Model 4200-SCS

Semiconductor Characterization System

The simple choice for complex characterization tasks

KEITHLEY

A GREATER MEASURE OF CONFIDENCE

The Model 4200-SCS is the best, most cost-effective solution for a growing list of applications:

- Semiconductor technology development

- Semiconductor process integration

- Incoming inspection, failure analysis

- Device reliability and lifetime testing

- Nanotechnology research

- High and low κ dielectrics

- Organic LEDs

- Hall Effect and Van der Pauw testing

- Op-amp characterization

- RFIC, high power MOSFET/BJT

Familiar Windows® Interface
No training, no floppies

Single click test sequencing
No programming

Configurable and scalable
Works now…grows later

Sub-femtoamp noise
See more, faster

Flexible data export and analysis
Go from results to reports in seconds

Visit **www.keithley.com/4200demo** for an online demonstration of how the
Model 4200-SCS simplifies device and materials testing and analysis.

A complete, integrated solution

All from one vendor

Industry-standard Windows-based GUI minimizes set-up and integration time.

Integrated industrial controller and additional RAM ensure high test throughput, plus system robustness, stability, and security.

Store test setups and results right on the system with the high capacity fixed disk drive. No sorting through floppy disks to find the desired test.

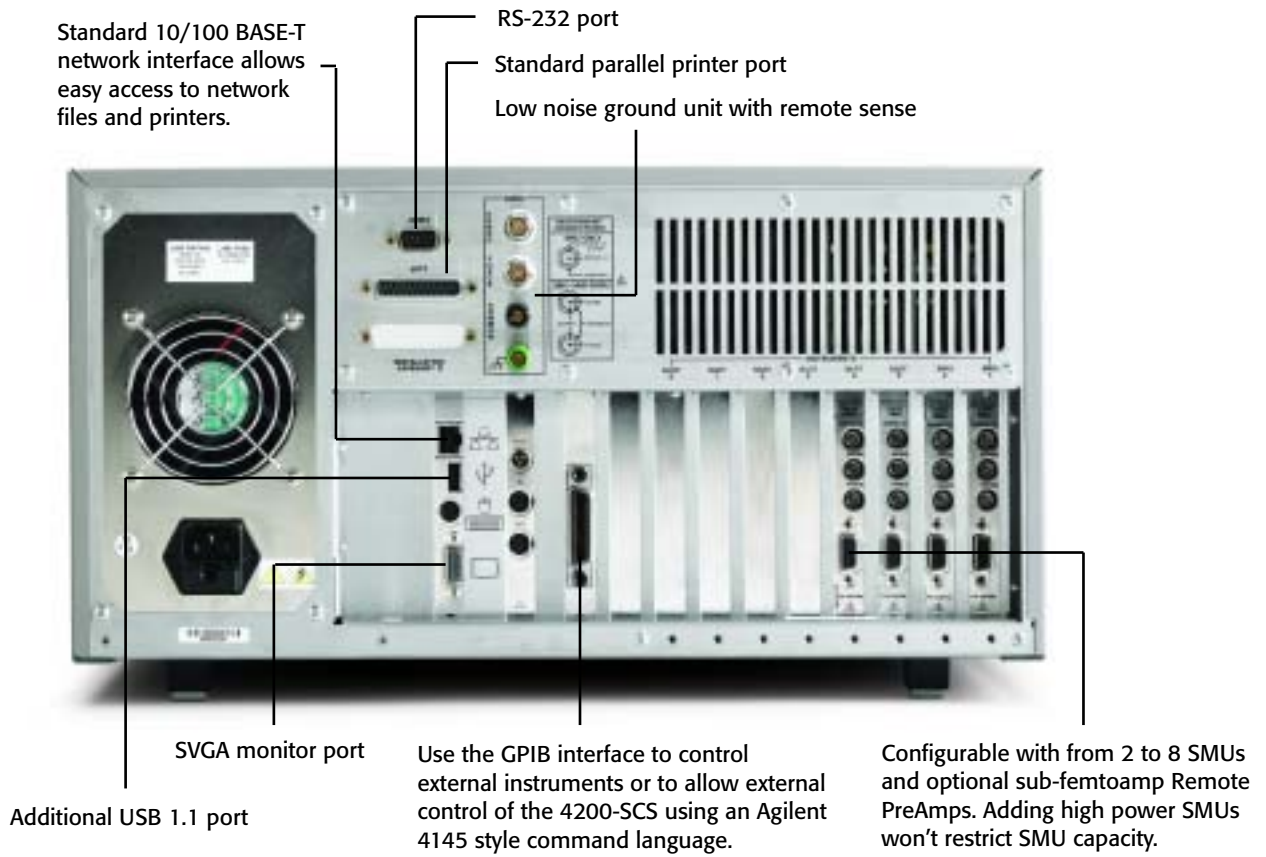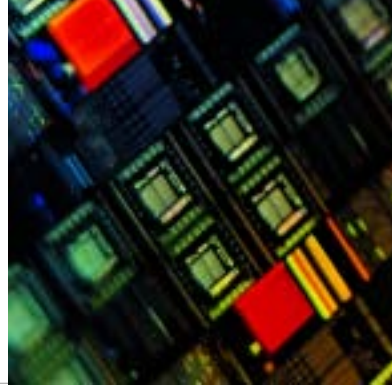High speed, high precision ADC per channel eliminates performance tradeoffs.

