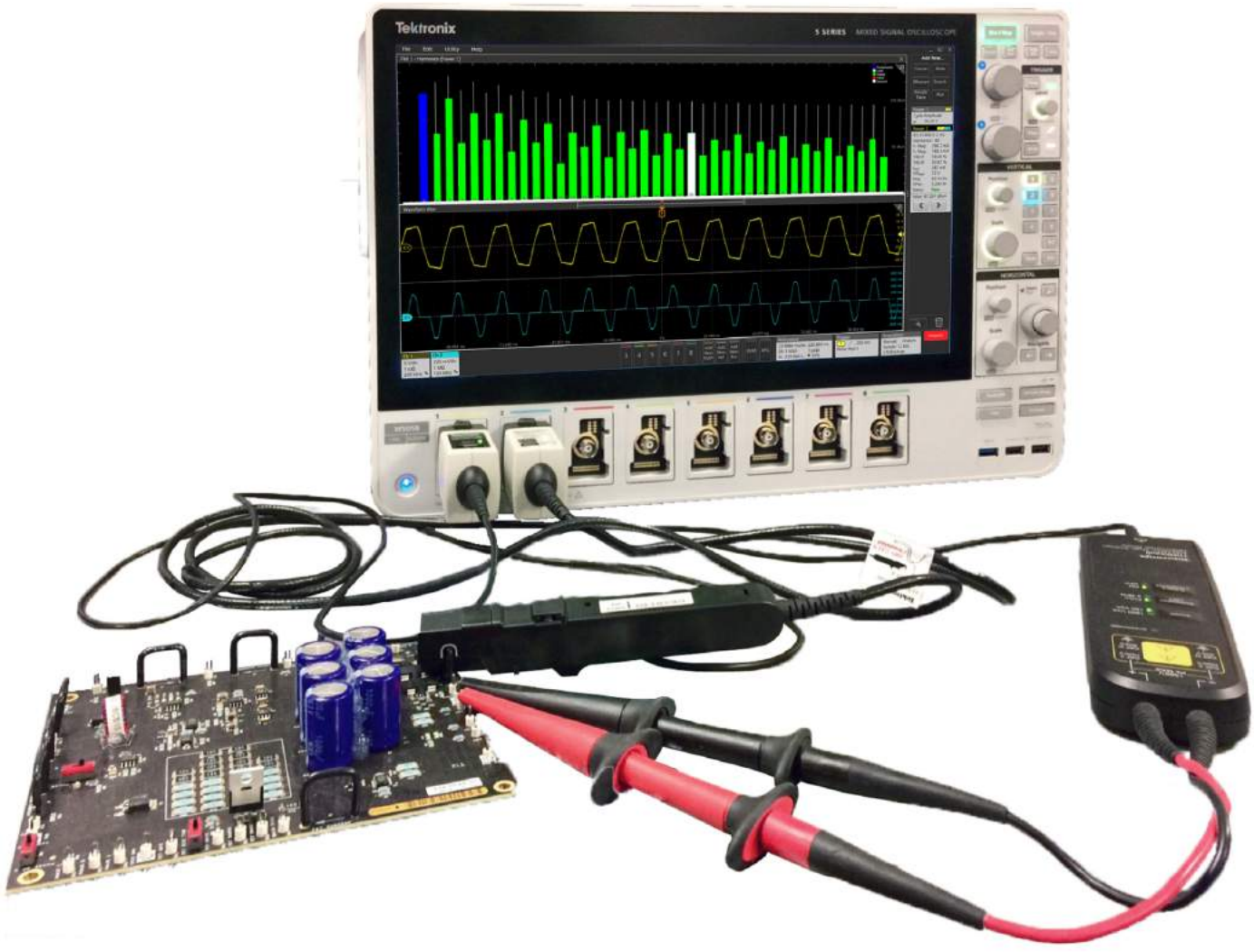
Tektronix

Advanced Power Measurement and Analysis

5 Series MSO Option 5-PWR Datasheet

Get more visibility into your power supply designs



Get more visibility into your power systems with Advanced Power Measurement and Analysis on the 5 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 the 5 Series MSO 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, signal visibility on up to 8 FlexChannel® inputs, and a 15.6-inch HD display, deliver a comprehensive view of your power system. The instrument supports 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

- **Line 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
- **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**
  - **Inductance** measures inductance of the core
  - **Magnetic Property** measures and plots the inductor B - H curve.
  - **Magnetic Loss** computes total magnetic loss
  - **I vs. ∫V** displays the plot of I and ∫V waveforms
- **Output measurements**
  - **Line Ripple**
  - **Switching Ripple**
  - **Efficiency** measures the power circuit efficiency by dividing the measured output power by the measured input power

Key features

- Add, configure, and remove automated measurements using the 5 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
- 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 and current harmonics are two 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

This group of 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:

