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KEITHLEY

Re-Inventing
High Power Semiconductor Device Characterization
Application Advice and Product Selection

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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 rated voltages and peak currents than ever before. Keithley offers 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 offer lower leakage, lower ON resistance, or both and create new requirements for test and measurement. More ...







	UPSs	High-End Power Supplies, Servers, etc.	HEVEV	Solar Panel Inverters	Industrial Motors	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 Current	2A–100A	0.5A–10A	50A–200A	75A	3A–100A	>150A	>200A
Rated Voltage	600V–1200V	600V	650V–2000V	600V–1200V	600V–1200V	Today: 690V, Trend: 3kV–4kV	>5kV

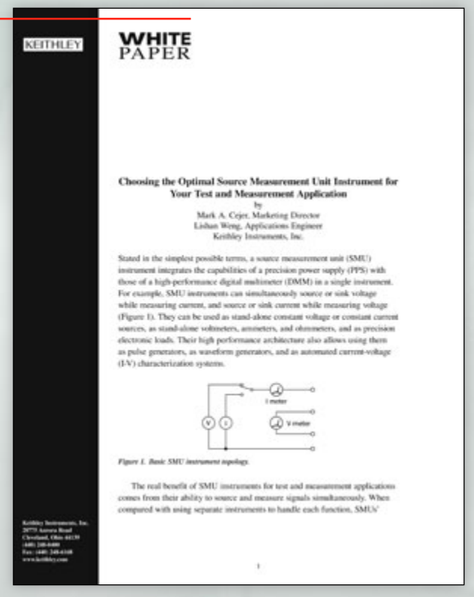
Want assistance, a quote, or to place an order?
Contact us online.

- Join the discussion on our application forum.

Learn How to Choose the Right SMU for Your Application

The popularity of SMU instruments has increased rapidly as more people discover that their tightly-integrated DMM and precision power supply capabilities can serve a wide variety of applications throughout the electronics and semiconductor industries. Learn how to evaluate instrument specifications carefully in order to choose the most appropriate SMU for a specific application. ***View our online webinar.***

- **Read the White Paper:**
  - Choosing the Optimal Source Measurement Unit Instrument for Your Test and Measurement Application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WHITE PAPER

Choosing the Optimal Source Measurement Unit Instrument for Your Test and Measurement Application

by

Mark A. Cejer, Marketing Director
Lishan Weng, Applications Engineer
Keithley Instruments, Inc.

Stated in the simplest possible terms, a source measurement unit (SMU) instrument integrates the capabilities of a precision power supply (PPS) with those of a high-performance digital multimeter (DMM) in a single instrument. For example, SMU instruments can simultaneously source or sink voltage while measuring current, and source or sink current while measuring voltage (Figure 1). They can be used as stand-alone constant voltage or constant current sources, as stand-alone voltmeters, ammeters, and ohmmeters, and as precision electronic loads. Their high performance architecture also allows using them as pulse generators, as waveform generators, and as automated current-voltage (I-V) characterization systems.

Figure 1. Basic SMU instrument topology.

The real benefit of SMU instruments for test and measurement applications comes from their ability to source and measure signals simultaneously. When compared with using separate instruments to handle each function, SMUs'

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
(440) 248-0400
Fax: (440) 248-6168
www.keithley.com

Click here for an online discussion on "What Is an SMU Instrument, and How Do You Decide Which One Is Right for Your Application?"

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

- Join the discussion on our application forum.

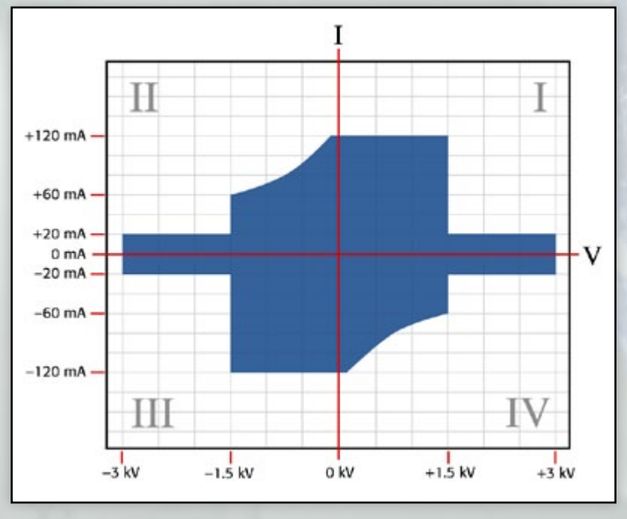
Characterize and Test High Voltage Electronics and Power Semiconductors

The ***Model 2657A High Power/High Voltage System SourceMeter® instrument*** adds high voltage to the Series 2600A System SourceMeter 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.

