



TEKTRONIX  
INNOVATION FORUM  
Engineering the Future

# Keithley Instruments: solutions for device characterization

From wafer to devices, how Keithley instruments can help you through the different stages of your project

Enrico Citti

High Speed Signals Symposium  
Israel 2023

# Keithley Instruments Inc.

## COMPANY OVERVIEW

Founded in 1946 by Joseph F. Keithley in Solon, Ohio.

You can spot “The Low-Level Measurements Handbook” in many Physics Depts. or Semiconductor Companies

<https://www.tek.com/document/handbook/low-level-measurements-handbook>



<https://www.electronicdesign.com/technologies/test-measurement/article/21795626/joseph-f-keithley-quality-service-innovation-integrity-qsii>

High Speed Signals Symposium



# Agenda

The word 'Agenda' is written in a large, bold, black sans-serif font. To its left is a graphic consisting of several parallel, slanted blue lines of varying lengths, creating a sense of motion or a list.

1. The R&D bench: power supplies, DMMs, ELoads and Multiplexers
2. Device and process characterization tools
3. Sensitive and accurate instrument



# Basic bench needs



# What are the customer pain points?

HAVE A LOOK AT A DESIGNER'S BENCH...

For sure you can spot the following instruments:

- Power supplies
- Multimeters
- Oscilloscopes
- Signal generators

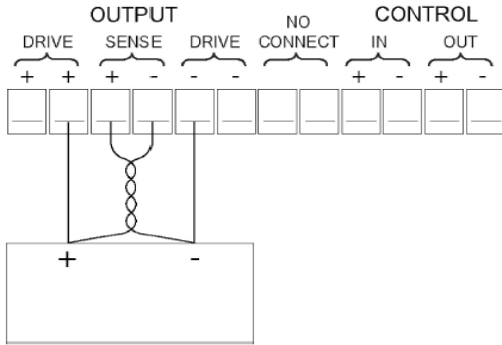


# Single and Multi-Channel Power Supplies





# 2200 – 2220 – 223x



Model	Channel	Power	Vout	Iout	Remote Interface	Kickstart Support	Topology	Remote Sense	Setting Resolution	DUT protection	Other Features
2200-20-5	1	100W	0-20V	0-5A	USB/GPIB	YES	Linear	Rear	1mV/0.1mA	Max Volt OVP	RI Output List Setup Recall
2200-30-5	1	150W	0-30V	0-5A	USB/GPIB	YES	Linear	Rear	1mV/0.1mA	Max Volt OVP	RI Output List Setup Recall
2200-32-3	1	96W	0-32V	0-3A	USB/GPIB	YES	Linear	Rear	1mV/0.1mA	Max Volt OVP	RI Output List Setup Recall
2200-60-2	1	150W	0-60V	0-2.5A	USB/GPIB	YES	Linear	Rear	1mV/0.1mA	Max Volt OVP	RI Output List Setup Recall

# 2220 – 223x (cont'd)

Model	Channel	Power	Vout	Iout	Remote Interface	Kickstart Support	Topology	Remote Sense	Setting Resolution	DUT protection	Other Features
2200-72-1	1	86W	0-72V	0-1.2A	USB/GPIB	YES	Linear	Rear	1mV/0.1mA	Max Volt OVP	RI Output List Setup Recall
2220-30-1	2	45W 45W	0-30V 0-30V	0-1.5A 0-1.5A	USB	YES	Linear	Rear	1mV/1mA	Max Volt OVP	RI Output List Setup Recall
2230-30-1	3	45W 45W 30W	0-30V 0-30V 0-6V	0-1.5A 0-1.5A 0-1.5A	USB	YES	Linear	Rear	1mV/1mA	Max Volt OVP	RI Output List Setup Recall
2231A-30-3	3	90W 90W 15W	0-30V 0-30V 0-5V	0-3A 0-3A 0-3A	USB(DB9)	YES	Linear	NA	10mV/1mA	Max Volt OVP	RI Output List Setup Recall
2230G-30-3	3	90W 90W 15W	0-30V 0-30V 0-5V	0-3A 0-3A 0-3A	USB/GPIB /RS232	YES	Linear	Rear	1mV/1mA	Max Volt OVP	RI Output List Setup Recall
2230G-30-6	3	180W 180W 15W	0-30V 0-30V 0-5V	0-6A 0-6A 0-3A	USB/GPIB /RS232	YES	Linear	Rear	1mV/1mA	Max Volt OVP	RI Output List Setup Recall
2230G-60-3	3	180W 180W 15W	0-60V 0-60V 0-5V	0-3A 0-3A 0-3A	USB/GPIB /RS232	YES	Linear	Rear	1mV/1mA	Max Volt OVP	RI Output List Setup Recall





# Low current resolution power supplies



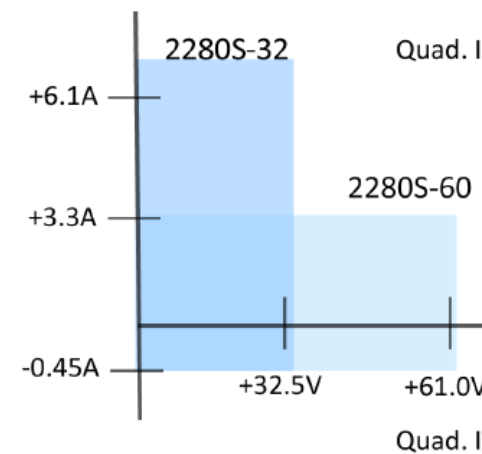


# 2280S

Model	Channel	Power	Vout	Iout	Remote Interface	Kickstart Support	Topology	Remote Sense	Setting Resolution	Current Measurement Resolution	DUT Protection
2280S-32-6	1	192W	0-32V	0-6A	USB/GPIB/LAN	YES	Linear	Rear	1mV/0.1mA	10nA	Max Volt OVP OCP
2280S-60-3	1	192W	0-60V	0-3.2A	USB/GPIB/LAN	YES	Linear	Rear	1mV/0.1mA	10nA	Max Volt OVP OCP



Figure 85: Series 2280 operating boundaries

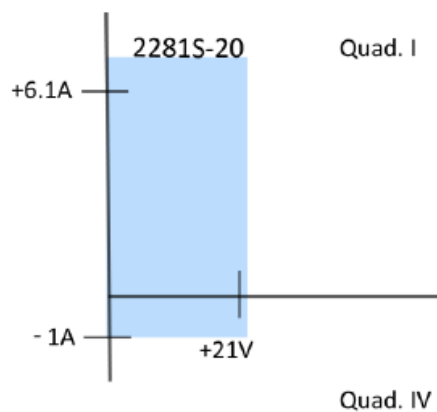




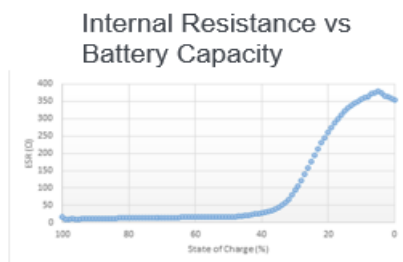
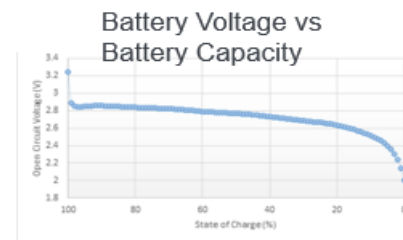
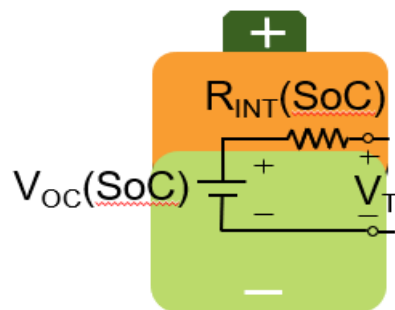
# 2281S-20-6

Model	Channel	Power	Vout	Iout	Remote Interface	Kickstart Support	Topology	Remote Sense	Setting Resolution	Current Measurement Resolution	DUT Protection
2281S-20-6	1	120W	0-20V	0-6A	USB/GPIB/LAN	YES	Linear	Rear	1mV/0.1mA	10nA	Max Volt OVP OCP