The integrated CD-RW drive allows high capacity backup and data transfer.

Communicate quickly with a wide range of PC accessories with the built-in USB interface.
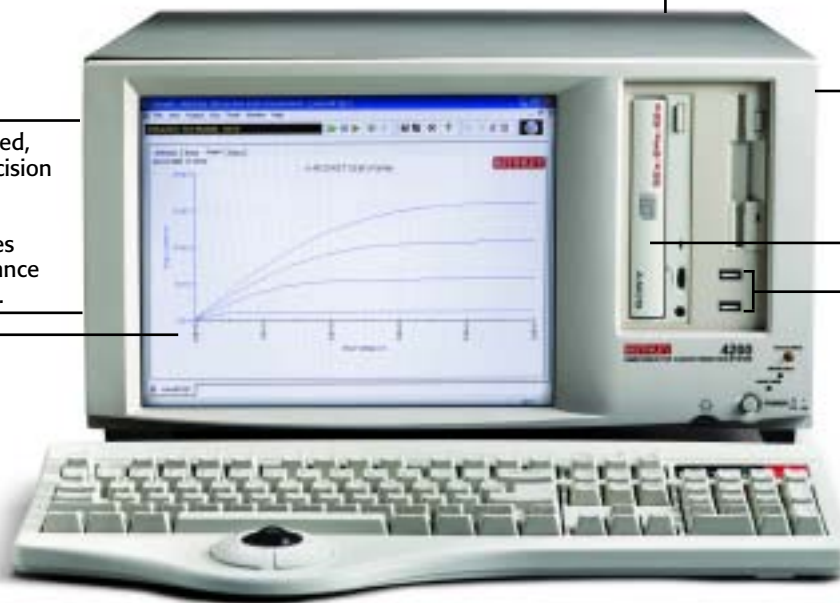
Keithley Interactive Test Environment (KITE)

- Even infrequent users can begin testing productively right away, without programming assistance, for a lower cost of test and faster ROI.

- The flexible user interface makes it easy to change parameters on the fly and test devices interactively with just a mouse click.

- Easy transition from the Agilent 4145/56. Work more productively by acquiring data, analyzing plots, and printing reports simultaneously.

- Export test settings, data, and plots to .xls, delimited text, .bmp, .jpg, or .tif file formats.

- Sample tests and projects for a variety of applications are included to simplify startup.

- Powerful stress-measure capabilities make reliability testing easier.

- Factory-supplied drivers for capacitance meters, switch matrices, pulse generators, and a variety of probers simplify building configurations for specialized applications.

- Optional drivers for leading modeling software packages let the Model 4200-SCS fit into any lab's test environment.

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Standard 10/100 BASE-T
network interface allows
easy access to network
files and printers.

RS-232 port

Standard parallel printer port

Low noise ground unit with remote sense

SVGA monitor port

Use the GPIB interface to control
external instruments or to allow external
control of the 4200-SCS using an Agilent
4145 style command language.

Configurable with from 2 to 8 SMUs
and optional sub-femtoamp Remote
PreAmps. Adding high power SMUs
won't restrict SMU capacity.

Additional USB 1.1 port

KEY SPECIFICATIONS

SMU Measurement Range	Voltage	1µV/200V
	Current	0.1fA/1A
SMU Measurement Resolution	Voltage	1µV
	Current	0.1fA
SMU Measurement Accuracy	Voltage	100µV
	Current	10fA
VMU Mode	Resolution	1µV
	Accuracy	80µV
Ground Unit Max. Current	Triax	2.6A
	Binding post	4.4A

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Intuitive interface

Speeds and simplifies device and material characterization and analysis

Define a test starting from the library of supplied setups.
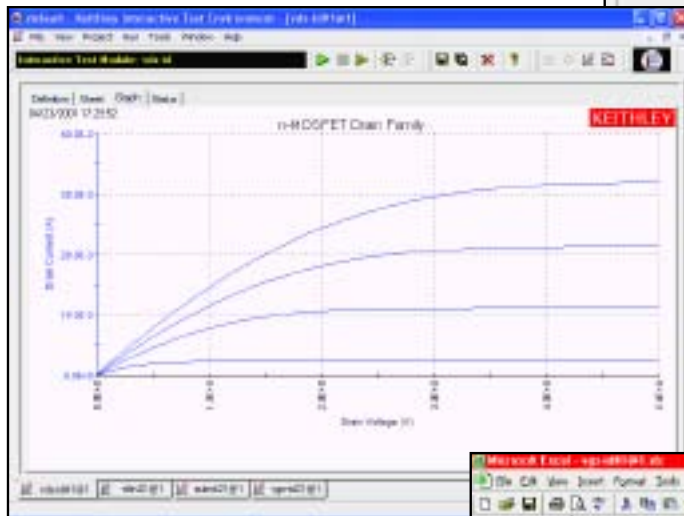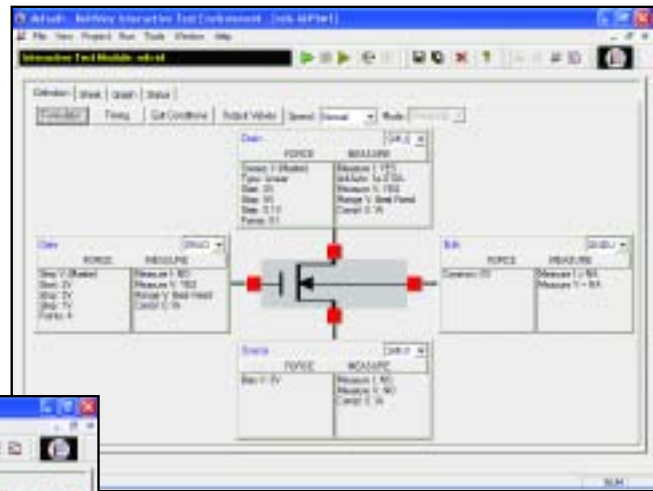
Click the on-screen Run button to start the test and view a real-time plot.

