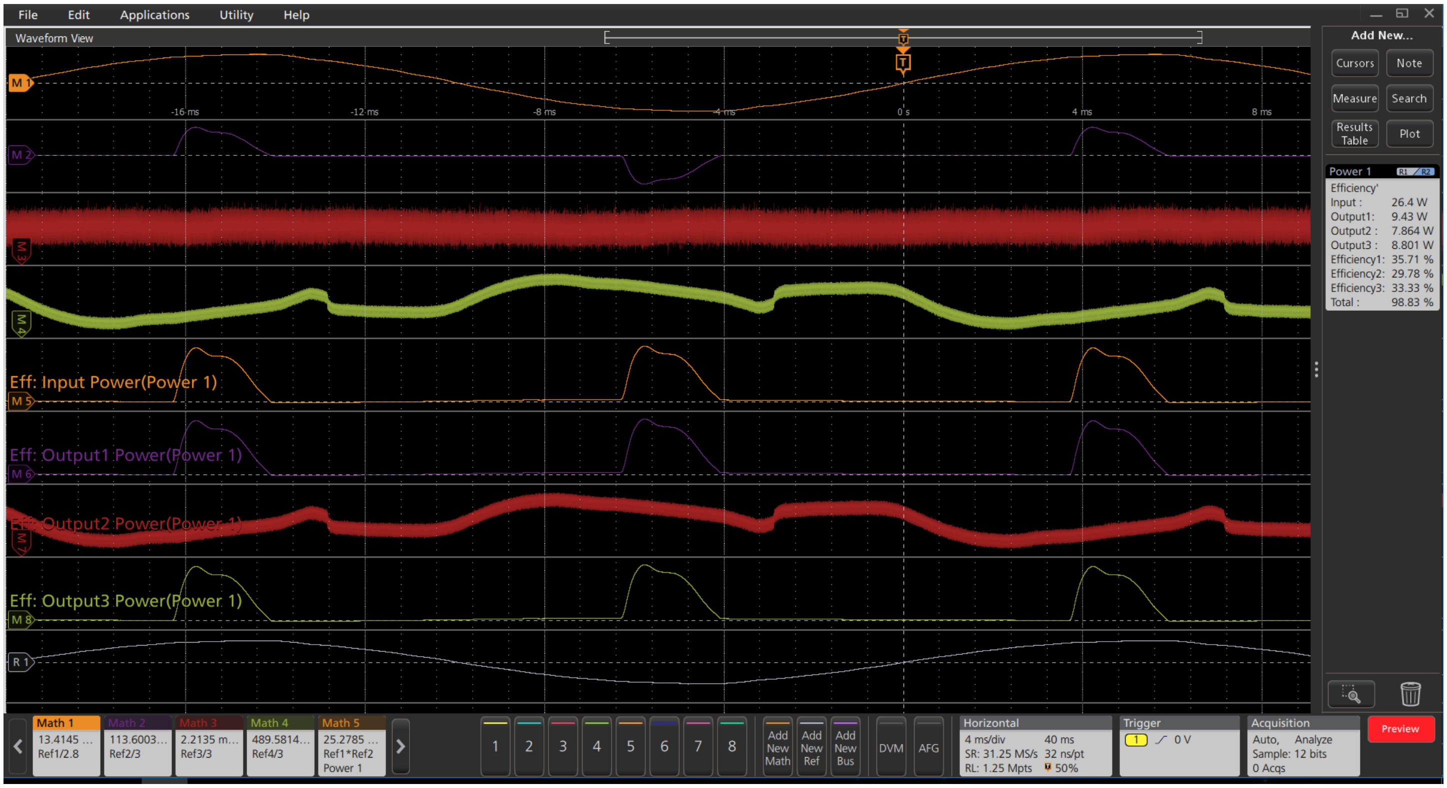


Ripple analysis helps distinguish low-frequency line ripple from higher frequency switching noise.

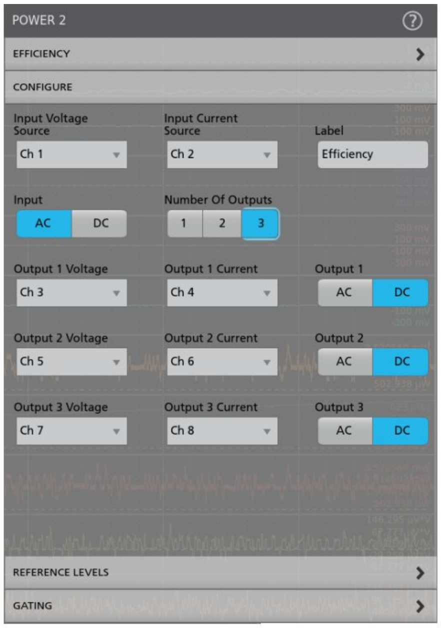
Efficiency

Device or product efficiency is a critical differentiator in today's competitive environment. Advanced Power Measurements and Analysis software lets you easily measure your product's power conversion efficiency (AC-DC, AC-AC, DC-DC, DC-AC).

It allows you to test efficiency on multiple outputs at once, for faster testing and validation. You can configure each output independently.



Efficiency measurement



Efficiency measurement configuration lets you test new generation multi-output power conversion devices (AC-DC, AC-AC, DC-DC, and DC-AC)

