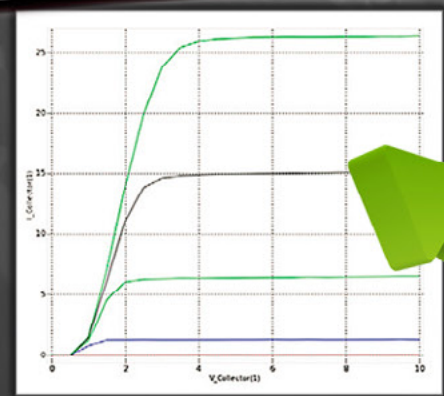
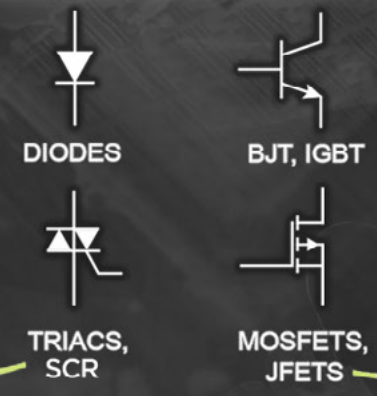


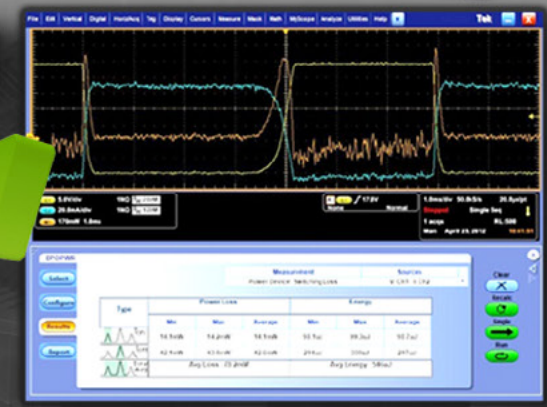
# Re-Inventing **High Power Semiconductor Device Characterization** Application Advice & Product Selection



DC Testing



AC Testing



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# Reinventing High Power Semiconductor Device Characterization

Green initiatives and energy efficiency standards worldwide have motivated engineers to find ways to design more efficient semiconductor devices and integrated circuits. High power semiconductor end applications are becoming increasingly demanding, requiring test instrumentation capable of characterizing significantly higher voltages, higher power levels, faster switching times, higher peak currents, and lower leakage currents than ever before. Tektronix and Keithley offer a broad spectrum of tools, both hardware and software, for power device characterization.

## Demand for Higher Power Semi Devices Will Require Pushing Instrumentation to New Extremes

Many segments of the electronics industry, including the semiconductor industry, are focused on increasing energy efficiency, including boosting the efficiency of energy generation, transmission, and consumption. Power semiconductor devices are used as switches or blocking devices in such applications as motor control, voltage regulation and power conversion. New “greener” devices can offer higher breakdown voltages, lower leakage currents, lower ON-resistances, higher power levels, and/or faster switching times and create new requirements for test and measurement. [More ...](#)



	UPSs	High-End Power Supplies, Servers, etc.	HEVEV	Solar Panel Inverters	Industrial Motors and Drives	Wind Turbines	Electronic Transmission, Rail Traction, Ships
Main Devices	FETs, IGBTs, Diodes	FETs, Diodes	FETs, IGBTs, Diodes	FETs, IGBTs, Diodes	FETs, IGBTs, Diodes	IGBTs, Diodes	IGBTs, Diodes
Peak Currents	2A–100A	0.5A–10A	50A–200A	75A	3A–100A	>150A	>200A
Rated Voltages	600V–1200V	600V	650V–2000V	600V–1200V	600V–1200V	Today: 690V, Trend: 3kV–4kV	>5kV

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# Testing for Today's and Tomorrow's Power Semiconductor Devices

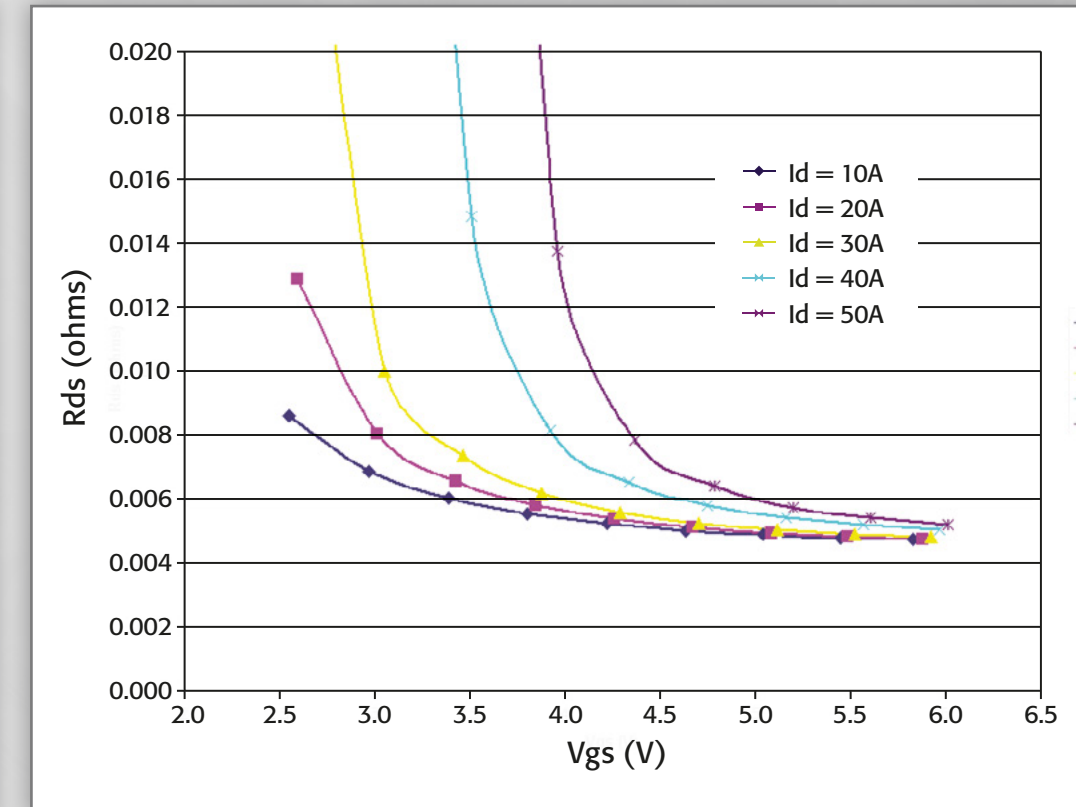
Due to more demanding end applications and the use of advanced materials such as Silicon Carbide (SiC) and Gallium Nitride (GaN) in today's power devices, test instrumentation must be capable of characterizing significantly higher voltages, higher power levels, faster switching times, higher peak currents, and lower leakage currents than ever before.

Even more significant, breakdown and leakage test are typically performed at 2–3 times the level of the rated or operating voltage. When the devices are in the ON state, they have to pass through tens or hundreds of amps with minimal loss; when they are OFF, they have to block thousands of volts with minimal leakage currents.

At the same time, semiconductor technology is being advanced so that it can operate at much higher frequencies to further drive efficiencies.



Comprehensive switching time analysis and characterization.



Low-level Rds measurements to support next-generation devices

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# Keithley's Configurable DC High Power Solutions



### Model 2636B SourceMeter® SMU Instrument

- Two independent SMU channels
- Up to 200V, up to 10A pulsed
- 0.1fA measurement resolution

### Model 2657A High Power Source Measurement Unit (SMU) Instrument

- Up to 3000V, Up to 180W of power
- 1fA measurement resolution
- Digitizing and integrating ADCs

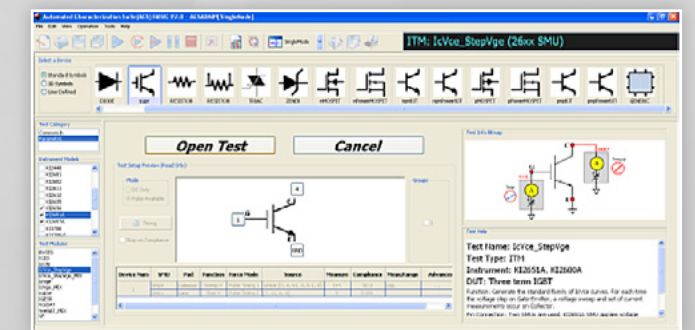


### Model 2651A High Power System SourceMeter Instrument

- Up to 50A pulsed (up to 100A with 2 units)
- Up to 2000W pulse / 200W DC power
- Pulse widths from 100µs to DC
- Digitizing and integrating ADCs

**Model 8010 Test Fixture:** Provides safe environment for testing at 3kV and at 100A

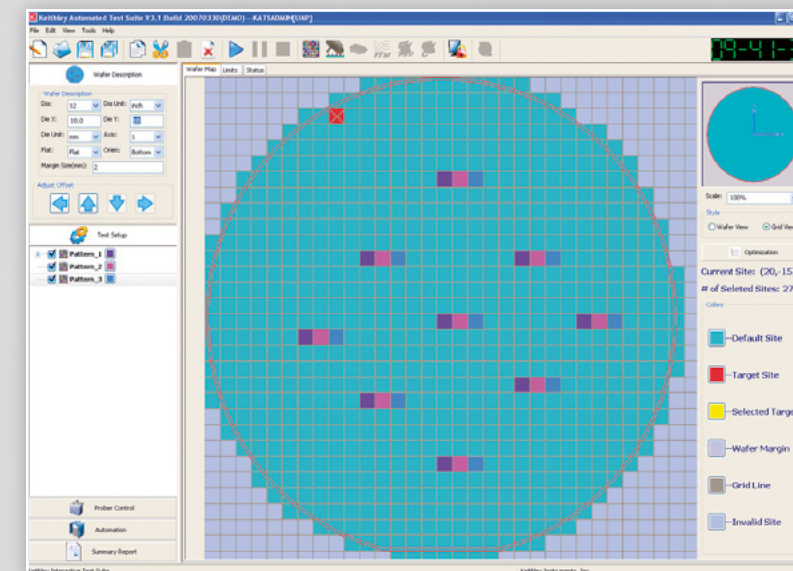
### Parametric Curve Tracer software: ACS Basic Edition



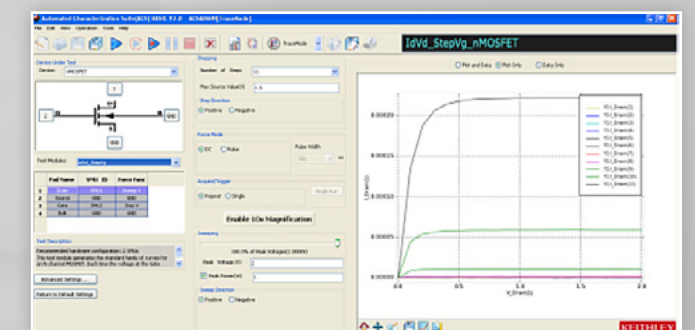
### TSP® Express Software: Web-based plug & play I-V characterization and test software with simple spreadsheet and graphing functionality

Site	V <sub>CE</sub> (V)	I <sub>C</sub> (mA)	V <sub>CE(sat)</sub> (V)	I <sub>C(sat)</sub> (mA)	β <sub>DC</sub>
1	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.0000	0.0000	0.0000	0.0000	0.0000
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25	0.0000	0.0000	0.0000	0.0000	0.0000
26	0.0000	0.0000	0.0000	0.0000	0.0000
27	0.0000	0.0000	0.0000	0.0000	0.0000

### Wafer-level software: ACS



### Parametric Test Mode



### Trace Mode

For fast and simple single device testing!