Click here to learn more



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

Model 2657A Applications

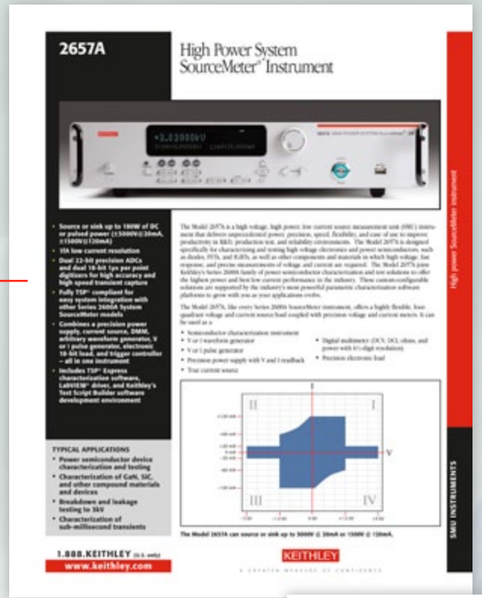
- Power semiconductor device characterization and testing
- Characterization of GaN, SiC, and other compound materials and devices
- Breakdown and leakage testing to 3kV
- Characterization of sub-millisecond transients

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.

Learn How to Perform a Simple Breakdown Test on a High Power, High Voltage IGBT Device. Click here.

Ready to learn more?

- Download the Model 2657A datasheet.



- Read the Application Note:
  - 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...

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

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

- Join the discussion on our application forum.

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

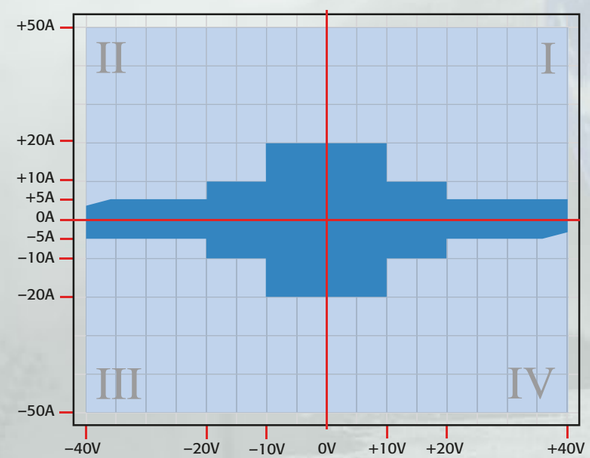
Our new ***Model 2651A High Power/High Current System SourceMeter® Instrument*** simplifies characterizing today's challenging high power electronics with unprecedented power, precision, speed, flexibility, and ease of use. It combines a highly flexible, four-quadrant voltage and current source/load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

- Source or sink 2,000W of pulsed power (±40V, ±50A), 200W of DC power (±10V@±20A, ±20V@±10A, ±40V@±5A)
- Easily connect two units (in series or parallel) to create solutions up to ±100A or ±80V
- 1pA resolution enables precise measurement of very low leakage currents
- 1μs 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.