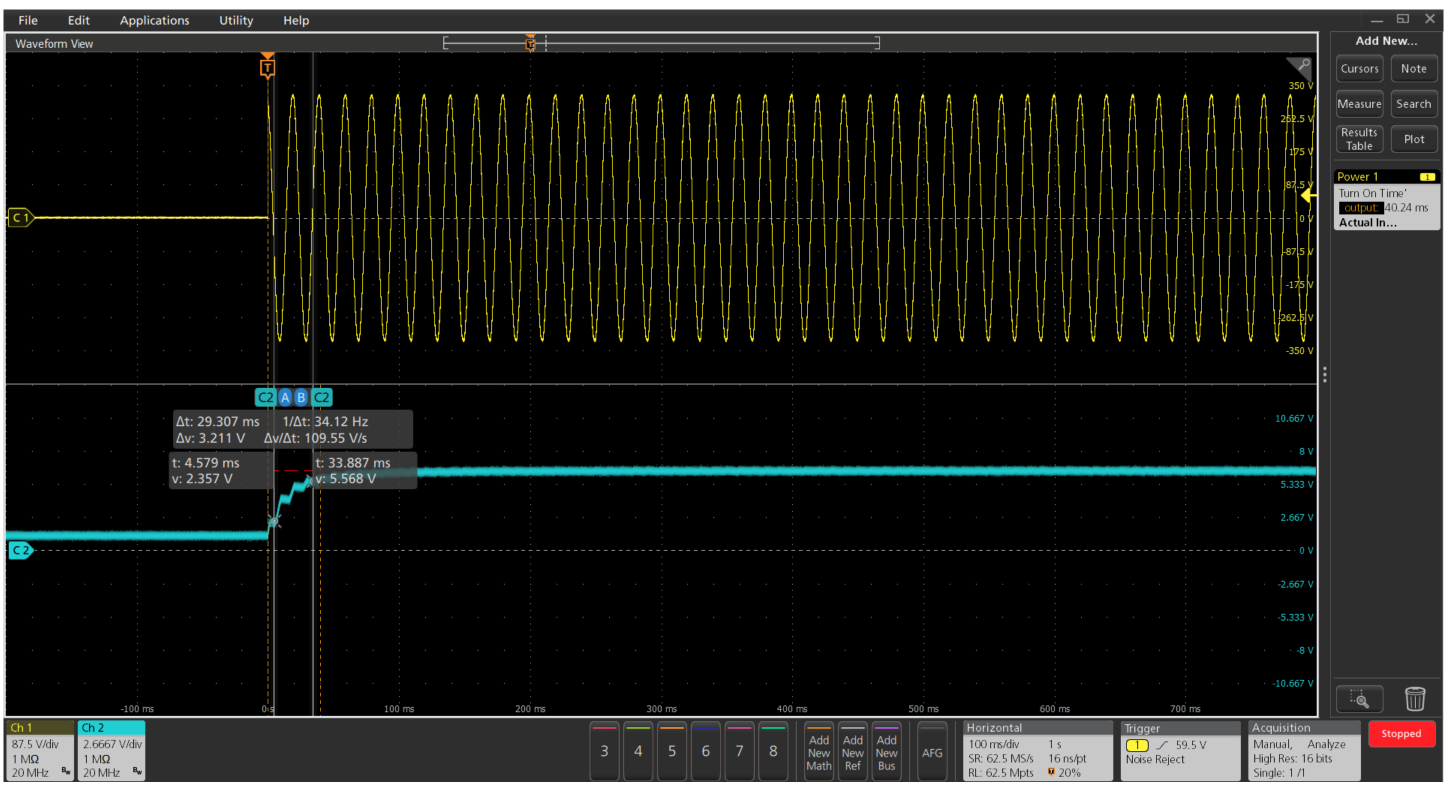
Turn on time and turn off time

Turn on time is defined as the time it takes for the output voltage to reach a steady state after the input voltage is turned on.

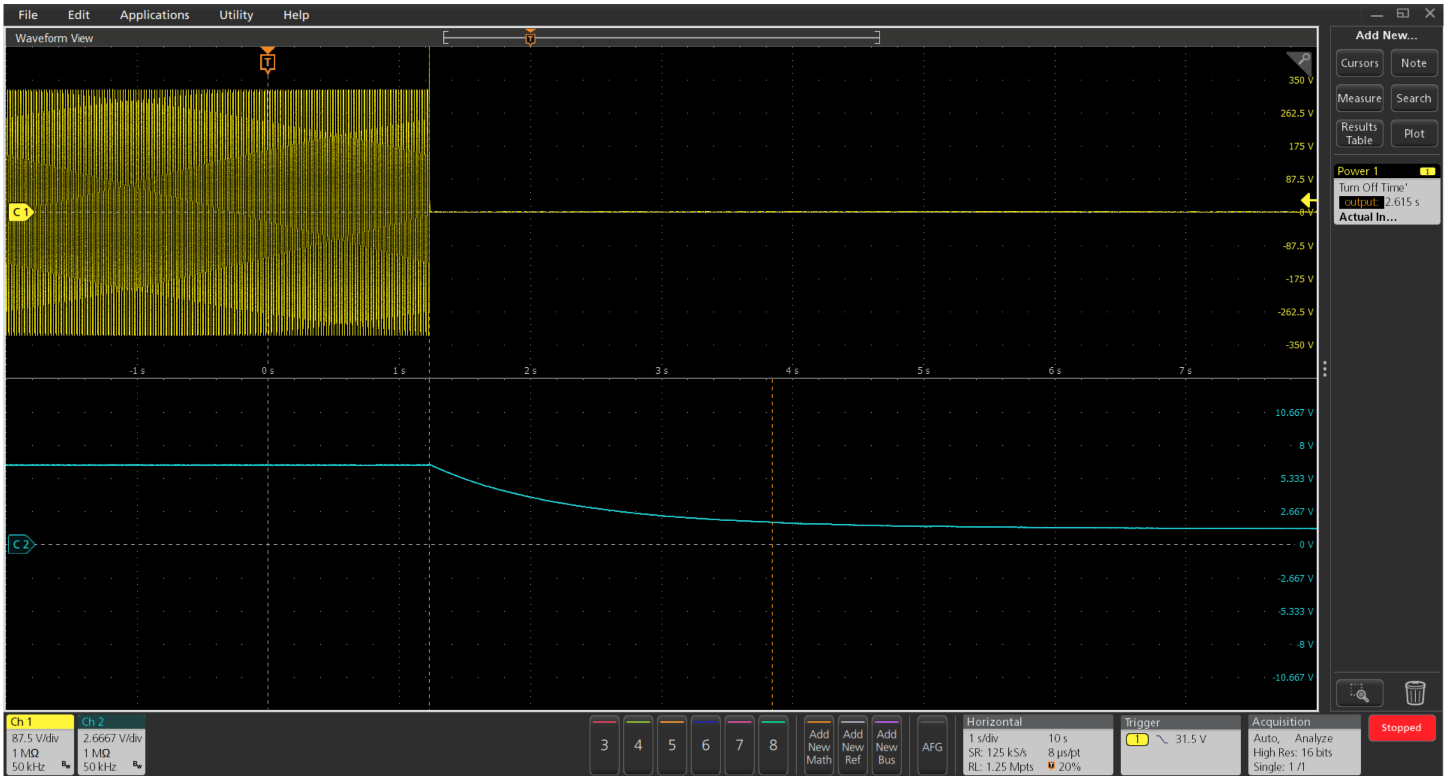
Turn off time is defined as the time it takes for the output to reach its zero state after the input voltage is switched off.

