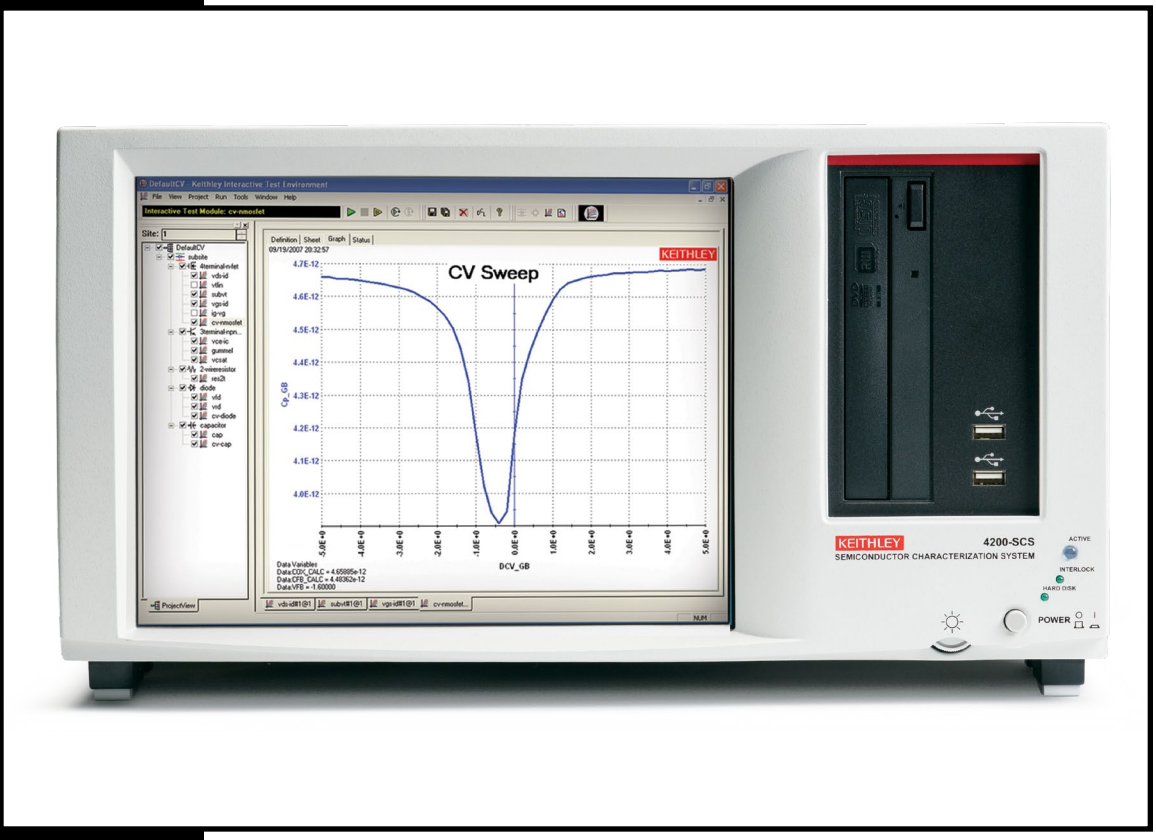
4200-SCS

Parameter Analyzer Technical Data



4200-SPEC Rev. O

Model 4200-SCS Technical Data

SEMICONDUCTOR

4200-SCS

Parameter Analyzer Technical Data

Introduction

The Keithley Model 4200-SCS is a modular, fully integrated parameter analyzer that performs electrical characterization of materials, semiconductor devices and processes. With an embedded Windows-based operating system, the 4200-SCS software provides a unified measurement interface that guides you through complex characterization tests, enabling you to focus on your research or development projects. Best of all, the graphical user interface, powerful graphing tools, parameter extractions, simple test sequencing and drivers for common analytical probers enable you to get to your results faster with minimal training. Some of the many devices that the 4200-SCS can characterize are:

MOSFET	Non-volatile Memory	Graphene	Wafer Level Reliability
BJT	Flash	Carbon Nanotubes	Failure Analysis
Diodes	RRAM	Solar Cells	Electrochemistry
Resistors	PCRAM	Flat Panel Displays	Modeling
Capacitors	FeRAM	LED & OLED	Processes
MEMS	PRAM	Carbon NanoFET	Nanowires

Key Features

- Modular 4200-SCS mainframe has nine instrument slots and a built-in low noise ground unit.
- 4200-SCS software with over 450 application tests supplied with the instrument.
- Performs current versus voltage (I-V) measurements.
  - Medium and High power Source Measure Units (SMU) have ±200V operation.
  - High and Medium power SMUs only occupy one instrument slot.
  - High-resolution, analog-to-digital converter (ADC) available on all SMUs.
- Performs capacitance versus voltage (C-V), capacitance versus time (C-t), and capacitance versus frequency (C-f) measurements from 1kHz–10MHz.
  - ±30V (60V differential) DC bias, expandable to ±200V (400V differential).
  - Built-in CVU Confidence Check diagnostic tool.
  - Built-in Connection Compensation tool.
- Performs very low frequency C-V measurements from 10mHz–10Hz.
- Performs quasi-static C-V measurements.
- Performs ultra-fast I-V measurements that are synchronized.

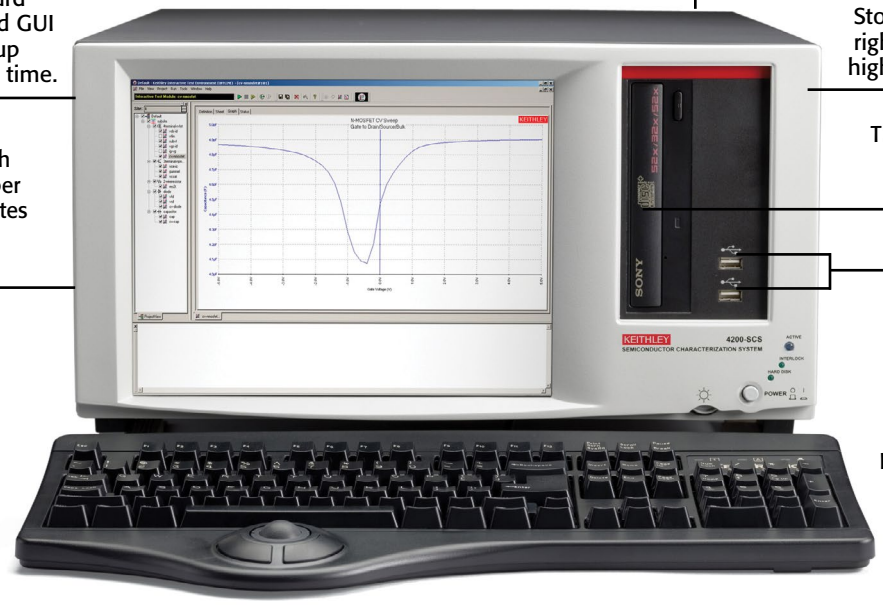
Integrated industrial controller and additional RAM ensure high test throughput, plus system robustness, stability, and security.

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

Store test setups and results right on the system with the high capacity fixed disk drive.