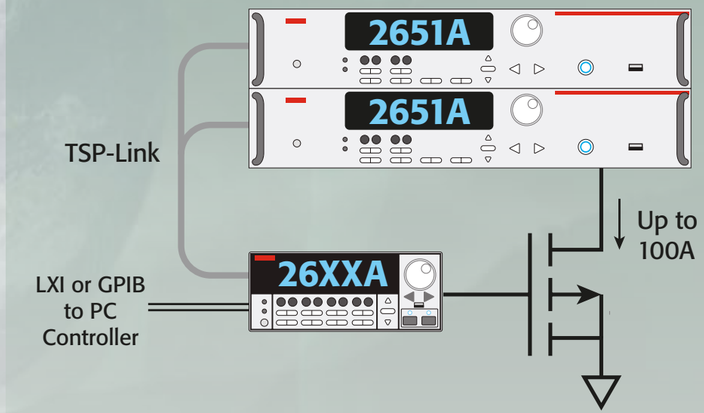
Click here to learn more



A single Model 2651A unit can source and sink up to ±40V and ±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

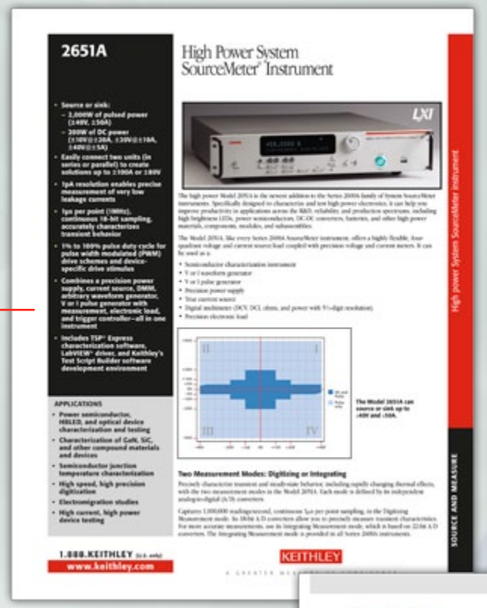
- Power semiconductor, high brightness LED (HBLED), and optical device characterization and testing
- Characterization of GaN, SiC, and other compound materials and devices
- Semiconductor junction temperature characterization
- Reliability testing
  - High speed, high precision digitization
  - Electromigration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



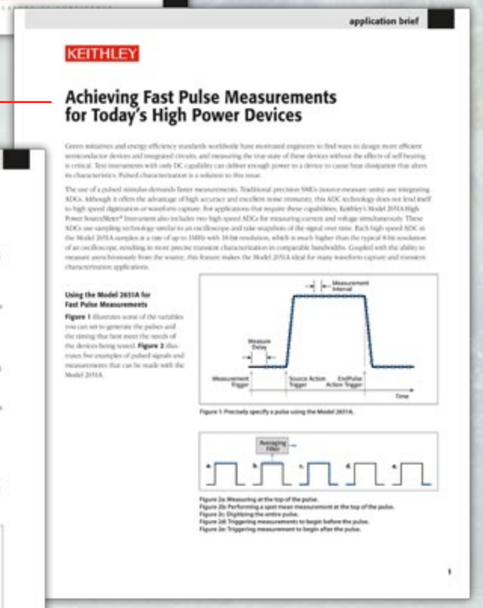
Built for building systems. The embedded TSP controller and TSP-Link interface in each Series 2600A instrument make it easy to link multiple Model 2651As and other Series 2600A instruments to create an integrated test system with up to 64 channels. Precision timing and tight channel synchronization are 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?

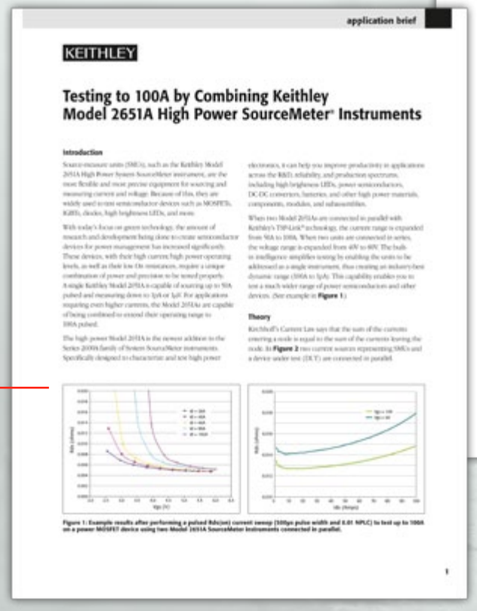
- Download the Model 2651A datasheet.



- 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® Instrumentss. 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?
Contact us online.