Export data in Excel workbook or ASCII formats and plots in bitmap, jpeg, or tiff formats for either online or offline analysis. Built-in Formulator, graphing, and calc sheet functions simplify complex analyses.

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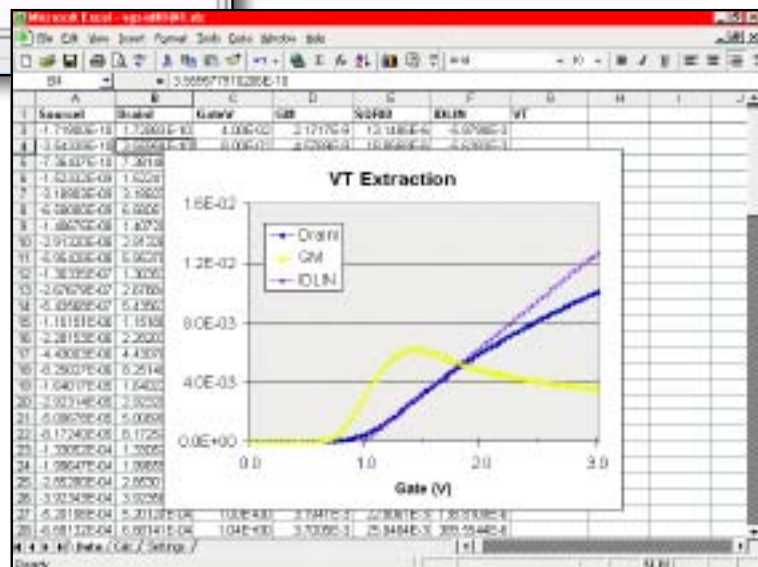
Automated test sequences without writing code

The Project Navigator organizes tests and controls test sequencing. Switching between different test setups and accessing test results is fast and simple. Sequence tests on a single device by clicking on the device in the Navigator, then clicking the Run button.
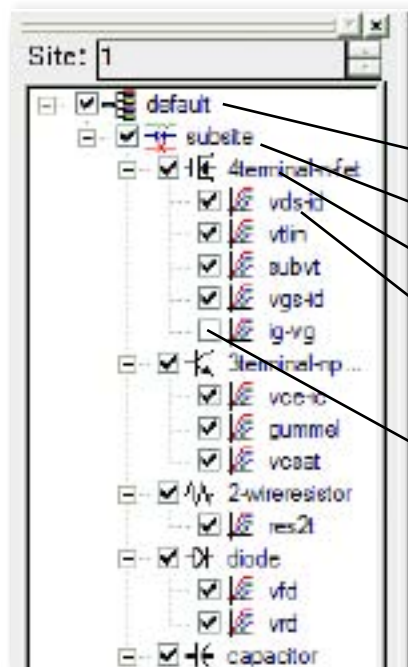
KITE operates on projects using an interface called the Project Navigator. The Project Navigator organizes tests into a logical hierarchy that parallels the physical layout of the devices on a wafer.

The project level organizes subsites and controls test sequencing for a single wafer.

The subsite level organizes devices and controls subsite test sequencing.

The device level organizes test modules, manages test module libraries, and controls device test sequencing.

The test module level performs tests, analyzes data, and plots results.

Test select/deselect checkboxes allow modifying existing test sequences quickly and easily.

The Keithley Interactive Test Environment is designed to let users understand device behavior quickly. When running a test sequence, users can view results and plots for completed tests while the sequence is still running. As shown here, multiple plots can be viewed at the same time to get a complete picture of device performance.
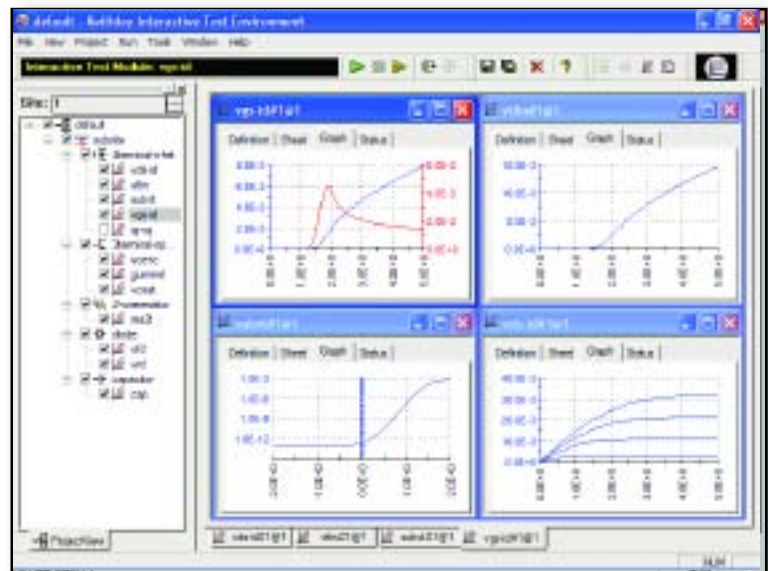
Visit www.keithley.com/4200demo for an online demonstration of how the Model 4200-SCS simplifies device and materials testing and analysis.