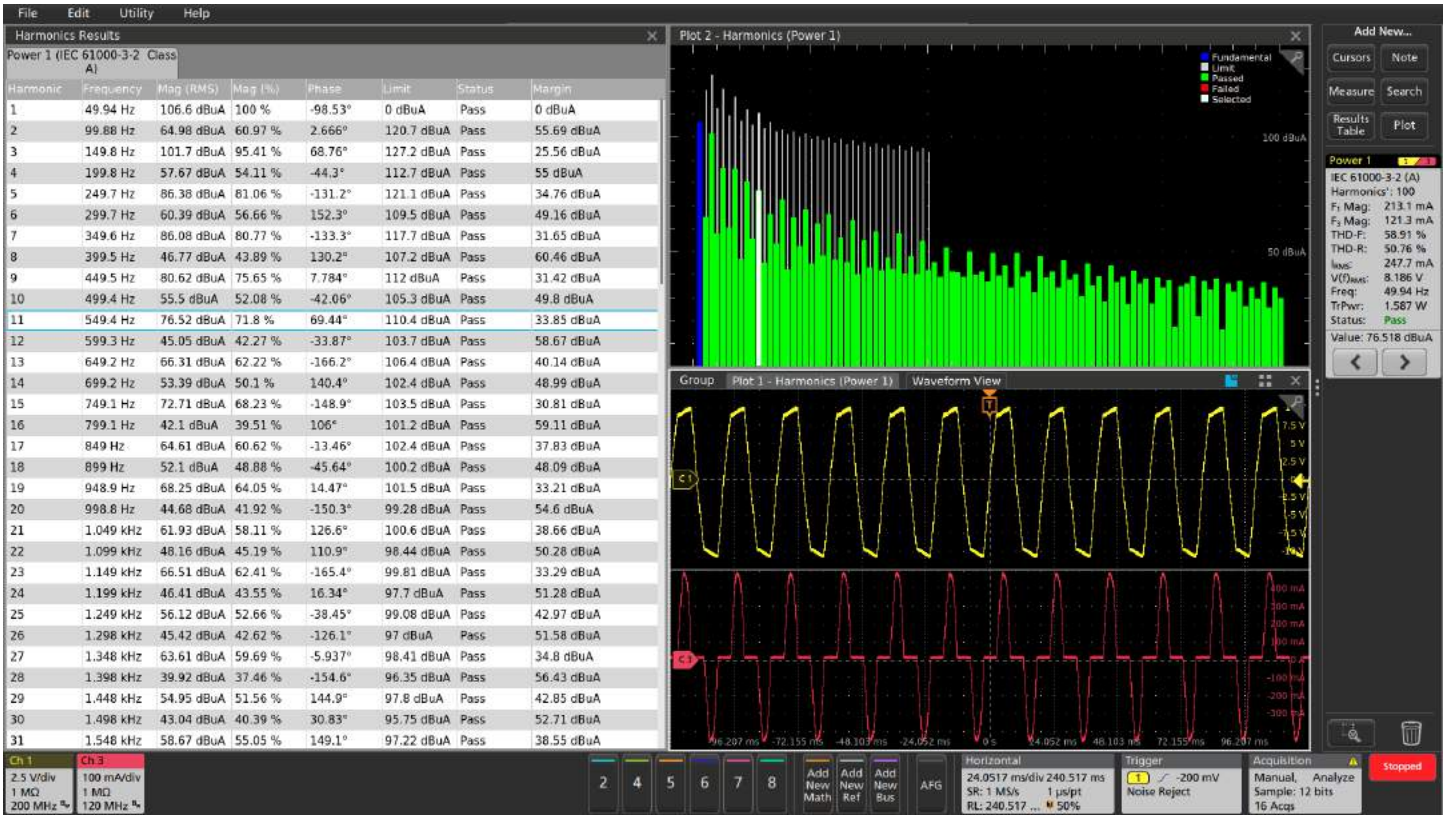
- RMS voltage and current
- Frequency
- True, apparent, and reactive power
- Power factor
- THD and crest factor

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, the 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)