# Tektronix AC High Power Solutions

## Mixed Signal Oscilloscopes

### Key Features

- High sample rates to capture transitions
- Deep record lengths for long acquisition
- Power analysis application software available
- Supports full range of high voltage, high current, and differential probes

### Typical Tests

- Comprehensive switching loss analysis
- Turn-on/Turn-off timing & characterization
- Recovery time
- Dynamic On Resistance

## Probes

Our probes and accessories are perfectly matched to our industry-leading oscilloscopes. With over 100 choices available, you're certain to find the probe that best fits your needs, including:

- High voltage probes to 40kV
- Current probes to 2000A
- High voltage differential probes to 6kV



## AFG3000C Arbitrary / Function Generator

### Key Features

- Function, arbitrary waveform, and pulse capabilities allow complete control loop characterization
- 12 standard waveforms and up to 20V p-p provide unmatched performance and versatility
- Pulse generation with variable duty cycle, slope times, noise add, and pulse width modulation capability
- Floating output with the capability to add external offset of up to 42V
- Expand the number of channels by synchronizing multiple units

### Typical Tests

Switching-time-related-tests:

- Stimulus for switching loss analysis
- Turn-on/turn-off timing & characterization
- Recovery time

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# High Power Device Characterization with Parametric Curve Tracers

Characterizing and testing today's high power semiconductor devices and components is placing a high demand on test equipment. Device design engineers need equipment that can support them throughout the complete lifecycle of a power device. Today, high power characterization systems are available in two main forms — complete turnkey systems and building blocks that must be configured by the user and completed with good software. Turnkey systems can be set up and running quickly, but they can be quite expensive and limited in the breadth of testing that can be performed.

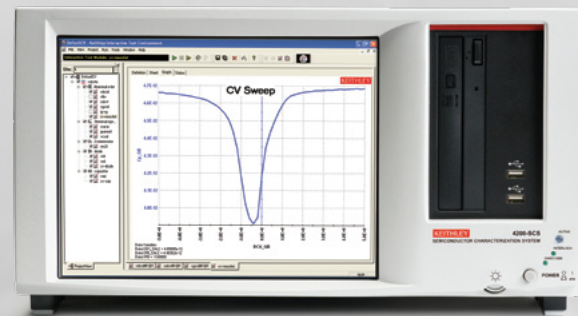
**Keithley's Parametric Curve Tracer** configurations are complete solutions configured with a variety of high quality instruments, cables, test fixturing, and software. This building block approach offers the advantages of easy upgrading or modification to meet changing test needs. Additionally, these instruments and accessories can be used across different test system platforms, such as for reliability or device qualification testing.

Keithley's Parametric Curve Trace configurations include everything necessary for the characterization engineer to develop a complete test system quickly. The configurations supports both parametric and trace test modes, thus including the best of a curve tracer and a parameter analyzer.

[Download the Parametric Curve Tracer Configurations datasheet.](#)



Curve Tracer



Parameter Analyzer



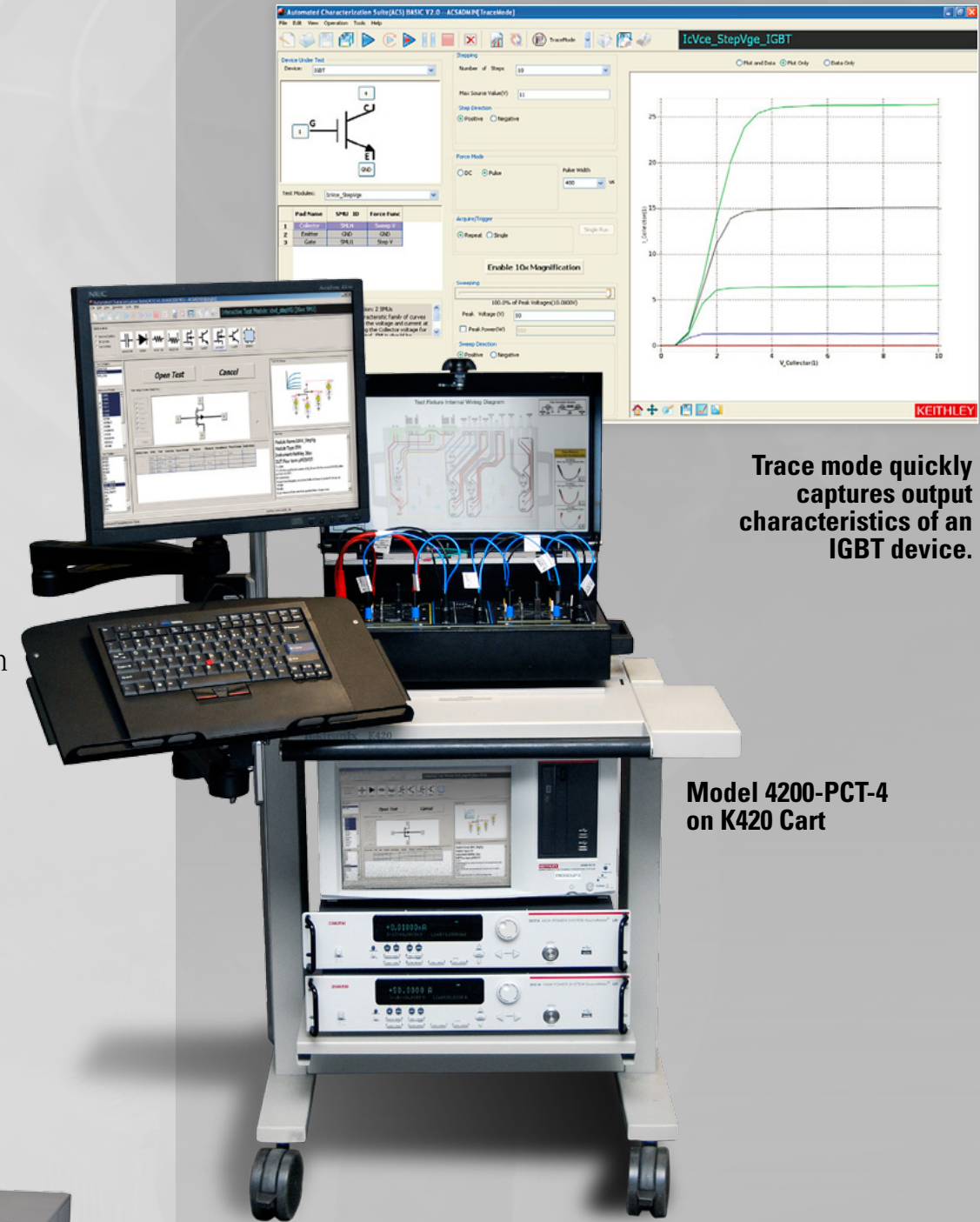
Parametric Curve Tracer

## Key Facts

- Configurable power levels
  - From 200V to 3kV
  - From 1A to 100A
- Wide dynamic range
  - From  $\mu$ V to 3kV
  - From fA to 100A
- Capacitance-voltage measurement
- DC or pulsed I-V to 50 $\mu$ s
- Test management software includes both trace mode for real-time control and parametric mode for parameter extraction

## Applications

- Power semiconductor device characterization and testing
- Characterization of GaN and SiC, LDMOS, and other devices
- Reliability studies on power devices
- Incoming inspection and device qualification



Trace mode quickly captures output characteristics of an IGBT device.

Model 4200-PCT-4 on K420 Cart

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# Characterize and Test High Voltage Electronics and Power Semiconductors

The **Model 2657A High Power/High Voltage System SourceMeter® instrument** adds high voltage to Keithley's SourceMeter SMU instruments family of high speed, precision source measurement units. Suitable for R&D, production, and QA/FA, it:

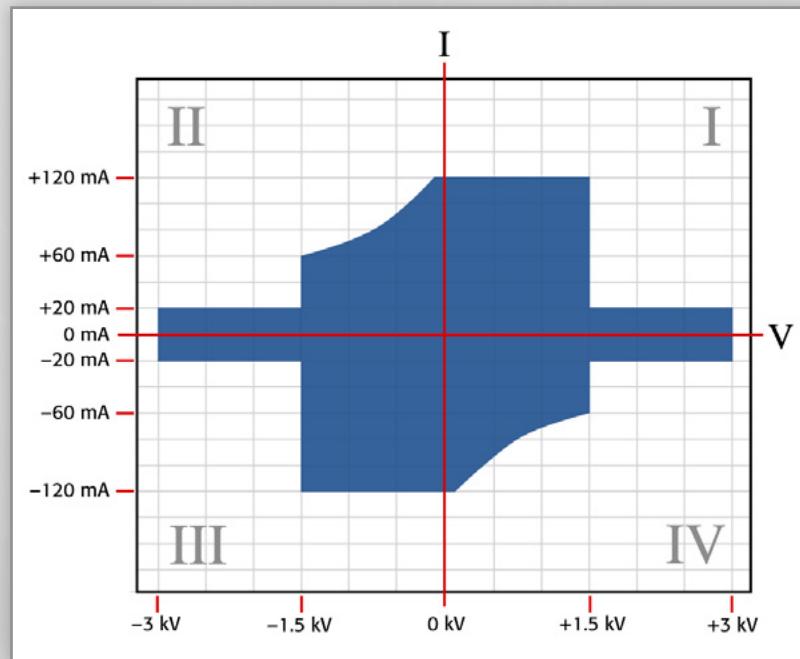
- Sources or sinks up to 3000V @ 20mA or 1500V @ 120mA –able to capture important parametric data that other equipment can't
- Provides 1fA (femtoamp) current measurement resolution for measuring the low-leakage requirements of next-generation devices
- Eliminates the hassle of integrating power supplies and instruments by combining a precision power supply, current source, DMM, arbitrary waveform generator, V or I pulse generator, electronic 18-bit load, and trigger controller.

Like the Model 2651A, the 2657A comes with dual 22-bit precision ADCs and dual 18-bit 1μs per point digitizers for high accuracy and high speed transient capture. Like other Series 2600A SMU instruments, it includes TSP® Express characterization software, LabVIEW® driver, and Keithley's Test Script Builder software development environment.



## Model 2657A Applications

- Power semiconductor device characterization and testing
- Characterization of GaN, SiC, and other compound materials and devices
- Breakdown and leakage testing to 3kV
- Characterization of sub-millisecond transients



The Model 2657A can source or sink up to 3000V @ 20mA or 1500V @ 120mA.