- Join the discussion on our application forum.

Discover how the Series 2600A family of System SourceMeter instruments simplifies high speed R&D and functional testing

The Model 2651A is one of seven ***Series 2600A System SourceMeter instruments*** for I V source-measure applications like yours. Each is designed for use as either bench-top I-V characterization tools or as building block components of multi-channel I-V test systems. Mix and match single- and dual-channel instruments for flexibility in building larger test systems. Individual models include:

- **2602A (Dual Channel) and 2601A (Single Channel). Scalable, High Throughput.** ***Learn more.***
- **2612A (Dual Channel) and 2611A (Single Channel). High voltage and pulsed output.** ***Learn more.***
- **2636A (Dual Channel) and 2635A (Single Channel). Low current and pulsed output.** ***Learn more.***
- **2651A (Single Channel). High power/high current.** ***Learn more.***
- **2657A (Single Channel). High power/high voltage.** ***Learn more.***

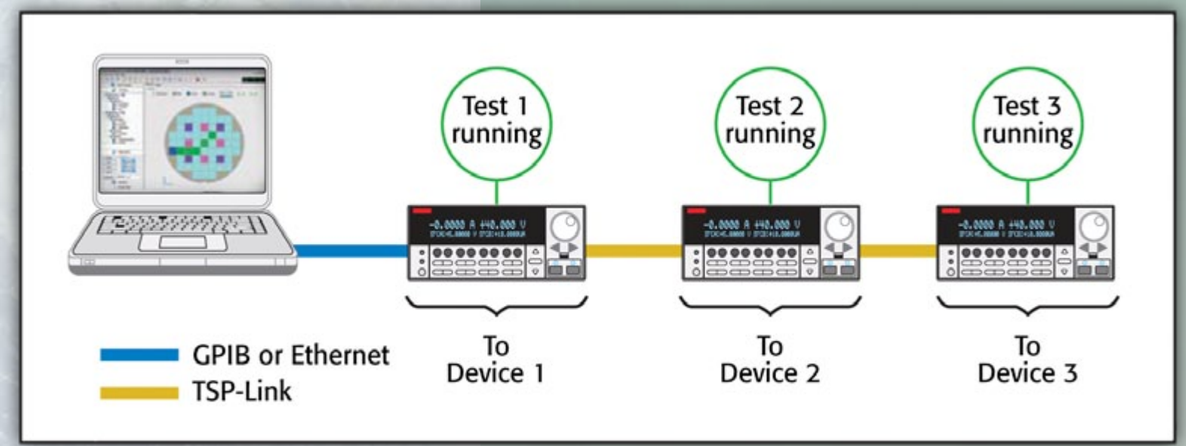
Common characteristics:

- Every model combines a power supply, true current source, DMM, arbitrary waveform generator, V or I pulse generator with measurement, electronic load, and trigger controller all in one instrument
- Family of products offers wide dynamic range
- 20,000 rdgs/s (using integrating ADCs)
- Precision timing and channel synchronization (<500ns)

Equally suited to the bench and the rack

- In bench-top applications, you can quickly and easily perform common I-V tests without programming by using the free TSP Express software tool provided with every instrument.
- For system-level applications, the Series 2600A's TSP-Link bus supports dedicated trigger lines that provide synchronous operations between multiple Series 2600A instruments and other TSP-enabled instruments, such as Series 3700 DMM/Switch Systems without the need for additional trigger connections. TSP and TSP-Link architecture provides the highest throughput in the industry, lowering your cost of test.
- A free Test Script Builder software tool helps you create, modify, debug, and store TSP test scripts for either bench or system applications. To make it easier to test, verify, and analyze semiconductor components, optional ACS Basic Edition software is also available.

Click here to learn more



Parallel testing with Series 2600A instruments. Each instrument in the system runs its own complete test sequence, creating a fully multi-threaded test environment. Test throughput is dramatically improved and the overall cost of test is reduced.

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

- Join the discussion on our application forum.