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

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



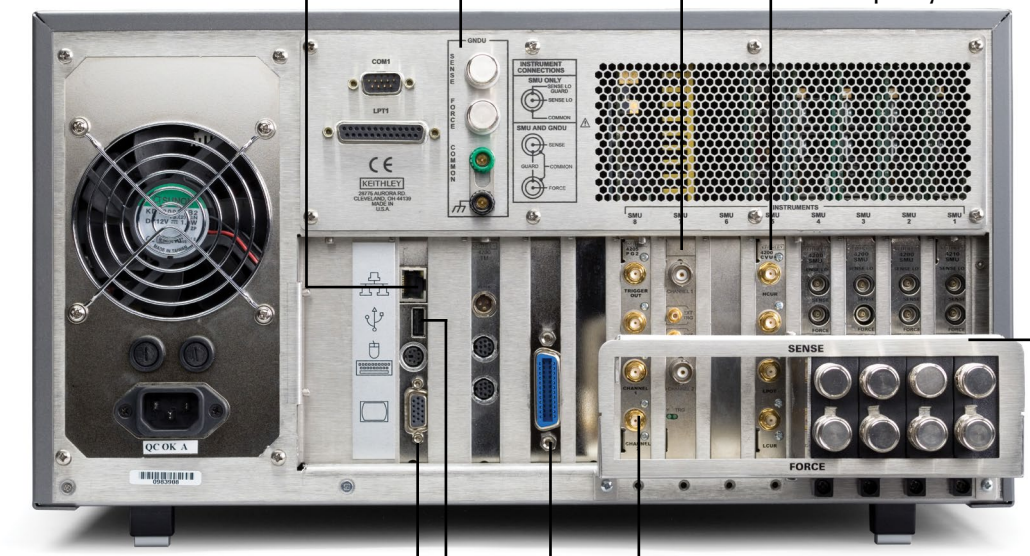
Communicate quickly with a wide range of PC accessories with the built-in USB interface.

Two LAN Ethernet ports (10/100/1000) allow easy access to network files and printers.

Low noise ground unit with remote sense

4200-SCP2 Digital Oscilloscope for measuring pulses and monitoring waveforms

Multi-frequency C-V module



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

SVGA monitor port

USB port

Dual-channel ultra-fast I-V module

Use the GPIB interface to control external instruments or to allow external control of the 4200-SCS.

4200-SCS Parameter Analyzer Technical Data

The nine slot 4200-SCS mainframe supports many instrument configurations that can include SMUs, C-V measurement units, Ultra-Fast Pulse I-V modules, pulse generators and oscilloscopes.

Modules	Description	Range	Measure Resolution	Slots Occupied	Modules per Mainframe
4200-SMU	Medium Power Source-Measure Unit	±210 V, ±100 mA	0.2 μV, 100 fA	1	9
4210-SMU	High Power Source-Measure Unit	±210 V, ±1 A	0.2 μV, 100 fA	1	9
4200-PA	Remote Preamplifier	Adds five current ranges to either high or medium power SMU	0.2 μV, 10 aA	—	9
4210-CVU	Capacitance-Voltage Unit	1 kHz – 10 MHz ±30 V bias (60 V differential)	—	1	1
4225-PMU	Ultra-Fast Pulse I-V Unit	±40 V, ±10 V	75 nA	1	6
4225-RPM	Remote Amplifier/Switch	±10 V	200 pA	—	9
4220-PGU	High Voltage Pulse Generator	±40 V (80 V p-p)	—	1	1
Ground Unit	Built-in, low noise ground unit	Triaxial connection: 2.6 A Binding post: 9.5 A	—	Built-in	1
4210-MMPC-x	Multi-Measurement Performance Cable Kit		—	—	—

Remote PreAmp

The low current measurement capabilities of any SMU can be extended by adding an optional Remote PreAmp (Model 4200-PA). The 4200-PA provides 10aA resolution by effectively adding five current ranges to either SMU model. The PreAmp module is fully integrated with the system; to the user, the SMU simply appears to have additional measurement resolution available. The Remote PreAmp is shipped installed on the back panel of the 4200-SCS for local operation. This installation allows for standard cabling to a prober, test fixture, or switch matrix. Users can remove the PreAmp from the back panel and place it in a remote location (such as in a light-tight enclosure or on the prober platen) to eliminate measurement problems due to long cables. Platen mounts and triax panel mount accessories are available.

Remote PreAmps are installed at the factory in numerical order, i.e., SMU1, SMU2, SMU3 … up to the number of PreAmps specified.

Remote Amplifier/Switch

The low current measurement capability of the Model 4225-PMU can be extended by adding the optional Model 4225-RPM Remote Amplifier/Switch. The RPM effectively adds three lower current ranges to any channel of the 4225-PMU Ultra-Fast I-V module. The RPM is fully integrated into the system software, so to the user it simply looks like three additional low current ranges. Additionally, the RPM acts as a multiplexer switch, allowing users to automatically switch between precision DC SMUs, the CVU, or the Ultra-Fast I-V modules.

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; 9.5A using 5-way binding posts.

LOAD CAPACITANCE: No limit.

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

Oscilloscope

The system supports two dual-channel integrated digital oscilloscope options: the Model 4200-SCP2 offers 8-bit resolution with a sample rate up to 2.5 gigasamples/second, while the Model 4200-SCP2HR provides 16-bit resolution and a sample rate up to 400 megasamples/second. Both can be programmed for automated measurement and data acquisition or used with the stand-alone GUI application provided to perform traditional oscilloscope tasks. They provide measurements in both the time (frequency, rise/fall time) and voltage domains (amplitude, peak-peak, etc.).

GENERAL

TEMPERATURE RANGE
Operating: +10° to +40°C.
Storage: –15° to +60°C.

HUMIDITY RANGE
Operating: 5% to 80% RH, non-condensing.
Storage: 5% to 90% RH, non-condensing.

ALTITUDE
Operating: 0 to 2000m.
Storage: 0 to 4600m.

POWER REQUIREMENTS: 100V to 240V, 50 to 60Hz.

MAXIMUM VA: 1000VA.

REGULATORY COMPLIANCE:
Safety: European Low Voltage Directive.
EMC: European EMC Directive.

DIMENSIONS: 43.6cm wide × 22.3cm high × 56.5cm deep (17⅝ in × 8¾ in × 22¼ in).

WEIGHT (approx.): 29.7kg (65.5 lbs) for typical configuration of four SMUs.

I/O PORTS: USB, SVGA, Printer, RS-232, GPIB, Ethernet, Mouse, Keyboard.

4200-SMU, 4210-SMU Source Measure Units and 4200-PA Preamplifier

SMUs can source either voltage or current, and can simultaneously measure both the voltage and current. Two SMU models are available: a medium power (100mA, 210V) version and a high power (1A, 210V) version. Each 4200-SCS system can be configured with up to nine medium or high power SMUs.

- 24-bit A/D converters on every SMU
- Full remote sense (Kelvin) capability
- Log & Linear measurement sweeps

General Information

Model 4200-SMU: Medium power SMU, 2.2W, kelvin, four-quadrant source/sink operation.

Model 4210-SMU: High power SMU, 22W, kelvin, four-quadrant source/sink operation.

Model 4200-PA: Remote pre-amplifier for either 4200-SMU or 4210-SMU.

Output Connectors:
4200-SMU and 4210-SMU: Dual mini-triaxial, female.
4200-PA: Dual triaxial, female.

CURRENT SPECIFICATIONS

				MEASURE		SOURCE	
		CURRENT RANGE[1]	MAX. VOLTAGE	DISPLAY RESOLUTION[3]	ACCURACY ±(% rdg + amps)	RESOLUTION[3]	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 nA	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	1 fA	0.050% + 100 fA	50 fA	0.060% + 300 fA
		100 pA	210 V	300 aA	0.100% + 30 fA	15 fA	0.100% + 80 fA
		10 pA	210 V	100 aA	0.500% + 15 fA	5 fA	0.500% + 50 fA
		1 pA	210 V	10 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		MEASURE		SOURCE	
	4200-SMU	4210-SMU	DISPLAY RESOLUTION[3]	Accuracy ±(% rdg + volts)	Resolution[3]	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	0.2 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.