Learn How to Perform a Simple Breakdown Test on a High Power, High Voltage IGBT Device. [Click here.](#)



Keithley offers a broad spectrum of tools, both hardware and software, for power device characterization. A typical device test system could include the high voltage Model 2657A, one or two high current Model 2651A instruments, and up to three low power SMU instruments (other Series 2600A instruments or the Model 4200-SCS semiconductor characterization system). System configuration is made safer and simpler with the optional new Model 8010 High Power Device Test Fixture or individual protection modules. TSP-Link® technology links Series 2600A instruments to form powerful multi-channel systems that rival the system speed of large ATE systems that cost tens of thousands of dollars more.

# Ready to learn more?

■ [Download the Model 2657A datasheet.](#)

■ **Read the Application Notes:**

– **Creating Multi-SMU Systems for High Power Semiconductor Characterization.**

The recent push for higher power, more efficient semiconductor devices has spurred the development of devices based on advanced materials that surpass the limitations of devices built on silicon. DC characterization of power semiconductor devices requires test systems that incorporate high voltage and high current source measurement units (SMUs). The steps required to properly build these test systems are detailed in this new application note. [More...](#)

– **Testing Power Semiconductor Devices with Keithley High Power System SourceMeter® SMU Instruments**

This application note highlights some of the most commonly performed power semiconductor device tests, the challenges associated with them, and how Keithley SMU instruments can simplify the testing process, especially when integrated into a Keithley Parametric Curve Tracer (PCT) configuration. [More ...](#)



**2657A** High Power System SourceMeter® Instrument

- Source or sink up to 180W of DC or pulsed power (3300V @ 20mA, 1500V @ 120mA)
- 1A low current resolution
- Dual 32-bit precision ADAS and dual 18-bit 1ps per point digitizers for high accuracy and high-speed transient capture
- Fully 15P<sup>+</sup> compliant for easy system integration with other Series 2600A System SourceMeter modules
- Combines a precision power supply, current source, DMM, arbitrary waveform generator, V or I pulse generator, electronic 10-bit limit, and trigger controller - all in one instrument
- Includes 15P<sup>+</sup> Express Characterization software, LANVIEW<sup>®</sup> driver, and Keithley's Test Script Builder software development environment

The Model 2657A is a high voltage, high power, low current source measurement unit (SMU) instrument that delivers unprecedented power, precision, speed, flexibility, and ease of use to improve productivity in R&D, production test, and reliability environments. The Model 2657A is designed specifically for characterizing and testing high voltage electronics and power semiconductor devices, such as diodes, IGBTs, and IGBTs, as well as other components and materials in which high voltage, fast response, and precise measurements of voltage and current are required. The Model 2657A joins Keithley's Series 2600A family of power semiconductor characterization and test solutions to offer the highest power and best low current performance in the industry. These custom-configurable solutions are supported by the industry's most powerful parametric characterization software platforms to grow with you as your application evolves.

The Model 2657A, like every Series 2600A SourceMeter instrument, offers a highly flexible, four-quadrant voltage and current source/load coupled with precision voltage and current meters. It can be used as a:

- Semiconductor characterization instrument
- V or I waveform generator
- V or I pulse generator
- Precision power supply with V and I readback
- True current source
- Digital multimeter (DCV, DCL, diode, and power with 6 1/2-digit resolution)
- Precision electronic load

**TYPICAL APPLICATIONS**

- Power semiconductor device characterization and testing
- Characterization of GaN, SiC, and other compound materials and devices
- Breakdown and leakage testing to 3kV
- Characterization of sub-millisecond transients



The Model 2657A can source or sink up to 300W @ 20mA or 150W @ 120mA.

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KEITHLEY  
Application Note Series  
Number 3163

**Creating Multi-SMU Systems with High Power System SourceMeter® Instruments**

**Introduction**  
The design and configuration of test systems for DC characterization of power semiconductor devices using high voltage and high current source measurement units (SMUs)

Keithley's Series 2600A SMUs were designed with evolving test systems in mind. The TSP-Link<sup>®</sup> instrument communication bus supports creating mainframe-less systems while still allowing sub-microsecond synchronization of multiple SMU channels.

One of the most powerful features of the Series 2600A capability is offers to build systems that address all of the customer's test requirements while maintaining seamless in performance. The Series 2600A family includes eight SMUs that offer a variety of functions and capabilities:

- Up to 50A pulse at 2000V (100A possible with two SMUs)
- Up to 3kV source at 60Hz, 1500V at 180W sub-picoamp measurement capability
- Up to 1A or 3A DC on lower-power SMUs. This is ideal when testing high power IGBTs with large base currents. This level of capability is generally unavailable in an off-the-shelf commercial test mainframe and would have once required configuring a custom or semi-custom ATE. Moreover, guard-alone instruments allows the test engineer to add capabilities as new test needs evolve. Stand-alone high-voltage SMUs can extend the current and voltage capabilities of conductor parametric analyzers and, therefore, the scope of tests that can be tested.

KEITHLEY  
Application Note Series  
Number 3204

**Testing Power Semiconductor Devices with Keithley High Power System SourceMeter® SMU Instruments**

**Introduction**  
The proliferation of electronic control and electronic power conversion into a variety of industries (e.g., energy generation, industrial motor drives and control, transportation, and IT) has spurred growth in power semiconductor device design and test. To demonstrate technology improvements, new device capabilities must be compared with those of existing devices. The use of semiconductor materials other than silicon demands the use of new processes, and, to be sustainable, these new processes must be tuned to deliver consistent results and high production yield. As new device designs are developed, reliability measurements are performed on many devices over long periods. Therefore, test engineers must identify test equipment that is not only accurate but scalable and cost-effective.

Power module design engineers—the consumers of the discrete power semiconductor components—work at the other end of the semiconductor device testing spectrum. They integrate the discrete components into designs for DC-DC converters, inverters, LED controllers, battery management chips, and many other devices. Driven by demands for higher energy efficiency, these engineers need to qualify the devices they receive from their vendors to ensure that they can withstand use in the application, predict how the efficiency of the power modules may be affected by the device, and finally validate the performance of the end product.

Keithley's SourceMeter SMU instruments give both device test engineers and power module design engineers the tools they need to make the measurements they require. Whether they're familiar with curve tracers, semiconductor parameter analyzers, or oscilloscopes, they can obtain accurate results simply and quickly. This application note highlights some of the most commonly performed tests, the challenges associated with them, and how Keithley SMU instruments can simplify the testing process, especially when integrated into a Keithley Parametric Curve Tracer (PCT) configuration.

**Background on Power Device Characterization**  
The switching power supply is one common electrical circuit element used in power management products. In its simplest form (Figure 1), its main components include a semiconductor such as a power MOSFET, a diode, and some passive components, including an inductor and a capacitor. Many also include a transformer for electrical isolation between the input and output. The semiconductor switch and diode alternatively

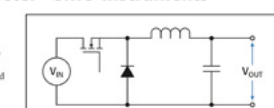


Figure 1. A simple schematic of a type of switching power supply. The switch is turned on and off at a controlled duty cycle to produce the desired output voltage.

When evaluating energy efficiency, it's important to understand the switching loss (energy loss that occurs during the short periods when the device is changing states) and conduction loss (energy losses that occur when the device is either on or off). Keithley SMU instrument-based solutions can help test engineers evaluate the device parameters that affect conduction loss.

Semiconductor devices are often used to create circuit protection. For example, some thyristor devices are used for overvoltage protection. To achieve that objective, such devices must trigger at the appropriate intended voltage and current, must withstand the intended voltage, and must behave in circuit with minimal current draw. High power instrumentation is required to qualify these devices properly.

This note focuses on the characterization of static power device parameters. These parameters can be divided into two broad categories: those that determine the performance of the device in its ON state and those that determine the performance in its OFF state. Table 1 lists common ON-state and OFF-state parameters for several power semiconductor devices that Keithley SMU instruments support. Many tests involve the use of multiple SMU instruments. Keithley's ACS Basic Edition software simplifies the test configuration by managing the configuration and data collection of all SMU instruments in the test system. Unlike general-purpose start-up software, ACS Basic Edition is designed specifically for semiconductor device characterization and includes a library of tests; users can focus on the test and device parameters rather than the SMU instrument configuration.

1. Alternative solutions are available for transient characterization of power devices. For more information, visit [www.keithley.com](http://www.keithley.com).



How to perform a simple breakdown test on a high power, high voltage IGBT device

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A GREATER MEASURE OF CONFIDENCE

Click on the video above – Learn how to Perform a Simple Breakdown Test on a High Power, High Voltage IGBT Device.

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# Get Unmatched Performance for Characterizing and Testing High Power, High Current Electronics

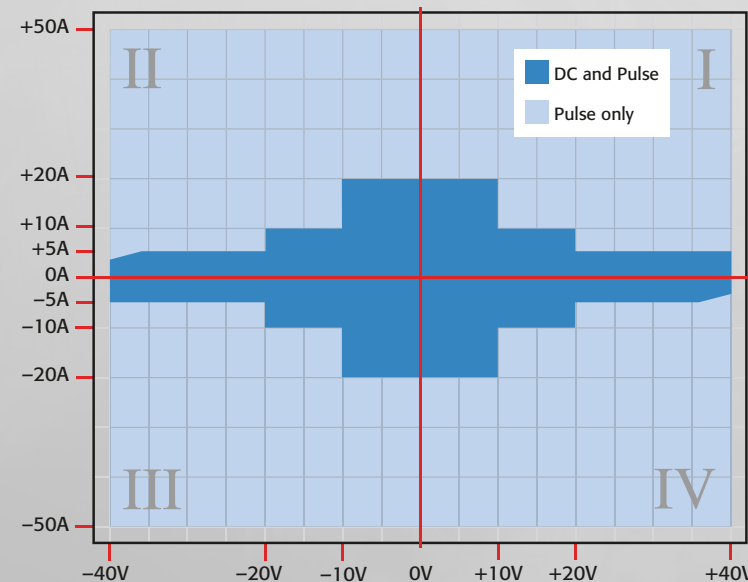
Our new **Model 2651A High Power/High Current System SourceMeter® Instrument** simplifies characterizing today's challenging high power electronics with unprecedented power, precision, speed, flexibility, and ease of use. It combines a highly flexible, four-quadrant voltage and current source/load with precision voltage and current meters.