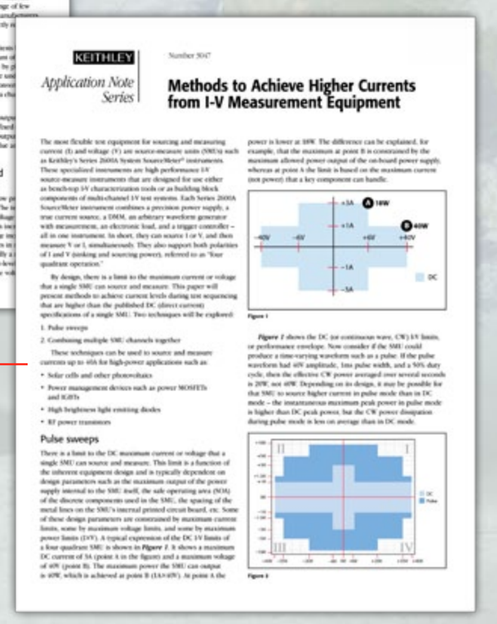
Ready to learn more?

- **Download the Series 2600A datasheet.**

- **Read an Application Note:**
  - **High Speed Testing of High Brightness LEDs –** Learn how to achieve throughput advantages and reduce the cost of test by using new test technologies, including instruments enabled with an embedded Test Script Processor.
  - **Methods to Achieve Higher Currents from I-V Measurement Equipment –** Discover how to achieve current levels during test sequencing that are higher than the published DC (direct current) specifications of a single SMU.


Series 2600A
System SourceMeter® Instruments


KEITHLEY
Application Note Series
Number 2030
High Speed Testing of High Brightness LEDs


KEITHLEY
Application Note Series
Number 3047
Methods to Achieve Higher Currents from I-V Measurement Equipment

WATCH AN ONLINE DEMONSTRATION:

Series 2600A Product Tour:
Explore this overview of Series 2600A source and measure solutions

TSP Technology Introduction:
See how our TSP technology redefines the boundaries of test instrumentation

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

- Join the discussion on our application forum.

Explore the Series 2400 SourceMeter instrument family

Series 2400 SourceMeter instruments are designed specifically for testing devices that demand tightly coupled precision voltage and current sourcing as well as measurement capabilities. Each is a single-channel instrument that is both a highly stable DC power source and a true instrument-grade 6½-digit multimeter. The power source characteristics include low noise, precision, and readback. The multimeter capabilities include high repeatability and low noise. The result is a compact, single-channel, DC parametric tester.

- Six models: 20–100W DC, 1000W pulsed, 1100V to 1μV, 10A to 10pA
- Source and sink (4-quadrant) operation, plus 2-, 4-, and 6-wire ohms functions
- 0.012% basic DCV measure accuracy with 6½-digit resolution
- Available high speed sense lead contact check function
- Programmable DIO port for automation/handler/prober control
- Up to 1700 readings/second at 4½ digits via the GPIB bus
- 5000 6½-digit readings can be stored in the non-volatile buffer memory

Built-In Test Sequencer

The Series 2400 Source Memory list provides faster and easier testing by allowing you to set up and execute up to 100 different test setups that can run without PC intervention.

- Stores up to 100 individual test configurations, each containing unique source settings, measurement settings, pass/fail criteria, etc., linked together to form a complete test suite
- Pass/fail limit test as fast as 500μs per point with onboard comparator that eliminates the delay caused when sending data to the computer for analysis
- Built-in, user definable math functions to calculate derived parameters

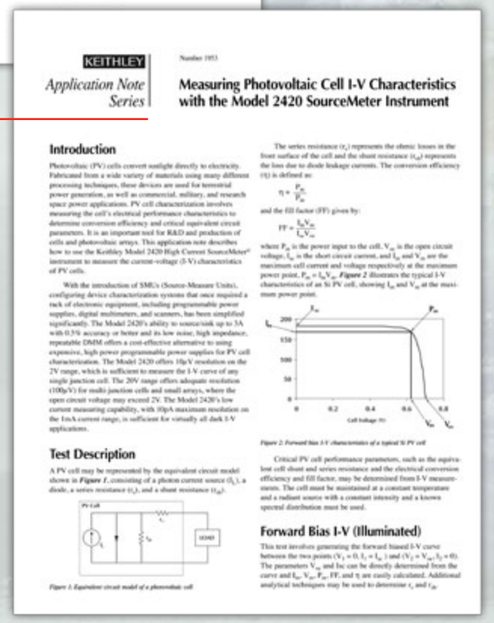
Click here to learn more

Series 2400 SourceMeter instruments are easy to set up and use, providing convenient DMM-like operation, while eliminating many of the connection, compatibility, and synchronization problems that occur when multiple instruments are used. You can source voltage or current while making measurements without changing connections. This not only makes it easier to use, it saves test time.