SPECIFICATION CONDITIONS

Specifications are the performance standards against which the Models 4200-SMU, 4210-SMU, and 4200-PA are tested. The measurement and source accuracy are specified at the termination of the supplied cables.

- 23°C ±5°C, within 1 year of calibration, RH between 5% and 60%, after 30 minutes of warm-up.
- Speed set to NORMAL.
- Guarded Kelvin connection.
- ±1°C and 24 hours from ACAL.

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.

4200-SMU, 4210-SMU Source Measure Units and 4200-PA Preamplifier (continued)

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	0.2 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; 9.5A using 5-way binding posts.

LOAD CAPACITANCE: No limit.

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

Supplemental Information

Supplemental information is not warranted but provides useful information about the Models 4200-SMU, 4210-SMU, and 4200-PA.

COMPLIANCE ACCURACY:
Voltage compliance equals the voltage source specifications.
Current compliance equals the current source specifications.

OVERSHOOT: <0.1% typical.
Voltage: Full scale step, resistive load, and 10mA range.
Current: 1mA step, R_L = 10kΩ, 20V range.

RANGE CHANGE TRANSIENT:
Voltage Ranging: <200mV.
Current Ranging: <200mV.

ACCURACY SPECIFICATIONS: Accuracy specifications are multiplied by one of the following factors, depending upon the ambient temperature and humidity.

Temperature	% Relative Humidity 5–60	60–80
10°–18°C	×3	×3
18°–28°C	×1	×3
28°–40°C	×3	×5

REMOTE SENSE: <10Ω in series with FORCE terminal not to exceed a 5V difference between FORCE and SENSE terminals. ±30V maximum between COMMON and SENSE LO.

MAXIMUM LOAD CAPACITANCE: 10nF.

MAXIMUM GUARD OFFSET VOLTAGE: 3mV from FORCE.

GUARD OUTPUT IMPEDANCE: 100kΩ.

MAXIMUM GUARD CAPACITANCE: 1500pF.

MAXIMUM SHIELD CAPACITANCE: 3300pF.

4200-SMU and 4210-SMU SHUNT RESISTANCE (FORCE to COMMON): $>10^{12}\Omega$ (100nA–1μA ranges).

4200-PA SHUNT RESISTANCE (FORCE to COMMON): $>10^{16}\Omega$ (1pA and 10pA ranges), $>10^{13}\Omega$ (100pA–100nA ranges).

NOISE CHARACTERISTICS (typical):
Voltage Source (rms): 0.01% of output range.
Current Source (rms): 0.1% of output range.
Voltage Measure (p-p): 0.02% of measurement range.
Current Measure (p-p): 0.2% of measurement range.

MAXIMUM SLEW RATE: 0.2V/μs.

4210-CVU Capacitance-Voltage Unit

The multi-frequency C-V module measures impedance by sourcing an AC voltage across the device under test (DUT),and then measures the resulting AC current and phase angle. Capacitance and conductance are derived parameters from the measured impedance and phase angle. The 4200-SCS software simplifies C-V measurements by including unique features such as:

- Confidence Check that checks the integrity of open, short and device under test (DUT) connections.
- AC Terminal Selection allows you to choose which terminal the AC ammeter is on for lower noise with a mouse click, no re-cabling.
- DC Bias Terminal Selection allows you to choose which terminal the DC bias is on for correct DC polarity with a mouse click, no re-cabling.

General Information

Model 4210-CVU: Multi-frequency, capacitance-voltage unit.

Measurement Configuration: Four-terminal pair, high POT, High CUR, Low POT, Low CUR.

Output Connectors: Four SMA, female.

Cable Length: 1.5m, 3m or custom selectable.

MEASUREMENT FUNCTIONS

MEASUREMENT PARAMETERS: Cp-G, Cp-D, Cs-Rs, Cs-D, R-jX, Z-theta.

RANGING: Auto and fixed.

MEASUREMENT TERMINAL CONFIGURATION: Four-terminal pair.

CONNECTOR TYPE: Four SMA (female) connectors.

CABLE LENGTH: 0m, 1.5m, 3m, or custom selectable.

INTEGRATION TIME: FAST, NORMAL, QUIET, and CUSTOM.

TEST SIGNAL

FREQUENCY RANGE: 1kHz to 10MHz.

MINIMUM RESOLUTION: 1kHz, 10kHz, 100kHz, 1MHz depending on frequency range.

SOURCE FREQUENCY ACCURACY: ±0.1%.

SIGNAL OUTPUT LEVEL RANGE: 10mV rms to 100mV rms.

RESOLUTION: 1mV rms.

ACCURACY: ±(10.0% + 1mV rms) unloaded (at rear panel).

OUTPUT IMPEDANCE: 100Ω, typical.

DC BIAS FUNCTION

DC VOLTAGE BIAS:
Range: ±30V (60V differential).
Resolution: 1.0mV.
Accuracy: ±(0.5% + 5.0mV) unloaded.

MAXIMUM DC CURRENT: 10mA.

SWEEP CHARACTERISTICS

AVAILABLE SWEEP PARAMETERS: DC bias voltage, frequency, AC voltage.

SWEEP TYPE: Linear, custom.

SWEEP DIRECTION: Up sweep, down sweep.

NUMBER OF MEASUREMENT POINTS: 4096.

MEASUREMENT ACCURACY [4]

Example of C/G Measurement Accuracy

Frequency	Measured Capacitance	C Accuracy [1]	G Accuracy [1, 2]
10 MHz [3]	1 pF	± 0.92%	± 590 ns
	10 pF	± 0.32%	± 1.8 µs
	100 pF	± 0.29%	± 17 µs
	1 nF	± 0.35%	± 99 µs
1 MHz	1 pF	± 1.17%	± 64 ns
	10 pF	± 0.19%	± 65 ns
	100 pF	± 0.10%	± 610 ns
	1 nF	± 0.09%	± 4 µs
100 kHz	10 pF	± 0.31%	± 28 ns
	100 pF	± 0.18%	± 59 ns
	1 nF	± 0.10%	± 450 ns
	10 nF	± 0.10%	± 3 µs
10 kHz	100 pF	± 0.31%	± 15 ns
	1 nF	± 0.15%	± 66 ns
	10 nF	± 0.08%	± 450 ns
	100 nF	± 0.10%	± 3 µs
1 kHz	1 nF	± 0.82%	± 40 ns
	10 nF	± 0.40%	± 120 ns
	100 nF	± 0.10%	± 500 ns
	1 µF	± 0.15%	± 10 µs

SUPPLEMENTAL CABLE SPECIFICATION [3]

4210-CVU Typical C Accuracy with 1.5m Cables (supplemental)

Measured Capacitance	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz
1 pF	N/A	±8.38%	±1.95%	±0.43%	N/A
10 pF	N/A	±0.94%	±0.21%	±0.18%	±1%
100 pF	N/A	±0.29%	±0.20%	±0.15%	±1%
1 nF	±0.72%	±0.17%	±0.12%	±0.16%	±2%
10 nF	±0.28%	±0.12%	±0.13%	±0.55%	N/A
100 nF	±0.12%	±0.13%	±0.22%	±1.14%	N/A
1 µF	±0.17%	±0.21%	N/A	N/A	N/A

4210-CVU Typical C Accuracy with 3m Cables (supplemental)

Measured Capacitance	1 kHz	10 kHz	100 kHz	1 MHz	10 MHz
1 pF	N/A	±8.5 %	±2.05%	±0.57%	N/A
10 pF	N/A	±0.96%	±0.23%	±0.21%	N/A
100 pF	N/A	±0.29%	±0.20%	±0.17%	N/A
1 nF	±0.72%	±0.17%	±0.12%	±0.18%	N/A
10 nF	±0.28%	±0.12%	±0.13%	±0.65%	N/A
100 nF	±0.12%	±0.13%	±0.22%	±1.16%	N/A
1 µF	±0.17%	±0.21%	N/A	N/A	N/A

NOTES

1. The capacitance and conductance measurement accuracy is specified under the following conditions: DX < 0.1.
2. Conductance accuracy is specified as the maximum conductance measured on the referenced capacitor.
3. These specs are typical. Typical and supplemental specs are non-warranted, apply at 23°C, and are provided solely as useful information.
4. Integration time: 1s or 10s below 10kHz.
   Test signal level: 30mV rms.
   At the rear panel of the 4210-CVU.
   All specifications apply at 23°C ±5°C, within one year of calibration, RH between 5% and 60%, after 30 minutes of warmup.

