

A GREATER MEASURE OF CONFIDENCE

KEITHLEY
A Tektronix Company

HOW TO CHOOSE AND APPLY Source Measure Unit Instruments

INSTRUMENT SELECTION ■ KEY APPLICATIONS ■ MEASUREMENT CAPABILITIES



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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 are the T&M industry's most powerful, fastest and highest resolution SMU instruments, 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).



Series 2600B SourceMeter SMU Instruments
Three new benchtop models offer best-in-class value and performance

First instrument-based SMU
(Series 23X)

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



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



1989

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)

2008



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)

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 these White Papers:

- [Choosing the Optimal Source Measurement Unit Instrument for Your Test and Measurement Application](#)
- [Rapidly Expanding Array of Test Applications Continues to Drive Source Measurement Unit Instrument Technology](#)



[Click here for an online discussion of SMU instruments versus power supplies or DMMs](#)

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

■ Join the discussion on our [application forum](#).

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

Series 2600B System SourceMeter instruments are 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:

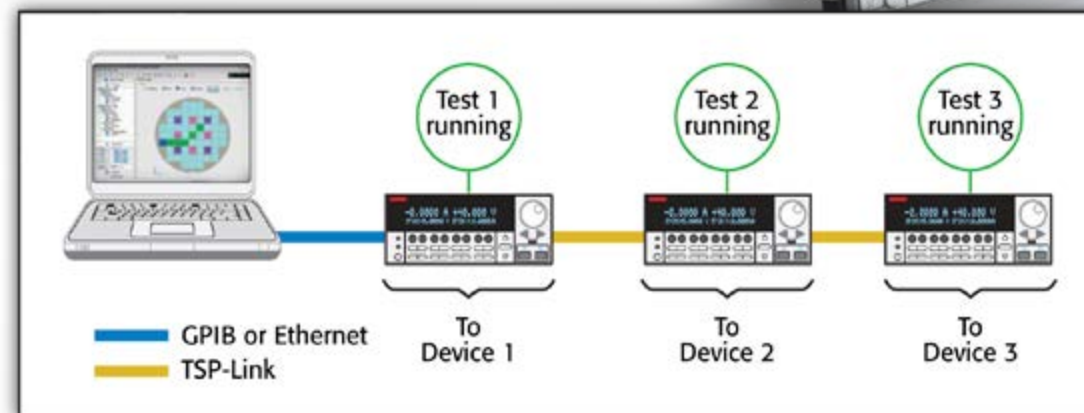
- **Models 2602B and 2604B (Dual Channel-Benchtop), and Model 2601B (Single Channel). Scalable, High Throughput. [Learn more.](#)**
- **Models 612B and 2614B (Dual Channel-Benchtop), and Model 2611B (Single Channel). High voltage and pulsed output. [Learn more.](#)**
- **Models 2636B and 2634B (Dual Channel-Benchtop), and Model 2635B (Single Channel). Low current and pulsed output. [Learn more.](#)**
- **Model 2651A (Single Channel). High Current. [Learn more.](#)**
- **Model 2657A (Single Channel). High power/high voltage, low current and pulsed output. [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 (10A pulse to 0.1fA, 200V to 100nv)
- 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 browser-based “Plug-n-Play” I/V characterization software provided with every instrument.
- For system-level applications, the Series 2600B’s TSP-Link bus supports dedicated trigger lines that provide synchronous operations between multiple Series 2600B instruments and other TSP-enabled instruments, such as Series 3700A 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.



Parallel testing with Series 2600B 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.

Series 2600B Applications

I-V functional test and characterization of a wide range of devices, including:

- Discrete and passive components
 - Two-leaded – Sensors, disk drive heads, MOVs, diodes, zener diodes, sensors, capacitors, thermistors
 - Three-leaded – Small signal BJTs, FETs, and more
- Simple ICs – Optos, drivers, switches, sensors
- Integrated devices – Analog ICs, RFICs, ASICs, SOC devices
- Optoelectronic devices such as LEDs, laser diodes, HBLEDs, VCSELs, displays
- Wafer level reliability – NBTI, TDDB, HCI, electromigration
- Solar cells
- Batteries

**Want assistance, a quote, or to place an order?
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- **Join the discussion on our [application forum.](#)**

Ready to learn more?