- Source or sink 2,000W of pulsed power ( $\pm 40V$ ,  $\pm 50A$ ), 200W of DC power ( $\pm 10V@ \pm 20A$ ,  $\pm 20V@ \pm 10A$ ,  $\pm 40V@ \pm 5A$ )
- Easily connect two units (in series or parallel) to create solutions up to  $\pm 100A$  or  $\pm 80V$
- 1pA resolution enables precise measurement of very low leakage currents
- $1\mu s$  per point (1MHz), continuous 18-bit sampling, accurately characterizes transient behavior



## Choice of digitizing or integrating measurement modes

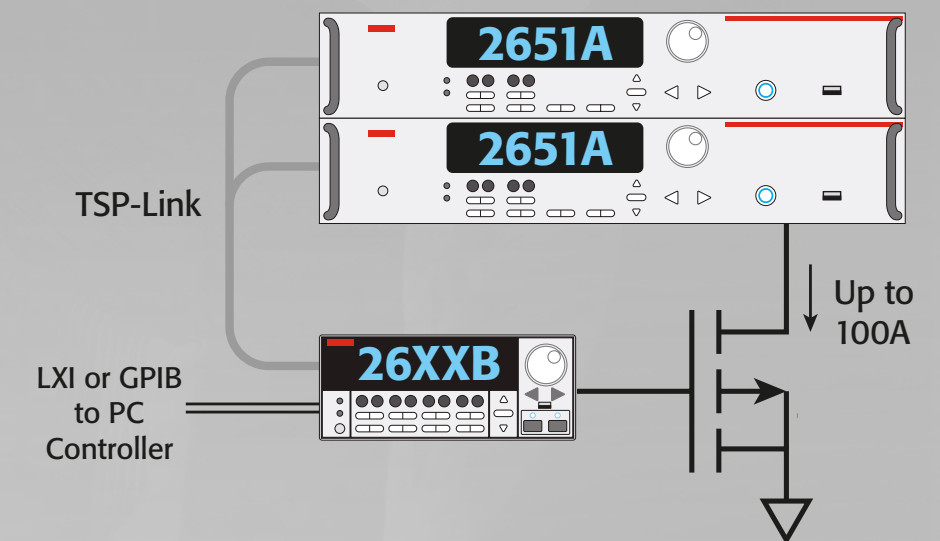
With the Model 2651A, you can choose from either digitizing or integrating measurement modes for precise characterization of both transient and steady-state behavior. Two independent ADCs define each mode—one for current and the other for voltage—which run simultaneously for accurate source readback without sacrificing test throughput. The digitizing measurement mode's 18-bit ADCs can support continuous one-microsecond-per-point sampling, making it ideal for waveform capture and measuring transient characteristics with high precision. The integrating measurement mode, based on 22-bit ADCs, supports applications that demand the highest possible measurement accuracy and resolution. This ensures precise measurements of the very low currents and voltages common in next-generation devices.



A single Model 2651A unit can source and sink up to  $\pm 40V$  and  $\pm 50A$ . Connect two units in parallel via the built-in TSP-Link expansion bus to extend the system's current range to 100A or connect them in series to expand the voltage range to 80V. The embedded Test Script Processor (TSP®) included simplifies testing by allowing you to address multiple units as a single instrument so that they act in concert. The built-in trigger controller can synchronize the operation of all linked channels to within 500 nanoseconds.

## Model 2651A Applications

- Power semiconductor, high brightness LED (HBLED), and optical device characterization and testing
- Characterization of GaN, SiC, and other compound materials and devices
- Semiconductor junction temperature characterization
- Reliability testing
- High speed, high precision digitization
- Electromigration studies



Built for building systems. The embedded TSP controller and TSP-Link interface in each Series 2600A instrument make it easy to link multiple Model 2651As and other Series 2600A instruments to create an integrated test system with up to 64 channels. Precision timing and tight channel synchronization are guaranteed with built-in 500ns trigger controllers. The fully isolated, independent channels of Series 2600A instruments allow true SMU-per-pin testing without the power and/or channel limitations of mainframe-based systems.

# Ready to learn more?

■ [Download the Model 2651A datasheet.](#)

■ **Read these Application Briefs:**

– [Achieving Fast Pulse Measurements for Today's High Power Devices.](#)

Learn how to achieve the fast, pulsed measurements needed for today's high power devices.

– [Testing to 100A by Combining Model 2651A High Power SourceMeter® Instruments.](#)

Learn how two of these instruments can be combined to test semiconductor devices for power management, even when those devices operate at currents beyond that of a single 2651A instrument.

Click on the video above to view our demo of how you can combine two Model 2651As to source currents as high as 100A!

Want assistance, a quote, or to place an order?  
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# Software for High Power Device Characterization

Keithley's Automated Characterization Suite (ACS) Software combines with the high power, precision, speed, and flexibility of Keithley's Series 2600 High Power System SourceMeter® SMU instruments and Parametric Curve Tracer configurations to create a complete environment for high power semiconductor component characterization. Depending on your application, choose from ACS Basic Edition for single device testing or ACS Standard Edition for wafer-level, multi-DUT test automation or reliability analysis.

## ACS Basic Edition for Semiconductor Component and Discrete Devices

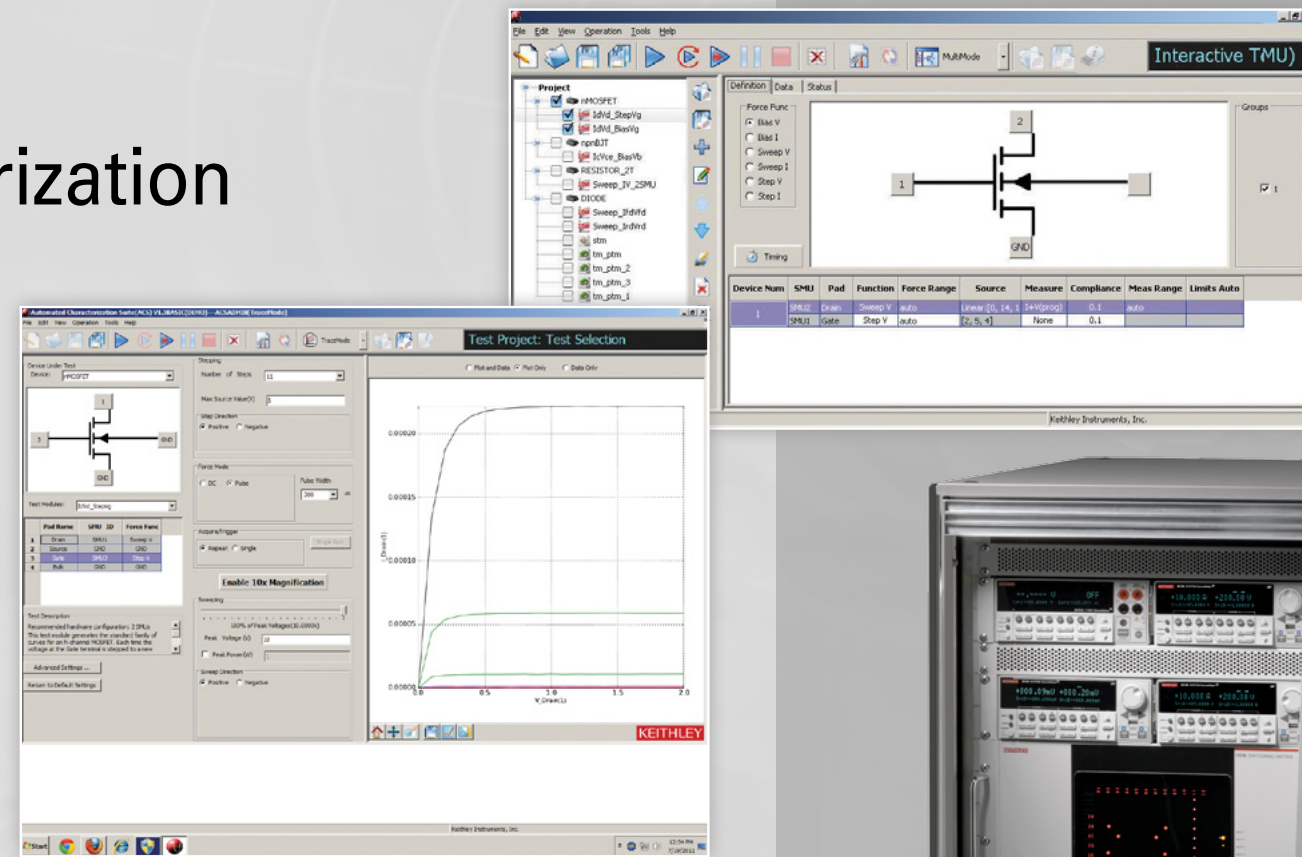
- Designed for discrete devices such as mosfets, BJTs, IGBTs, diodes, resistors, etc.
- Rich set of test libraries for fast and easy test setup without programming
- Built-in analysis tools for extracting parametric data
- Includes both interactive, real-time trace mode and parametric mode

[Download the ACS Basic Edition data sheet.](#)

## ACS Standard Edition for Characterization, Parametric Testing, Reliability Test, and Die Sort

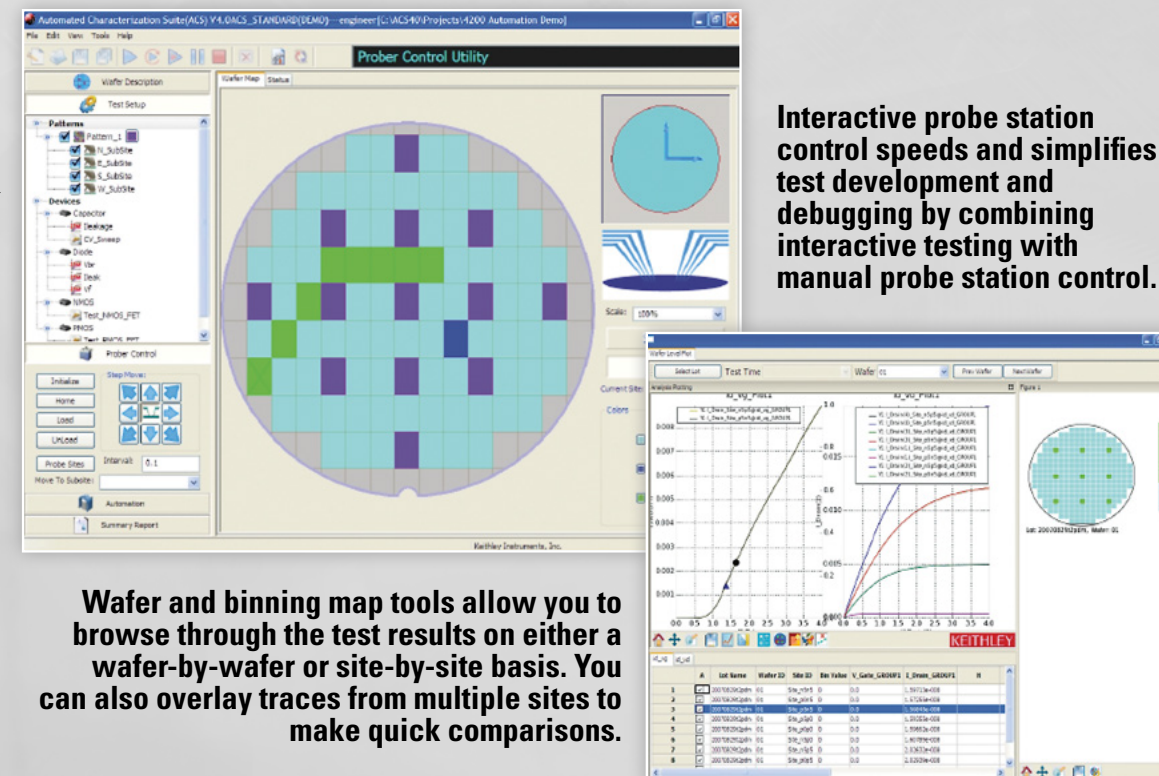
- Supports a wide array of instruments and probers
- Develop and execute tests at the device, site, wafer, and cassette level
- Supports multiple SourceMeter® source measure unit (SMU) instruments for parallel test

[Download the ACS Standard Edition data sheet.](#)



Trace mode supports interactive testing of a device.