4210-CVU Capacitance-Voltage Unit (continued)

Additional C-V Measurement Options

Model 4200-CVU-PWR

C-V POWER PACKAGE TYPICAL PERFORMANCE CHARACTERISTICS

MEASUREMENT PARAMETERS: Cp-Gp, DCV, timestamp.
RANGING: 1pF to 1nF.
MEASUREMENT TERMINALS: 2-wire SMA, with BNC adapters.
TEST SIGNAL: 100kHz to 10MHz, 10mV to 100mV.
DC VOLTAGE SOURCE: ±200V with 5mV resolution.
DC CURRENT: 100mA or 300mA maximum.
TYPICAL CP ACCURACY @ 1MHz: 1.0%.
DC CURRENT SENSITIVITY: 10nA/V.
SMU BIAS TERMINALS SUPPORTED: 4.

Ramp Rate Quasistatic C-V

The ramp rate quasistatic C-V method uses two medium or high power SMU modules. Below are typical performance characteristics.

RAMP RATE QUASISTATIC C-V TYPICAL PERFORMANCE CHARACTERISTICS

MEASUREMENT PARAMETERS: Cp, DCV, timestamp.
RANGING: 1pF to 1nF.
Measurement Terminals: Triaxial guarded.
Ramp Rate: 0.1V/s to 1V/s.
DC Voltage: ±200V.
TYPICAL CP ACCURACY: 5% at 1v/s ramp rate.

Very Low Frequency C-V

The Very Low Frequency C-V method uses two medium or high power SMU modules. Below are typical performance characteristics.

VERY LOW FREQUENCY C-V (VLF-CV)

MAXIMUM UNITS PER CHASSIS: Requires two SMU instruments (either Model 4200-SMU or 4210-SMU) and two Model 4200-PA Remote Preamplifiers. Any two SMU instruments/PAs can be used for a VLF C-V measurement.
MEASUREMENT PARAMETERS: CP-GP, Cp-D, Cs-Rs, Cs-D, R-jX, Z-Theta, DCV, Timestamp.
FREQUENCY RANGE: 10mHz to 10Hz.
MEASUREMENT RANGE: 1pF to 10nF.
TYPICAL RESOLUTION: 3.5 digits, minimum typical 10fF.
AC SIGNAL: 10mV to 3V rms.
DC BIAS: ±20V on the High terminal, 1μA maximum.

Example of Included Libraries

- C-V, C-t, and C-f measurements and analysis of:
  - High and low κ structures
  - MOSFETs
  - BJTs
  - Diodes
  - III-V compound devices
  - Carbon nanotube (CNT) devices
- Doping profiles, T_{OX}, and carrier lifetime tests
- Junction, pin-to-pin, and interconnect capacitance measurements
- Solar cells including Si, organic, thin film, CIGS, etc.

The C-V instrument integrates directly into the Model 4200-SCS chassis. It can be purchased as an upgrade to existing systems or as an option for new systems.

4225-PMU Ultra-Fast Pulse I-V, 4225-RPM Remote Amplifier/Switch, 4220-PGU Pulse Generator

The dual channel, Model 4225-PMU provides the combination of ultra-fast voltage waveform generation with fast, simultaneous voltage and current measurements. The optional single-channel Model 4225-RPM Remote Amplifier/Switch module provides lower current ranges for the 4225-PMU and also automatically switches measurement modes between the 4200-SCS SMU's, 4210-CVU and 4225-PMU. The 4220-PGU is a dual-channel, voltage-only pulse generator.

General Information

Model 4225-PMU: Dual channel, ultra-fast pulse/measure unit.

Model 4225-RPM: Single-channel, remote amplifier/switch module for the 4225-PMU.

Model 4220-PGU: Dual-channel, voltage-only pulse generator.

Cable Length:

4225-PMU & 4220-PGU: Four 2m SMA.

4225-RPM: One 2m HDMI cable.

Output Connectors:

4225-PMU: Four female SMA and two HDMI.

4225-RPM:

Input: Two female triaxial connectors for SMU, two female SMA for 4210-CVU, one HDMI for 4225-PMU.

Output: Two female triaxial connectors.

4220-PMU: Four female SMA connectors.

Since measurement speed is integrally linked to settling time, accuracy, resolution and noise, the following charts illustrate the typical measurement performance. These values do not include settling time for the interconnect or device-under-test.

CURRENT MEASUREMENT TYPICAL MINIMUM TIMING PARAMETERS [1]

4225-PMU (with or without optional 4225-RPM Remote Amplifier/Switch)

	10V Range		40V Range		
Current Measure Ranges	10 mA	200 mA	100 µA	10 mA	800 mA
Recommended Minimum Pulse Width [2]	160 ns	70 ns	6.4 µs	770 ns	770 ns
Recommended Minimum Measure Window [2]	20 ns	20 ns	1 µs	100 ns	100 ns
Recommended Minimum Transition Time [3]	20 ns	20 ns	1 µs	100 ns	100 ns
Noise [4]	15 µA	50 µA	75 nA	5 µA	200 µA
Settling Time [5]	100 ns	30 ns	4 µs	500 ns	500 ns

CURRENT MEASUREMENT TYPICAL MINIMUM TIMING PARAMETERS [1]

4225-RPM Remote Amplifier/Switch (RPM optional to 4225-PMU)

	10V Range					
Current Measure Ranges	100 nA	1 µA	10 µA	100 µA	1 mA	10 mA
Recommended Minimum Pulse Width [2]	134 µs	20.4 µs	8.36 µs	1.04 µs	370 ns	160 ns
Recommended Minimum Measure Window [2]	10 µs	1.64 µs	1 µs	130 ns	40 ns	20 ns
Recommended Minimum Transition Time [3]	1 µs	360 ns	360 ns	40 ns	30 ns	20 ns
Noise [4]	200 pA	2 nA	5 nA	50 nA	300 nA	1.5 µA
Settling Time [5]	100 µs	15 µs	6 µs	750 ns	250 ns	100 ns

VOLTAGE MEASUREMENT TYPICAL MINIMUM TIMING PARAMETERS [1]

4225-PMU and 4225-RPM

	4225-PMU		4225-RPM
Voltage Measure Ranges	10 V	40 V	10 V
Recommended Minimum Pulse Width [2]	70 ns	150 ns	160 ns
Recommended Minimum Measure Window [2]	20 ns	20 ns	20 ns
Recommended Minimum Transition Time [3]	20 ns	100 ns	20 ns
Noise [4]	2 mV	8 mV	1 mV
Settling Time [5]	30 ns	30 ns	100 ns

NOTES FOR THE TYPICAL PERFORMANCE WINDOW SECTION:

1. All typical values measured with an open circuit.
2. Using default measure window of 75% to 90% of pulse top. Recommended minimum pulse width = (Settling Time) / 75%.
3. Recommended rise/fall time to minimize overshoot.
4. RMS noise measured over the Recommended Minimum Measure Window for the given voltage or current range, typical.
5. Time necessary for the signal to settle to the DC accuracy level. (Example: 10mA settling time on the PMU 10V range is defined when the signal is within 1.25% of the final value. This calculation: Accuracy = 0.25% + 100µA = 0.25% + (100µA/10mA) = 0.25% + 1% = 1.25%).