■ Download the Series 2600B 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.

■ Test Applications:

– **Migrating from Keithley's Series 2400 SourceMeter® SMU instrument to a Series 2600B SourceMeter SMU Instrument?** Learn how the new Model 2600B instrument is capable of emulating the mode of operation of the Model 2400 by accepting SCPI commands.

Series 2600B System SourceMeter® SMU (Source-Measure Unit) Instruments

- Tightly integrated, 4-quadrant voltage/current source and precision instruments offer best in class performance with 6 1/2 digit resolution.
- Family of models offer industry's widest dynamic range: 100 pA to 5 A and 200V to 1000V
- Built-in, Java-based test software enables using a plug & play I-V characterization and test software.
- TSP (Test Script Processor) technology enables using test programs inside the test program for best in class system-level throughput.
- TSP Link expansion technology for multi-channel parallel test without a multimeter.
- Software emulation for Keithley's Model 2400 SourceMeter SMU instrument.
- USB 2.0, LAN, GPIB, RS-485, and digital I/O interfaces.
- Free software drivers and development/debug tools.



Application Note Series Number 2001

High Speed Testing of High Brightness LEDs

Introduction

Visible light emitting diodes (LEDs) have gained a reputation for high efficiency and long lifetimes, which has led to their use in a growing list of applications, including automotive displays and exterior lights, backlighting for televisions and video monitors, street lights, outdoor signs, and interior lighting. Extensive research and development efforts by LED manufacturers have led to the creation of LEDs with higher efficiency, longer lifetimes, greater chromaticity, drive current, and thermal stability. To ensure the reliability and cost-effective testing of LEDs, test systems, test methods, and test equipment are being developed. LED testing involves all stages of production, from development, component and final test of packaged parts. Test methods often include a multitude of test conditions and test parameters that are beyond the scope of traditional test equipment. This note describes how to achieve the test of LED using new test technologies, including instruments enabled with an embedded Test Script Processor.

LED testing involves all stages of production, from development, component and final test of packaged parts. Test methods often include a multitude of test conditions and test parameters that are beyond the scope of traditional test equipment. This note describes how to achieve the test of LED using new test technologies, including instruments enabled with an embedded Test Script Processor.

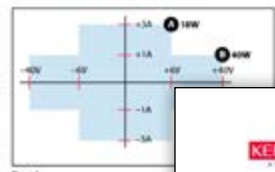
LED testing involves all stages of production, from development, component and final test of packaged parts. Test methods often include a multitude of test conditions and test parameters that are beyond the scope of traditional test equipment. This note describes how to achieve the test of LED using new test technologies, including instruments enabled with an embedded Test Script Processor.

Application Note Series Number 2002

Methods to Achieve Higher Currents from I-V Measurement Equipment

The most flexible test equipment for sourcing and measuring current (I) and voltage (V) are source-measure units (SMUs), such as Keithley's Series 2600B System SourceMeter® instruments. These specialized instruments are high performance I-V source-measure instruments that are designed for use either as benchtop I-V characterization tools or as building block components of multi-channel I-V test systems. Each Series 2600B SourceMeter instrument combines a precision power supply, a true current source, a DMM, an arbitrary waveform generator with measurement, an electronic load, and a signal conditioner – all in one instrument. In short, they can source 1 or V, and then measure V or I, simultaneously. They also support both polarities of I and V sourcing and sourcing power, referred to as "four quadrant operation."

By design, there is a limit to the maximum current or voltage that a single SMU can source and measure. This limit is a function of the inherent equipment design and is typically dependent on design parameters such as the maximum output of the power supply internal to the SMU, the safe operating area (SOA) of the discrete components used in the SMU, the spacing of the metal lines on the SMU's internal ground circuit board, etc. Some of these design parameters are constrained by maximum current limits, while for maximum voltage limits, and some for maximum power limits (P_{max}). A typical expression of the DC I-V limits of a four quadrant SMU is shown in Figure 1. It shows a maximum DC current of 1A (point A in the figure) and a maximum voltage of 10V (point B). The maximum power the SMU can source is 10W, which is achieved at point C (1A/10V). At point D, the power is lower at 5W. The difference can be explained, for example, that the maximum at point B is constrained by the maximum allowed power output of the on-board power supply, whereas at point A the limit is based on the maximum current that a key component can handle.