Combined I-V and C-V
## in a single test environment
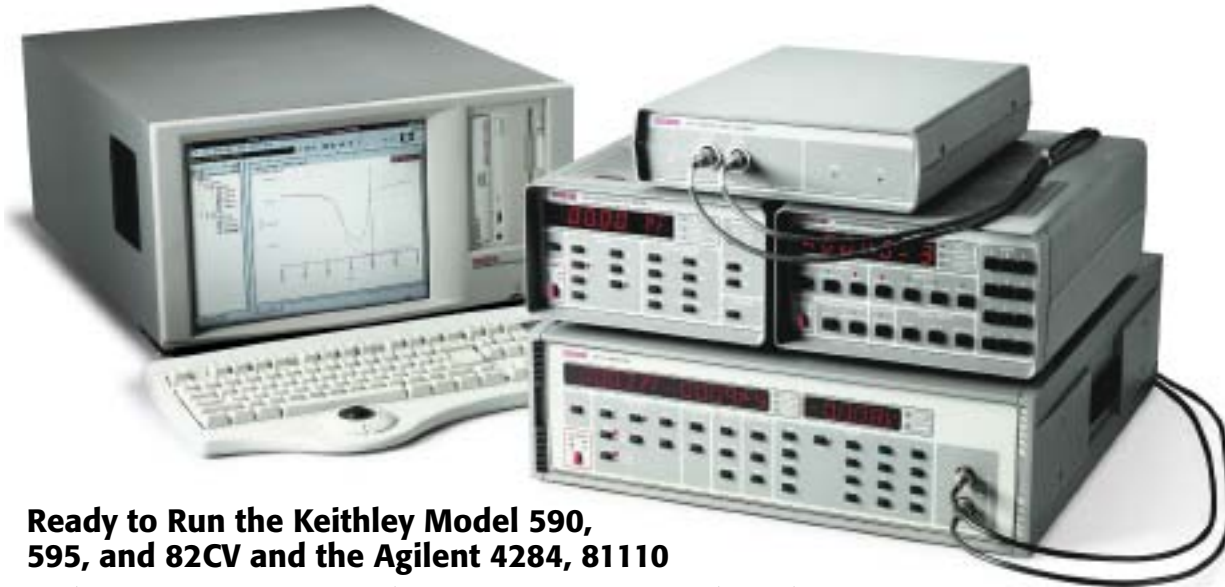
Ready to Run the Keithley Model 590, 595, and 82CV and the Agilent 4284, 81110

Need to incorporate a C-meter or pulse generator into your semiconductor characterization system? Just set the GPIB address, install the GPIB cable, and the Model 4200-SCS is ready to start testing. Keithley-supplied User Test Modules load external instrument data directly into the system's analysis and graphing tools. Combining the Model 82 Simultaneous C-V system and the Model 4200-SCS allows making simultaneous high frequency and quasistatic C-V measurements with a single voltage sweep. Typical applications include:

- Oxide Charge Characterization
- MIS Device Parameters
- Doping Profiles
- Minority Carrier Lifetime

Extend the 4200-SCS with C Language Test Libraries

KITE's unique User Test Module feature allows the 4200-SCS to address external instrumentation and handle advanced test algorithm requirements. These modules give lab users a "fill in the blank" interface to C language subroutines. Everything needed to collect, analyze, and report results is integrated in one application. User Test Modules support viewing and graphing data in real time to monitor test progress. The Keithley User Library Tool (KULT), provided with the 4200-SCS, allows integrating these subroutines easily into a test sequence.

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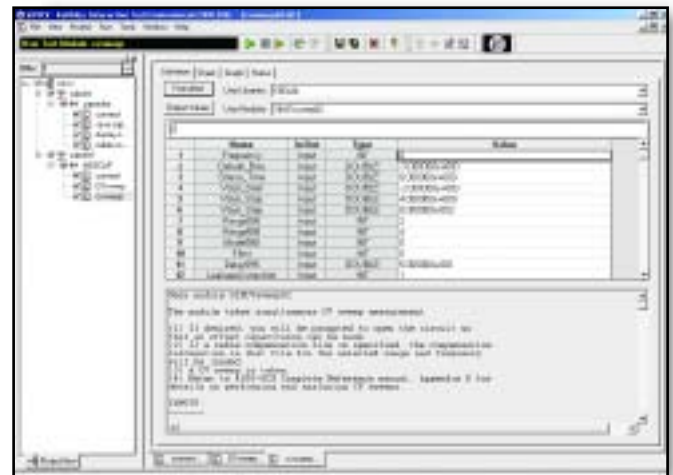
Superior measurements
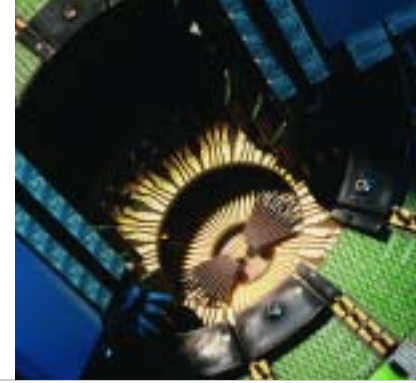
PreAmp Technology Enhances Measurement Speed and Sensitivity

It's easy to connect the Model 4200-SCS to a probe station or a switch matrix with standard triax cables.