Multi test mode allows multiple tests to be performed on a device.



Interactive probe station control speeds and simplifies test development and debugging by combining interactive testing with manual probe station control.

Wafer and binning map tools allow you to browse through the test results on either a wafer-by-wafer or site-by-site basis. You can also overlay traces from multiple sites to make quick comparisons.

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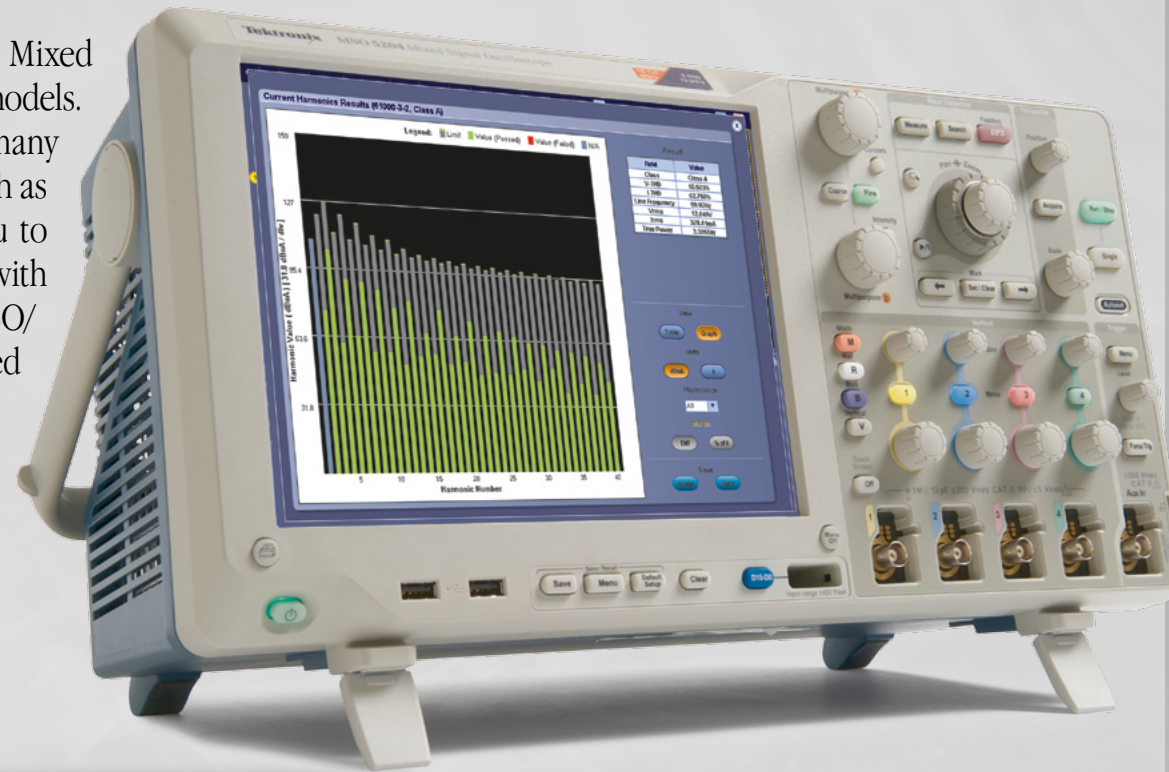
# MSO/DPO5000 Mixed Signal Oscilloscopes

Offering up to 2GHz bandwidth and 10GS/s sample rate, the MSO/DPO5000 Mixed Signal Oscilloscope Series features affordable, yet powerful Windows®-based models. With over 25 different application software packages available, you can test many different applications with a single instrument. Exclusive Tektronix features such as FastAcq with DPX® technology and a superior suite of triggers enable you to quickly find intermittent events that other oscilloscopes miss. Combine that with comprehensive analysis tools and innovative Wave Inspector® controls, the MSO/DPO5000 Series provides the feature-rich tools you need to simplify and speed debug of your complex design.

## Key Performance Specifications

- 2GHz, 1GHz, 500MHz, and 350MHz bandwidth models
- Up to 10GS/s real-time sample rate on one or two channels and up to 5GS/s on all four channels
- Up to 250 megapoint record length with MultiView zoom™
- >250,000wfms/s maximum waveform capture rate with FastAcq™
- FastFrame™ segmented memory acquisition mode with >310,000 waveforms per second capture rate
- Standard 10MΩ passive voltage probes with less than 4pF capacitive loading and 500MHz or 1GHz analog bandwidth
- User-selectable bandwidth limit filters for better low-frequency measurement accuracy
- Suite of advanced triggers, with optional Visual Trigger

[Read the MSO/DPO5000 Mixed Signal Oscilloscope Data Sheet](#)



**Mixed Signal Oscilloscopes**  
MSO5000, DPO5000 Series Datasheet

**Key features**

- Wave Inspector® controls provide easy navigation and automated search of waveform data
- MyScope® custom control windows and right mouse click menus for exceptional efficiency
- 53 automated measurements, waveform histograms, and FFT analysis for simplified waveform analysis
- TekVPI® probe interface supports active, differential, and current probes for automatic scaling and units
- 10.4 in. (264 mm) Bright XGA Display with Touch Screen
- Small footprint and lightweight – Only 8.12 in. (206 mm) deep and less than 15 lb. (6.7 kg)

**Connectivity**

- Two USB 2.0 host ports on the front panel and four on the rear panel for quick and easy data storage, printing, and connecting USB peripherals
- USB device port on the rear panel for easy connection to a PC or GPIB control with an adapter
- Integrated 10/100/1000BASE-T Ethernet port for network connection and Video Out port to export the oscilloscope display to a monitor or projector
- Microsoft® Windows 7 64-bit operating system for easy connectivity and integration into your environment
- LXI Class compliant

**Mixed signal design and analysis (MSO Series)**

- Automated triggering, decode, and search on parallel buses
- Pin-channel threshold settings
- MagView™ high-speed acquisition provides 60.6 ps fine timing resolution on digital channels

**Key performance specifications**

- 2 GHz, 1 GHz, 500 MHz, and 350 MHz bandwidth models
- Up to 10 GS/s real-time sample rate on one or two channels and up to 5 GS/s on all four channels
- Up to 250 megapoint record length with MultiView zoom™
- >250,000 wfms/s maximum waveform capture rate with FastAcq™
- FastFrame™ segmented memory acquisition mode with >310,000 waveforms per second capture rate
- Standard 10 MΩ passive voltage probes with less than 4 pF capacitive loading and 500 MHz or 1 GHz analog bandwidth
- 16 digital channels (MSO Series)
- User-selectable bandwidth limit filters for better low-frequency measurement accuracy
- Suite of advanced triggers, with optional Visual Trigger

Tektronix understands that engineers rely on an oscilloscope throughout their design cycle, from prototype turn-on to production testing. The MSO/DPO5000 Series oscilloscopes' unique capabilities combined with exceptional signal acquisition performance and analysis accelerate your measurement tasks.

**Read the MSO/DPO5000 Mixed Signal Oscilloscope Data Sheet**

Tektronix

[Watch the on-line demo](#)

**The MSO/DPO5000 Series**

Introduction | Serial Bus Analysis | Digital Analysis | Search and Mark | Extended Analysis | Simulation

Pause | 0:11 / 1:55 | Turn Subtitles On | Turn Audio Off | Replay

**The MSO/DPO5000 Series**

Many applications, one scope

- I²C, SPI
- RS-232
- Ethernet
- USB 2.0
- Parallel Bus
- Power Analysis
- Jitter
- Limit/Mask Testing

[Request a Live Demo](#) [Request Pricing](#)

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## Key Features

- Optional power analysis module enables quick and accurate analysis of switching loss, harmonics, safe operating area (SOA,) modulation, ripple, and slew rate (di/dt, dv/dt.)
- TekVPI® probe interface supports active, differential, and current probes for automatic scaling and units
- Wave inspector® controls provide easy navigation and automated search of waveform data
- 53 automated measurements, waveform histograms, and FFT analysis for simplified waveform analysis
- 10.4 in. (264 mm) bright XGA display with touch screen
- Small footprint and lightweight – only 8.12 in. (206 mm) deep and less than 15 lb. (6.7 kg)

**Want assistance, a quote, or to place an order?**  
**Contact us online.**

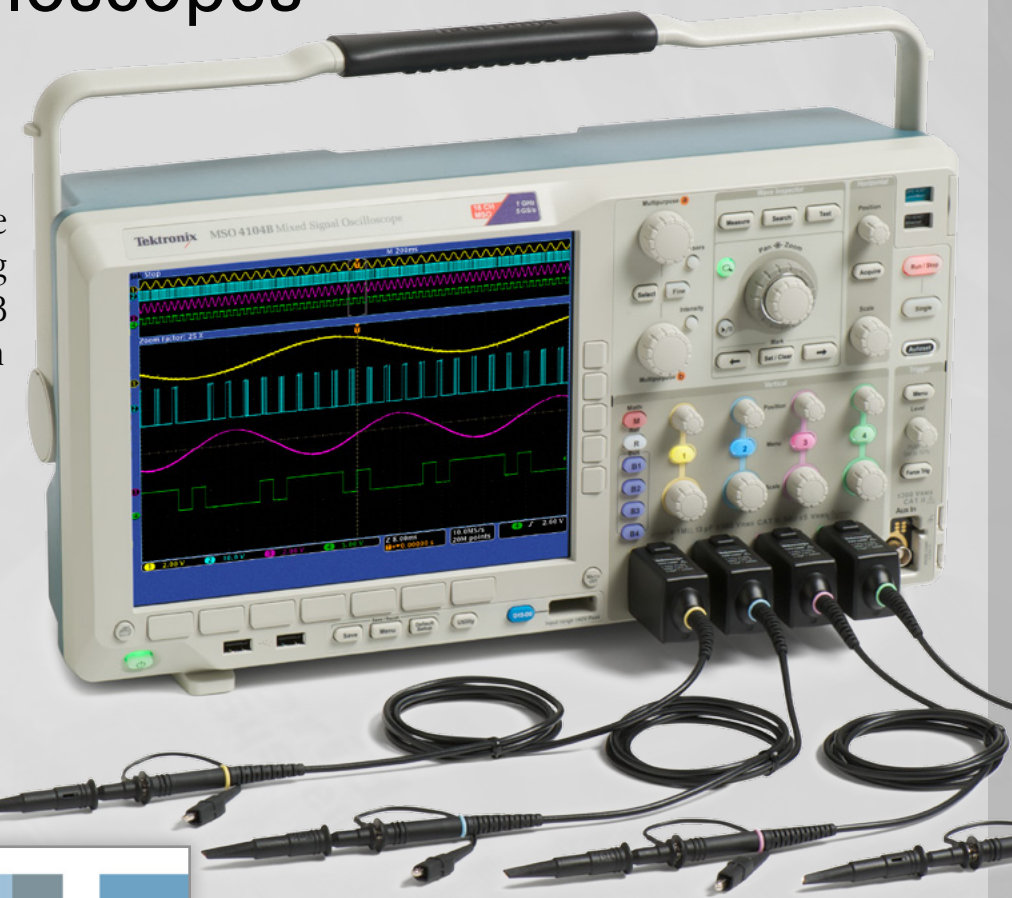
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# MSO/DPO4000B Mixed Signal Oscilloscopes

With the MSO/DPO4000B Mixed Signal Oscilloscope Series, you can analyze up to 20 analog and digital signals with a single instrument to quickly find and diagnose problems in complex designs. Bandwidths up to 1 GHz and up to 5X oversampling on all channels ensure you have the performance you need to see fast-changing signal details. To capture long windows of signal activity while maintaining fine timing resolution, the MSO/DPO4000B Series offers deep record length of up to 20M points standard on all channels. And with Wave Inspector® controls for rapid waveform navigation, limit and mask testing, and automated power analysis – your Tektronix oscilloscope provides the feature-rich tools you need to simplify and speed debug of your complex design.