Application Note Series Number 2003

Migrating Test Applications from the Keithley Model 2400 SourceMeter® SMU Instrument to a Series 2600B System SourceMeter SMU Instrument

Introduction

Keithley's Series 2600B System SourceMeter instruments are the test and measurement industry's latest SMU (Source Measure Unit) instruments. Based on Keithley's third generation SMU architecture, the Series 2600B line combines fast and accurate analog performance with up to two source and measure channels in a half-rack package. They are also capable of extremely high speed test sequencing and automation as a result of their embedded TSP™ (Test Script Processor) scripting engine. Additionally, the Series 2600B provides full software emulation of Keithley's second generation SMU architecture, based on the Model 2400 instrument, enabling these users to easily and quickly migrate their applications to the new, higher throughput Series 2600B instruments.

Test software based on SCPI (Standard Commands for Programmable Instruments) commands is used to control the Model 2400 instrument. Serially, Series 2600B instruments don't natively respond to SCPI commands. Instead, they use a command set known as E3, (Enterprise Command Language) commands. This difference in command sets once required users to re-write their code if they wished to use a Series 2600B instrument in the place of a Model 2400. For many users with existing test methods, writing new software to support the new instrument's command set was simply not feasible due to the time and cost involved or simply because the source code was not available. Today, however, Series 2600B instruments provide a solution for these users because they are able to accept the SCPI commands of the Model 2400 by using a 2400 Personality Script.

The TSP scripting engine of Series 2600B instruments runs a test script named Personal2400 to emulate the operation of a Model 2400. This script accepts the SCPI commands of the Model 2400 and then quickly and seamlessly translates them into the native E3 commands that Series 2600B instruments understand. The TSP scripting engine can accomplish this translation so quickly that, for a typical Model 2400 SCPI command sequence, users can expect up to a 2x improvement in test execution time when they replace a Model 2400 with a Series 2600B instrument running the Personal2400 script. Once the script is up and running, from the perspective of a Series 2600B instrument program, the instrument appears simply to be a Series 2400.

Advanced Capabilities of the 2400 Personality Script

Because of the Model 2400's industry popularity, other SMU instruments have been developed in an attempt to emulate it. However, many of the Model 2400's key capabilities are omitted. The Series 2600B are the only SMU instruments that emulate all Model 2400 commands, including source-memory sweeps, linear log, and list sweeps, Trigger Link and digital I/O, status model, and administration queries.

Source Memory Sweeps

Source memory sweeps allow the instrument to be pre-loaded with multiple source and measure configurations and then cycle through them quickly from a single command. Source-Memory is critical to high-speed production testing with the Model 2600B. The Personal2400 script has full support for Source-Memory sweeps, including highly advanced features like Source-Memory location branching.

Linear, Log and List Sweeps

Sweeps allow the instrument to cycle quickly through multiple source values, taking measurements at each point. The Personal2400 script uses the Series 2600B line's advanced Trigger model to perform sweeps, giving users more accuracy with less timing jitter than sweeps performed on the original Model 2400, which results in even more consistent measurements.

Trigger Link and Digital I/O

The Personal2400 script supports the Trigger Link and digital I/O ports of the Model 2400. This is critical for high-speed automated testing applications and synchronization with other pieces of equipment. The pins from the Trigger Link and digital I/O ports on the Model 2400 have all been mapped to the pins of the 25-pin D-sub connector on the back of Series 2600B instruments. Table 1 outlines the complete pin mapping.

Status Model

The status model is used to monitor the state of the instrument and generate service requests (SRQs) to signal the controller to perform an operation on the instrument. It is often used to measure system responsiveness. The Personal2400 script supports all registers of the 2400 status model and generates SRQs from these registers.



PLUG & PLAY SOFTWARE:
View this demonstration of Java-based Plug & Play test software for I/V characterization of devices.