It is very important for SMPS to operate at specified turn on and turn off time. If the delay between mains power and SMPS startup is not as per design (typically 1 ms) it can disrupt the operation of some sensitive loads. Most embedded systems use more than one power supply and many use multiple outputs.

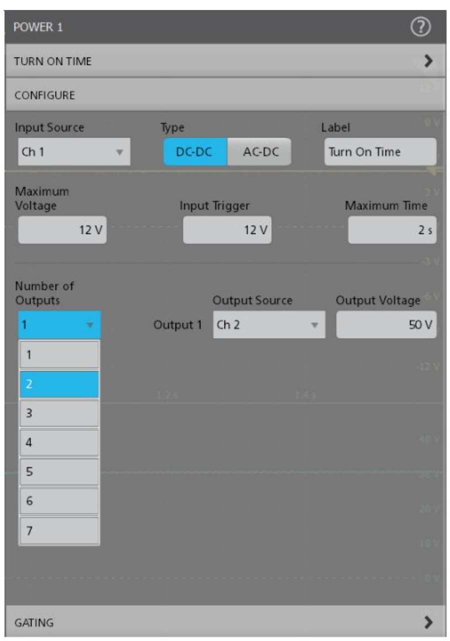
4-PWR-BAS, 5-PWR and 6-PWR automates this measurement for up to 5 outputs (4 Series MSO) or up to seven outputs (5 Series MSO) or up to 3 outputs (6 Series MSO) simultaneously.



Turn on time measurement



Turn off time measurement



The Turn on time measurement configuration supports multiple output devices

The Turn off time measurement configuration supports multiple outputs

Frequency response analysis (available only in 5/6-PWR)

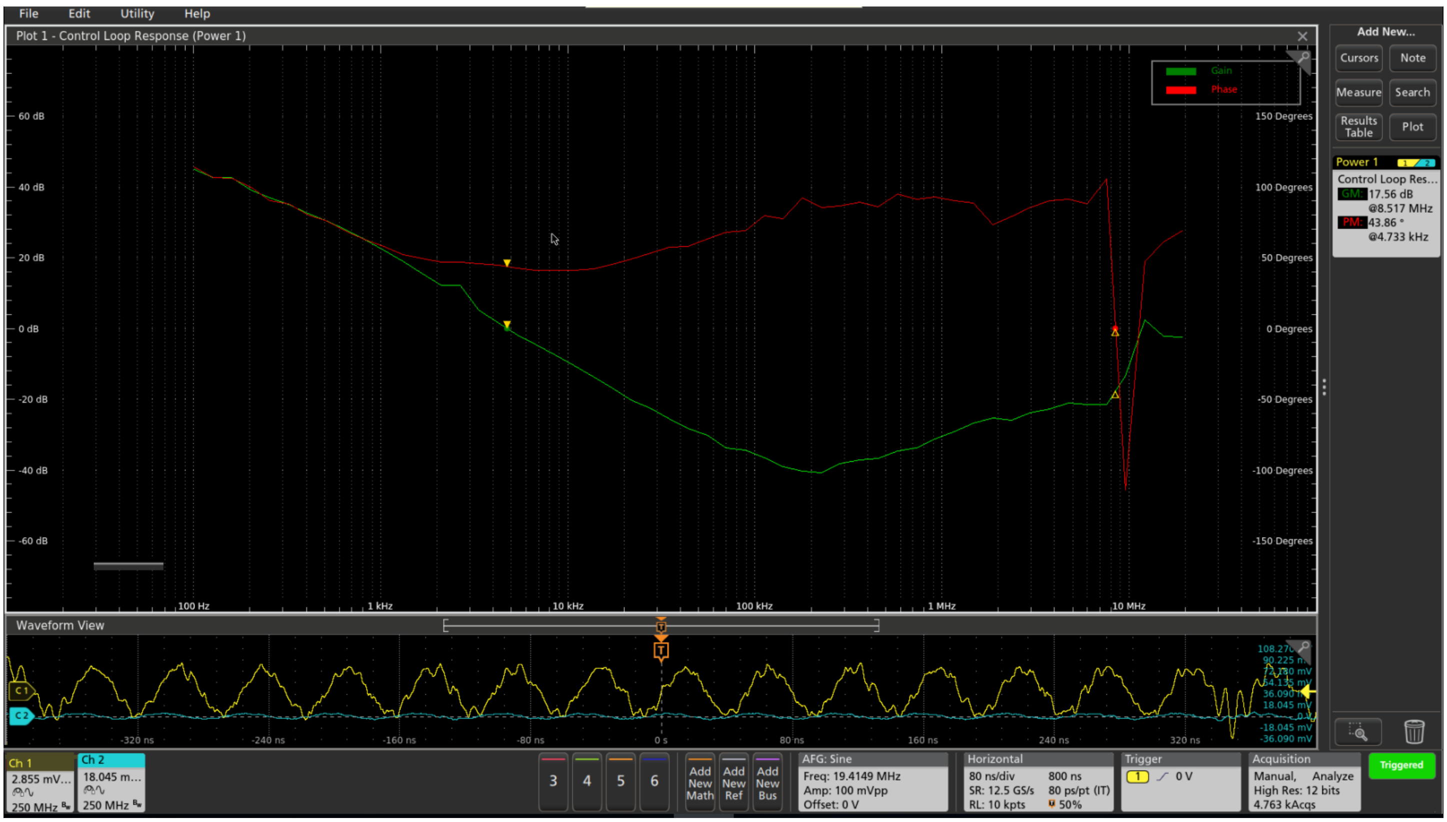
The Control Loop Response analysis (Bode plots), Power Supply Rejection Ratio (PSRR) and Impedance measurement provide key measurements to ensure stable, low-noise power supply designs. While it is possible to perform this analysis with a vector network analyzer or dedicated frequency response analyzer, these instruments can require significant setup time and long learning curves. Advanced Power Measurement and Analysis enables frequency response analysis right on the 5 and 6 Series MSOs, taking advantage of the optional, built-in or external arbitrary/function generator.