Switching component analysis

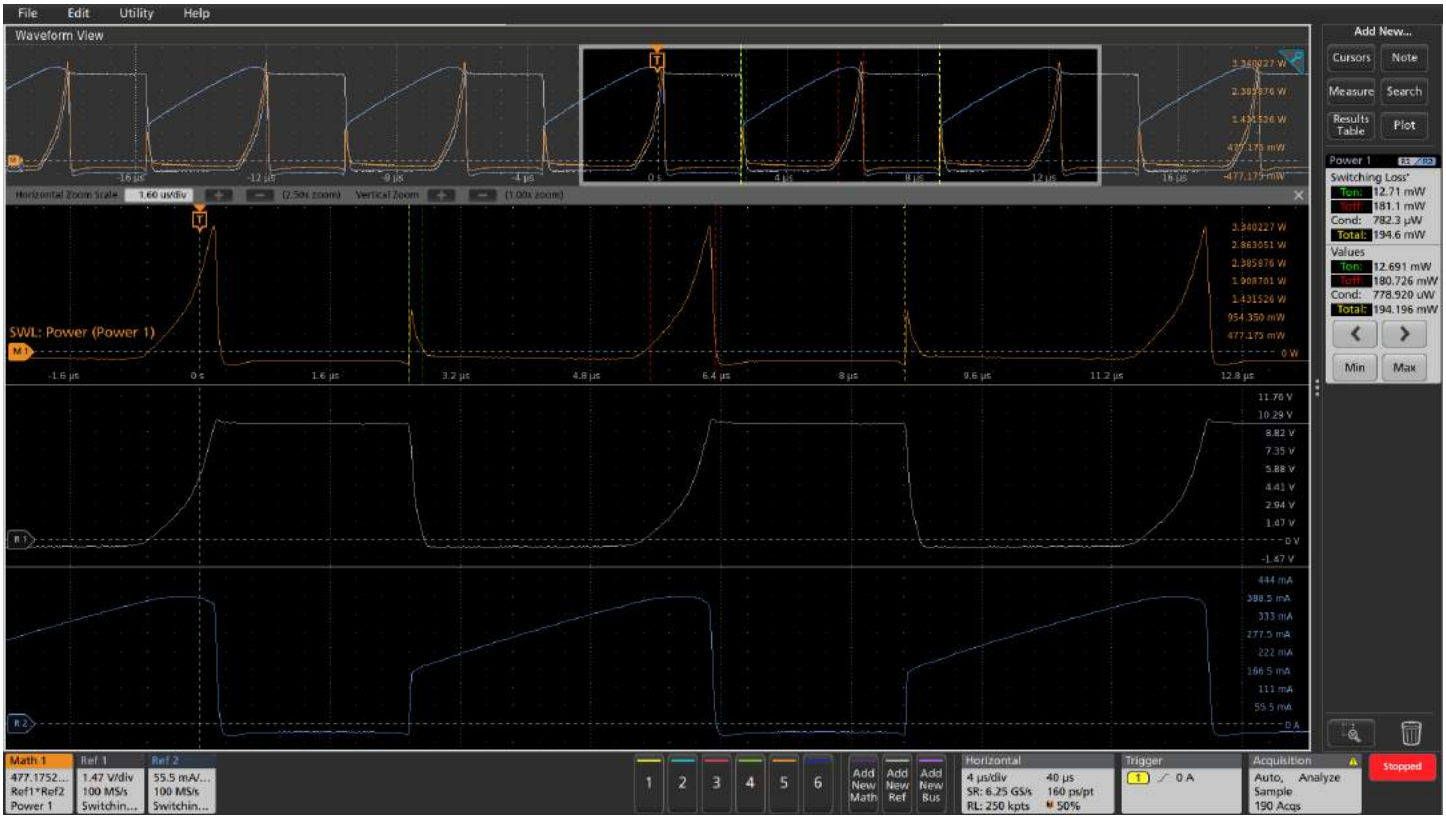
The accurate calculation and evaluation of energy loss in power supplies has become even more critical with the drive toward higher power conversion efficiency and greater reliability.

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, 5-PWR automatically computes 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.