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

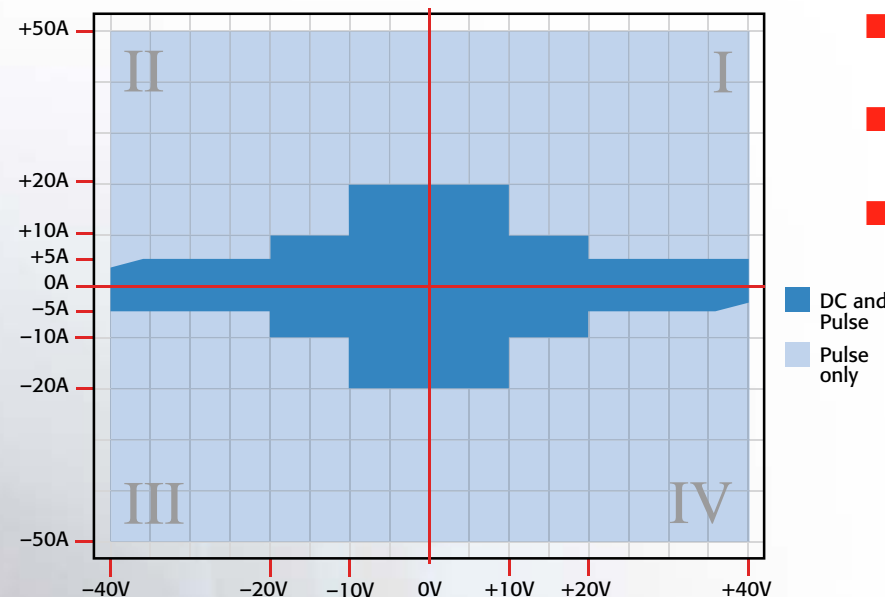
Our **Model 2651A High Power System SourceMeter® Instrument** simplifies characterizing today's challenging high power electronics with unprecedented power, precision, speed, flexibility, and ease of use. It combines a highly flexible, four-quadrant voltage and current source/load with precision voltage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

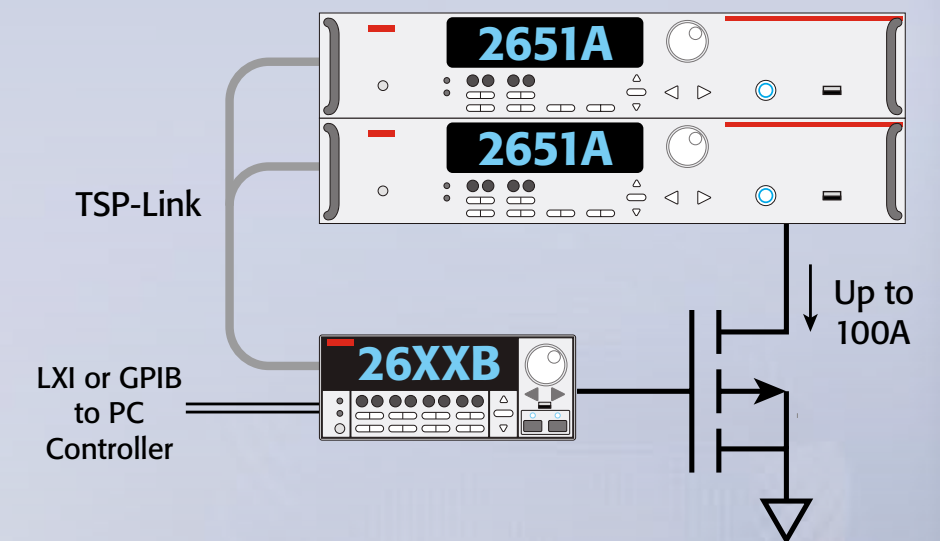
With the Model 2651A, you can choose from either digitizing or integrating measurement modes for precise characterization of both transient and steady-state behavior. Two independent ADCs define each mode—one for current and the other for voltage—which run simultaneously for accurate source readback 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 2600B instrument make it easy to link multiple Model 2651As and other Series 2600B 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 2600B 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?
[Contact us online.](#)