## Key Performance Specifications

- 1-GHz, 500-MHz, 350-MHz, and 100-MHz bandwidth models
- 2 and 4 analog channel models
- Up to 5 GS/s sample rate on all channels
- Up to 20 mega-point record length on all channels
- >50,000 wfm/s maximum waveform capture rate
- Suite of advanced triggers



## Key Features

- Optional power analysis module enables quick and accurate analysis of switching loss, harmonics, safe operating area (SOA), modulation, ripple, and slew rate (di/dt, dv/dt.)
- TekVPI® probe interface supports active, differential, and current probes for automatic scaling and units
- Wave Inspector® controls provide easy navigation and automated search of waveform data
- 41 automated measurements, and FFT analysis for simplified waveform analysis
- 10.4 in. (264 mm) bright XGA color display



**Ships with one passive probe per analog channel, with up to 1GHz bandwidth and an industry-best 3.9pF of capacitive loading.**

**Mixed Signal Oscilloscopes**  
MSO4000B, DPO4000B Series Datasheet

**Key features**

- Wave Inspector® controls provide easy navigation and automated search of waveform data
- 41 automated measurements, and FFT analysis for simplified waveform analysis
- 16 digital channels (MSO series)
- Mixed signal design and analysis (MSO series)
  - Automated triggering, decode, and search on parallel buses
  - Per-channel threshold settings
  - Multichannel setup and hold triggering
- MagVi™ High-speed acquisition provides 60.6 ps fine time resolution on digital channels
- Optional serial triggering and analysis - automated serial triggering, decode, and search options for PC, SPI, USB, Ethernet, CAN, LIN, FlexRay, RS-232/422/485/UART, ML, STD-1553, and PS/LR/LUT
- TekVPI® probe interface supports active, differential, and current probes for automatic scaling and units
- 10.4 in. (264 mm) bright XGA color display
- Small footprint and lightweight - Only 5.8 in. (147 mm) deep and (5 kg)

**Connectivity**

- Two USB 2.0 host ports on the front panel and two on the rear panel for quick and easy data storage, printing, and connecting a USB keyboard
- USB 2.0 device port on the rear panel for easy connection to a PC or direct printing to a PicoBridge®-compatible printer
- Integrated 10/100/1000BASE-T Ethernet port for network connection and video out port to export the oscilloscope display to a monitor or projector

**Key performance specifications**

- 1 GHz, 500 MHz, 350 MHz, and 100 MHz bandwidth models
- 2 and 4 analog channel models
- Up to 5 GS/s sample rate on all channels
- Up to 20 mega-point record length on all channels
- >50,000 wfm/s maximum waveform capture rate
- Standard passive voltage probes with less than 4 pF capacitive loading and 500 MHz or 1 GHz analog bandwidth
- Suite of advanced triggers

Tektronix

**MSO/DPO Series of Mixed Signal Oscilloscopes**

Overview | Serial Bus Analysis | Digital Analysis | Search & Mark | Product Comparison | Simulation

Pause II 0:24 / 2:22 Turn Subtitles On Turn Audio Off Replay

The MSO/DPO Series

- Analog signals
- Digital signals
- Decoded serial and parallel buses

Find the Right Product for You | Request a Live Demo | Request Pricing

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[Watch the product demo.](#)

[Read the MSO/DPO4000B Mixed Signal Oscilloscope Data Sheet](#)

**Want assistance, a quote, or to place an order? Contact us online.**

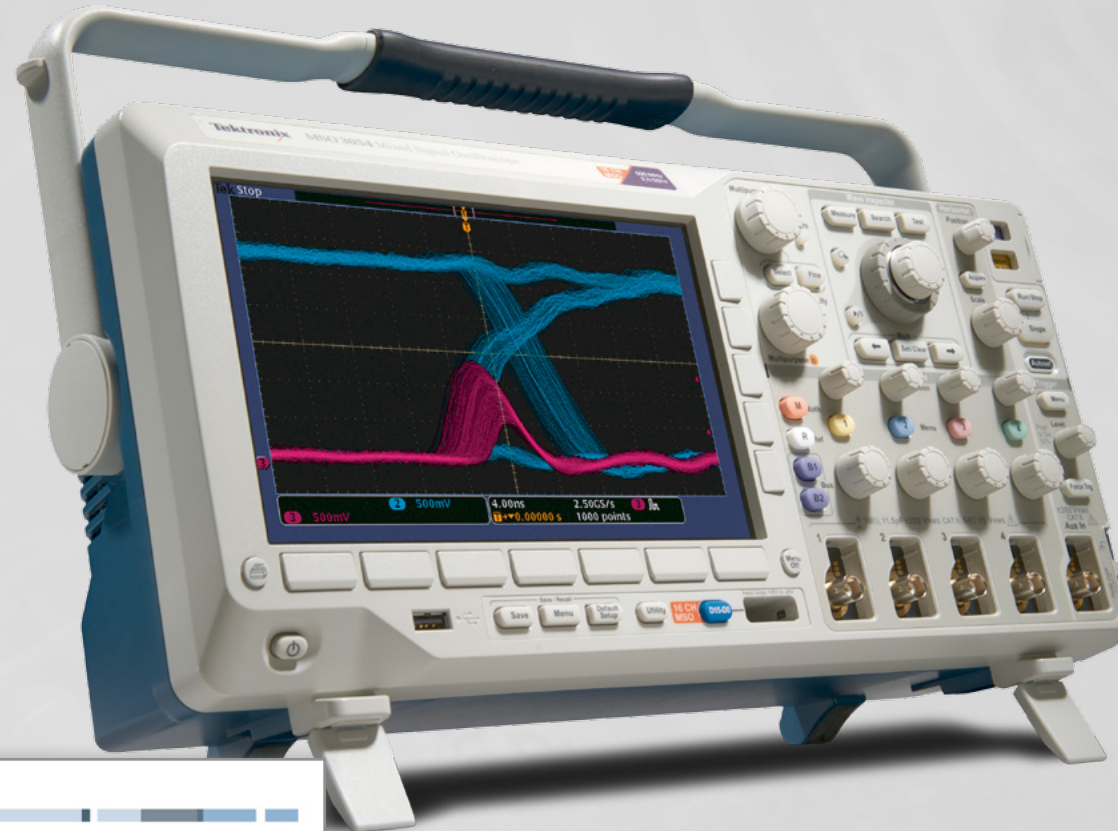
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# MSO/DPO3000 Mixed Signal Oscilloscopes

With the MSO/DPO3000 mixed signal oscilloscope series, you can analyze up to 20 analog and digital signals with a single instrument to quickly find and diagnose problems in complex designs. Bandwidths up to 500MHz and a minimum of 5x oversampling on all channels ensure you have the performance you need for many of today's mainstream applications. To capture long windows of signal activity while maintaining fine timing resolution, the MSO/DPO3000 offers a deep record length of 5M points standard on all channels.

## Key Performance Specifications

- 500, 300, and 100 MHz bandwidth models
- Bandwidth is upgradable (up to 500MHz)
- Two and four analog channel models
- 2.5GS/s sample rate on all channels
- 5 mega-point record length on all channels
- >50,000wfm/s maximum waveform capture rate
- Suite of advanced triggers



**Mixed Signal Oscilloscopes**  
MSO3000 Series, DPO3000 Series Datasheet

- Mixed signal design and analysis (MSO series)
  - Automated triggering, decode, and search on parallel buses
  - Multichannel setup and hold triggering
  - MagVu™ high-speed acquisition provides 121.2 ps fine timing resolution on digital channels
- Optional serial triggering and analysis - automated serial triggering, decode, and search options for PC, SPI, CAN, LIN, RS-232/422/485/UART, and PSL/PLU/TDM
- TekVPI™ probe interface supports active, differential, and current probes for automatic scaling and units
- 9 in. (229 mm) WVGA widescreen color display
- Small footprint and lightweight - Only 5.8 in. (147 mm) deep and 9 lb (4 kg)

**Connectivity**

- USB 2.0 host port on both the front panel and rear panel for quick and easy data storage, printing, and connecting a USB keyboard
- USB 2.0 device port on the rear panel for easy connection to a PC or direct printing to a PrintEdge™-compatible printer
- Integrated 10/100 Ethernet port for network connection and video out port to export the oscilloscope display to a monitor or projector

**Optional application support**

- Power analysis
- HDV and custom video analysis

**Key features**

- Wave Inspector® Controls provide easy navigation and automated search of waveform data
- 29 automated measurements, and FFT analysis for simplified waveform analysis
- 16 digital channels (MSO series)

**MSO/DPO Series of Mixed Signal Oscilloscopes**

Overview | Serial Bus Analysis | Digital Analysis | Search & Mark | Product Comparison | Simulation

Pause II 0:16 / 2:22 Turn Subtitles On Turn Audio Off Replay

The MSO/DPO Series

Find the Right Product for You | Request a Live Demo | Request Pricing

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[Read the MSO/DPO3000 Mixed Signal Oscilloscope Data Sheet](#)

[Watch the on-line demo.](#)

## Key Features

- Optional power analysis module enables quick and accurate analysis of switching loss, harmonics, safe operating area (SOA,) modulation, ripple, and slew rate (di/dt, dv/dt.)
- TekVPI® probe interface supports active, differential, and current probes for automatic scaling and units
- Wave Inspector® Controls provide easy navigation and automated search of waveform data
- 29 automated measurements, and FFT analysis for simplified waveform analysis
- 9in. (229mm) WVGA widescreen color display
- Small footprint and lightweight – Only 5.8in (147 mm) deep and 9lb (4 kg)

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# Power Measurement and Analysis Software

## DPOPWR | DPO4PWR | DPO3PWR

DPOPWR Power Measurement and Analysis Software transforms Tektronix Windows oscilloscopes into sophisticated analysis tools that quickly perform switching component analysis on power semiconductor devices and then generate detailed test reports in customizable formats to document results. DPOPWR, DPO4PWR, and DPO3PWR software is used with Tektronix MSO/DPO5000, MSO/DPO4000, and MSO/DPO3000 Series Mixed Signal Oscilloscopes.