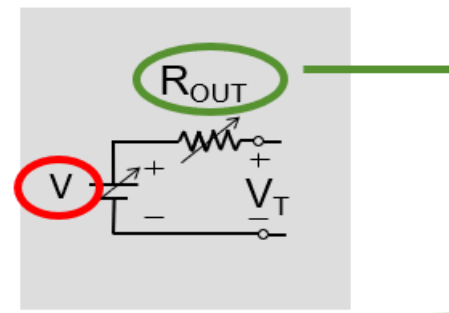
Figure 95: Sink operation



## Battery Model



## Battery Simulator Model



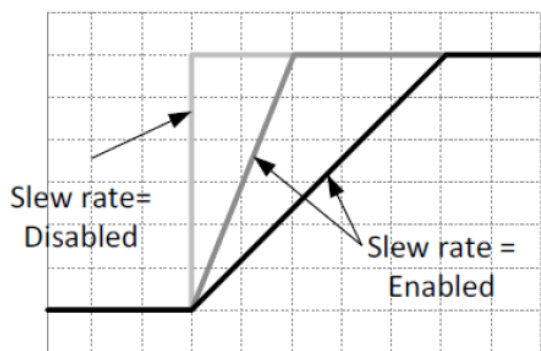
- Special-Function Power Supply with:
- Programmable output resistance
  - Battery discharge emulation
  - Fast response to load changes

**...Want more  
power?**





# 2260B



On the 2260B, the internal resistance of the power supply can be user-defined in software. (Internal Resistance Setting, page 87). When the internal resistance is set it can be seen as a resistance in series with the positive output terminal. This allows the power supply to simulate power sources that have internal resistances such as lead acid batteries.







# 2260B

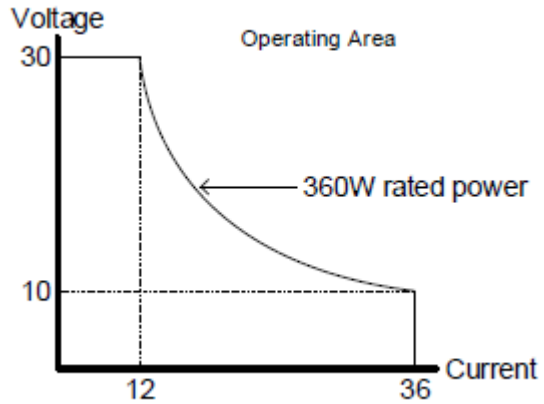
Model	Channel	Power	Vout	Iout	Remote Interface	Kickstart Support	Topology	Remote Sense	Setting Resolution	Current Measurement Resolution	DUT Protection
2260B-30-36	1	360W	0-30V	0-36A	USB/LAN	YES	Switching	Rear	1mV/1mA	1mA	Max Volt OVP OCP
2260B-80-13	1	360W	0-80V	0-13.5A	USB/LAN	YES	Switching	Rear	2mV/1mA	1mA	Max Volt OVP OCP
2260B-250-4	1	360W	0-250V	0-4.5A	USB/LAN	YES	Switching	Rear	5mV/1mA	1mA	Max Volt OVP OCP
2260B-30-72	1	720W	0-30V	0-72A	USB/LAN	YES	Switching	Rear	1mV/2mA	2mA	Max Volt OVP OCP
2260B-80-27	1	720W	0-80V	0-80A	USB/LAN	YES	Switching	Rear	2mV/2mA	2mA	Max Volt OVP OCP
2260B-250-9	1	720W	0-250V	0-9A	USB/LAN	YES	Switching	Rear	5mV/1mA	1mA	Max Volt OVP OCP
2260B-800-2	1	720W	0-800V	0-2.88A	USB/LAN	YES	Switching	Rear	14mV/1mA	1mA	Max Volt OVP OCP



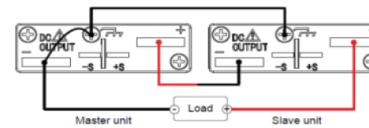
# 2260B (cont'd)

Model	Channel	Power	Vout	Iout	Remote Interface	Kickstart Support	Topology	Remote Sense	Setting Resolution	Current Measurement Resolution	DUT Protection
2260B-30-108	1	1080W	0-30V	0-108A	USB/LAN	YES	Switching	Rear	1mV/3mA	3mA	Max Volt OVP OCP
2260B-80-40	1	1080W	0-80V	0-40.5A	USB/LAN	YES	Switching	Rear	2mV/3mA	3mA	Max Volt OVP OCP
2260B-250-13	1	1080W	0-250V	0-13.5A	USB/LAN	YES	Switching	Rear	5mV/1mA	1mA	Max Volt OVP OCP
2260B-800-4	1	1080W	0-800V	0-4.32A	USB/LAN	YES	Switching	Rear	14mV/1mA	1mA	Max Volt OVP OCP

## Series and Parallel Operation



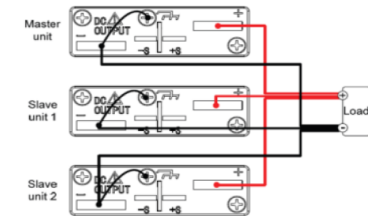
Series connection of 2 supplies



Double the output voltage to 60V or 160V

Note: 30V and 80V models only

Parallel connection of 3 supplies



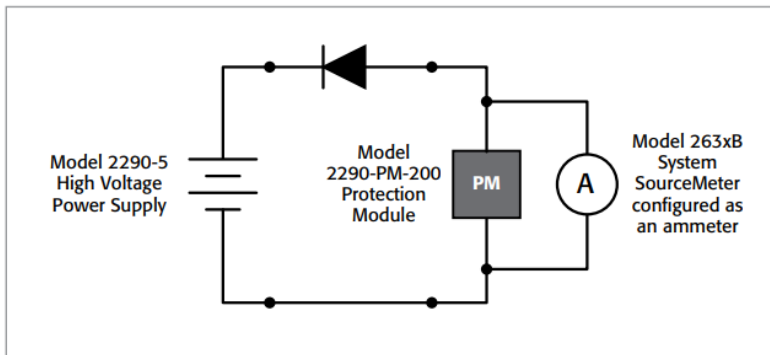
Triple the output current up to max. 324A

# Special applications power supplies



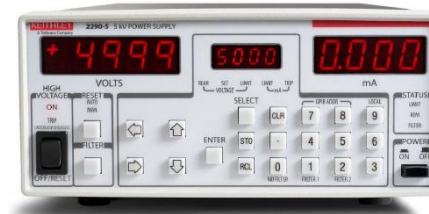
# 2290-x

Model	Channel	Power	Vout	Iout	Remote Interface	Kickstart Support	DUT protection	Topology
2290-5	1	25W	+50 - +5000V	5mA	GPIB	NO	Max Volt OVP OCP	Switching
2290-10	1	10W	+100 - +10000V	1mA	GPIB/RS232	NO	Max Volt OVP OCP	Switching



Reverse breakdown testing of a high voltage diode using a Keithley SourceMeter SMU instrument to measure leakage current. The 2290-PM-200 SMU Protection Module protects the SourceMeter SMU instrument from high voltage when the diode breaks down.