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 to provide a single 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.

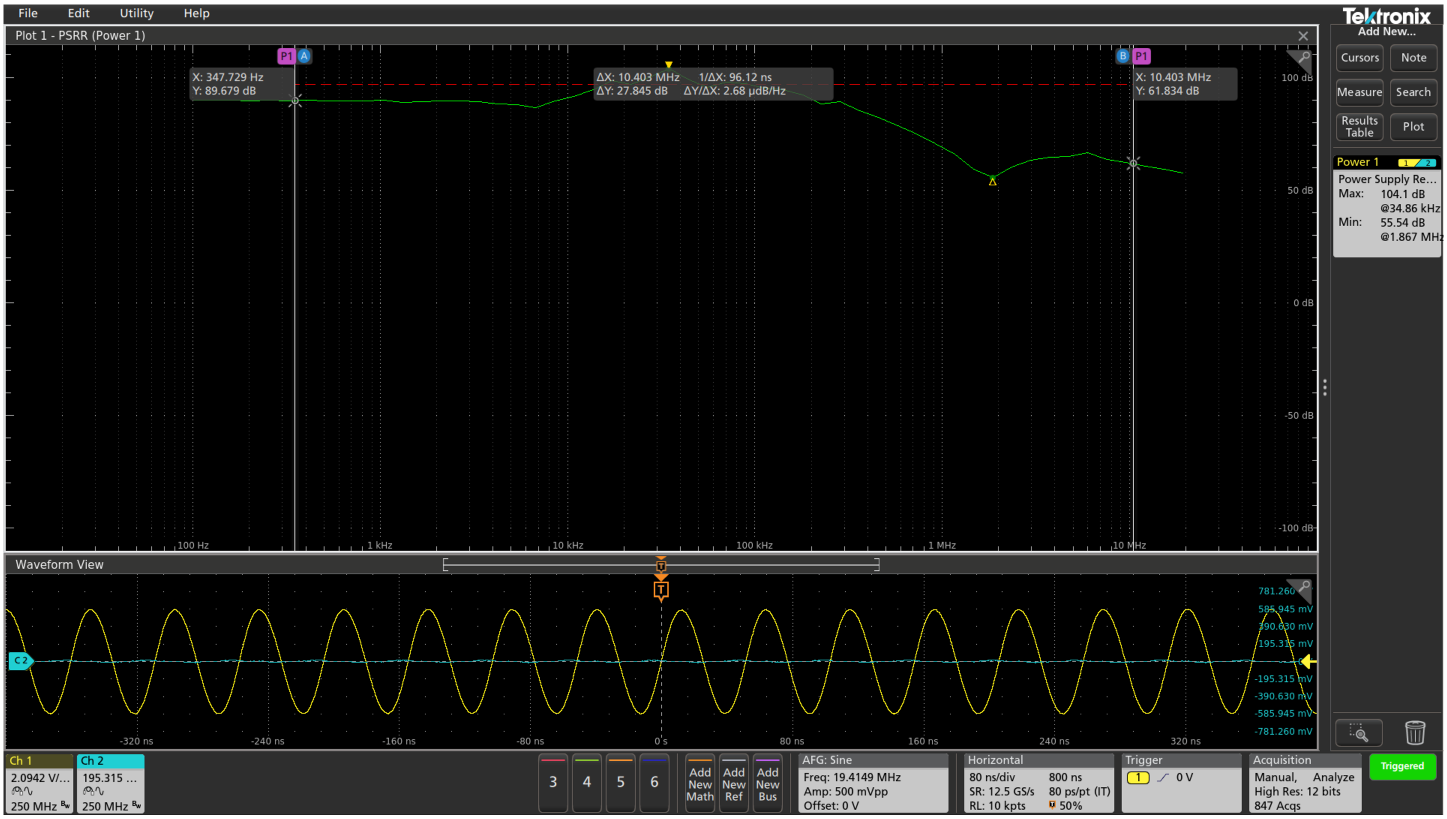
Control loop response measurement configuration allows user to set START and STOP frequencies, select constant/amplitude profile, Impedance, and points per decade for better plot rendering.



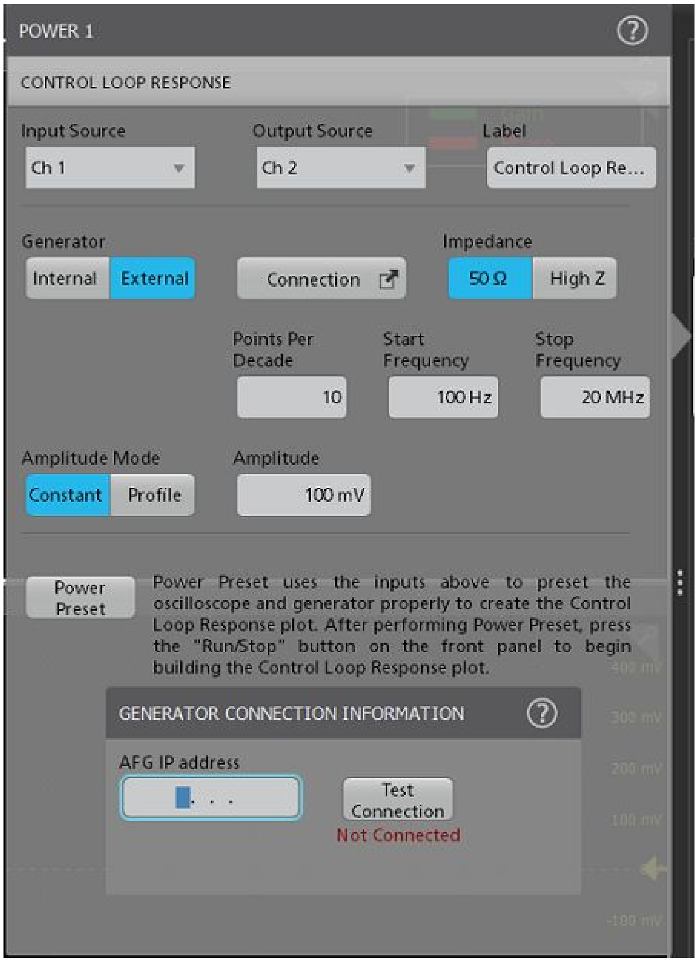
Control Loop Response (Bode plots) plots gain and phase versus frequency and calculates the gain margin and phase margin.