Ready to learn more?

- Download the Series 2400 datasheet.

- Read an Application Note:
  - Measuring Photovoltaic Cell I-V Characteristics with the Model 2420 SourceMeter Instrument – Discover how to use the Model 2420 High Current SourceMeter instrument to measure the current-voltage (I-V) characteristics of photovoltaic cells in order to characterize their conversion efficiency.



Click on the video above – Learn how to use saved setups with the Series 2400 SourceMeter Instrument Family.

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

- Join the discussion on our application forum.

Tools for Completing a High Power Test System

Every Keithley 26xxA SourceMeter includes these Features/Functions

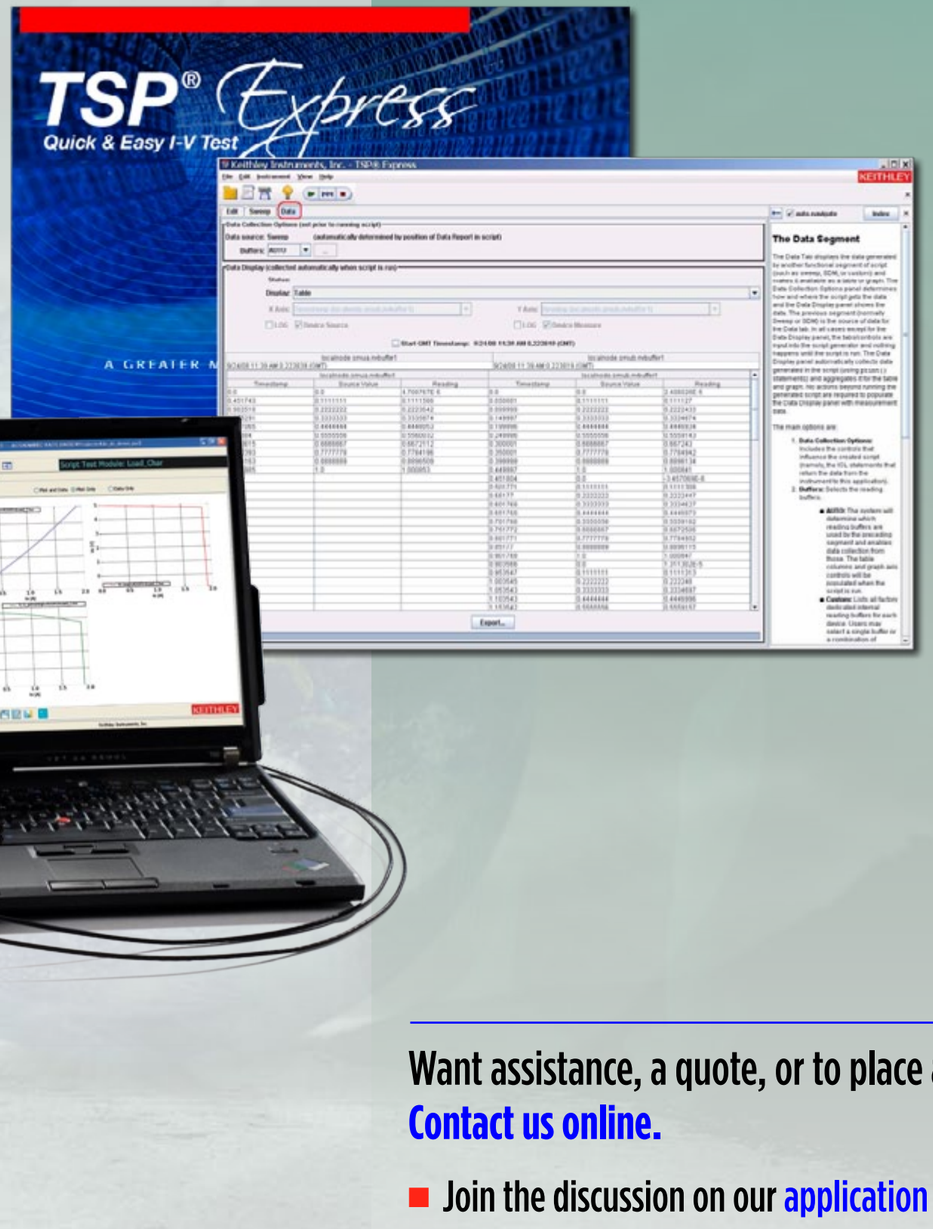
- ***TSP Link***® allows linking the Model 2657A with other Series 2600A instruments to form a larger integrated system with up to 32 nodes.
- ***TSP Express, Keithley's LXI-based I-V test software utility.*** Users can simply connect a PC to the LXI LAN port and access TSP Express with any Java-enabled web browser. Test results can be viewed in either graphical or tabular format and then exported to a .csv file for use with spreadsheet applications.
- ***Test Script Builder*** application for creating, modifying, debugging, running, and managing TSP scripts.
- ***IVI-based LabVIEW® driver*** to simplify integrating the Model 2657A into LabVIEW test sequences.