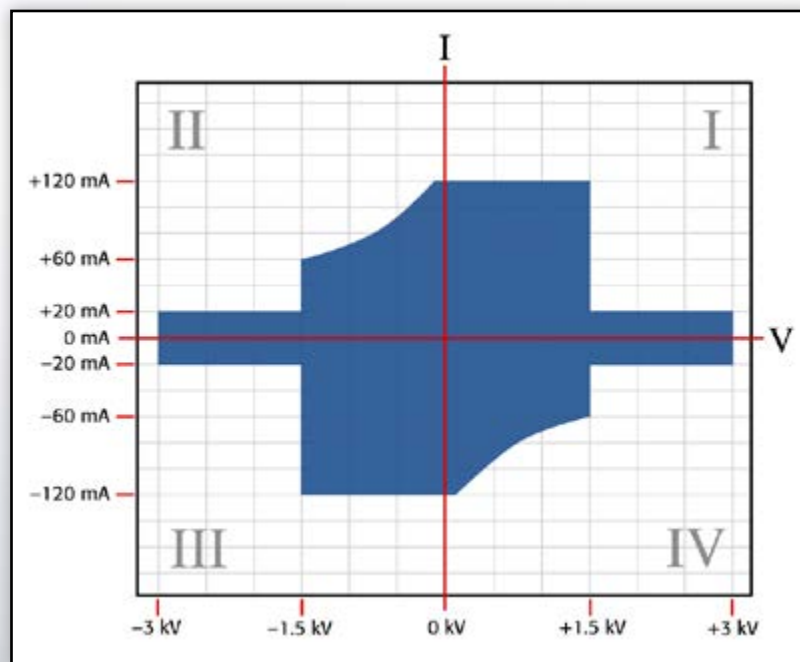
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Characterize and Test High Voltage Electronics and Power Semiconductors

The **Model 2657A High Power System SourceMeter® instrument** is 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 2600B SMU instruments, it includes TSP® Express characterization software, LabVIEW® driver, and Keithley's Test Script Builder software development environment.



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 2600B 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 2600B 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.

2657A High Power System SourceMeter Instrument

Source or sink up to 100W of DC or pulsed power (1300W/20ms, 1500W/10ms)

5A low current resolution

20-bit precision ADCs and dual 16-bit 750 psd period digitizers for high accuracy and high speed instrument response

Fully 100% compliant for many system integrations with other Series 26000 System SourceMeter models

Combines a precision power supply channel, 100W auxiliary waveform generator, V and I pulse generator, electronic 10:1 load, and trigger controller – all in one instrument

Includes 100+ Express characterization software, LabVIEW driver, and Keithley's Test Script Builder software development environment

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-millimeter transistors

The Model 2657A is a high voltage, high power, low current source measurement unit (SMU) instrument that delivers exceptional power, precision, speed, flexibility, and ease of use to improve productivity in SMU production use and reliability measurement. The Model 2657A is designed specifically for characterizing and testing high-voltage devices and power semiconductor, such as diodes, IGBTs, and MOSFETs, as well as other components and materials in which high voltage, low response, and precise measurement of voltage and current are required. The Model 2657A provides Keithley's Series 26000 family of power semiconductor characterization and test solutions to offer the highest power and low loss current performance in the industry. These comprehensive solutions are supported by the industry's most powerful parameter characterization software solutions to give you the most complete test system.

The Model 2657A, like every Series 26000 SourceMeter instrument, offers a highly flexible, low-impedance voltage and current source load coupled with precision voltage and current meters. It can be used as a:

- Semiconductor characterization instrument
- V and I waveform generator
- V or I pulse generator
- Precision power supply with V and I feedback
- True current source
- Digital multimeter (DMM), DMM, ohm, and power with 10-bit resolution
- Precision electronic load

Keithley

- 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...](#)

Application Note Series

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) involves several steps:

- Selecting equipment to meet test demands
- Selecting cabling and ensuring it connects the instruments to the device under test (DUT)
- Verifying system safety and measurement precision
- Optimizing the instrument setup to ensure measurement integrity
- Controlling the instrumentation hardware

Power semiconductor device devices are designed so that in the ON state, a device delivers a lot of power to the load and consumes minimal power from the power source. High efficiency, in its OFF state, the device delivers nearly zero power to the load and consumes minimal power from the power source (leakage current is small). Therefore, characterization or DC parameter test of power semiconductor can be broken into two categories: ON-state and OFF-state characterization. This application note considers the application of test to these two categories. Specific examples of test systems built with a variety of Keithley SourceMeter® Source Measurement Unit (SMU) instruments will also be presented.