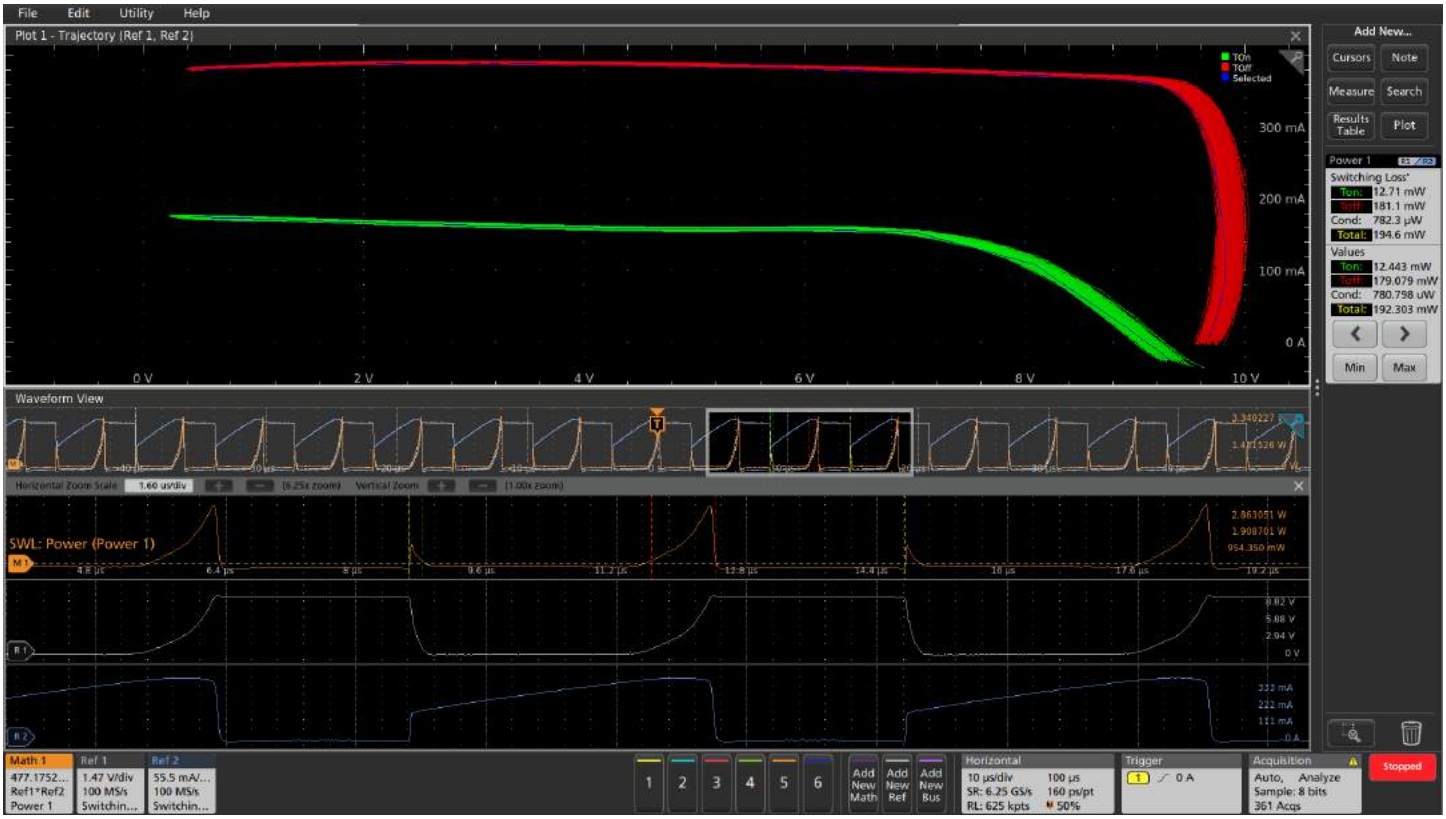
The 5 Series MSO is designed to work with IsoVu optically isolated probes, enabling designers to perform accurate switching measurements even in the presence of high common mode signals.



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.

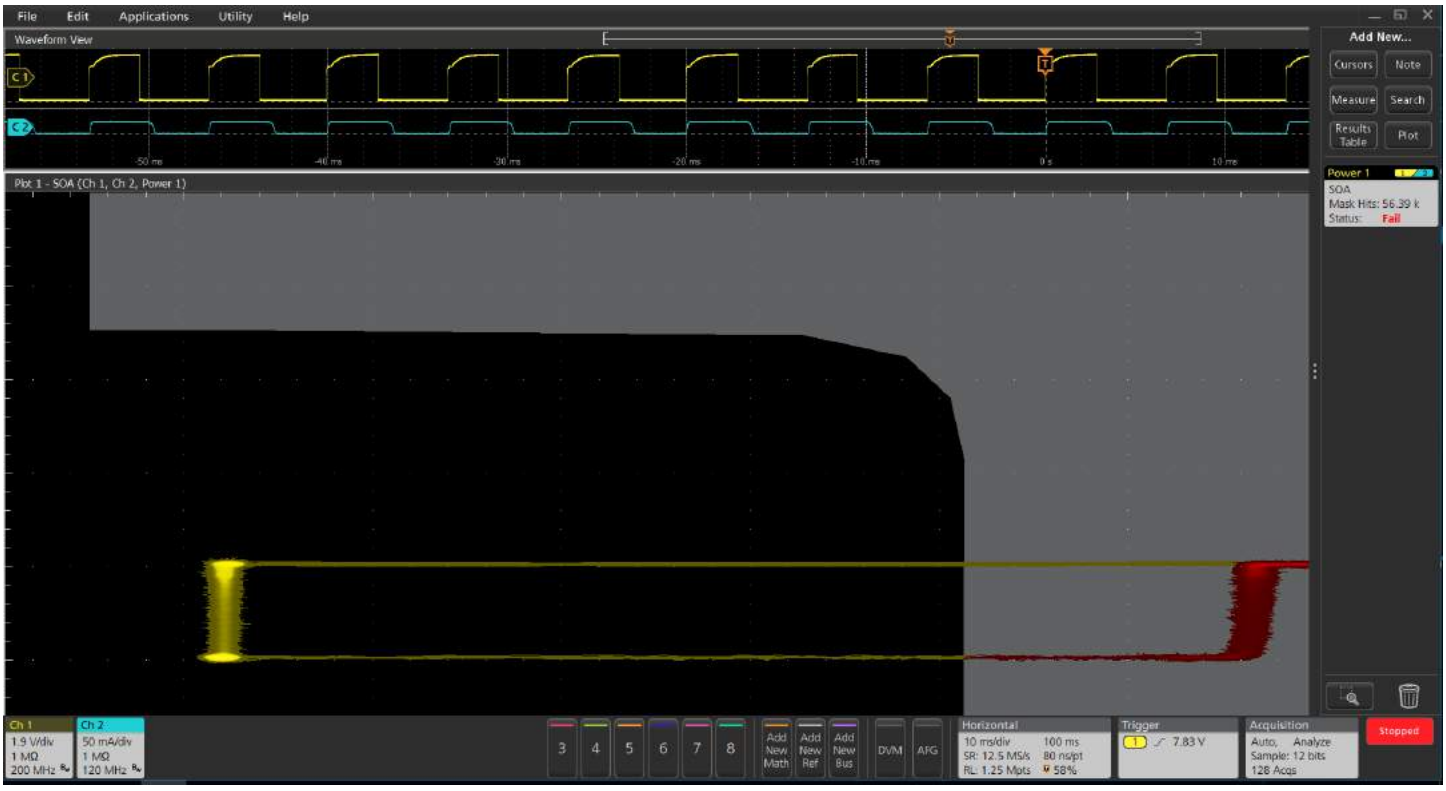
To get an overview of the switching loss for all captured cycles, you can use the trajectory plot. It automatically plots the voltage across the switch versus current through the switch during turn-on and turn-off, letting you judge the range of switching loss for all cycles at a glance.