Options Available for an Additional Charge

ACS Basic Edition maximizes the productivity of technicians and engineers in research and development and is optimized for parametric testing of component and discrete (packaged) semiconductor devices.

The ***Model 8010 High Power Device Test Fixture*** provides safe and easy connections for testing packaged high power devices at up to 3000V or 100A.

The ***Models 2657A-PM-200 Protection Module and 2657A-LIM-3 Low Interconnect Module*** make it easier to connect multiple instruments to a probe station safely.



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Discover how you benefit from our legacy of innovation in Source-Measure Unit engineering

Our latest generation of System SourceMeter® instruments offers the T&M industry's best combination of precision, throughput, and functionality. When used individually, they bring together everything we've learned about engineering instruments that deliver unparalleled performance. They're also flexible, efficient, I-V source-and-measure building blocks for creating fast, powerful, and cost-effective test and measurement systems for electronic devices. Keithley has been a leading provider of integrated sourcing and measurement solutions since the late 1980s, when we introduced our first generation of source-measure units (SMUs).

First one-microsecond per point digitizing SMU instrument (Model 2651A)
First 200W DC, 2000W pulsed SMU instrument (Model 2651A)
First 3,000V, 180W SMU with 1fA current measurement resolution (Model 2657A)

First half-rack, DMM-like SMU instrument (Model 2400)

First instrument-based SMU (Series 23X)

1989

First two-channel, half-rack SMU instrument (Model 2602)
First script-based SMU instrument (Models 2601/2602)

2005

today

First 1000V SMU instrument (Model 237)

1995

2000

First one-kilowatt pulsed SMU instrument (Model 2430)

First sub-femtoamp SMU instrument (Model 6430)

First SMU instrument with parallel test expansion capability (Series 2600A)

System SourceMeter® SMU Instruments

Feature	2651A / 2657A High Current / High Voltage	2635A / 2636A Low Current	2602A / 2612A Dual Channel	2601A / 2611A Single Channel
# of Channels	1 (optional expansion to 32)	1 – 2 (optional expansion to 64)	2 (optional expansion to 64)	1 (optional expansion to 32}
Current Max / Min	50A pulse / 1fA	10A pulse / 0.1fA	10A pulse / 100fA	10A pulse / 100fA
Voltage Max / Min	3,000V / 1uV	200V / 100nV	200V / 100nV	200V / 100mV
Power	2000W pulse / 200W DC	30W per channel	30 – 40W per channel	30 – 40W
Max readings / sec	38,500 1uSec / pt., 18-bit digitizer	20,000	20,000	20,000
Interface	GPIB, LAN (LXI), RS-232, Digital I/O, TSP-Link® channel expansion bus	GPIB, LAN (LXI), RS-232, Digital I/O, TSP-Link® channel expansion bus	GPIB, LAN (LXI), RS-232, Digital I/O, TSP-Link® channel expansion bus	GPIB, LAN (LXI), RS-232, Digital I/O, TSP-Link® channel expansion bus
Connectors	2651A: Screw terminal, adaptors for banana 2657A: HV triax, 5HV	Triax	Screw terminal, adaptors for banana or triax	Screw terminal, adaptors for banana or triax