Select Equipment to Meet Test Demands

Power devices typically require high power instrumentation at only one or two terminals. For example, characterizing the OFF-state of a high voltage n-channel MOSFET requires a high voltage supply at the drain, all other terminals are driven with lower voltage supplies. Conversely, when characterizing the ON-state performance, high current flows from drain to source, thereby requiring that only these two terminals be used for maximum power. Test researchers who are making the transition from using lower power devices to higher power devices can reuse some of their existing test equipment at the gate and substrate terminals. Being able to use the same test equipment for multiple devices allows users to maximize their return on investment.

In order to select appropriate test equipment, it's essential to know the minimum and maximum current and voltage that will be necessary to source and measure. If at all possible, select equipment that has the capability to exceed beyond these values in order to accommodate the development of new devices.

Keithley's Series 26000 SMUs were designed with enabling test systems in mind. The 100W/20ms or 150W/10ms maximum bus supports creating multi-channel systems while still allowing sub-millisecond synchronization of multiple SMU channels.

One of the most powerful features of the Series 26000 is the ability to offer a built-in system that addresses all of the application's test requirements while maintaining seamless system performance. The Series 26000 family includes eight models that offer a variety of functions and capabilities:

- Up to 5A pulse at 2000V (300A possible with two SMUs)
- Up to 5W source at 100V, 150W at 100V
- Sub-picoamp measurement capability
- Up to 1A or 5A 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 instrument and would have once required configuring a custom or semi-custom ATS. Moreover, using stand-alone instruments allows the test engineer to add new capabilities as new test needs evolve. Stand-alone high-power SMUs can extend the current and voltage capabilities of semiconductor parameter analyzers and, therefore, the scope of devices that can be tested.

Selecting Cabling and Fixturing to Connect the Instruments to the Device

Determine the Interface to the Device

In the past, more power semiconductor manufacturers had to package a device in order to test it because there was no widely available technology that allowed delivering tens of amps or thousands of volts to a device on a wafer.

The availability of commercial probe stations is allowing some manufacturers to view the opportunity to lower their cost of test by testing devices on wafers.

Deciding whether to test packaged devices or devices on wafers is a balance between the large capital costs of a probe versus the smaller (but repeatedly) costs of packaging devices prior to test. Keithley solutions apply to both packaged test and wafer-level testing.

For testing packaged devices, system developers should take advantage of commercial test fixtures, paying attention to the supported device packages and any opportunity for customization. Keithley offers the Model 8000 High Power

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

KEITHLEY 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.

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

Series 2400 Applications

- Devices including discrete semiconductor devices, passive devices, transient suppression devices, ICs, RFICs, MMICs, laser diodes, laser diode modules, LEDs, photodetectors, circuit protection devices (TVS, MOV, fuses, etc.), connectors, switches, relays
- Tests including low voltages/resistances, LIV, IDDQ, I-V characterization, isolation and trace resistance, temperature coefficient, forward voltage, reverse breakdown, leakage current, DC parametric test, DC power source, HIPOT, dielectric withstanding



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:

– **Diode Production Testing with the Series 2400 SourceMeter Instrument** – Read about the three basic DC parametric tests most diodes undergo during final inspection: forward voltage, breakdown voltage, and leakage current test.

– **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.

Series 2400 SourceMeter Line

Keithley's SourceMeter family is designed specifically for test applications that demand tight, repeatable accuracy and precision. All SourceMeter models provide precise voltage and current sourcing as well as measurement capabilities. Each SourceMeter instrument is built with a highly stable DC power source and a true instrumentation-grade V-range amplifier. The power source characteristics include low noise, precision, and stability. The measurement capabilities include high repeatability and low noise. The result is a compact, single-channel DC parametric tester. In operation, these instruments can act as a voltage source, a current source, a voltage meter, a current meter, and an ohmmeter. Manufacture of components and modules for the semiconductor, automotive, computer, automotive, and medical industries will find that the SourceMeter instruments available for a wide range of characterization and production test applications.

Advantages of a Tightly Integrated Instrument

In today's source and measurement circuitry in a single unit, these instruments offer a variety of advantages over systems configured with separate source and measurement instruments. For example, they maintain the time required for test station development, setup, and measurement, while lowering the overall cost of system ownership. They simplify the test process itself by eliminating much of the complex mechanical and electrical wiring associated with using multiple instruments. And, their compact full rack size provides the same "test station" in the test rack or bench.