Power Supply Rejection Ratio (PSRR)

The PSRR measurements enable 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 5/6 Series 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 (V_{in}/V_{out}) at each frequency within the swept band, and plots the result.



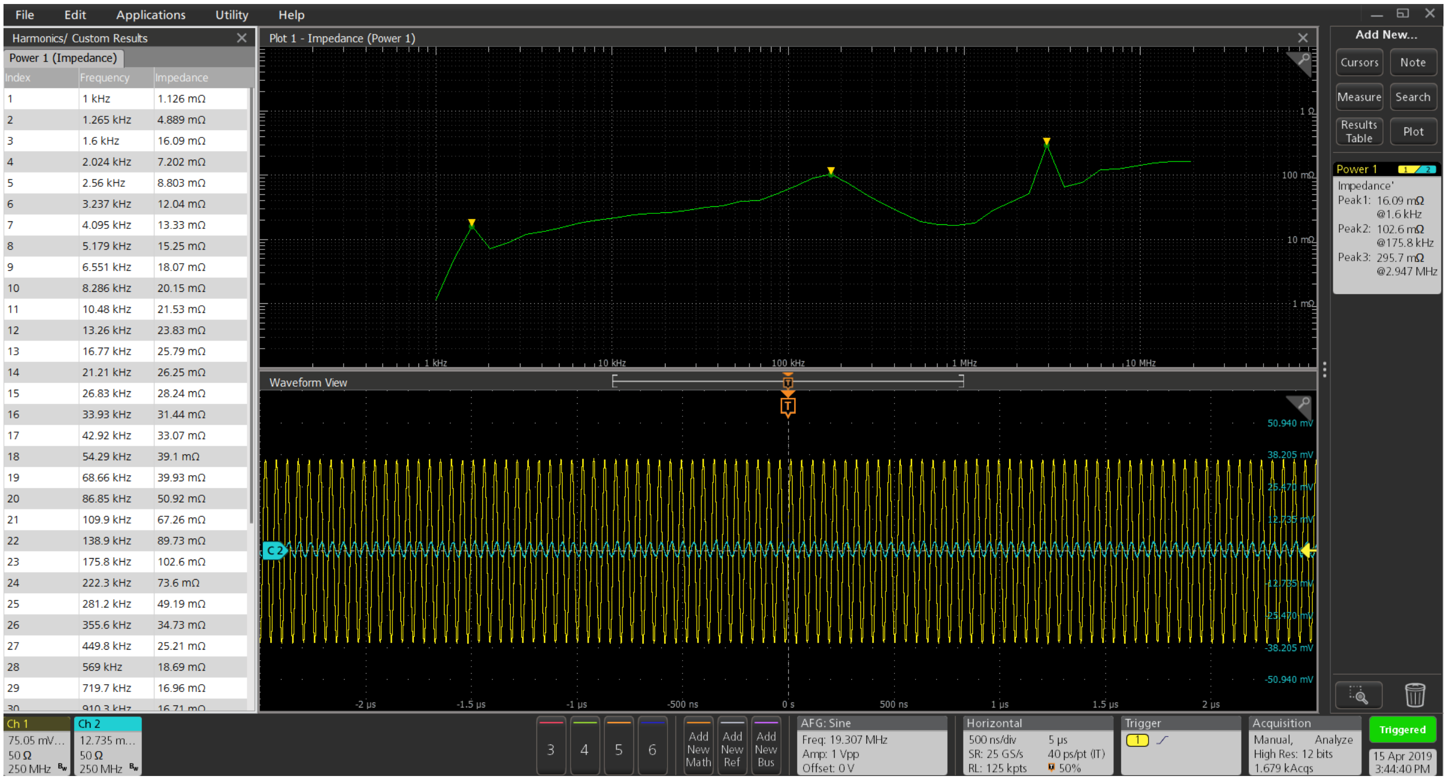
Power Supply Rejection Ratio (PSRR) plots the rejection ratio over frequencies and annotates the min and max values



Control loop response and Power supply rejection ratio measurement allow you to set START and STOP frequencies of default internal AFG or external AFG31000 series. They also allow you to select constant/amplitude profile, impedance, and points per decade for better plot rendering

Impedance

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 5/6 Series MSO or an external Tektronix AFG31000 Series function generator, along with a power divider, an injection transformer (such as the Picotest J2102A 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 result. TPR1000/4000 power rail probes, P6150 probes, or a direct SMA connection are recommended.



Impedance measurement with results table and results badge showing values for the peak impedance points.

Smart probes deliver accurate results

Reducing noise and eliminating probing errors are among the best ways to improve the accuracy of power system measurements. The 4/5/6 Series MSO and Advanced Power Measurement and Analysis software support a wide range of probes to help address different measurement needs, and include several features designed to help minimize probing problems.

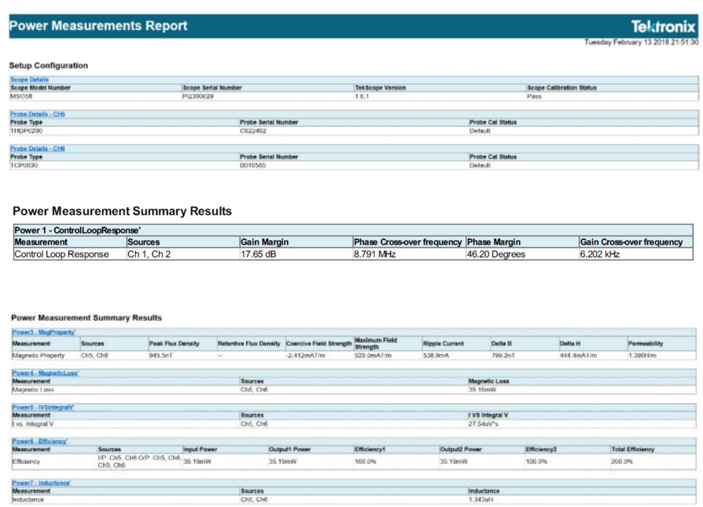
The system uses voltage and current probes with the TekVPI interface which supports communication between probes and the scope. This allows the probe to communicate its scale setting automatically to the oscilloscope. On appropriate probes, it enables control of ranges from the front panel of the scope, and it allows probes to communicate error conditions such as a partially open jaw or a need for degaussing on current probes.