4225-PMU Ultra-Fast Pulse I-V, 4225-RPM Remote Amplifier/Switch, 4220-PGU Pulse Generator (continued)

4225-PMU and 4220-PGU Specifications [1]

PULSE/LEVEL [2]

		10V Range	40V Range
V_{OUT}	50 Ω into 1 MΩ	–10 V to +10 V	–40 V to +40 V
V_{OUT}	50 Ω into 50 Ω	–5 V to +5 V	–20 V to +20 V
Accuracy		±(0.5% + 10 mV)	±(0.2% + 20 mV)
Resolution	50 Ω into 50 Ω	<250 µV	<750 µV
	50 Ω into 1 MΩ	<0.5 mV	<1.5 mV
Overshoot/Pre-shoot/ Ringing [3]	50 Ω into 50 Ω	±(3% + 20 mV)	±(3% + 80 mV)
	50 Ω into 50 Ω, typical best case	±(2% + 20 mV)	±(0.8% + 40 mV)
Baseline Noise		±(0.3% + 1 mV) RMS typical	±(0.1% + 5 mV) RMS typical
Source Impedance		50 Ω Nominal	50 Ω Nominal
Current into 50Ω Load (at full scale)		±100 mA typical	±400 mA typical
Short Circuit Current		±200 mA	±800 mA
Output Connectors		SMA	SMA
Output Limit		Programmable limit to protect the device under test	

TIMING

	10 V Range Source Only	10 V Range with Meas.	40 V Range Source Only	40 V Range with Meas.
Frequency Range	1 Hz to 50 MHz	1 Hz to 8.3 MHz	1 Hz to 10 MHz	1 Hz to 3.5 MHz
Timing Resolution	10 ns	10 ns	10 ns	10 ns
RMS Jitter (period, width), typical	0.01% + 200 ps	0.01% + 200 ps	0.01% + 200 ps	0.01% + 200 ps
Period Range	20 ns to 1 s	120 ns to 1 s	100 ns to 1s	280 ns to 1s
Accuracy	±1%	±1%	±1%	±1%
Pulse Width Range	10 ns to (Period–10 ns)	60 ns to (Period–10 ns)	50 ns to (Period–10 ns)	140 ns to (Period–10 ns)
Accuracy	±(1% + 200 ps)	±(1% + 200 ps)	±(1% + 5 ns)	±(1% + 5 ns)
Programmable Transition Time (0%–100%)	10 ns to 33 ms	20 ns to 33 ms	30 ns to 33 ms [4]	100 ns to 33 ms
Transition Slew Rate Accuracy	±1% (transitions > 100 ns)	±1% (transitions > 100 ns)	±1% (transitions > 1 µs)	±1% (transitions > 100 ns)
Solid State Relay Open/Close Time	25 µs	25 µs	25 µs	25 µs

ACCURACY

CURRENT MEASUREMENT (4225-PMU Only)

	10 V Range		40 V Range		
Current Measure Ranges	10 mA	200 mA	100 µA	10 mA	800 mA
Accuracy (DC)	±(0.25% + 100 µA)	±(0.25% + 250 µA)	±(0.25% + 1 µA)	±(0.5% + 100 µA)	±(0.25% + 3 mA)

4225-RPM CURRENT MEASUREMENT

	10 V Range					
Current Measure Ranges	100 nA	1 µA	10 µA	100 µA	1 mA	10 mA
Accuracy (DC)	±(0.5% + 1 nA)	±(0.5% + 1 nA)	±(0.5% + 30 nA)	±(0.5% + 100 nA)	±(0.5% + 1 µA)	±(0.5% +10 µA)

4225-PMU and 4225-RPM VOLTAGE MEASUREMENT

	±10V PMU	±40V PMU	±10V RPM
Accuracy (DC)	±(0.25% + 10 mV)	±(0.25% + 40 mV)	±(0.25% + 10 mV)

VOLTAGE SOURCE ABSOLUTE BEST PERFORMANCE

When used only as a voltage source (that is, without measurements of voltage or current), the Model 4225-PMU can actually exceed the level of performance listed in these specifications. The following table is provided only to offer the user a clearer idea of the Model 4225-PMU's absolute best performance as achievable under optimal conditions. This should not be interpreted as a guarantee that the Model 4225-PMU will achieve this level of performance in typical use cases.

10V RANGE:

Rise Time: <10ns.
Pulse Width: 10ns (full width half maximum).
Period: 20ns.
Overshoot/Preshoot/Ringing: ±(2% + 20mV).

40V RANGE:

Rise Time: 50ns to 10V, 100ns to 40V.
Pulse Width: 50ns.
Period: 100ns.
Overshoot/Preshoot/Ringing: ±(0.5% + 40mV).

NOTES

1. Unless stated otherwise, all specifications assume a 50Ω termination.
2. Level specifications are valid after 50ns typical settling time (after slewing) for the 10V source range and after 500ns typical settling time (after slewing) for the 40V source range into a 50Ω load.
3. With transition time of 20ns (0%–100%) for the 10V source range and 100ns (0%–100%) for the 40V source range.
4. 40V Range minimum programmable transition time (source only) is 30ns for voltage <10V and 100ns for voltages >10V.
5. For multiple 4225-PMU or 4220-PGU cards in a single 4200-SCS chassis.
6. Per channel.

All specifications apply at 23° ±5°C, within one year of calibration, RH between 5% and 60%, after 30 minutes of warmup.

TRIGGER

TRIGGER OUTPUT IMPEDANCE: 50Ω.
TRIGGER OUTPUT LEVEL: TTL.
TRIGGER IN IMPEDANCE: 10kΩ.
TRIGGER IN LEVEL: TTL.
TRIGGER IN TRANSITION TIMING, MAXIMUM: <100ns.
TRIGGER IN TO PULSE OUTPUT DELAY: 400ns.
TRIGGER SYNCHRONIZATION/JITTER [5]: <2ns.

SEGMENT ARB® AND TIMING

4220-PGU, 4225-PMU w/ or w/o 4225-RPM

MAX. NUMBER OF SEGMENTS [6]: 2048.
MAX. NUMBER OF SEQUENCES [6]: 512.
MAX. NUMBER OF SEQUENCE LOOPS: 10^{12}.
TIME PER SEGMENT: 20ns to 40s.
SEGMENT TIMING RESOLUTION: 10ns.
CONTROL PARAMETERS FOR EACH SEGMENT:
Start V
Stop V
Duration
Measurement window (PMU or PMU+RPM only)
Measurement type (PMU or PMU+RPM only)
RMS JITTER (SEGMENT): 0.01 % + 200 ps typical.