Model 2290-5 **5kV** Power Supply



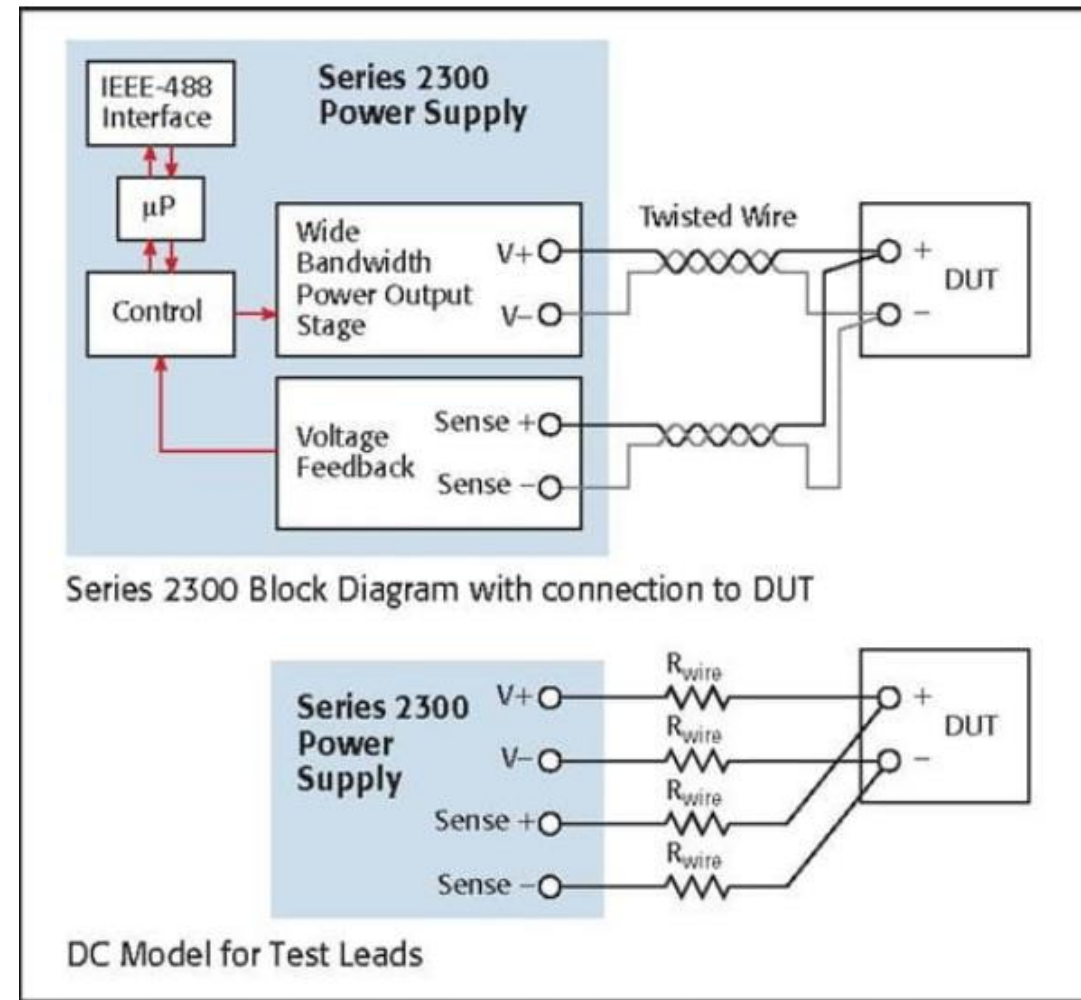
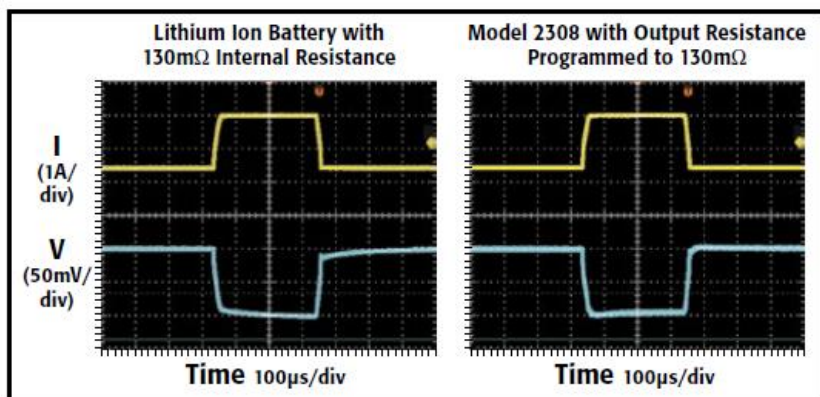
- +50V to +5,000VDC
- Up to 5mA current output (25W)
- 1µA current measurement resolution
- Ultra-low output noise; 3mVrms @5kV with output filter enabled
- Safety interlock
- GPIB interface

Model 2290-10 **10kV** Power Supply



- +100V to +10,000VDC
- Up to 1mA output (10W)
- 1µA current measurement resolution
- Low output noise; 1Vrms maximum
- Safety interlock
- RS-232 and GPIB interfaces

# 230x



# 230x

Model	Channel	Power	Vout	Iout	Remote Interface	Kickstart Support	Remote Sense	Current Readback Measurement Resolution		
2302	1	45W	0-15V	0-5A	GPIB	NO	Rear	0.1uA	DVM inputs	
2303	1	45W	0-15V	0-5A	GPIB	NO	Rear	0.1uA	DVM inputs	
2306	2	45W*	0-15V	0-5A	GPIB	YES	Rear	0.1uA	DVM inputs	Charger Simulation
2306-PJ	2	45W*	0-15V	0-5A	GPIB	YES	Rear	10uA	DVM inputs	Charger Simulation
2308	2	45W	0-15V	0-5A	GPIB	NO	Rear	0.1uA	DVM inputs	Charger Simulation



# Electronic Loads



# Series 2380 electronic Loads

## CONVENIENT BENCHTOP TESTING



Feature	Benefit
25kHz Dynamic Load Cycling	Test power sources that have to respond to fast-changing loads
Independent Instrument in 2U, ½-Rack benchtop case (200W and 250W models)	Convenient form factor for a designer's bench. No need to buy a mainframe and modules.
Multiple Interfaces, USB, GPIB, and RS-232 are standard	User has interface options
Wide range of Operating modes: CC, CV, CR, CP, Battery Test, LED Test	Flexibility to test a wide range of power conversion devices with convenient setups for testing batteries and LED drivers
0.05% Basic Measurement Accuracy Resolution as low as 0.1mV and 10uA	Easily see small changes

# DMMs and DAQs



# Performance Level Bench/System DMMs

## FROM 5½ TO 8½ DIGITS

Model 2001, 7 ½-Digits, 15 measurement functions including special low resistance modes, GPIB



Model 2002, 8 ½-Digits, 16 measurement functions including enhanced AC measurement modes, GPIB



# DMM7510 7½ Digit Graphical Sampling Multimeter

TOUCHSCREEN, DIGITIZING, MULTIPLE INTERFACES AND MORE



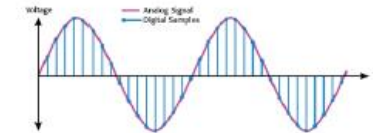
DMM7510 7½-Digit Graphical Sampling Multimeter



High Precision DMM



Touchscreen Interface



1MS/sec Digitizer

# DMM6500 and the DAQ6510

TOUCHSCREEN, DIGITIZING, MULTIPLE INTERFACES AND MORE

DMM6500 6 ½-Digit Bench/System DMM



DAQ6510 Data Acquisition and Logging, Multimeter System





# Rear Panel Details

DMM6500



PC Interface: USB & LAN LXI  
I/O: BNC, Trigger In/Out

Scanner Card  
Option slot

Rear Inputs

User Installable  
Communication Card

DAQ6510



Two Slots: 77xx Plug-In Switch Modules

# 3700A System Switch/Multimeter



	No. of Channels	Card Configuration	Type of Relay	Contact Configuration	Max. Voltage	Max. Current Switched	Comments
3720	60 (Dual 1x30)	Multiplexer	Latching electromechanical	2 Form A	300 V	1 A	2 independent 1x30 multiplexers. Automatic temperature reference when used with screw terminal accessory (3720-ST)
3721	40 (dual 1x20)	Multiplexer	Latching electromechanical	2 Form A	300 V (ch 1-40), 60 V (ch 41-42)	2 A (ch 1-40), 3 A (ch 41-42)	2 independent 1x20 multiplexers. Automatic temperature reference when used with screw terminal accessory (3721-ST)
3722	96 (dual 1x48)	Multiplexer	Latching electromechanical	2 Form A	300 V	1 A	2 independent 1x48 multiplexers
3723	60 (dual 1x30) or 120 single-pole (dual 1x60)	Multiplexer	Dry reed	1 Form A	200 V	1 A	2 independent 1x30 multiplexers
3724	60 (dual 1x30)	Multiplexer	FET solid-state	2 Form A	200 V	0.1 A	2 independent 1x30 multiplexers. Automatic temperature reference when used with screw terminal accessory (3724-ST)
3730	6x16	Matrix	Latching electromechanical	2 Form A	300 V	1 A	Columns can be expanded through the backplane or isolated by relays
3731	6x16	Matrix	Dry reed	2 Form A	200 V	1 A	Relay actuation time of 0.5 ms. Columns can be expanded through the backplane or isolated by relays
3732	448 crosspoints (Quad 4x28)	Matrix	Dry reed	1 Form A	200 V	0.75 A	Banks can be connected together via bank configuration relays to create a single 4x112 or dual 4x56 matrix. Analog backplane relays also included for card-to-card expansion. Row expansion with 3732-ST-R accessory to create a dual 8x28 or single 16x28 matrix.
3740	32	Independent	Latching electromechanical	28 Form C, 4 Form A	300 VDC/250 VAC (Form A)	2 A (Form C), 7 A (Form A)	32 general purpose independent channels.
3760	10	Multiplexer	Nonlatching electromechanical	2 Form C	500V	5 A	Single 1x10 high current multiplexer
3761	10	Multiplexer	Dry reed	Form A	30 V	100 mA	Single 1x10 low current multiplexer
3762	10	Multiplexer	Dry reed	2 Form A	1000 V	0.5 A	Single 1x10 high voltage multiplexer
3765	4x5	Matrix	Nonlatching electromechanical and dry reed	Form A	8 V	100 mA	Specialty 4x5 matrix for Hall Effect and van der Pauw measurements.