PreAmps can be mounted on the probe station with either a platen base or a triax mounting bracket. By reducing the signal path between the DUT and the PreAmp from several feet to a fraction of an inch, the Model 4200-SCS can eliminate cable effects like parasitic capacitance and leakage currents, for more accurate low-level measurements.
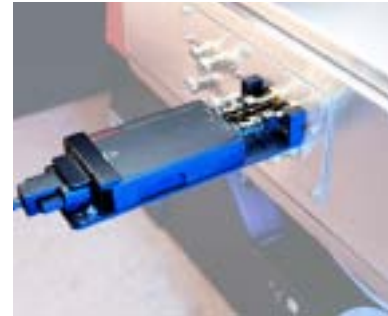
4200-SCS SOURCE-MEASURE UNITS

	Max. Voltage	Max. Current	Max. Power
4200-SMU Medium Power	200V	100mA	2W
4210-SMU High Power	200V	1A	20W

Unlike less flexible competitive solutions, the Model 4200-SCS can be configured with from two to eight Source-Measure Units, available in either medium power or high power designs. While more recent competitors require two slots to hold a single high power module, the Model 4200-SCS can be specified with any combination of eight SMUs, of which up to four can be high power SMUs. Both models provide 100fA resolution for making precise low-level measurements. Optional Remote PreAmps extend the resolution of either SMU to 0.1fA for applications that demand the industry's best low current performance.

LOW CURRENT PERFORMANCE

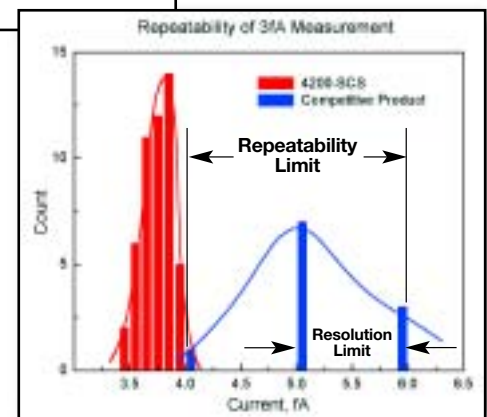| 10×	Better Resolution (0.1fA)
3×	Faster Measurement
4×	Better Repeatability

When configured with an optional Remote PreAmp, the Model 4200-SCS provides faster readings with less noise than competitive characterization technology. The time plot shows the system's superior resolution and speed response to a 3fA current step. The histogram illustrates the greater repeatability of the results from the 4200-SCS after the current step. The 4200-SCS technology lets users see more and see it faster, with better repeatability, than ever before.


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Compatible with your lab

Options for New Applications

A growing variety of options are available to expand the Model 4200-SCS's capabilities. We've given it the flexibility to interface with Celestry's BSIMPro and Agilent's IC-CAP modeling applications or Silvaco's UTMOST SPICE modeling software via the system's built-in GPIB interface. Instrument drivers allow these packages to control the Model 4200-SCS directly, just like any piece of instrumentation linked to the modeling station. The Model 4200-SCS also offers a GPIB command set that emulates the Model 4145 command set with extensions to provide access to the delay and timing controls options, ranges, and resolution now available.
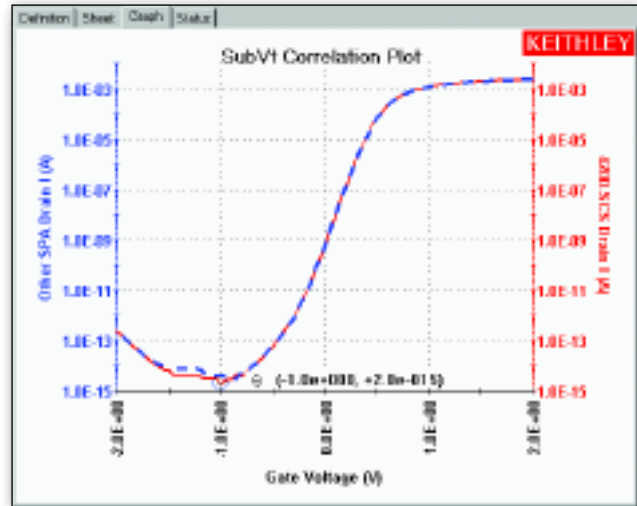

High measurement correlation with existing test solutions

Semiconductor Characterization Systems Applications Comparison

By supporting a comprehensive range of characterization applications, the Model 4200-SCS simplifies the buying decision. It combines wide configuration flexibility with industry-leading measurement capabilities, so it makes it unnecessary to sacrifice future expandability to address current testing requirements.