4200-SCP2 1.25GS Dual-Channel Oscilloscope Card and 4200-SCP2HR 200MS Dual-Channel Oscilloscope Card Specifications[1]

ANALOG INPUT[1]

	4200-SCP2	4200-SCP2HR
No. of Channels	2	2
Bandwidth (50Ω)	DC to 750 MHz	DC to 250 MHz, typical
Bandwidth (1MΩ)	DC to 350 MHz	DC to 125 MHz, typical
Full Scale Input Range (50 Ω)	0.05, 0.1, 0.25, 0.5, 1, 2, 5, 10 (Vp-p)	0.05, 0.1, 0.25, 0.5, 1, 2, 5, 10 (Vp-p)
Full Scale Input Range (1 MΩ)	0.1, 0.2, 0.5, 1, 2.5, 5, 10, 20, 50, 100 (Vp-p)	0.25, 0.5, 1.25, 2.5, 5, 10, 25, 50 (Vp-p)
DC Gain Accuracy	<±1% of full scale	< ±0.25% of full scale
Impedance	1 MΩ||12 pF or 50 Ω	1 MΩ||12 pF or 50 Ω
Impedance Accuracy	±1%	±1%
Coupling	DC or AC	DC or AC
Offset Adjust	±(full scale range/2)	±(full scale range/2)
Offset Accuracy	±(1% offset + 1% full scale)	±1%
Input Connectors	BNC	BNC
Absolute Maximum Input (50 Ω)	±5V DC	±5V DC
Absolute Maximum Input (1 MΩ)	±210V DC	±210V DC

ANALOG-TO-DIGITAL CONVERTER

	4200-SCP2	4200-SCP2HR
Resolution	8 bit	16 bit
Sample Rate	2.5 kS/s to 1.25 GS/s in 1, 2.5, 5 steps 2.5 GS/s (1 channel interleaved)	10 kS/s to 200 MS/s in 1, 2.5, 4, 5 steps 400 MS/s (1 channel interleaved)
Memory Depth	1 MS/channel 2 MS on 1 channel, interleaved	1 MS/channel 2 MS on 1 channel, interleaved
Acquisition Time Range	50 ns to 419 seconds	250 ns to 3,355 seconds
Acquisition Modes	Normal, Average, Envelope, and Equivalent-time	Normal, Average, Envelope, and Equivalent-time

TRIGGER

	4200-SCP2	4200-SCP2HR
Trigger Source	Channels 1 or 2, External, Pattern, Software	Channels 1 or 2, External, Pattern, Software
Post-Trigger Delay	0 to 655 seconds	0 to 655 seconds
Pre-Trigger Delay	0 to waveform time	0 to waveform time
Trigger Hold Off Range	0 to 655 seconds	0 to 655 seconds
Trigger Modes	Edge or Pulse Width	Edge or Pulse Width
Edge Trigger Mode	Rising or Falling Edge	Rising or Falling Edge
Pulse Width Range	20ns to 655 seconds, 10ns resolution	20ns to 655 seconds, 10ns resolution
External Trigger Input	TTL Compatible, 10 kΩ input impedance	TTL Compatible, 10 kΩ input impedance
Connector	SMB	SMB

OPTIONAL SCOPE PROBE: 4200-SCP2-ACC

BANDWIDTH: 70MHz (4200-SCP2); 15MHz (4200-SCP2HR).

ATTENUATION: 1×.

MAX DC: 300V DC rated.

LOADING: 100pF and 1MΩ.

LENGTH: 1m.

CONNECTOR: BNC.

NOTES

Inputs are referenced to 4200 chassis ground

All specifications apply at 23°±5°C, within 1 year of calibration, RH between 5% and 60%, after 30 minutes of warmup.

4200-BTI-A Ultra-Fast NBTI/PBTI Option

The Model 4200-BTI-A package is ideal for wafer- and cassette-level automation. It combines Keithley's advanced DC I-V and ultrafast I-V measurement capabilities with automatic test executive software to provide the most advanced NBTI/PBTI test platform available in the semiconductor test industry. The 4200-BTI-A package includes all the instruments, interconnects, and software needed to make the most sophisticated NBTI and PBTI measurements on leading-edge silicon CMOS technology, including:

- One Model 4225-PMU Ultra-Fast I-V Module
- Two Model 4225-RPM Remote Amplifier/Switches
- Automated Characterization Suite (ACS) Standard Version 4.2 Software (or later)
- Ultra-Fast BTI Test Project Module
- Cabling

The Model 4200-BTI-A offers the best high-speed, low-current measurement sensitivity available in a single-box integrated solution. For example:

- Supports sub-microsecond pulse characterization of drain current at reduced drain voltage, minimizing drain-to-source fields that could otherwise skew test results.
- Ensures that source/measure instrumentation won't be the limiting factor when making low-level measurements.

The ACS software, which is provided in the package, supports building complex test sequences, including up to 20 measurement sequences and full prober integration. It also:

- Easily integrates DC I-V and ultra-fast I-V measurements into a pre- and post-stress measurement sequence.
- Characterizes degradation and recovery behaviors using either AC or DC stress.
- Incorporates single pulse charge trapping (SPCT) measurements into longer stress-measure sequences.

4200-SCS Software

The 4200-SCS software provides a unified measurement interface that guides you through complex characterization tests, enabling you to focus on your research or development projects. The 4200-SCS software also provides a variety of tools for operating and maintaining the parameter analyzer.

General Information

Keithley Interactive Test Environment (KITE) – The graphical user interface for testing and characterizing your devices, materials and processes.

Keithley User Library Tool (KULT) – Assists test engineers to create custom test routines as well as use existing Keithley and third-party C-language subroutine libraries. Users can edit and compile subroutines, then integrate libraries of subroutines with KITE, allowing the 4200-SCS to control an entire test rack from a single user interface. Requires optional Model 4200-Compiler.

Keithley External Control Interface (KXCI) – Controls the 4200-SCS from an external computer via GPIB bus.

Keithley Configuration Utility (KCON) – Allows test engineers to define the configuration of GPIB instruments, switch matrices, and analytical probers connected to the 4200-SCS. It also provides diagnostic functions.

KPulse – A graphical user interface that is a non-programming alternative to configure and control the installed Model 4225-PMU or 4220-PGU pulse generator modules. It is used for quick tests requiring minimal interaction with other 4200-SCS test resources.

KScope – A graphical user interface that provides a non-programming alternative to configure and control the system's oscilloscope module (either Model 4200-SCP2HR or 4200-SCP2).

Operating system – A standard distribution of Microsoft Windows 7. Upgrades are available for older systems. Contact your Keithley sales representative for supported versions and service packs.

Key Features

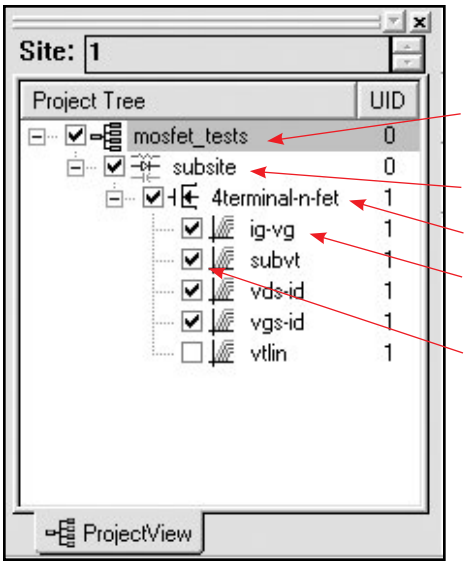
- Categorized and predefined application tests
- GUI-based application test editor
- Execute single, append and sequential measurement tests

The Keithley Interactive Test Environment (KITE)

The Keithley Interactive Test Environment (KITE) is the Model 4200-SCS Windows device characterization application. It provides advanced test definition, parameter analysis and graphing, and automation capabilities required for modern semiconductor characterization.

KITE Projects

A project is a collection of related tests, organized in a hierarchy that parallels the physical layout of the devices on a wafer. KITE operates on projects using an interface called the project navigator. The project navigator simplifies organizing test files, test execution, and test sequencing.



The project navigator organizes tests into a logical hierarchy presented in a browser style format. This structure allows users to define projects around wafer testing:

The project level organizes subsites and controls wafer looping execution.