# Kickstart Software

CONTROLLING DMMS, MULTIPLEXERS AND POWER SUPPLIES



The screenshot displays the Kickstart Software interface for a new project. The main window is titled "Data Logger-1" and shows a scan configuration. A red box highlights the "Suite Apps" sidebar, which includes "Data Logger", "DMM", "I-V Characterizer", "Power Supply", "Scope", and "Specialty Apps" (Battery Simulator). The "DMM" app is currently selected, showing a reading of "1.946".

The "Data Logger-1" window shows a scan configuration with the following settings:

- Function: DC Voltage
- Range: Auto
- NPLC: 1
- Units: V
- Channel: 1001
- Name: 1001
- Channel Delay: 0 s
- AutoZero:
- LineSync:

The "DMM-1" window shows the measurement settings for the selected DMM:

- Function: DC Voltage
- Range: Auto
- NPLC: 1
- Auto Zero: On
- Units: V
- Trigger Mode: Immediate
- Measure Delay: 0.00 s
- Measure Count: 100
- Start at HH:MM: 6/12/2023 5:20
- Rel Value: 0
- Filter Digital: Disabled
- Format: mX+b
- M: 1.00
- B: 0.00
- Units: X
- Limit 1:  Upper Limit: 1 V, Lower Limit: -1 V
- Limit 2:  Upper Limit: 1 V, Lower Limit: -1 V

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# Characterizing your devices

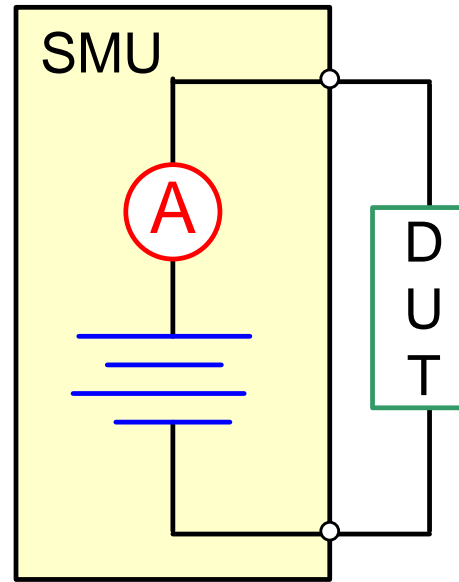


# What is an SMU?

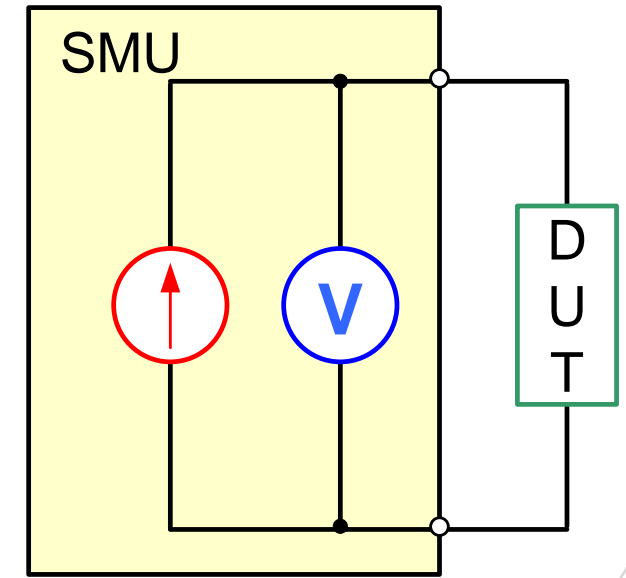
DC I-V characterization of electronic devices are often performed by Source Measure Units, or SMU.

An SMU is a single instrument that can:

- Source voltage and measure current
- Source current and measure voltage

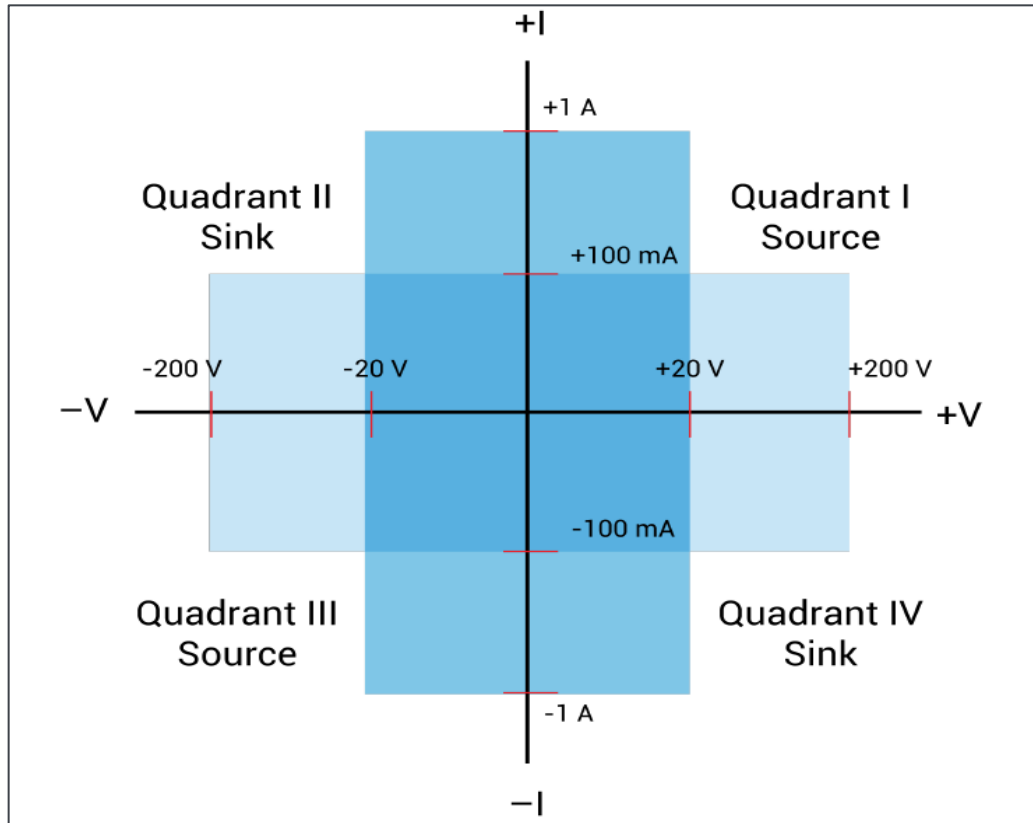


**Source V, Measure I**



**Source I, Measure V**

# Four Quadrant Operation: Source and Sink



## 4200A SMU Operating Boundaries

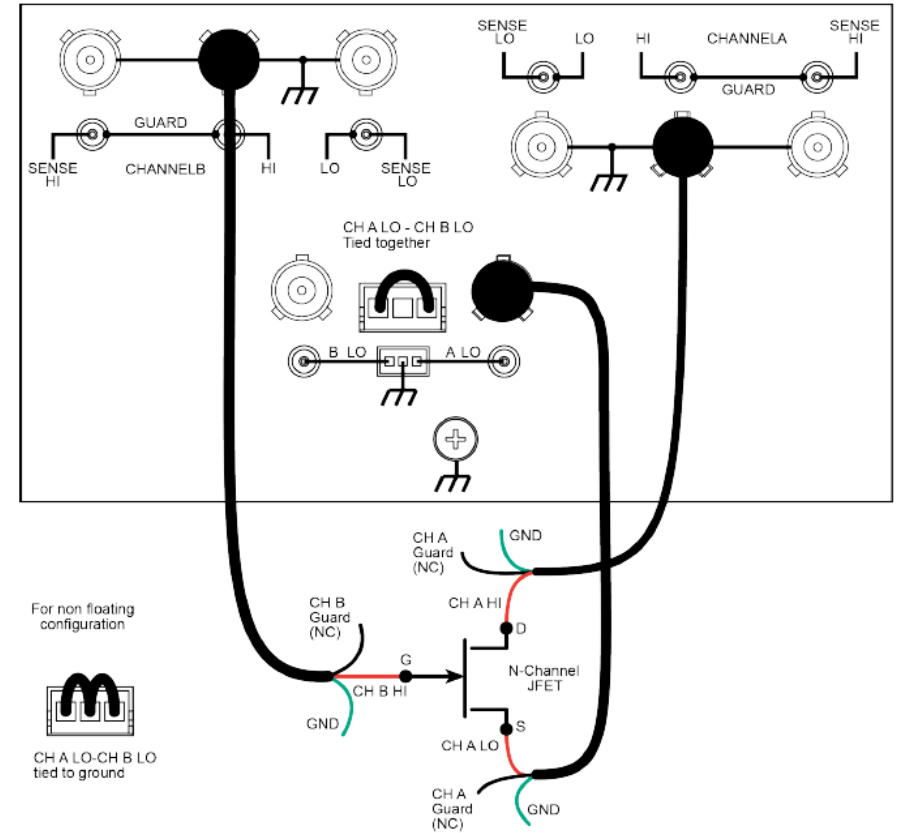
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SMUs can operate in one of four quadrants:

- Quadrants I and III are sourcing (I and V have same polarity):
  - **Sourcing SMUs deliver power to load.**
  - **Apps: device characterization, resistivity, sensors**
- Quadrants II and IV are sinking (I and V have different polarity):
  - **Sinking SMUs dissipate power.**
  - **Apps: batteries, solar cells**

# SMU IV characterization







# Keithley Family of SMU - Instruments

## 26XXB



### HIGH SPEED SYSTEM SMUS FOR DEMANDING APPLICATIONS

#### Series 2600B System SourceMeter SMU Instruments

- Tightly integrated, 4-quadrant voltage/current source and measure instruments offer best-in-class performance with 6½-digit resolution
- Family of models offers industry's widest dynamic range:
- 10 A pulse to 0.1 fA and 200 V to 100 nV
- TSP technology embeds complete test programs inside the instrument for best-in-class system-level throughput
- TSP-Link® expansion technology for multi-channel parallel test without a mainframe
- Complete production test without sacrificing footprint
- USB 2.0, LXI-C, GPIB, RS-232, and digital I/O interfaces

[2600B LEARN MORE](#)

Model	2601B	2602B	2604B	2611B	2612B	2614B	2634B	2635B	2636B
Channels	1	2	2	1	2	2	2	1	2
Max Current Source/Measure Range	3 A DC / 10 A Pulse	3 A DC / 10 A Pulse	3 A DC / 10 A Pulse	1.5A DC / 10 A Pulse	1.5A DC / 10 A Pulse	1.5A DC / 10 A Pulse	1.5A DC / 10 A Pulse	1.5A DC / 10 A Pulse	1.5A DC / 10 A Pulse
Max Voltage Source/Measure Range	40 V	40 V	40 V	200 V	200 V	200 V	200 V	200 V	200 V
Measurement Resolution (Current/Voltage)	100 fA / 100 nV	100 fA / 100 nV	100 fA / 100 nV	100 fA / 100 nV	100 fA / 100 nV	100 fA / 100 nV	1 fA / 100 nV	0.1 fA / 100 nV	0.1 fA / 100 nV
Max Output Power	40 W DC / 200 W Pulse	40 W DC / 200 W Pulse	40 W DC / 200 W Pulse	30 W DC / 200 W Pulse	30 W DC / 200 W Pulse	30 WDC / 200 W Pulse	30 W DC / 200 W Pulse	30 W DC / 200 W Pulse	30 W DC / 200 W Pulse



2604B/2614B rear panel (Single channels 2601B, 2611B, 2635B not shown)



2636B rear panel





# Keithley Family of SMU - Instruments

## TOUCH TEST INVENT 24XX

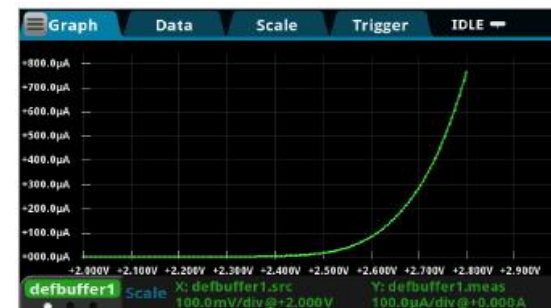


### TOUCH, TEST, INVENT WITH A GRAPHICAL TOUCHSCREEN SMU

#### 2450, 2460, 2461, and 2470 SourceMeter SMU Instruments

- Five-inch, high resolution capacitive touchscreen GUI
- 0.012% basic measure accuracy with 6½-digit resolution
- Wide coverage up to 1100 V, 7 A DC, 10 A pulse, 1000 W max.
- Source and sink (4-quadrant) operation
- Dual 1 MS/s digitizers for fast sampling measurements (2461 only)
- Enhanced sensitivity with 20 mV and 10 nA source/measure ranges (2450 only)
- Built-in, context-sensitive front panel help
- SCPI and Test Script Processor (TSP®) programming modes
- Front-panel USB 2.0 memory I/O port for transferring data, test scripts, or test configurations

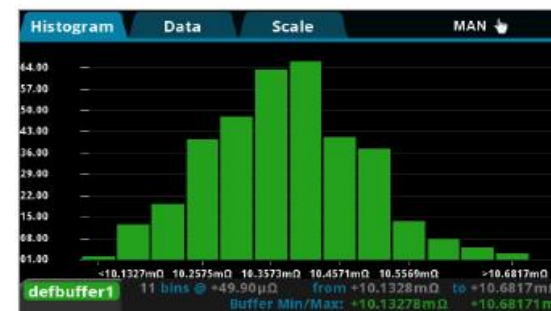
Model	2450	2460	2461	2470
Max Current Source/Measure Range	1 A	7 A	10 A	1 A
Max Voltage Source/Measure Range	200 V	100 V	100 V	1000 V
Measurement Resolution (Current / Voltage)	1pA / 10 nV	10 pA / 100 nV	1 pA / 100 nV	10 fA / 100 nV
Max Output Power	20 W	100 W	1000 W	20 W

[2450 LEARN MORE](#)[2460 LEARN MORE](#)[2461 LEARN MORE](#)[2470 LEARN MORE](#)

#### READING TABLE

Buffer: Active (defbuffer1)

Index	Time	Reading	Source
62	11/14 11:30:49.891111	+0.08699 mA	+1.84858 V
63	11/14 11:30:49.962316	+0.08913 mA	+1.87886 V
64	11/14 11:30:50.033464	+0.09134 mA	+1.90919 V
65	11/14 11:30:50.104618	+0.09355 mA	+1.93952 V
66	11/14 11:30:50.175782	+0.09576 mA	+1.96982 V
67	11/14 11:30:50.246938	+0.09797 mA	+2.00013 V
68	11/14 11:30:50.318112	+0.10018 mA	+2.03042 V
69	11/14 11:30:50.389283	+0.10239 mA	+2.06071 V
70	11/14 11:30:50.460450	+0.10460 mA	+2.09100 V
71	11/14 11:30:50.531604	+0.10682 mA	+2.12133 V





# Keithley Family of SMU - Instruments

265XA



## 2651A 50 Amp High Power System SourceMeter SMU Instrument

- Source or sink:
  - 2,000 W of pulsed power ( $\pm 40$  V,  $\pm 50$  A)
  - 200 W of DC power ( $\pm 10$  V @  $\pm 20$  A,  $\pm 20$  V @  $\pm 10$  A,  $\pm 40$  V @  $\pm 5$  A)
- Easily connect two units (in series or parallel) to create solutions up to  $\pm 100$  A or  $\pm 80$  V
- 1 pA resolution enables precise measurement of very low leakage currents
- 1  $\mu$ s per point (1 MHz), 18-bit sampling, accurately characterizes transient behavior
- 1% to 100% pulse duty cycle for pulse width modulated (PWM) drive schemes and device specific drive stimulus

[2651A LEARN MORE](#)