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.

$RDS_{(on)}$ measurement

Magnetic analysis

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

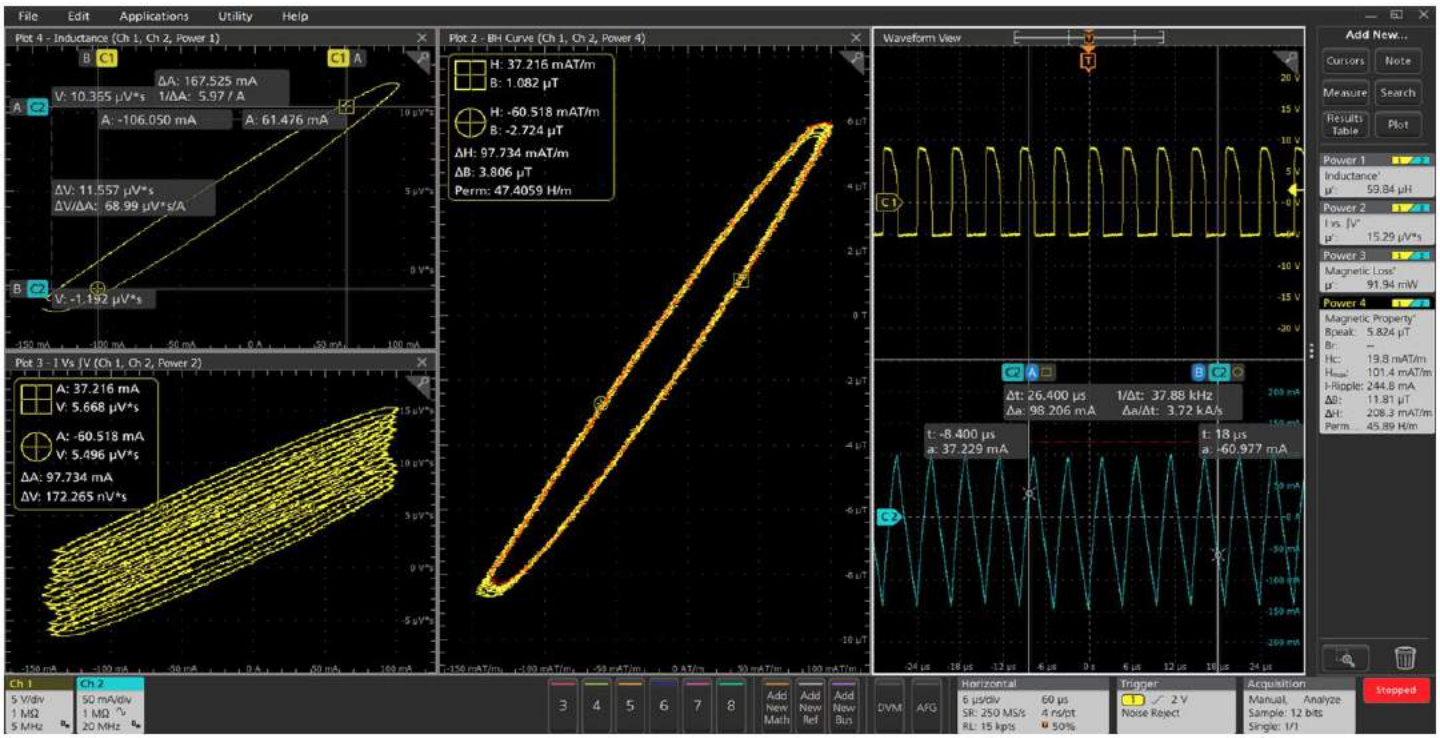
An analysis of magnetic power losses is essential to accurately characterize the efficiency, reliability, and performance of a switching power supply. Advanced Power Measurement and Analysis software measures the inductive total magnetic power loss, as shown in the following figure.