Power of Five Instruments in One (IV Source, IVR Measure)

The tightly integrated nature of a SourceMeter instrument provides many advantages over separate instruments. For example, it provides faster test times by reducing I/O traffic, and simplifies test program development. It also protects the device under test from damage due to an incorrectly formed waveform, as both the current and voltage source are programmable with built-in safety features. It also helps maintain device measurement integrity. If the waveform reaches a programmed limit, then the source is clamped at the limit, providing built protection.

ACCESSORIES AVAILABLE

KEY FEATURES AND BENEFITS

- Five instruments in one (IV Source, IVR Measure)
- Six models: 10-100W DC, 100W peak, 100W to 10A, 10A to 100A
- Source and sink (4-quadrant) operation
- 0.02% basic measure accuracy with 50-digit resolution
- 2-, 4-, and 8-wire remote V-sense and measure sensing
- 1700 readings/second at 800kHz 1MS Comp
- Pass/Fail comparator for fast sorting/sorting
- Available high speed sense lead contact check function
- Programmable DUT port for automation/handoff/prober control
- Standard GPIB, GPI, RS-232 and Keithley Trigger Link interfaces
- Keithley LabTracer 2.0 I-V curve tracing application software (download)

1.888.KEITHLEY or www.keithley.com

KEITHLEY Application Note Series

Diode Production Testing with Series 2400 SourceMeter Instruments

Introduction

Performing single-point pass/fail DC tests on packaged diodes is critical to ensure compliance with manufacturers' specifications and to identify and avoid out-defective devices before they are shipped. Most types of diodes undergo at least three basic DC parametric tests during final inspection process: the Forward Voltage Test (V_f), Breakdown Voltage Test (V_{br}), and Leakage Current Test (I_{leak}). While the reliability of these tests is essential to ensuring product quality, it's equally important that they be conducted quickly to maintain high production throughput.

Usually, several instruments are required to make these tests, such as a DMM, voltage source, and current source. However, as the number of instruments in the test system increases, the slower the overall measurement process becomes, reducing test throughput.

A system configured with a separate DMM and source takes up substantially more rack space than a system built with all these functions in one unit. In addition to higher equipment costs, these separate instruments also mean there are three sets of commands to learn, complicating system programming and maintenance. Using multiple instruments and sources also makes trigger timing more complex and increases triggering uncertainty. Integrating the source and DMM into a single instrument also extends the amount of test traffic throughput.

Figure 1 illustrates the test points for each of the tests described.

Test Descriptions

Forward Voltage Test

The forward voltage test is designed to determine the orientation of the diode safely and quickly prior to completing functional tests on the device. The breakdown characteristics of the diode are used to generate an indication of the diode's polarity in one of two ways. A positive current can be sourced through the diode and the voltage measured. A voltage of less than 1V (typically) indicates forward polarity of the diode, while a high voltage indicates breakdown and reverse polarity. Alternatively, a negative current can be sourced, in which case a voltage measurement less than 1V indicates reverse polarity, while a high voltage indicates breakdown and forward polarity. The choice between these two methods for polarity testing depends primarily on the overall structure of the test program.

KEITHLEY Application Note Series

Measuring Photovoltaic Cell I-V Characteristics with the Model 2420 SourceMeter Instrument

Introduction

Photovoltaic (PV) cells convert sunlight directly to electricity. Fabricated from a wide variety of materials using many different processing techniques, these devices are used for terrestrial power generation, as well as commercial, military, and research space power applications. PV cell characterization involves measuring the cell's electrical performance characteristics to determine conversion efficiency and critical equivalent circuit parameters. It is an important tool for R&D and production of cells and photovoltaic arrays. This application note describes how to use the Keithley Model 2420 High Current SourceMeter instrument to measure the current-voltage (I-V) characteristics of PV cells.