## 2657A 3000 Volt High Power System SourceMeter SMU Instrument

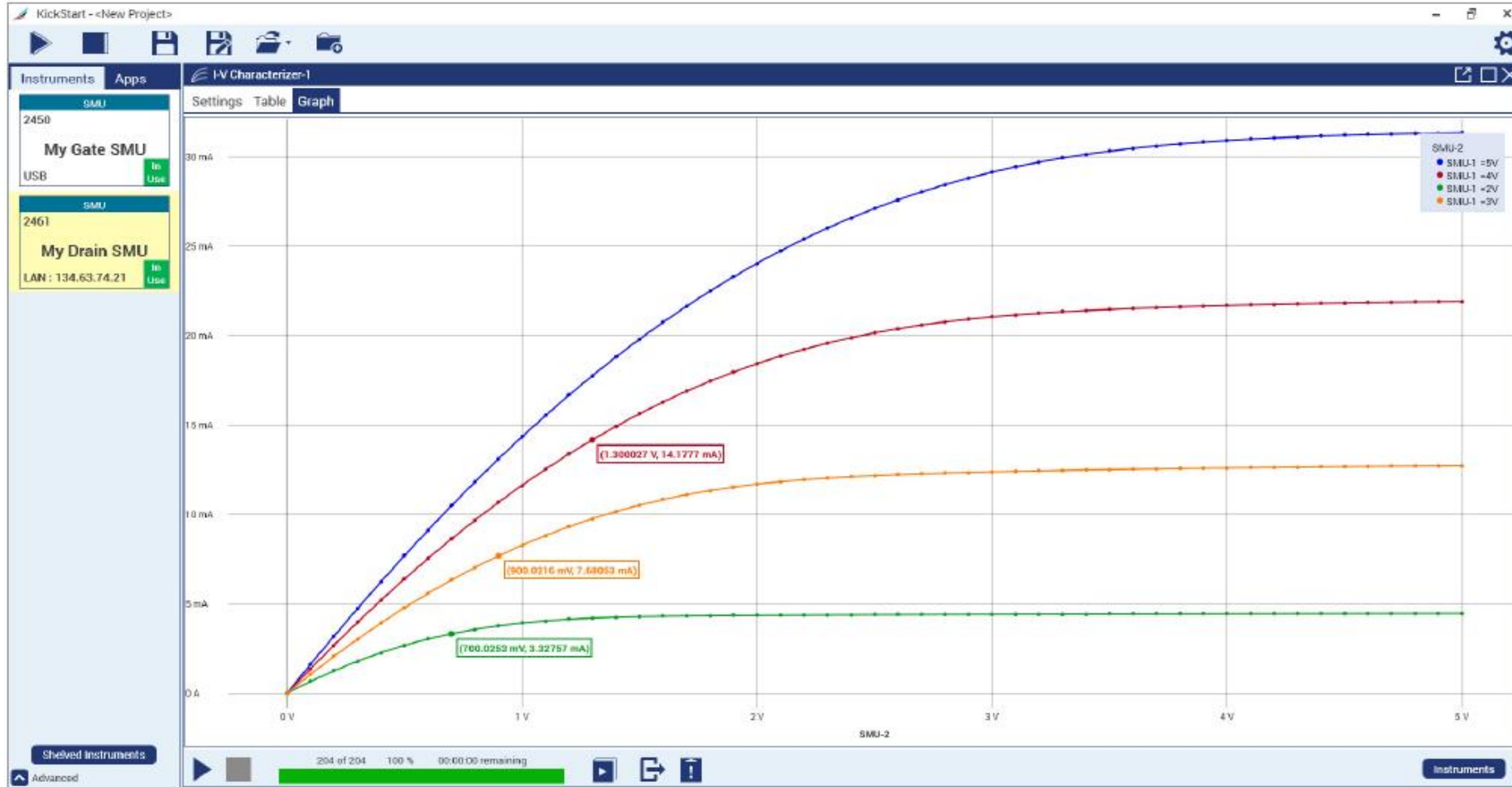
- Source or sink up to 180 W of DC or pulsed power, ( $\pm 3000$  V @ 20 mA,  $\pm 1500$  V @ 120 mA)
- 1 fA low current resolution
- Dual 22-bit precision ADCs and dual 18-bit 1  $\mu$ s per point digitizers for high accuracy and high speed transient capture
- Fully TSP<sup>®</sup> compliant for easy system integration with Series 2600B System SourceMeter models and 24XX Graphical SMUs

[2657A LEARN MORE](#)



# Kickstart Software

## CONTROLLING SMUS

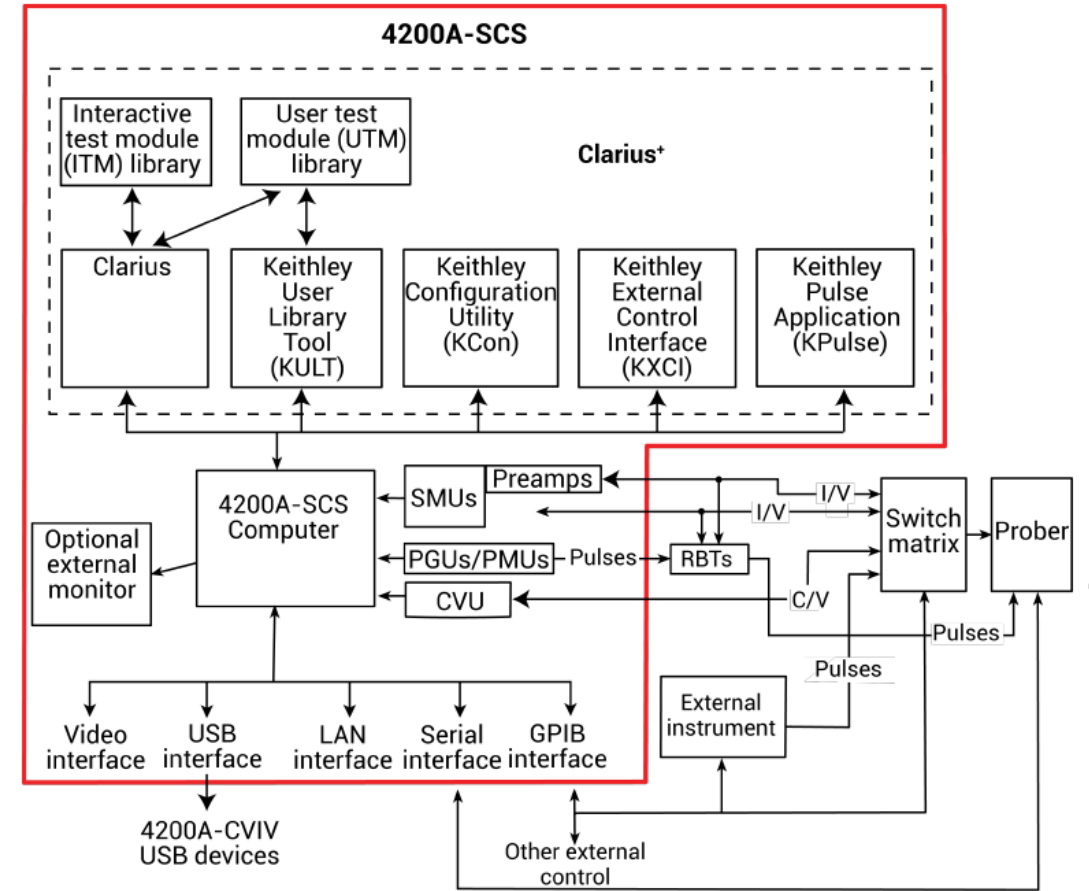




**What about a  
one box  
solution?**



# 4200A-SCS parameter analyzer





# A Complete Solution from DC to Pulse

4200A-SCS Parameter Analyzer			
System Software	Clarius™ with >250 application tests/projects/devices		
I-V Measurements	Medium Power SMU 210V, 100mA	High Power SMU 210V, 1A	Remote Pre-amplifier 0.1 fA resolution
Pulse I-V/Transient	Pulse Measure Unit	Pulse Generator Unit	
C-V Measurements	Capacitance-Voltage Unit 1kHz to 10MHz	Ramp-Rate (Quasi Static) C-V	Very Low Frequency VLF C-V
Switching	IV/CV Multi-Switch Module	Remote Preamplifier/Switch Module	Ultra Low Current Switch Matrices
Drivers for Probe stations, temp. controllers, external equipment			





# Failure Analysis

## A TASK FOR 4200A-SCS



### APPLICATION NOTE

#### Nanoprobing SEM Solution for In Situ Semiconductor Failure Analysis

Failure analysis measurements for automotive industry are conducted to identify and localize fabrication defects in transistors and integrated circuits interconnections. Resistivity measurements, transistor characterization, EBIC and EBAC are here performed with Imina Technologies nanoprobe platform and successfully used to achieve this goal.