For timing-critical measurements such as switching loss, the analysis software can query voltage or current probes and use nominal delay values to remove timing skew and synchronize voltage and current waveforms for accurate and repeatable results.

The system is compatible with IsoVu Isolated Measurement Systems. These differential probing systems provide complete optical isolation, bandwidth up to 1 GHz, and extremely high common mode rejection, making them ideal for V_{GS}, V_{DS} or V_{SHUNT} measurements in power systems. For optimizing designs that use wide bandgap switching devices such as GaN or SiC transistors, IsoVu probes are unbeatable.

Automated report generation

Data collection, archiving, and documentation can be tedious, but they are critical in the design and development process. 4-PWR-BAS, 5-PWR and 6-PWR 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 as .pdf files. A sample report is shown below.



Power Measurements Report Tektronix

Tuesday February 13 2018 21:51:30

Setup Configuration

Scope Details

Scope Model Number	Scope Serial Number	TekScope Version	Scope Calibration Status
MSO58	PQ300029	1.6.1	Pass

Probe Details - CH5

Probe Type	Probe Serial Number	Probe Cal Status
THDP0200	C022402	Default

Probe Details - CH6

Probe Type	Probe Serial Number	Probe Cal Status
TCP0030	B010565	Default

Power Measurement Summary Results

Power 1 - ControlLoopResponse'

Measurement	Sources	Gain Margin	Phase Cross-over frequency	Phase Margin	Gain Cross-over frequency
Control Loop Response	Ch 1, Ch 2	17.65 dB	8.791 MHz	46.20 Degrees	6.202 kHz

Power Measurement Summary Results

Power3 - MagProperty'

Measurement	Sources	Peak Flux Density	Retentive Flux Density	Coercive Field Strength	Maximum Field Strength	Ripple Current	Delta B	Delta H	Permeability
Magnetic Property	Ch5, Ch6	945.5nT	--	-2.412mAT/m	520.0mAT/m	538.9mA	799.2nT	444.4mAT/m	1.306H/m

Power4 - MagneticLoss'

Measurement	Sources	Magnetic Loss
Magnetic Loss	Ch5, Ch6	35.19mW

Power5 - IVSIntegralV'

Measurement	Sources	I VS Integral V
I vs. Integral V	Ch5, Ch6	27.54uV*s

Power6 - Efficiency'

Measurement	Sources	Input Power	Output1 Power	Efficiency1	Output2 Power	Efficiency2	Total Efficiency
Efficiancy	I/P: Ch5, Ch6 O/P: Ch5, Ch6, Ch5, Ch6	35.19mW	35.19mW	100.0%	35.19mW	100.0%	200.0%

Power7 - Inductance'

Measurement	Sources	Inductance
Inductance	Ch5, Ch6	1.343uH

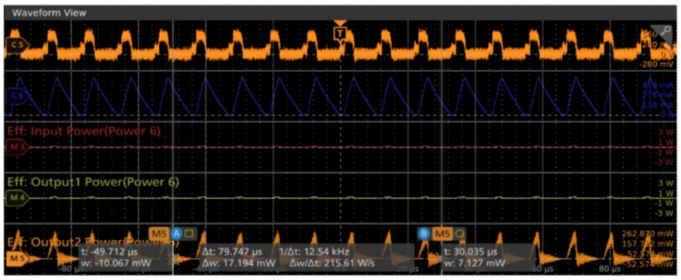
Power Measurement Detailed Results

Power3 - MagProperty														
Measurement	**Test**	**Sources**	**Mean'**	**Min'**	**Max'**	**PK-PK'**	**Std Dev'**	**Population'**	**Accum Mean**	**Accum Min**	**Accum Max**	**Accum Pk-Pk**	**Accum Std Dev**	**Accum Pop**
Magnetic Property	Peak Flux Density	Ch5, Ch6	945.5nT	901.5nT	988.9nT	87.38nT	22.12nT	16	352.8nT	-491.4nT	1.310uT	1.801uT	456.2nT	25650
Magnetic Property	Retentive Flux Density	Ch5, Ch6	--	--	--	--	--	0	--	--	--	--	--	0
Magnetic Property	Coercive Field Strength	Ch5, Ch6	-2.412mAT/m	-2.412mAT/m	-2.412mAT/m	0.000AT/m	0.000AT/m	1	33.27mAT/m	-8.509mAT/m	359.6mAT/m	386.1mAT/m	89.51mAT/m	515
Magnetic Property	Maximum Field Strength	Ch5, Ch6	520.0mAT/m	520.0mAT/m	520.0mAT/m	0.000AT/m	0.000AT/m	1	515.0mAT/m	9.135mAT/m	524.3mAT/m	515.1mAT/m	41.90mAT/m	587
Magnetic Property	Ripple Current	Ch5, Ch6	538.9mA	538.2mA	540.3mA	2.102mA	604.6uA	16	293.8mA	1.261mA	543.8mA	542.5mA	256.2mA	25650
Magnetic Property	Delta B	Ch5, Ch6	799.2nT	799.2nT	799.2nT	0.000T	0.000T	1	694.7nT	1.420pT	872.7nT	872.7nT	179.2nT	587
Magnetic Property	Delta H	Ch5, Ch6	444.4mAT/m	444.4mAT/m	444.4mAT/m	0.000AT/m	0.000AT/m	1	401.8mAT/m	463.6uAT/m	451.0mAT/m	450.5mAT/m	105.5mAT/m	587
Magnetic Property	Permeability	Ch5, Ch6	1.386H/m	1.386H/m	1.386H/m	0.000H/m	0.000H/m	1	1.360H/m	10.30mH/m	1.902H/m	1.892H/m	162.5mH/m	587