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.



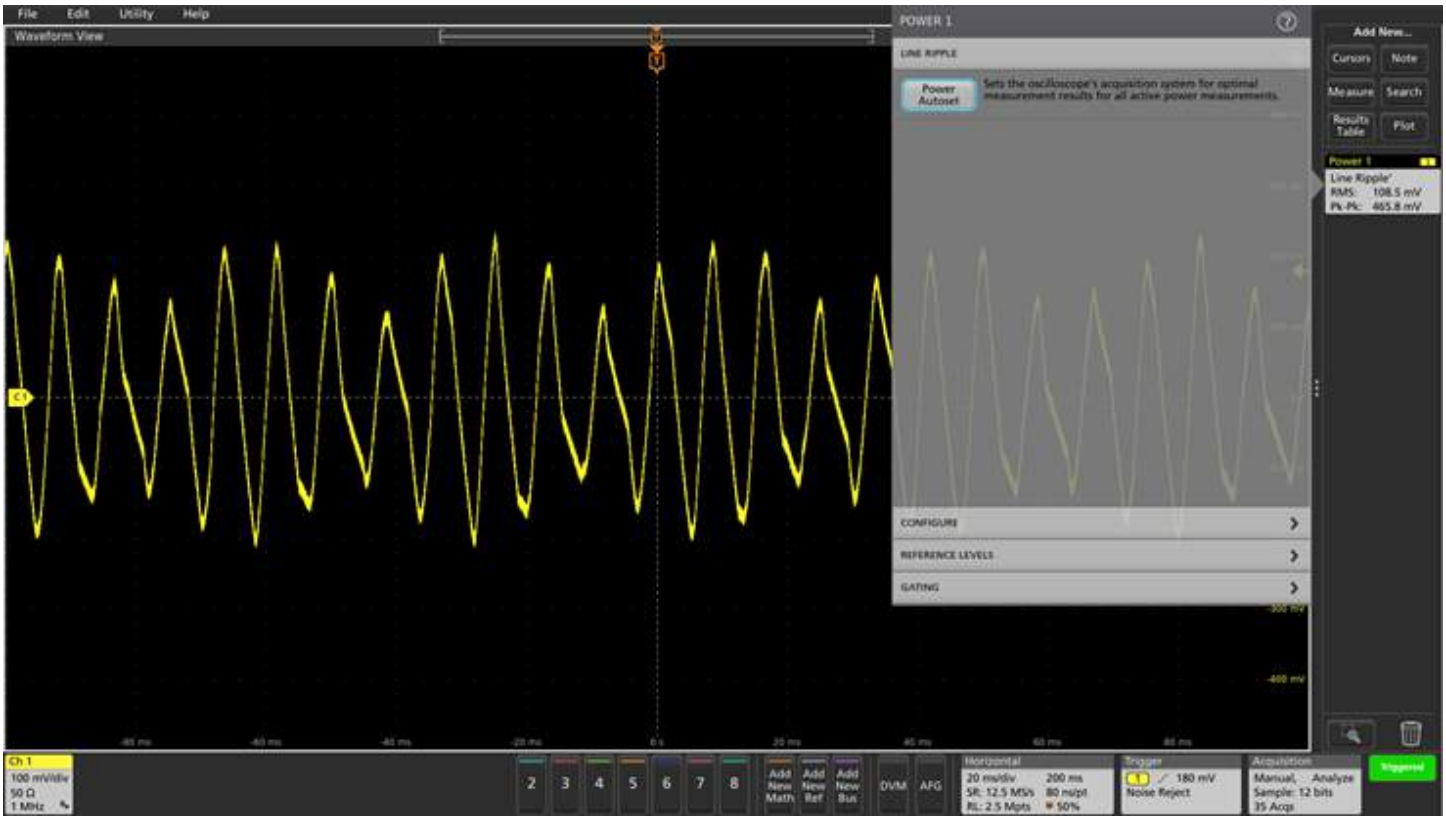
Magnetic Analysis measurement with B-H curve, I vs. ∫V, and Inductance plots