In collaboration with:  
 Fraunhofer CAM  
 Halle, Germany  
[www.cam.fraunhofer.de](http://www.cam.fraunhofer.de)



Imina Technologies products in use:  
 - miBot™ BT-14 nanomanipulator  
 - Nanoprobing SEM Platform kit

In this example, PMOS transistor characteristics were measured with the nanoprobe method. First metallization levels were removed by chemical-mechanical polishing in order to isolate a single transistor and to have access to alumina metal lines. Then, four tungsten needles were put in contact with the source, drain, gate and well nodes of the transistor [Figure 5]. A Keithley 4200 SCS semiconductor characterization system was used to generate I/V curves of source and drain for several gate voltage potentials [Figure 6].

High Speed Signals Symposium

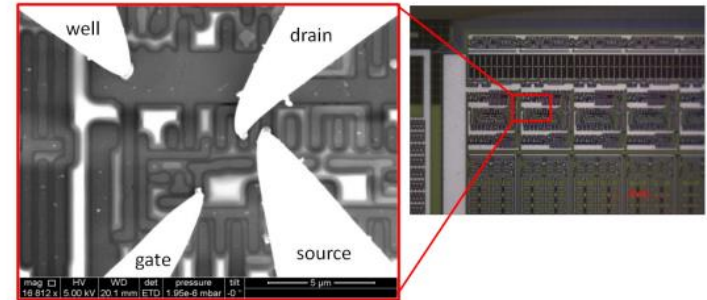


Figure 5. Electrical probing of a single PMOS transistor.

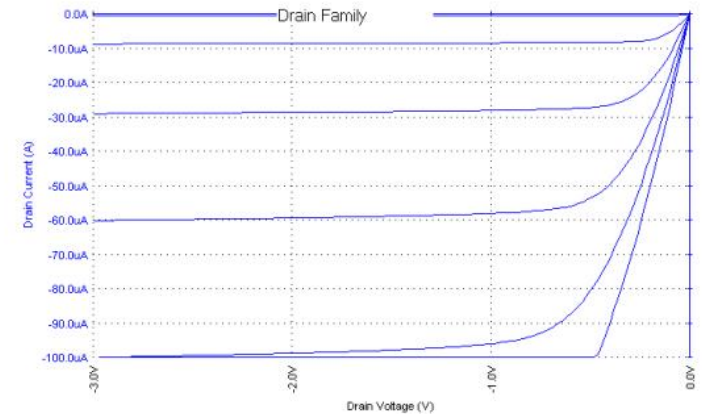
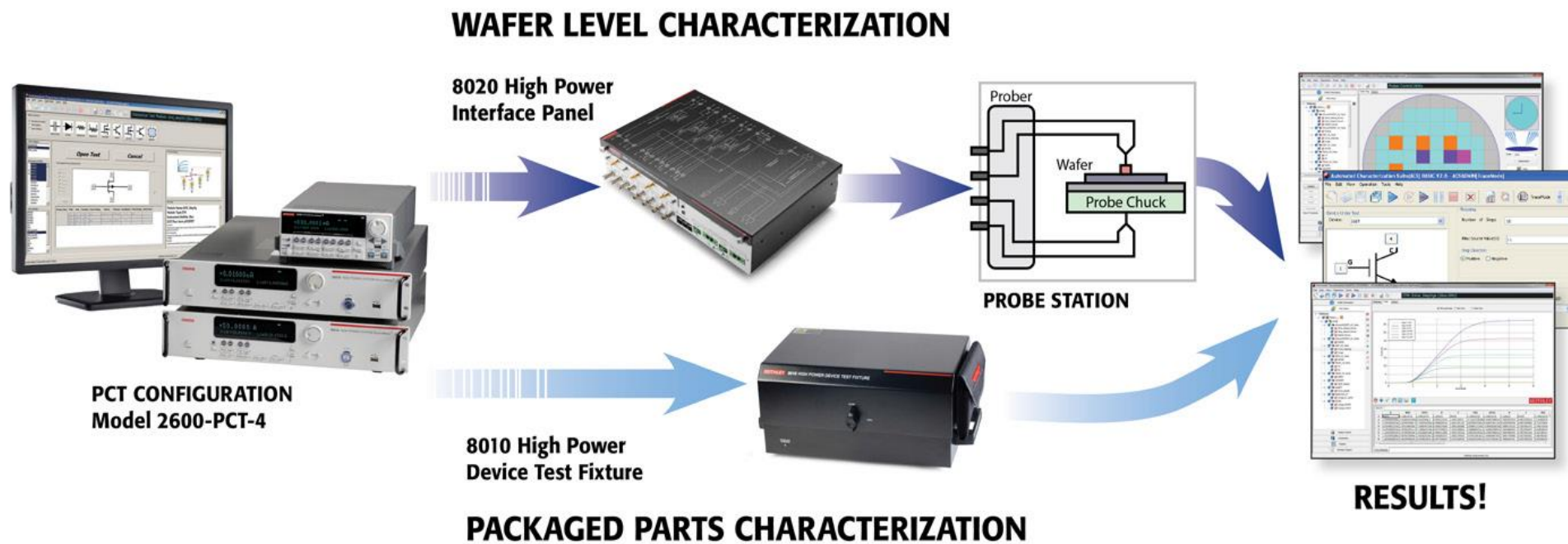


Figure 6. Transistor characteristics: I/V curves function of different gate voltage potentials.

# High Voltage and High Current Characterization



# 2600 – PCT - xB



# 2600 – PCT - xB



## Configuration Selector Guide

Model <sup>1</sup>	Collector/ Drain Supply <sup>2</sup>		Step Generator Base/Gate Supply	Auxiliary Supply
	High Voltage Mode	High Current Mode		
Low Power	2600-PCT-1B	200 V/10 A	200 V/10 A	N/A
High Current	2600-PCT-2B	200 V/10 A	40 V/50 A	200 V/10 A
High Voltage	2600-PCT-3B	3 kV/120 mA	200 V/10 A	200 V/10 A
High Current and High Voltage	2600-PCT-4B	3 kV/120 mA	40 V/50 A	200 V/10 A

1. Contact your Keithley field applications engineer for custom configurations.
2. Add a Model 2651A to increase high current mode to 50A or 100A.
3. PCT-CVU Multi-Frequency capacitance meter can be added to any configuration.

# Parametric testing



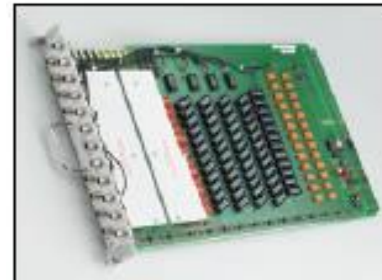
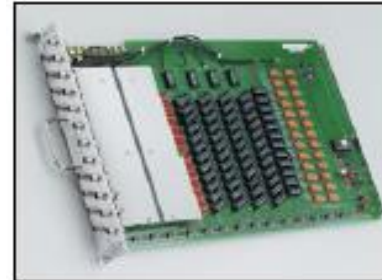


# S5xx systems



# Switch matrix mainframes

707B/708B



**Model 7174A Low Current Matrix Card:** This 8×12 card is designed for semiconductor research, development, and production applications that demand high quality switching of I-V and C-V signals. Its low leakage and minimal dielectric absorption ensure that key device measurements can be performed many times faster than with earlier switching technologies. Its superior low current performance makes it ideal for use with both Models 2635B and 2636B System SourceMeter® SMU Instruments for adding high speed I-V source and measurement capabilities and for accessing the I-V and C-V measurement capabilities of the Model 4200-SCS Parameter Analyzer.

**Model 7072 Semiconductor Matrix Card:** This 8×12 switch supports the low level and high impedance measurements encountered in semiconductor parametric tests on wafers and devices. It provides two low current paths with just 1pA maximum offset current for sensitive sub-picoamp measurements, and two other paths optimized for measuring C-V characteristics from DC to 1MHz. Four more high quality signal paths with <20pA offset current provide for general-purpose signal switching up to 100nA or 200V.