### Key Features

- Performs switching loss measurements on power semiconductor devices using Tektronix Windows-based oscilloscopes
- Customizable safe operating area mask testing with linear and log scale for reliability testing
- Sophisticated report generation saves time

### Switching Component Analysis

The accurate calculation and evaluation of energy loss in power supplies has become even more critical with the drive to higher power conversion efficiency and greater reliability. Although almost all components of a power supply contribute to energy losses, the majority of energy losses in a switch-mode power supply (SMPS) occur when the switching transistor transitions from an OFF to an ON state and vice versa. DPOPWR measures the switching losses by measuring the voltage drop across the switching device and the current flowing through the switching device.

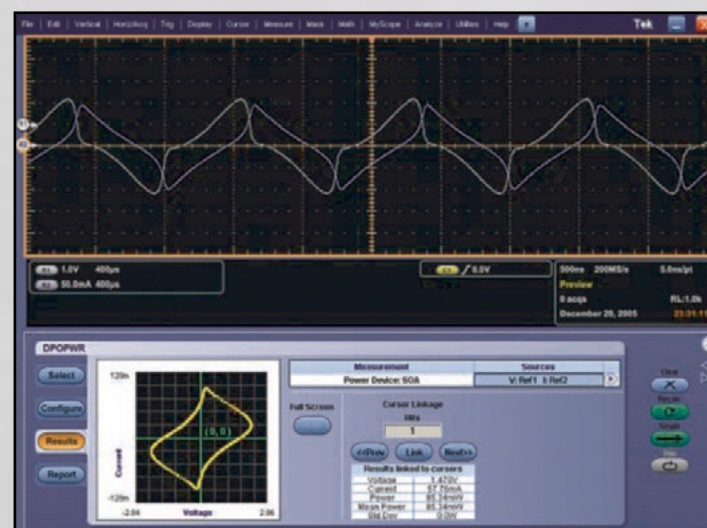
### Safe Operating Area

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. Limit testing can also be used with SOA plots to automate the validation.

[Read the Power Measurement and](#)



DPOPWR switching loss measurements.



DPOxPWR Safe Operating Area (SOA) display.

# Power Probes

## High Voltage Probes

- Wide range of voltage measurements – Up to 40kV peak (100ms pulse)
  - Single-ended or differential
- [Learn more.](#)



## Current Probes

- Easy to use and accurate AC/DC current measurements
  - Amplitude measurements from 1mA to 2,000A
  - DC up to 2GHz
  - Split core and solid core construction
- [Learn more.](#)



## Differential Probes

- Bandwidth up to 30GHz
  - Easily measure differential signals
  - Low input capacitance: down to <math><0.3\text{pF}</math>
  - High common mode rejection ratio (CMRR)
  - Wide range of probe tips for easier circuit access
- [Learn more.](#)



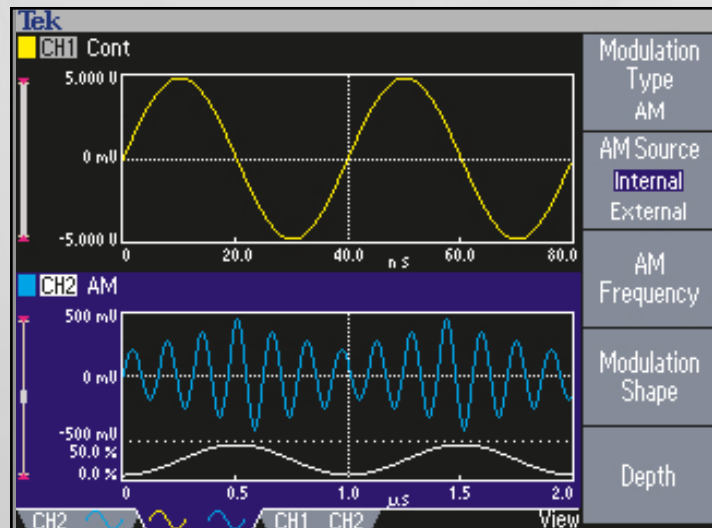
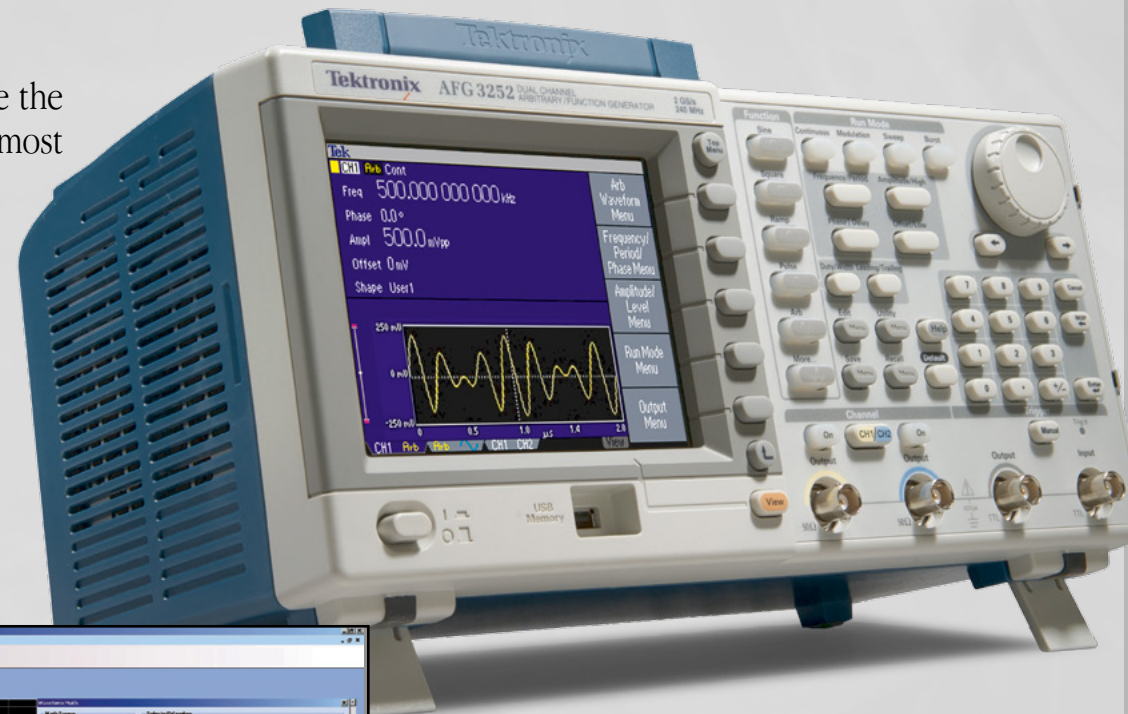
Need help finding the right probe for your application? Visit the online, interactive Probe Selector Tool at [www.tektronix.com/probes](http://www.tektronix.com/probes) to match your need with the correct probe. [Click Here.](#)

# AFG3000C Arbitrary/Function Generator

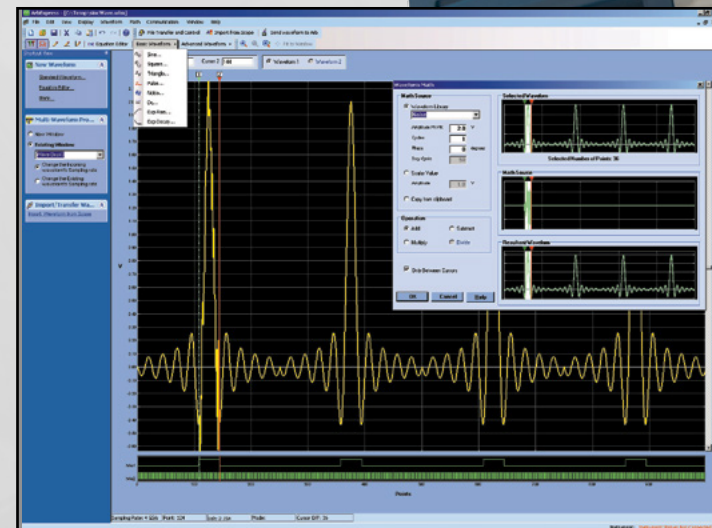
Unmatched performance, versatility, intuitive operation, and affordability make the AFG3000C Series of Function, Arbitrary Waveform, and Pulse Generators the most useful instruments in the industry.

## Switching-time-related-tests:

- Stimulus for switching loss analysis
- Turn-on/turn-off timing & characterization
- Recovery time



Large color display shows your settings and waveforms at a single glance.




Create and modify waveforms with ease with the included ArbExpress® software.

[Read the AFG3000C Arbitrary/Function Generator Data Sheet](#)

## Key Features

- 14 bits, 250 MS/s, 1 GS/s, or 2 GS/s Arbitrary Waveforms
- Amplitude up to 20 Vp-p
- 5.6 in. Color TFT LCD Display for Full Confidence in Settings and Waveform Shape
- Multilanguage and Intuitive Operation Saves Setup Time
- Pulse Waveform with Variable Edge Times
- Sweep and Burst
- Dual-channel Models Save Cost and Bench Space
- USB, GPIB, and LAN
- LabVIEW and LabWindows/IVI-C Drivers

### Arbitrary Function Generators AFG3000C Series Datasheet



#### Features & Benefits

- 10 MHz, 25 MHz, 50 MHz, 100 MHz, or 240 MHz Sine Waveforms
- 14 bits, 250 MS/s, 1 GS/s, or 2 GS/s Arbitrary Waveforms
- Amplitude up to 20 V<sub>pp</sub> into 50 Ω Loads
- 5.6 in. Color TFT LCD Display for Full Confidence in Settings and Waveform Shape
- Multilanguage and Intuitive Operation Saves Setup Time
- Pulse Waveform with Variable Edge Times
- AM, FM, PM, FSK, PWM
- Sweep and Burst
- Dual-channel Models Save Cost and Bench Space
- USB Connector on Front Panel for Waveform Storage on Memory Device
- USB, GPIB, and LAN
- LabVIEW and LabWindows/IVI-C Drivers

#### Applications

- Electronic Test and Design
- Sensor Simulation
- Functional Test
- Education and Training

#### Product Description

Unmatched performance, versatility, intuitive operation, and affordability make the AFG3000C Series of Function, Arbitrary Waveform, and Pulse Generators the most useful instruments in the industry.

#### Superior Performance and Versatility

Users can choose from 12 different standard waveforms. Arbitrary waveforms can be generated up to 128 K in length at high sampling rates. On pulse waveforms, leading and trailing edge time can be set independently. External signals can be connected and added to the output signal. Dual-channel models can generate two identical or completely different signals. All instruments feature a highly stable time base with only ±1 ppm drift per year.