The subsite level organizes devices and controls subsite test sequencing and stress/measure looping.

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.

Selectable checkboxes allow enabling/disabling individual tests/plans.

Test Modules

Within KITE, two types of test modules are provided to capture the test input parameters, data analysis, and plot setting for data. Interactive Test Modules provide a point-and-click interface for defining test input parameters and controlling the 4200-SCS SMUs. User Test Modules provide a fill-in-the-blank interface to either factory-provided or user-written C language subroutines. These subroutines can control internal 4200-SCS instruments and/or external instruments and systems through the RS-232 or GPIB interface. This dual approach provides an extendable test environment that gives the users the same capabilities for data analysis, plotting, output, and automation, whether the instrument used is part of the base system or an external instrument. It also offers users the flexibility to write complex test algorithms for control of either internal or external instruments.

Definition Tab—Interactive Test Module

The Definition Tab of an ITM provides a point-and-click interface for setting test input parameters that control the 4200-SCS SMUs and defining parameter extractions. Two modes are available:

Sweep Mode

Forcing Functions	Common, Voltage Bias, Current Bias (VMU), Voltage Sweep, Current Sweep, Voltage Step, Current Step, Voltage List Sweep, Current List Sweep, Open, C-V Differential Bias, C-V Frequency Sweep, Pulsed I-V, Waveform
Measuring Functions	**Precision DC I-V SMU:** Measure voltage, current, and timestamp up to 4096 points per SMU
	C-V (AC Impedance): Cp-Gp, Cs-Rs, Cp-D, Cs-D, R+jX, Z-theta, DCV, frequency, timestamp up to 4096 points per sweep
	Ultra-Fast I-V: Voltage and current (spot mean) simultaneously in Pulsed I-V mode; voltage, current, and time digitized simultaneously in Waveform Capture mode, up to 1 million digitized points

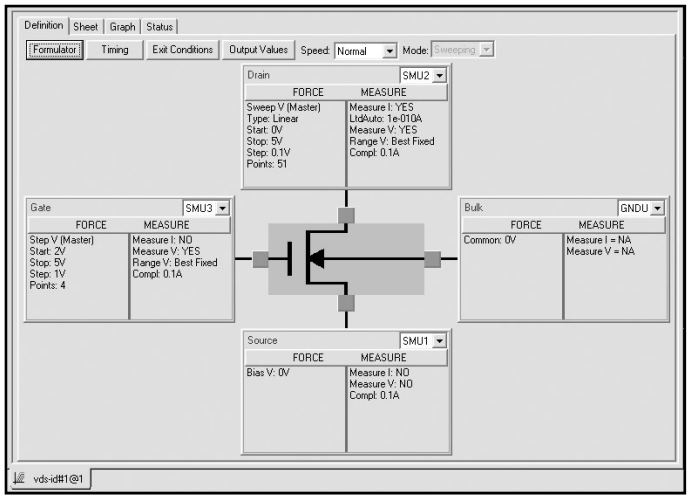
SEMICONDUCTOR

Interactive Test Modules (ITM) are built from three different major functions: Definition, Sheet, and Graph. The Definition Tab allows the operator to define a sweep or sampling mode test using a graphical approach. The Sheet Tab stores acquired data and provides an Excel®-like workbook for viewing and analyzing test results. The Graph Tab provides a full-featured data plotting tool capable of producing report-ready graphs. The Status Tab reports any errors that would interfere with test execution.

Sampling Mode

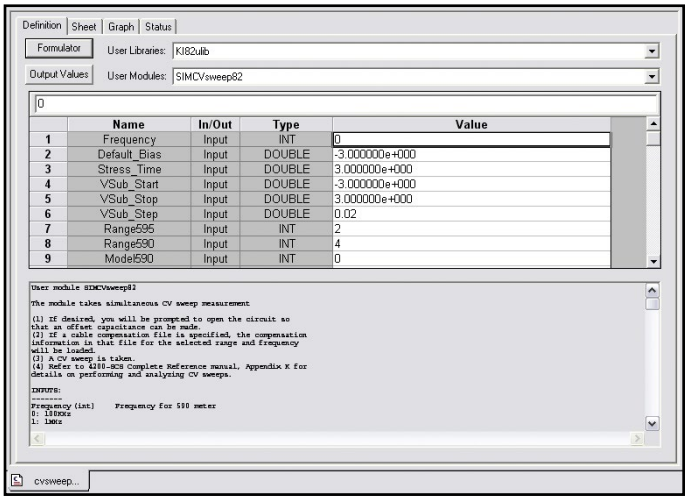
Precision DC I-V or C-V: Linear sampling at fixed voltage, current, or frequency. Up to 4096 points. Programmable hold time and interval time from 1ms to 1000s.

Ultra-Fast I-V: Simultaneous 14-bit, 5ns to 1ms sampling of voltage and current on up to 8 channels with <3ns synchronization. 4096 data points on every channel. Up to 1 million data points per channel in UTM mode.

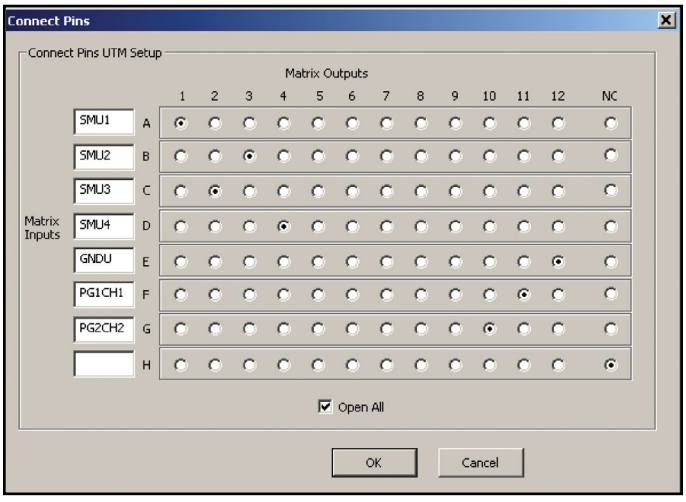


Definition Tab—User Test Module

The Definition Tab of a UTM presents users a tabular fill-in-the-blank interface for entering input parameters to call a C language subroutine. UTMs provide the ability to control internal SMUs and GPIB and RS-232 devices. This screen allows the user to select a user library, a subroutine module, and then enter the desired input parameters. Test results are returned to the Sheet Tab for viewing and analysis. Select UTMs have a GUI interface to simplify operation.



The User Test Module (UTM) has virtually identical functionality as the ITM. However, users enter input parameters in a tabular interface in the UTM's Definition Tab.



GUI to control switch matrix UTMs.

Data Analysis

Two methods of parameter extraction are available. The Formulator provides automated line fits and parameter extraction. A spreadsheet offers standard spreadsheet analysis tools. Many of the sample libraries include parameter extraction examples.