	Model 4200-SCS	Competitor's High Performance System	Competitor's Medium Performance System	Competitor's Modular box + Windows GUI + external PC + GPIB interface
General measurements (failure analysis, device characterization)	■	■	■	■
Nanotechnology research (low current, low voltage)	■	■		
High κ dielectrics (multi-frequency C-V, charge pumping)	■			
Low κ dielectrics	■	■	■	■
Hall Effect and Van der Pauw testing	■			
Copper interconnects (low voltage)	■		■	
Op-amp characterization (high channel count)	■			■
RFIC, high power MOSFET/BJT (high power source/measure)	■			■
Device reliability and lifetime testing (HCI, NBTI, Q_{BD}, and EM)	■			

Integrated switching control
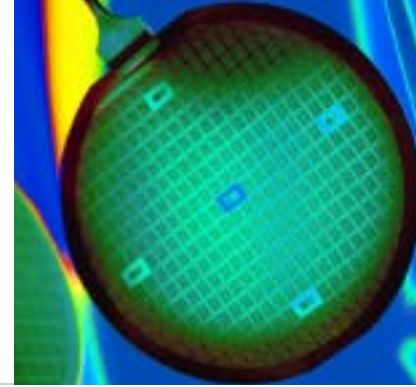
Three different standard switch configurations make it easy to find the best match for the application. Based on Keithley's six-slot Model 707A and single-slot Model 708A switch matrix mainframes, they include all the components, cabling, and instructions needed to assemble the switch matrix and incorporate it into the 4200-SCS test environment. Once the switch is installed, users can connect instrument terminals to output pins in minutes with a simple "fill-in-the-blank" interface in the Keithley Configuration Utility (KCON). No need to remember and program row and column closures—system applications and standard user libraries manage routing test signals from instruments to DUT pins.

Standard Switch Matrix Configurations

General Purpose	Low Current	Ultra Low Current
<100pA **Uses Model 7071 switch card**	**<1pA** **Uses Model 7072 switch card**	**<100fA** **Uses Model 7174A switch card**

General Purpose	Low Current	Ultra Low Current
• Component ATE • Best match to the 4200-SCS without optional PreAmps • Excellent for remote sense applications • Low cost, high density cables • Expandable from 8×12 to 8×72	• Basic device characterization • Good match to the 4200-SCS with or without optional PreAmps • Local sense, excellent for C-V meters and pulse generators • Standard triax cables • Expandable from 8×12 to 8×72	• High performance device characterization • Best match for the 4200-SCS when equipped with optional PreAmps • Standard triax cables

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Expanded reliability testing capabilities

Characterize device lifetimes accurately and economically

New stress-measure capabilities make the Model 4200-SCS ideal for both packaged level and wafer level reliability testing applications. The system's sequencer controls the order of stress-measure steps, so any 4200-SCS test can be inserted into the measurement phase. Test sequences are completely user-programmable and can include both standard Interactive Test Modules, like $V_{t\text{-lin}}$, and custom User Test Modules. Multiple tests can be run during each measure step, and switch controls can isolate individual devices that were stressed in parallel. Several JEDEC-compliant sample projects are provided with the system, including projects for standard WLR tests like Hot Carrier Injection or Channel Hot Carrier, Negative Bias Temperature Instability, Charge to Breakdown, and Electromigration. All of these projects are easily customizable to adapt to specific WLR testing requirements.
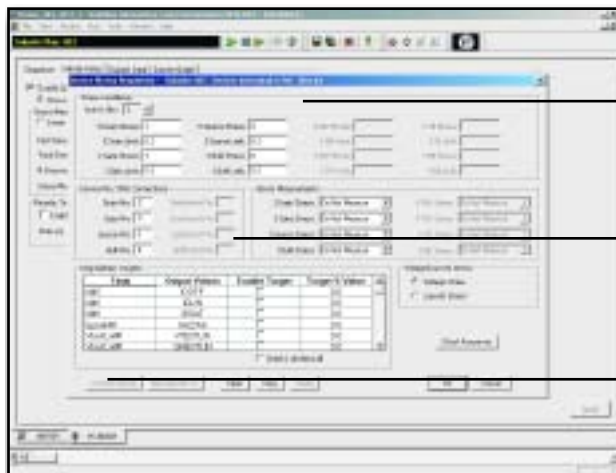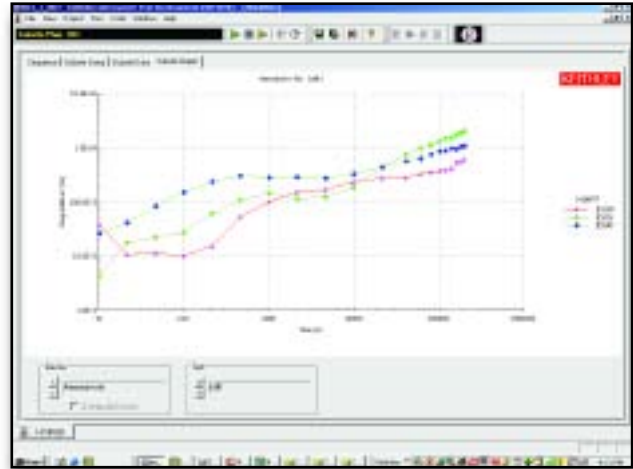
Define stress voltage or current desired easily.

Built-in switch matrix control supports stressing up to 20 devices in parallel.

Set degradation targets and exit tests automatically when the parameter target is reached.

KTEI makes it simple to set up the desired stress conditions and patterns graphically.

Examine results from multiple devices stressed in parallel.

Stress and graph data on a logarithmic or linear time scale.