#### Intuitive User Interface Shows More Information at a Single Glance

Color TFT LCD screen on all models shows all relevant waveform parameters and graphical wave shape at a single glance. This gives full confidence in the signal settings and lets you focus on the task at hand. Shortcuts provide direct access to frequently used functions and parameters. Others can be selected conveniently through clearly structured menus. This reduces the time needed for learning and relearning how to use the instrument. Look and feel are identical to the world's most popular TDS3000 Oscilloscopes.

#### ArbExpress™ Software Included for Creating Waveforms with Ease

With the PC software waveforms can be seamlessly imported from any Tektronix oscilloscope, or defined by standard functions, equation editor, and waveform math.

**Tektronix**

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# SourceMeter® SMU Instruments for Power Device Characterization and Test



Feature	2651A / 2657A High Current / High Voltage	2634B / 2635B / 2636B Low Current	2602B / 2612B Dual Channel	2601B / 2611B Single Channel	2604B / 2614B Dual Channel Benchtop
# of Channels	1 (optional expansion to 32 via TSP-Link®)	1 – 2 (optional expansion to 64 via TSP Link for 2635B/2363B)	2 (optional expansion to 64 via TSP-Link)	1 (optional expansion to 32 via TSP-Link)	2
Current Max / Min	2651A: 50A pulse/100fA 2657A: 120mA/1fA	2634B: 10A pulse/1fA 2636B, 2635B: 10A pulse/0.1fA	10A pulse/100fA	10A pulse/100fA	10A pulse/100 fA
Voltage Max / Min	2651A: 40V/100nV 2657A: 3,000V/100nV	200V/100nV	40V/100nV for 2602B 200V/100nV for 2612B	40V/100nV for 2601B 200V/100nV for 2611B	40V/100nV for 2604B 200V/100nV for 2614B
System-Level Automation	Digital I/O, TSP-Link, Contact Check	Digital I/O, TSP-Link, Contact Check (not available on 2634B)	Digital I/O, TSP-Link, Contact Check	Digital I/O, TSP-Link, Contact Check	N/A
Max readings / sec	38,500 1µSec/pt., 18-bit digitizer	20,000	20,000	20,000	20,000
Computer Interface	GPIB, LAN (LXI), RS-232	GPIB, LAN (LXI), RS-232, USB	GPIB, LAN (LXI), RS-232, USB	GPIB, LAN (LXI), RS-232, USB	GPIB, LAN (LXI), RS-232, USB
Connectors/Cabling	2651A: Screw terminal, adaptors for banana 2657A: HV triax, SHV	Triax	Screw terminal, adaptors for banana or triax	Screw terminal, adaptors for banana or triax	Screw terminal, adaptors for banana or triax



Feature	2430 High Power SourceMeter Instrument	2410 High V SourceMeter Instrument	2420 / 2425 / 2440 High I SourceMeter Instruments
Current Max / Min	10.5A pulse / 100pA	1.05A / 10pA	5.25A/ 100pA
Voltage Max / Min	200V / 1uV	1100V / 1uV	100V / 1uV
Power	1100W	22W	110W
Max readings / sec	2,000	2,000	2,000
Interface	GPIB, RS-232, Digital I/O, Trigger Link Trigger Bus	GPIB, RS-232, Digital I/O, Trigger Link Trigger Bus	GPIB, RS-232, Digital I/O, Trigger Link Trigger Bus
Connectors	Banana (front / rear)	Banana (front / rear)	Banana (front / rear)



# Keithley Parametric Curve Tracer Configurations



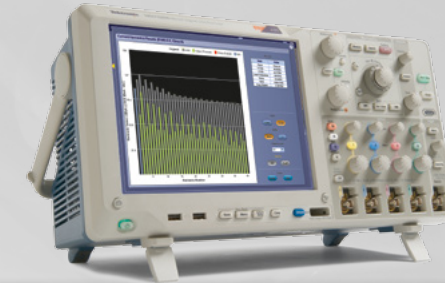
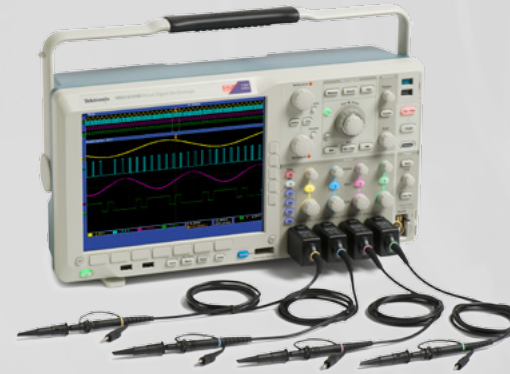
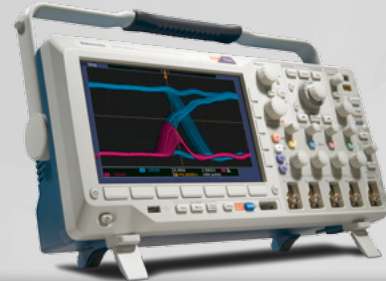
Model	2600-PCT-1	2600-PCT-2	2600-PCT-3	2600-PCT-4	4200-PCT-2	4200-PCT-3	4200-PCT-4
<b>Type</b>	Entry Level	High Current	High Voltage	High Current and Voltage	High Current + C-V	High Voltage + C-V	High Current and Voltage + C-V
<b>Collector/ Drain Supply</b>	<b>High Voltage Mode</b>	200V/10A	200V/10A	3KV/120mA	200V/1A	3KV/120mA	3KV/120mA
	<b>High Current Mode</b>	200V/10A	40V/50A	200V/10A	40V/50A	200V/1A	200V/1A
<b>Step Generator (Base/Gate supply)</b>	200V/10A	200V/10A	200V/10A	200V/10A	200V/1A	200V/1A	200V/1A
<b>Typical Applications</b>	Incoming Inspection, FA, QA, Reliability, Design Qual, Product Dev.	Incoming Inspection, FA, QA, Reliability, Design Qual, Product Dev.	Incoming Inspection, FA, QA, Reliability, Design Qual, Product Dev.	Incoming Inspection, FA, QA, Reliability, Design Qual, Product Dev.	Data Sheet Generation, Modeling, General Characterization	Data Sheet Generation, Modeling, General Characterization	Data Sheet Generation, Modeling, General Characterization
<b>Software</b>	ACS Basic Edition with Trace Mode and Parametric Mode, single and sequenced tests, sample power device libraries						
<b>Test Fixture</b>	Model 8010 High Power Device Test Fixture supports 3KV/100A Includes TO-220, TO-247, Axial, Custom sockets, sample demo parts (BJT, MOSFET, diode, etc.)						

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# Oscilloscopes Selector Guide



Feature	MSO/DPO3000	MSO/DPO4000B	MSO/DPO5000
<b>Channels</b>	2, 4 analog channels; 16 digital channels (MSO3000)	2, 4 analog channels; 16 digital channels (MSO4000B)	2, 4 analog channels; 16 digital channels (MSO4000B)
<b>Bandwidth</b>	100 MHz to 500 MHz	100 MHz to 1 GHz	350 MHz to 2 GHz
<b>Sample Rate</b>	2.5 GS/s (analog); 121.2 ps (8.25 GS/s) MagniVu™ (digital)	2.5 GS/s to 5 GS/s (analog); 60.6 ps (16.5 GS/s) MagniVu™ (digital)	5 GS/s to 10 GS/s (analog); 60.6 ps (16.5 GS/s) MagniVu™ (digital)
<b>Max Record Length</b>	5 Mpoints	Up to 20 Mpoints	Up to 250 Mpoints
<b>Trigger Types</b>	Edge, Sequence, Logic, Pulse Width, Runt, Timeout, Set-up and Hold, Rise/Fall Time, Video, Extended Video*, I2C*, SPI*, CAN*, LIN*, FlexRay*, RS-232/422/485/UART*, I2S/LJ/RJ/TDM*, MIL-STD-1553*, Parallel (MSO3000)	Edge, Sequence, Logic, Pulse Width, Runt, Timeout, Set-up and Hold, Rise/Fall Time, Video, Extended Video*, I2C*, SPI*, USB*, Ethernet*, CAN*, LIN*, FlexRay*, RS-232/422/485/UART*, I2S/LJ/RJ/TDM*, MIL-STD-1553*, Parallel (MSO4000B)	Edge, Sequence, Logic, Pulse Width, Glitch, Runt, Timeout, Transition, Set-up and Hold, Rise/Fall Time, Video, I2C*, SPI*, USB (Low, Full, High)*, RS-232/422/485/UART*, Parallel (MSO5000), Visual Trigger*
<b>Connectivity</b>	USB Host (x2), USB Device, LAN (10/100 mBase-T Ethernet), Video Out, GPIB*	USB Host (x4), USB Device, LAN (10/100/1000 Base-T Ethernet, LXI Class C Compliant), Video Out, GPIB*	USB Host (x6), USB Device, LAN (10/100/1000 Base-T Ethernet, LXI Class C Compliant), Video Out, GPIB*
<b>Waveform Math and Analysis</b>	29 Automated Measurements, Waveform and Screen Cursors, Arithmetic and Advanced Waveform Math, FFT, Measurement Statistics  Optional: DPO3PWR: Power Analysis; DPO3VID: HDTV and Custom Triggering	41 Automated Measurements, Waveform and Screen Cursors, Arithmetic and Advanced Waveform Math, Measurement Statistics, Waveform Histograms  Optional: DPO4PWR: Power Analysis; DPO4LMT: Limit and Mask Testing; DPO4VID: HDTV and Custom Triggering	53 Automated Measurements, Waveform and Screen Cursors, Arithmetic and Advanced Waveform Math, FFT, Measurement Statistics, Waveform Histograms  Optional: DPOPWR: Power Analysis DDRA: DDR Memory Bus Analysis; DJA: DPOJET Advanced Jitter and Eye Diagram Analysis; ET3: Ethernet Compliance Test Solution; LT: Waveform Limit Testing; MTM: Mask Testing; SignalVu Vector Signal Analysis; USB: USB Compliance Test Solution; VET: Visual Triggering; MOST: MOST 50/150 Compliance Test Solution; HSIC: HSIC Electrical Validation; USBPWR: USB Power Adapter/ EPS Compliance Automated Test Solution
<b>Software</b>	PC Communications Software: OpenChoice® Desktop, NI LabVIEW Signal Express™ Tektronix Edition LE	PC Communications Software: OpenChoice® Desktop, NI LabVIEW Signal Express™ Tektronix Edition LE	PC Communications Software: NI LabVIEW Signal Express™ Tektronix Edition LE

\*Optional

## Want to learn more about how Keithley is Re-Inventing High Power Semiconductor Device Characterization?



Keithley Instruments hosts an online applications forum to encourage idea exchange, discussions among users. [Join the discussion today.](#)

To learn more about how Keithley's high performance SMUs can enhance the productivity of your test and measurement applications, contact your local Keithley representative or [ask us a question online.](#)

### Contact us by phone, fax, mail, or email:

#### KEITHLEY CORPORATE HEADQUARTERS

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Toll-free: 800-552-1115  
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