Power6 - Efficiency														
Measurement	**Test**	**Sources**	**Mean'**	**Min'**	**Max'**	**PK-PK'**	**Std Dev'**	**Population'**	**Accum Mean**	**Accum Min**	**Accum Max**	**Accum Pk-Pk**	**Accum Std Dev**	**Accum Pop**
Efficiency	Input Power	Ch5, Ch6	35.19mW	35.19mW	35.19mW	0.000W	0.000W	1	35.79mW	777.7uW	39.01mW	38.23mW	3.051mW	587
Efficiency	Output1 Power	Ch5, Ch6	35.19mW	35.19mW	35.19mW	0.000W	0.000W	1	35.79mW	777.7uW	39.01mW	38.23mW	3.051mW	587
Efficiency	Efficiency1	I/P: Ch5, Ch6 O/P: Ch5, Ch6	100.0%	100.0%	100.0%	0.000%	0.000%	1	100.0%	100.0%	100.0%	0.000%	0.000%	587
Efficiency	Output2 Power	Ch5, Ch6	35.19mW	35.19mW	35.19mW	0.000W	0.000W	1	35.79mW	777.7uW	39.01mW	38.23mW	3.051mW	587
Efficiency	Efficiency2	I/P: Ch5, Ch6 O/P: Ch5, Ch6	100.0%	100.0%	100.0%	0.000%	0.000%	1	100.0%	100.0%	100.0%	0.000%	0.000%	587
Efficiency	Total Efficiency	I/P: Ch5, Ch6 O/P: Ch5, Ch6, Ch5, Ch6	200.0%	200.0%	200.0%	0.000%	0.000%	1	200.0%	200.0%	200.0%	0.000%	0.000%	587

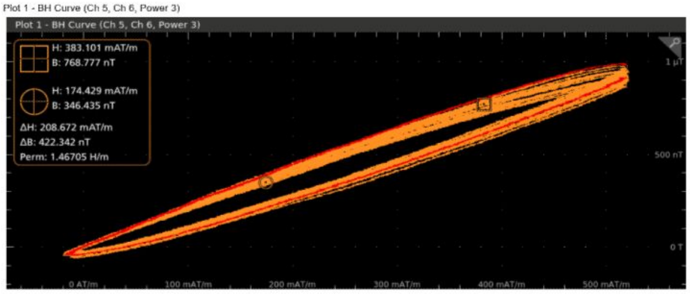
Views

Time Domain View

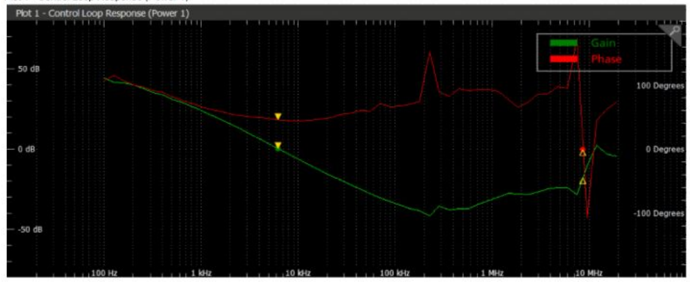


Plots

Plot 1 - BH Curve (Ch 5, Ch 6, Power 3)



Plot 1 - Control Loop Response (Power 1)



Individual Measurement Configuration

Power3 - MagProperty									
Voltage Source Ref Levels		Current Source Ref Levels		Configurations		Gating		General	
Global Enabled	True	Global Enabled	True	ResultantCurr	math2	Gating Type	None	Custom Measurement Name	Magnetic Property
Base Top Method	Automatic	Base Top Method	Automatic	SecWndgCount	Zero				
RiseHigh	90%	RiseHigh	90%	Measunits	SI				
RiseMid	50%	RiseMid	50%	Edgesource	Voltage				
RiseLow	10%	RiseLow	10%	Primaryturns	1				
FallHigh	90%	FallHigh	90%	MagLength	1m				
FallMid	50%	FallMid	50%	CrossSection	1mÂ²				
FallLow	10%	FallLow	10%						
Hysteresis	15%	Hysteresis	15%						

Specifications

Input analysis	True power, Apparent power, Power factor, Reactive power, Crest factor, Phase angle, THD, Harmonics, Input capacitance, Inrush current, D0-160G, Pre-compliance testing for EN61000-3-2, EN61000-3-2 AM14, and MIL-STD-1399 (400 Hz) standards
Amplitude measurements	Cycle Amplitude, Cycle Top, Cycle Base, Cycle Minimum, Cycle Maximum, and Cycle Peak-to-Peak
Timing analysis	Pulse width, Duty cycle, Period, and Frequency variation versus time
Switching analysis	Switching loss, Turn-on (T_{on}), Turn -off (T_{off}), Conduction loss (cond), Safe operating area (SOA), SOA with Mask testing, di/dt, dv/dt, and $RDS_{(on)}$
Magnetic analysis (available only in 5/6-PWR)	Inductance, Magnetic Property, Magnetic Loss, and I vs.∫V
Output analysis	Ripple (line frequency, switching frequency), Efficiency, Turn On Time, Turn Off Time
Frequency response analysis (available only in 5/6-PWR)	**Bode and PSSR** Control Loop Response (Bode plot) and Power Supply Rejection Ratio (PSRR). PSRR plots rejection ratio vs frequency. Control Loop Response (Bode plot) calculates gain and phase margin. Requires TPP0502, two probes. Uses oscilloscope built-in generator or external Tektronix AFG 31000 Series. Dynamic range: Bode is typically 55 dB and PSRR is typically 85 dB. Frequency: 10 Hz to 50 MHz (with option AFG). 10 Hz to maximum sine frequency (with AFG31000 Series) Amplitude: up to 5 V (needs Option AFG or external AFG31000 Series 10V p-p). Requires Picotest isolation and injector transformers. **Impedance Measurement** Impedance: Requires a TPR1000/4000 power rail probe or P6150 or Direct SMA cable with DC block. Frequency: 10Hz to 50MHz for internal AFG and 10Hz to max of AFG31000 Series in case of external. Minimum Impedance can be measured is 10 milli Ohm and maximum is 47 Ohms
Plots	Time trend, Trajectory plot, Histogram, Bar graph, B-H curve, Inductance plot, I vs. ∫V, Phase, Gain, and Rejection ratio plots.
Report	MHT and PDF format, Data export to CSV format
Degauss/Deskew (static)	Automatic detection of probes, Auto Zero. User can deskew probes from the menus for each channel
Source support	Live analog signals, reference waveforms, and math waveforms