The subsite data sheet simplifies collecting data from a series of tests, making it easy to track parameters and degradation trends over time. User-programmable parameter degradation targets indicate when devices have failed or degraded sufficiently for the test's needs. Similarly, user-programmable compliance exit conditions can be used to trigger end-of-test. Data from customized reliability test sequences, which may take days or even weeks to complete, is graphed in real time, so it's easy to track the progress of a on-going sequence.

Scroll easily through results from multiple tests.

Tracks cumulative stress time.

Automatically calculates percent degradation.

Additional device characterization solutions

Keithley's free LabTracer software can coordinate the measurement and sourcing activities of up to four **Series 2400 SourceMeter® instruments** at once, and collect voltage and/or current readings from any of the instruments, as well as a timestamp for each measurement set. This software application offers an alternative method of collecting important device characteristics in a familiar format.

The **Model 4500-MTS Multi-Channel I-V Test System** is a DC source-measure test system optimized for high speed parallel testing. It supports up to 36 source-measure channels while automatically managing complex channel coordination tasks such as inter-channel triggering and communications. It minimizes system complexity by eliminating the need for external trigger control and instrument communications buses.

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Performance comparison

		Model 4200-SCS	Competitor's Medium or High Performance System	Competitor's Modular Box + Windows GUI + External PC + 3rd Party GPIB Solution
Measurement Capabilities	Current resolution	0.1fA	10fA or 1fA	10fA
	Maximum current	1A	100mA	1A
	Maximum SMU Configuration — Medium Power SMUs	8 MP	4 MP	8 MP
	Maximum SMU Configuration — High Power SMUs	4 MP + 4 HP	—	0 MP + 4 HP
	Optional Low Noise Remote PreAmp	YES	NO	NO
	Upgradable	YES	NO	YES
	Required self-calibration (ACAL) interval	24 hours	30 minutes	1 hour
	High precision (22-bit) ADC per channel	YES	NO	NO
	Lowest SMU current range/offset	1pA/10fA	1nA/3pA or 10pA/20fA	1nA/3pA
	Lowest SMU voltage range/offset	200mV/80µV	2V/700µV or 2V/200µV	2V/700µV
Data Acquisition and Control	User interface	Windows GUI	Pushbutton	Windows GUI
	View multiple tests simultaneously	YES	NO	YES
	Test sequencing on devices or wafers	Single click	IBASIC programming	Multiple clicks
	Factory-supplied C-V drivers and analysis	YES	NO	YES
	Factory-supplied switch drivers	YES	Sort of. . .	YES
	Factory-supplied prober drivers	YES	NO	YES
	Extendable GUI can support any RS-232 or GPIB device	YES	NO	YES
	Agilent 4145 style command set	YES	YES	NO
	Hardware/GUI architecture	PCI/Windows	Front panel	PC→Windows→USB→GPIB →Proprietary
	Microprocessor/memory per channel	YES	NO	Low resolution only ADCs
Plotting and Reporting	Built-in Excel-style spreadsheet	YES	NO	NO
	Direct .xls file export	YES	NO	NO
	Export graphs to .bmp, .jpg, or .tif	YES	NO	Via PC
Connectivity	Operating system	Windows	Proprietary	Windows on external PC
	CD-RW and high capacity fixed disk for data archiving	YES	NO	Via PC
	Networking	Windows	Limited NFS	Via PC
	Printing	Any Windows driver	Limited HP printer	Via PC
	Portable media	CD-RW & floppy drives	Floppy drive	Via PC
Support	Supplied by a single vendor responsible for all service & support	YES	YES (front panel operation)	NO
	Ongoing software support	KTE Interactive[1]	User-written	IC/V 2.1 Lite[2]
	Supports instrument drivers added by users	YES	NO	NO

1. Backed by a 3-year track record and with an ongoing maintenance and development schedule.
2. Requires hardware key for security, which can be difficult to replace if lost.

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Condensed Specifications

CURRENT SPECIFICATIONS

Current Range[1]	Max. Voltage	Measure Resolution[3]	Measure Accuracy ±(% rdg + amps)	Source Resolution[3]	Source Accuracy ±(% rdg + amps)
4210-SMU[2] High Power SMU					
1 A	21 V	1 µA	0.100 % + 200 µA	50 µA	0.100 % + 350 µA
100 mA	210 V	100 nA	0.045 % + 3 µA	5 µA	0.050 % + 15 µA
4200-SMU[2] Medium Power SMU					
100 mA	21 V	100 nA	0.045 % + 3 µA	5 µA	0.050 % + 15 µA
10 mA	210 V	10 nA	0.037 % + 300 µA	500 nA	0.042 % + 1.5 µA
1 mA	210 V	1 nA	0.035 % + 30 nA	50 nA	0.040 % + 150 nA
100 µA	210 V	100 pA	0.033 % + 3 nA	5 nA	0.038 % + 15 nA
10 µA	210 V	10 pA	0.050 % + 600 pA	500 pA	0.060 % + 1.5 nA
1 µA	210 V	1 pA	0.050% + 100 pA	50 pA	0.060 % + 200 pA
100 nA	210 V	100 fA	0.050% + 30 pA	5 pA	0.060% + 30 pA
4200-SMU and 4210-SMU with optional 4200-PA PreAmp					
10 nA	210 V	10 fA	0.050 % + 1 pA	500 fA	0.060 % + 3 pA
1 nA	210 V	3 fA	0.050 % + 100 fA	50 fA	0.060 % + 300 fA
100 pA	210 V	1 fA	0.100 % + 30 fA	15 fA	0.100 % + 80 fA
10 pA	210 V	0.3 fA	0.500 % + 15 fA	5 fA	0.500 % + 50 fA
1 pA	210 V	100 aA	1.000% + 10 fA	1.5 fA	1.000% + 40 fA

VOLTAGE COMPLIANCE: Bipolar limits set with a single value between full scale and 10% of selected voltage range.