**Model 7072-HV High Voltage Semiconductor Matrix Card:** Like the Model 7072, the 7072-HV is designed to handle low level, high voltage, and high impedance signals. It provides two signal paths capable of switching 1300V with less than 1pA of offset current, so it's ideal for switching the high voltage signals encountered in breakdown measurements or oxide integrity testing. Two paths are optimized for C-V measurements from DC to 1MHz or for switching low currents with a common ground. Four additional high quality signal paths with less than 20pA offset current provide for signal switching to 200V.

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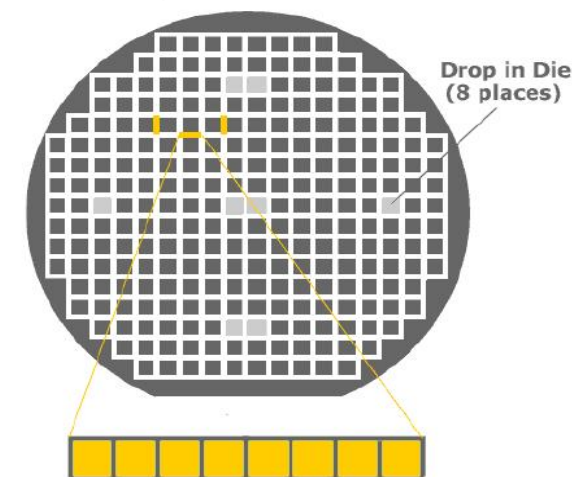
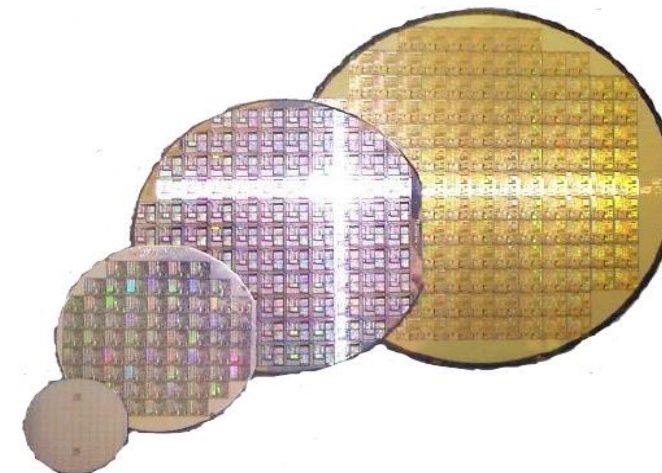
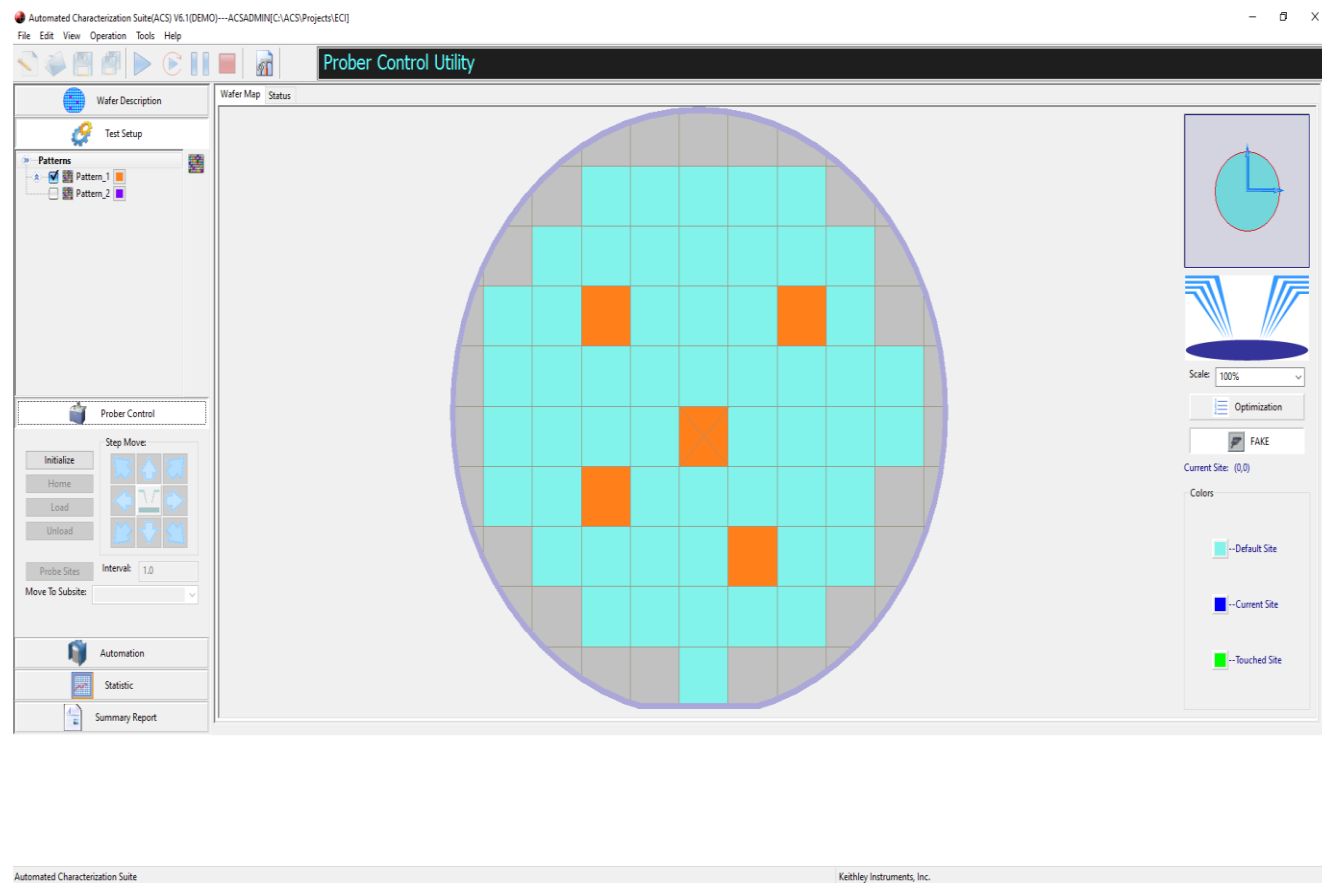






# Controlling Probe Stations and Matrix

ACS STANDARD



# Counting Electrons!!!



# Material Characterization

## ELECTROMETERS AND PICOAMMETERS



6485  
Picoammeter

5½ digits – 10fA resolution



6487  
Picoammeter with  
500V Voltage  
source

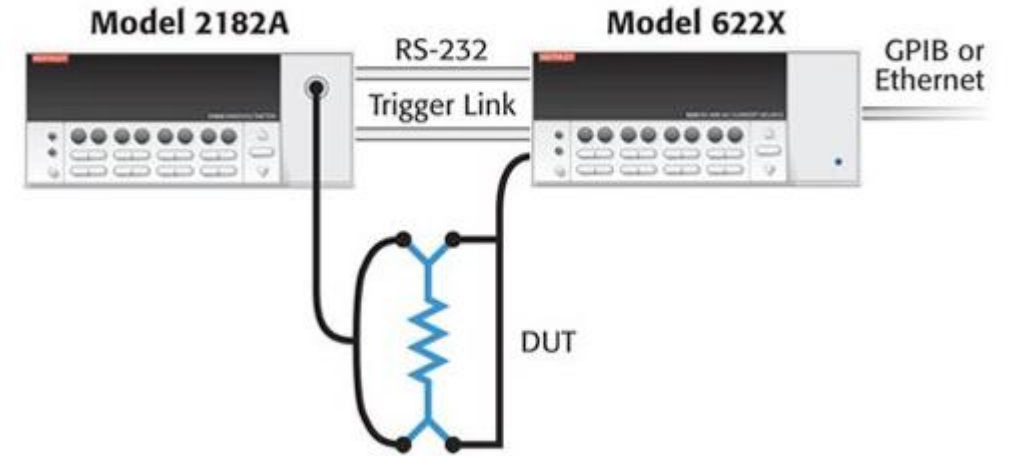


6517B  
Electrometer with  
1000V Voltage  
source

6½ digits – 10aA resolution

# Material Characterization

## NANOVOLTMETER AND CURRENT SOURCE



# THANK YOU

## Contact Information

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