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

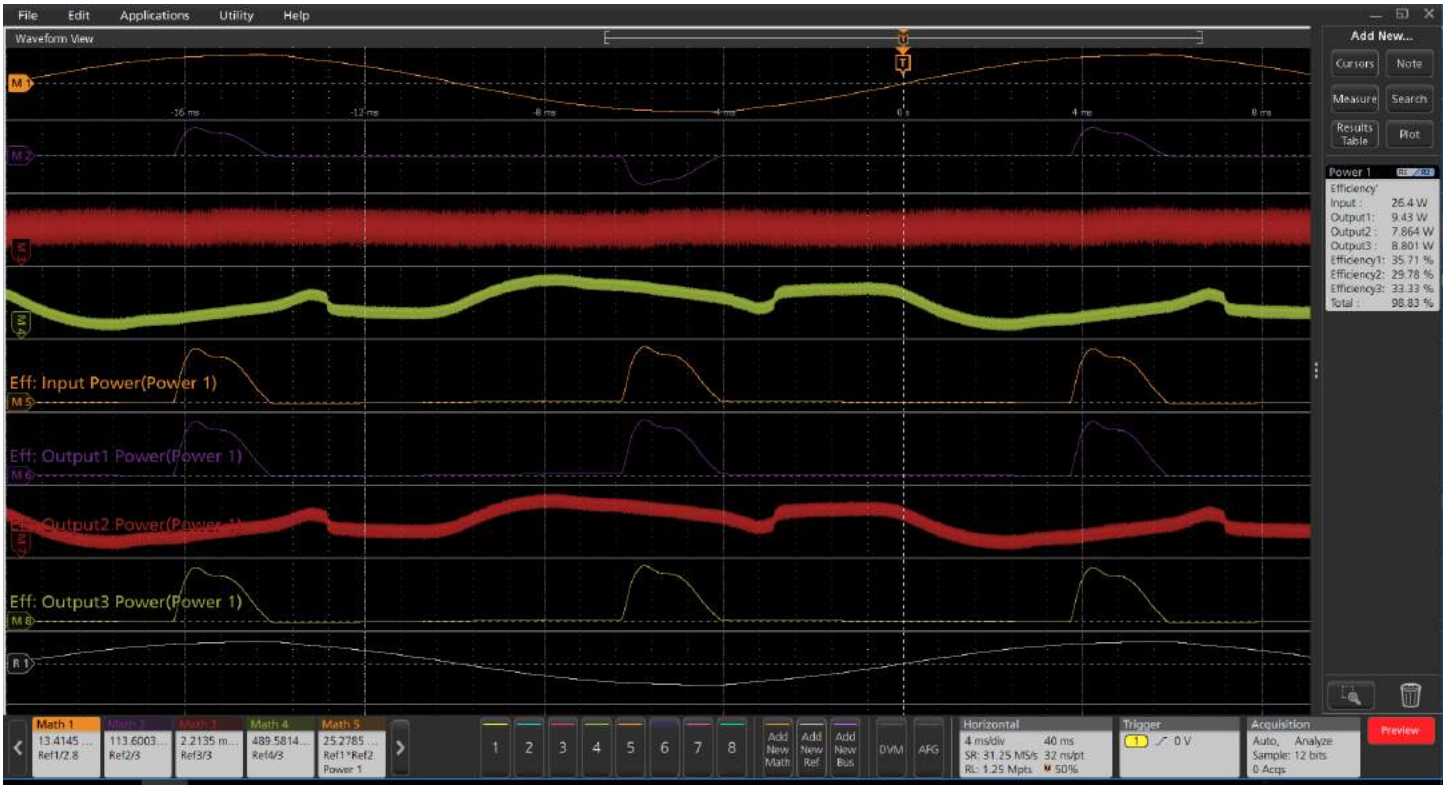
The quality of a power supply's DC output should be clean, with minimal AC noise and ripple. Advanced Power Measurements and Analysis software measures ripple to help you isolate the cause. Line ripple measurements indicate the amount of AC signal related to the input line frequency (since the input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



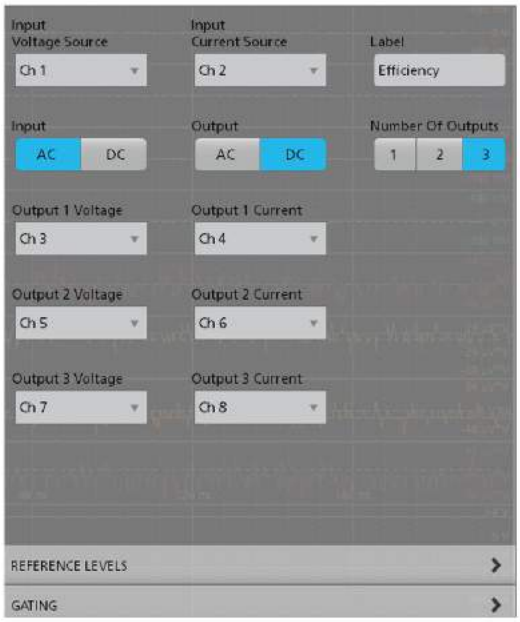
Ripple analysis helps distinguish low-frequency line ripple from higher frequency switching noise.