With the introduction of SMCs (Source-Measure Units), configuring device characterization systems that once required a rack of electronic equipment, including programmable power supplies, digital multimeters, and scanners, has been simplified significantly. The Model 2420's ability to source/sink up to 1A with 0.1% accuracy or better and its low noise, high impedance, repeatable DMM offers a cost-effective alternative to using expensive, high power programmable power supplies for PV cell characterization. The Model 2420 offers 10pV resolution on the IV range, which is sufficient to measure the I-V curve of any single junction cell. The 20V range offers adequate resolution (100pV) for multi-junction cells and small arrays, where the open circuit voltage may exceed 2V. The Model 2420's low current measuring capability, with 10pA measurement resolution on the 1mA current range, is sufficient for virtually all dark I-V applications.

Test Description

A PV cell may be represented by the equivalent circuit model shown in Figure 1, consisting of a photon current source (I_{ph}), a diode, a series resistance (R_s), and a shunt resistance (R_{sh}).

Forward Bias I-V (Illuminated)

This test involves generating the forward biased I-V curve between the two points ($V_1 = 0, I_1 = I_{sc}$) and ($V_2 = V_{oc}, I_2 = 0$). The parameters I_{sc} and I_{oc} can be directly determined from the curve and $I_{ph} = I_{sc} - I_{leak}$, R_s and R_{sh} are easily calculated. Additional analytical techniques may be used to determine I_{ph} and I_{leak} .

Keithley 2400 Series SourceMeter Instruments

How To Use Saved Setups

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.**

When you need the lowest noise and drift specifications available, choose the Model 6430

The **Model 6430 Sub-Femtoamp Remote SourceMeter instrument** offers you sensitivity, noise, and input resistance specifications superior to an electrometer's. It also offers the lowest noise (just 400aA p-p) and best long-term stability of any instrument available.

- Measures current, voltage, and resistance
- 0.4fAp-p noise
- >1016 input resistance on voltage measurements
- 6½-digit resolution
- Up to 2000 source/measure readings/second
- Programmable digital I/O and GPIB interfaces for fast component characterization or selection

The Model 6430's Remote PreAmp provides a very sensitive bi-directional amplifier with sensitive feedback elements for measuring or sourcing currents at the DUT. The amplified signals the Remote PreAmp produces are not subject to cable noise as they are carried to the controlling mainframe. This architecture makes the Model 6430 the most sensitive current measurement instrument on the market.

Model 6430 Applications

- Low current measurements
 - Particle beam experiments, including precision mass spectrometry
 - Single-electron tunneling and other quantum experiments
- High resistance measurements
 - Research on insulators, dielectrics, polymers, etc.
 - Precise measurements of high resistances
- Four-terminal low resistance measurements
- Semiconductor research and characterization
 - Measuring sub-femtoamp gate currents
 - Characterizing sub-threshold I-V curves
 - Characterizing prober performance
- Component testing
 - Development labs
 - Production facilities

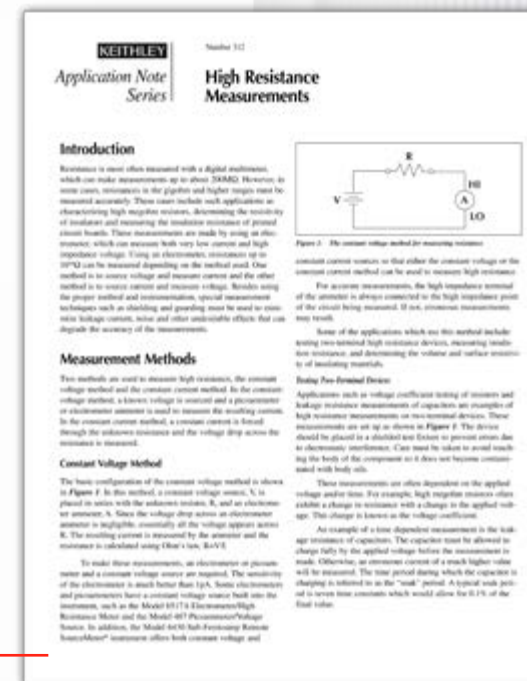


Want to learn more?

- [Download the Model 6430 datasheet.](#)



- **Learn how to make high resistance measurements. [Click here.](#)**
 - Learn how to apply the Model 6430 to both constant voltage and constant current techniques for resistance measurement.



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

- [Join the discussion on our application forum.](#)

System SourceMeter® SMU Instruments



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/2636B)	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	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)

Want to learn more about applications for Keithley's growing family of SMUs?



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.](#)

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A Greater Measure of Confidence

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