Feature	6430 Low I SourceMeter	2430 High Power SourceMeter Instrument	2410 High V SourceMeter Instrument	2420 / 2425 / 2440 High I SourceMeter Instruments	2400 / 2401 Low Power SourceMeter Instruments
Current Max / Min	105mA / 10aA	10.5A pulse / 100pA	1.05A / 10pA	5.25A/ 100pA	1.05A / 10pA
Voltage Max / Min	200V / 1uV	200V / 1uV	1100V / 1uV	100V / 1uV	200V / 1uV
Power	2W	1100W	22W	110W	22W
Max readings / sec	256	2,000	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	GPIB, RS-232, Digital I/O, Trigger Link Trigger Bus	GPIB, RS-232, Digital I/O, Trigger Link Trigger Bus
Connectors	Triax	Banana (front / rear)	Banana (front / rear)	Banana (front / rear)	Banana (front / rear)

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Contact us online.

- Join the discussion on our **application forum**.

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

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139
Phone: 440-248-0400
Toll-free: 800-552-1115
Fax: 440-248-6168
info@keithley.com

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WORLDWIDE HEADQUARTERS

Within the USA: **1-888-534-8453**
Outside the USA: **+ 1-440-248-0400**
Email: applications@keithley.com
Additional contact information at www.keithley.com

EUROPE

Germany: **(+49) 89 849 307 40**

ASIA

China: **(+86) 10 8447 5556**
Japan: **(+81) 3 6714 30 70**
Korea: **(+82) 2 574 7778**
Taiwan: **(+886) 3 572 9077**

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KEITHLEY

KEITHLEY INSTRUMENTS, INC. ■ 28775 AURORA RD. ■ CLEVELAND, OH 44139-1891 ■ 440-248-0400 ■ Fax: 440-248-6168 ■ 1-888-KEITHLEY ■ www.keithley.com

BELGIUM
Sint-Pieters-Leeuw
Ph: 02-3630040
Fax: 02-3630064
info@keithley.nl
www.keithley.nl

CHINA
Beijing
Ph: 86-10-8447-5556
Fax: 86-10-8225-5018
china@keithley.com
www.keithley.com.cn

FRANCE
Les Ulis
Ph: 01-69868360
Fax: 01-69868361
info@keithley.fr
www.keithley.fr

GERMANY
Germering
Ph: 089-84930740
Fax: 089-84930734
info@keithley.de
www.keithley.de

INDIA
Bangalore
Ph: 080-30792600
Fax: 080-30792688
support_india@keithley.com
www.keithley.in

ITALY
Peschiera Borromeo (Mi)
Ph: 02-5538421
Fax: 02-55384228
info@keithley.it
www.keithley.it

JAPAN
Tokyo
Ph: 81-3-6714-3070
Fax: 81-3-6714-3080
info.jp@keithley.com
www.keithley.jp

KOREA
Seoul
Ph: 82-2-574-7778
Fax: 82-2-574-7838
keithley@keithley.co.kr
www.keithley.co.kr

MALAYSIA
Penang
Ph: 60-4-643-9679
Fax: 60-4-643-3794
sea@keithley.com
www.keithley.com

NETHERLANDS
Son
Ph: 040-2675502
Fax: 040-2675509
info@keithley.nl
www.keithley.nl

SINGAPORE
Singapore
Ph: 65-6747-9077
Fax: 65-6747-2991
sea@keithley.com
www.keithley.com.sg

TAIWAN
Hsinchu
Ph: 886-3-572-9077
Fax: 886-3-572-9031
info_tw@keithley.com
www.keithley.com.tw

UNITED KINGDOM
Bracknell
Ph: 044-1344-392450
Fax: 044-1344-392457
info@keithley.co.uk
www.keithley.co.uk

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