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). With multiple output power products becoming a standard design, the Advanced Power Measurements and Analysis software enables designers to test these products in one go. This ensures faster testing and validation time, thereby meeting faster time to market needs.



Efficiency measurement



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

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 5 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.

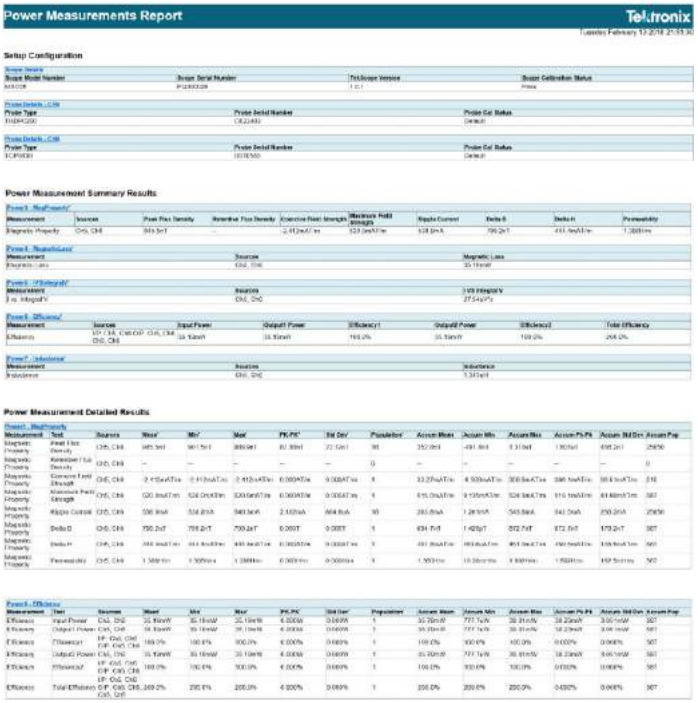
The system uses voltage and current probes with the TekVPI interface which supports communication between probes and the scope. This allows the probe to communicate its scale setting automatically to the oscilloscope. On appropriate probes, it enables control of ranges from the front panel of the scope,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

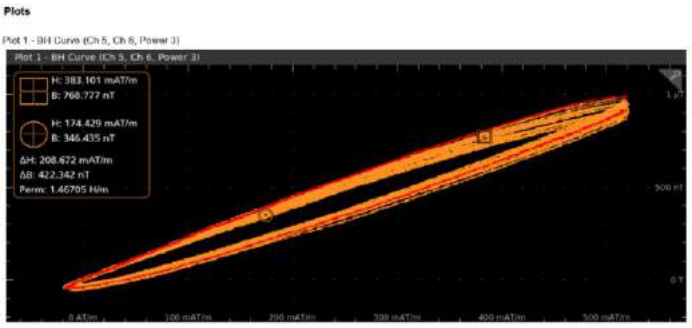
For timing-critical measurements such as switching loss, the analysis software can query voltage or current probes and use nominal delay values to remove timing skew and synchronize voltage and current waveforms for accurate and repeatable results.

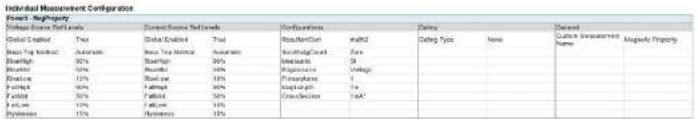
The system is compatible with IsoVu Isolated Measurement Systems. These differential probing systems provide complete optical isolation, bandwidth up to 1 GHz, and extremely high common mode rejection, making them ideal for V_{GS}, V_{DS} or V_{SHUNT} measurements in power systems. For optimizing designs 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. 5-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.







Specifications

Input analysis	True power, Apparent power, Power factor, Reactive power, Crest factor, Phase angle, THD, Harmonics, 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	Inductance, Magnetic Property, Magnetic Loss, and I vs.∫V
Output analysis	Ripple (line frequency, switching frequency) and Efficiency
Plots	Time trend, Trajectory plot, Histogram, Bar graph, B-H curve, Inductance plot, and I vs. ∫V plot.
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	5-PWR, 5-PS2	5 Series MSO oscilloscopes (MSO54, MSO56, MSO58, MSO58LP)
Product upgrade option	SUP5-PWR	
Floating license	SUP5-PWR-FL	5 Series MSO oscilloscopes (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.

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	5-PS2
Deskew fixture	067-1686-xx

Power solution bundles

5 Series MSO PS bundle options	Description
5-PS2	5-PWR, TCP0030A, THDP0200, 067-1686-xx deskew fixture

Complete power probing portfolio

Use the following list of probes with option 5-PWR power to ensure complete solution to power measurement capabilities on the 5 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.	
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.	

Probe type	Description	
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).	

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.

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.

Product Area Assessed: The planning, design/development and manufacture of electronic Test and Measurement instruments.

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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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