Ordering information

Models

Product	Options	Supported instruments
New Instrument order option	4-PWR-BAS,4-PS2 5-PWR, 5-PS2, 5-PS2FRA 6-PWR, 6-PS2, 6-PS2FRA	4 Series MSO (MSO44,MSO46) 5 Series MSO (MSO54, MSO56, MSO58, MSO58LP) 6 Series MSO (MSO64)
Product upgrade option	SUP4-PWR-BAS SUP5-PWR SUP6-PWR	
Floating license	SUP4-PWR-BAS-FL SUP5-PWR-FL SUP6-PWR-FL	4 Series MSO (MSO44,MSO46) Floating licenses are transferrable from any 4 Series oscilloscope to any other 4 Series oscilloscope, for use of one instrument at a time. 5 Series MSO (MSO54, MSO56, MSO58, MSO58LP) Floating licenses are transferrable from any 5 Series oscilloscope to any other 5 Series oscilloscope, for use of one instrument at a time. 6 Series MSO (MSO64) Floating licenses are transferrable from any 6 Series oscilloscope to any other 6 Series oscilloscope, for use of one instrument at a time.

Additional information about power analysis is available at http://www.tek.com/application/power-supply-measurement-and-analysis.

Recommended probes and accessories

Accessory type	Recommended
AC/DC current probes	TCP0020, TCP0030A, TCP0150
AC current probes	TRCP0300, TRCP0600, TRCP3000
Medium-voltage differential probes	TDP0500, TDP1000
High-voltage differential probes	THDP0200, THDP0100, TMDP0200
IsoVu isolated differential probes	TIVM1/L, TIVH08/L, TIVH05/L, TIVH02/L
High-voltage passive probes	P5100A, P6015A
Deskew pulse generator	TEK-DPG
Power solution bundles	4-PS2 5-PS2, 5-PS2FRA 6-PS2, 6-PS2FRA
Deskew fixture	067-1686-xx

Accessory type	Recommended
Probes for frequency response analysis (supported only in 5/6-PWR)	TPP0502: Two probes For Impedance measurement • TPR1000/TPR4000 probe • P6150 1x probe • Direct SMA with DC block
Accessories for frequency response analysis (supported only in 5/6-PWR)	Picotest Line injector J2120A for PSRR (10 Hz to 10 MHz) Picotest Isolation transformers (for Bode) http://picotest.com: • J2100A (1 Hz to 5 MHz) • J2101A (10 Hz to 45 MHz) Picotest transformers (for Impedance): • Common mode transformer: J2012A/J2113A for Differential Amplifier • DC Block is needed with P6150 probe or SMA cable setup. • 6dB Power Splitter is needed.

Power solution bundles

5/6 Series MSO PS bundle options	Description
4-PS2	4-PWR-BAS, TCP0030A, THDP0200, 067-1686-xx deskew fixture
5-PS2	5-PWR, TCP0030A, THDP0200, 067-1686-xx deskew fixture
6-PS2	6-PWR, TCP0030A, THDP0200, 067-1686-xx deskew fixture
5-PS2FRA	5-PS2, two TPP0502 probes
6-PS2FRA	6-PS2, two TPP0502 probes

Complete power probing portfolio

Use the following list of probes with option 4-PWR-BAS/5-PWR/6-PWR power to ensure complete solution to power measurement capabilities on the 5/6 Series MSO oscilloscopes.

Probe type	Description	
High voltage differential probes	The THDP0100/THDP0200/TMDP0200 high-voltage differential probes are the best choice for making non-ground referenced, floating measurements. These probes provide bandwidths to 200 MHz and voltage ranges up to 6000 V.	
	The P5200A/P5202A/P5205A/P5210A high-voltage differential probes are the best choice for making non-ground referenced, floating or isolated measurements. These probes provide bandwidths to 100 MHz and voltage ranges up to 5600 V.	

Probe type	Description	
Optically Isolated differential probes	The TIVM1, TIVH08, TIVH05, and TIVH02 optically-isolated differential probes are the best choice for accurately resolving high bandwidth, differential signals, ideal for testing wide bandgap designs. The probes are available in 3 m and 10 m lengths. The TIVM1 provides 1 GHz bandwidth and can measure differential signals up to ±50 Vpk in the presence of common mode voltages up to 60 kV. The TIVH08, TIVH05, and TIVH02 provide 800 MHz, 500 MHz, and 200 MHz, respectively, and can measure differential signals up to ±2500 Vpk in the presence of common mode voltages up to 60 kV.	
Current probes	Tektronix offers a broad portfolio of current probes, including AC/DC current probes that provide bandwidths up to 120 MHz and best-in-class current clamp sensitivity down to 1 mA.	
	AC-only Rogowski probes include the TRCP300 (9 Hz to 30 MHz, 250 mA to 300 A peak), TRCP600 (12 Hz to 30 MHz, 500 mA to 600 A peak), and TRCP3000 (1 Hz to 16 MHz, 500 mA to 3000 A peak).	
Mid-voltage differential probes	The TDP0500/TDP1000 medium-voltage differential probes are the best choice for making non-ground referenced, floating or isolated measurements. These probes provide bandwidths to 1 GHz and voltage ranges up to ±42 V (DC + pk AC).	

Probe type	Description	
Probes for control loop analysis and power supply rejection ratio	TPP0502 is the recommended passive probe FRA measurement. It has the attenuation of 2X and bandwidth of 500 MHz. It also offers low capacity loading.	
Probes for Impedance measurement	TPR1000 and TPR4000 are the recommended probes for the Impedance measurement. The TPR1000 and TPR4000 probes provide a low-noise measurement solution (oscilloscope and probe), which is critical to not confuse the noise of the oscilloscope and probe with the noise and ripple of the measured DC supply. The higher input impedance in the probes minimizes the oscilloscope loading effect on the DC rails (50 kΩ at DC). P6150 and Direct SMA cable with DC Block can also be used for Impedance measurement.	

For a complete listing of compatible probes for each oscilloscope, please refer to http://www.tek.com/probes for specific information on the recommended models of probes and any necessary probe adapters.

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For Further Information. Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit www.tek.com.

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