VOLTAGE SPECIFICATIONS

Voltage Range[1]	Max. Current 4200-SMU	Max. Current 4210-SMU	Measure Resolution[3]	Measure Accuracy ±(% rdg + volts)	Source Resolution[3]	Source Accuracy ±(% rdg + volts)
200 V[4]	10.5 mA	105 mA	200 µV	0.015 % + 3 mV	5 mV	0.02% + 15 mV
20 V	105 mA	1.05 A	20 µV	0.01 % + 1 mV	500 µV	0.02% + 1.5 mV
2 V	105 mA	1.05 A	2 µV	0.012 % + 150 µV	50 µV	0.02% + 300 µV
200 mV	105 mA	1.05 A	1 µV	0.012 % + 100 µV	5 µV	0.02% + 150 µV

CURRENT COMPLIANCE: Bipolar limits set with a single value between full scale and 10% of selected current range.

Additional Specifications

MAX. OUTPUT POWER: 22 watts for 4210-SMU and 2.2 watts for 4200-SMU (both are four-quadrant source/sink operation).

DC FLOATING VOLTAGE: COMMON can be floated ±32 volts from chassis ground.

VOLTAGE MONITOR (SMU in VMU mode):

Voltage Range	Measure Resolution	Measure Accuracy ±(%rdg + volts)
200 V	200 µV	0.015% + 3 mV
20 V	20 µV	0.01% + 1 mV
2 V	2 µV	0.012% + 110 µV
200 mV	1 µV	0.012% + 80 µV

INPUT IMPEDANCE: >$10^{13}\,\Omega$.

INPUT LEAKAGE CURRENT: <30pA.

MEASUREMENT NOISE: 0.02% of measurement range (rms).

DIFFERENTIAL VOLTAGE MONITOR:

Differential Voltage Monitor is available by measuring with two SMUs in VMU mode, or by using the low sense terminal provided with each SMU.

GROUND UNIT

Voltage error when using the ground unit is included in the 4200-SMU, 4210-SMU, and 4200-PA specifications. No additional errors are introduced when using the ground unit.

OUTPUT TERMINAL CONNECTION: Dual triaxial, 5-way binding post.

MAXIMUM CURRENT: 2.6A using dual triaxial connection; 4.4A using 5-way binding posts.

LOAD CAPACITANCE: No limit.

CABLE RESISTANCE: FORCE ≤1Ω, SENSE ≤10Ω

NOTES

1 All ranges extend to 105% of full scale.
2 Specifications apply on these ranges with or without a 4200-PA.
3 Specified resolution is limited by fundamental noise limits. Measured resolution is 6½ digits on each range. Source resolution is 4½ digits on each range.
4 Interlock must be engaged to use the 200V range.

Visit **www.keithley.com/4200demo** for an online demonstration of how the Model 4200-SCS simplifies device and materials testing and analysis.

A greater measure of confidence

With more than a half-century of expertise in making demanding low level measurements, we offer customers a greater measure of testing confidence on the production floor, in the QA lab, and in R&D. To learn how we can help you keep pace with changing technologies, call your local Keithley sales engineer or visit our website.

Our applications engineers are here to help

Configuring a system can be confusing. The semiconductor test experts in Keithley's Applications Engineering team are here to help you solve your toughest device characterization challenges, before and after the sale.

All the support you need

For applications assistance, call us on our toll-free hotline at 1-888- KEITHLEY (534-8453) from 8:00 am to 8:00 pm ET (U.S. only). For assistance beyond those hours, send our Applications Engineering Department a facsimile (440-248-6168) or an e-mail message (product_info@keithley.com) and we'll respond as soon as possible. Applications assistance is also available via the web, with many reference materials available online, as well as convenient forms for contacting our Applications Engineers. We maintain worldwide facilities and affiliates, which offer native language support services. Visit our web site for current listings: www.keithley.com

Call us or visit www.keithley.com for free copies of application notes:

#2197—Evaluating Hot Carrier Induced Degradation of MOSFET Devices

#2239—Gate Dielectric Capacitance-Voltage Characterization Using the Model 4200

#2240—Evaluating Oxide Reliability

#2241—Making Ultra-Low Current Measurements with the Low-Noise Model 4200-SCS

#2311—DC Electrical Characterization of RF Power Transistors

#2361—Writing Prober Drivers for the Model 4200-SCS

#2457—Making Charge-Pumping Measurements with the Model 4200-SCS

#2475—Four-Probe Resistivity and Hall Voltage Measurements with the Model 4200-SCS

#2481—I-V Electrical Measurements of Nanoscale Wires and Tubes Using the Model 4200-SCS

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FREE Model 4200-SCS technical data booklet

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KEITHLEY

A G R E A T E R M E A S U R E O F C O N F I D E N C E

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