Formulator functions

The Formulator performs data transformations for performing parameter analysis and line fits. The Formulator supports the following functions:

- ***Mathematical Functions***
  Addition (+), subtraction (-), division (/), multiplication (*), exponent (^), absolute value (ABS), value at an index position (AT), Average (AVG), moving average (MAVG), conditional computation (COND), derivative (DELTA), differential coefficient (DIFF), exponential (EXP), square root (SQRT), natural logarithm (LN), logarithm (LOG), integral (INTEG), standard deviation (STDEV), moving summation (SUMMV), arc cosine (ACOS), arc sine (ASIN), arc tangent (ATAN), cosine (COS), sine (SIN), tangent (TAN)
- ***Conversion Functions***
  Radians to degrees (DEG), degrees to radians (RAD)
- ***Line Fits and Parameter Extraction Functions***
  Exponential line fit (EXPFIT), coefficient a (EXPFITA), coefficient b (EXPFITB)
  Linear Fit (LINFIT), linear slope (LINFITSLP), x intercept (LINFITXINT), y intercept (LINFITYINT)
  Logarithmic line fit (LOGFIT), coefficient a (LOGFITA), coefficient b (LOGFITB)
  Linear Regression line fit (REGFIT), slope (REGFITSLP), x intercept (REGFITXINT), y intercept (REGFITYINT)
  Tangent line fit (TANFIT), slope (TANFITSLP), x intercept (TANFITXINT), y intercept (TANFITYINT)
  Polynomial line fit including POLYFIT2, POLY2COEFF, and POLYNFIT.
  Maximum value (MAX), minimum value (MIN), midpoint (MEDIAN)
- ***Search Functions***
  Find Down (FINDD), Find Up (FINDU), Find using linear interpolation (FINDLIN)
  Maximum position (MAXPOS), minimum position (MINPOS)
  First Position (FIRSTPOS), Last Position (LASTPOS)
  Sub Array (SUBARRAY), return a specified number of points (INDEX)

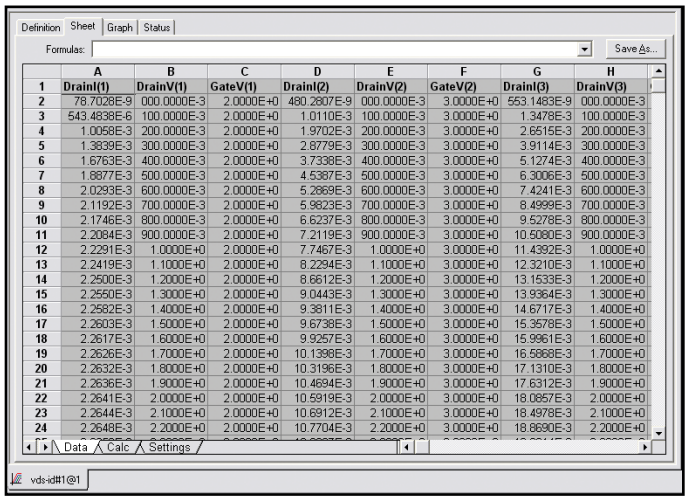
Formulator Constants

The Formulator supports user-supplied constants for use in parameter extractions. These constants are factory installed:

PI = 3.14159 rad (π)
K = 1.38065×10^{-23} J/K (Boltmann's constant)
Q = 1.60218×10^{-19} C (Charge of electron)
M_0 = 9.10938×10^{-31} kg (Electron mass)
E_V = 1.60218×10^{-19} J (Electron voltage)
U_0 = 1.25664×10^{-6} N/A^2 (Permeability)
E_0 = 8.85419×10^{-12} F/m (Permittivity of a vacuum)
H = 6.62607×10^{-34} J-s (Planck's constant)
C = $2.99792 \times 10^{+8}$ m/s (Speed of light)
KT/Q = 0.02568 V (Thermal voltage)

Sheet Tab—Data Viewing and Analysis

The Sheet Tab of a test module captures data from a test execution and allows calculations in a spreadsheet. The Sheet Tab operates like an Excel workbook with the following spreadsheets: Data, Calc, Settings, and Append.



	A	B	C	D	E	F	G	H
1	DrainI(1)	DrainV(1)	GateV(1)	DrainI(2)	DrainV(2)	GateV(2)	DrainI(3)	DrainV(3)
2	78.7028E-9	000.0000E-3	2.0000E+0	480.2807E-9	000.0000E-3	3.0000E+0	553.1483E-9	000.0000E-3
3	543.4838E-6	100.0000E-3	2.0000E+0	1.0110E-3	100.0000E-3	3.0000E+0	1.3478E-3	100.0000E-3
4	1.0058E-3	200.0000E-3	2.0000E+0	1.9702E-3	200.0000E-3	3.0000E+0	2.6515E-3	200.0000E-3
5	1.3839E-3	300.0000E-3	2.0000E+0	2.8779E-3	300.0000E-3	3.0000E+0	3.9114E-3	300.0000E-3
6	1.6763E-3	400.0000E-3	2.0000E+0	3.7338E-3	400.0000E-3	3.0000E+0	5.1274E-3	400.0000E-3
7	1.8877E-3	500.0000E-3	2.0000E+0	4.5387E-3	500.0000E-3	3.0000E+0	6.3006E-3	500.0000E-3
8	2.0293E-3	600.0000E-3	2.0000E+0	5.2869E-3	600.0000E-3	3.0000E+0	7.4241E-3	600.0000E-3
9	2.1192E-3	700.0000E-3	2.0000E+0	5.9823E-3	700.0000E-3	3.0000E+0	8.4999E-3	700.0000E-3
10	2.1746E-3	800.0000E-3	2.0000E+0	6.6237E-3	800.0000E-3	3.0000E+0	9.5278E-3	800.0000E-3
11	2.2084E-3	900.0000E-3	2.0000E+0	7.2119E-3	900.0000E-3	3.0000E+0	10.5080E-3	900.0000E-3
12	2.2291E-3	1.0000E+0	2.0000E+0	7.7487E-3	1.0000E+0	3.0000E+0	11.4392E-3	1.0000E+0
13	2.2419E-3	1.1000E+0	2.0000E+0	8.2294E-3	1.1000E+0	3.0000E+0	12.3210E-3	1.1000E+0
14	2.2500E-3	1.2000E+0	2.0000E+0	8.6612E-3	1.2000E+0	3.0000E+0	13.1533E-3	1.2000E+0
15	2.2550E-3	1.3000E+0	2.0000E+0	9.0443E-3	1.3000E+0	3.0000E+0	13.9364E-3	1.3000E+0
16	2.2582E-3	1.4000E+0	2.0000E+0	9.3811E-3	1.4000E+0	3.0000E+0	14.6717E-3	1.4000E+0
17	2.2603E-3	1.5000E+0	2.0000E+0	9.6738E-3	1.5000E+0	3.0000E+0	15.3578E-3	1.5000E+0
18	2.2617E-3	1.6000E+0	2.0000E+0	9.9257E-3	1.6000E+0	3.0000E+0	15.9961E-3	1.6000E+0
19	2.2626E-3	1.7000E+0	2.0000E+0	10.1398E-3	1.7000E+0	3.0000E+0	16.5868E-3	1.7000E+0
20	2.2632E-3	1.8000E+0	2.0000E+0	10.3196E-3	1.8000E+0	3.0000E+0	17.1310E-3	1.8000E+0
21	2.2636E-3	1.9000E+0	2.0000E+0	10.4694E-3	1.9000E+0	3.0000E+0	17.6312E-3	1.9000E+0
22	2.2641E-3	2.0000E+0	2.0000E+0	10.5919E-3	2.0000E+0	3.0000E+0	18.0857E-3	2.0000E+0
23	2.2644E-3	2.1000E+0	2.0000E+0	10.6912E-3	2.1000E+0	3.0000E+0	18.4978E-3	2.1000E+0
24	2.2648E-3	2.2000E+0	2.0000E+0	10.7704E-3	2.2000E+0	3.0000E+0	18.8690E-3	2.2000E+0

Data Sheet

The Data sheet displays test results in real time. It is read-only so that results cannot be modified.

Calc Sheet

A spreadsheet that operates much like a standard Microsoft Excel spreadsheet is available for computation with each test. The spreadsheet tool supports these functions:

Functions in the KITE Calc sheet

ABS	ACOS	ACOSH	ASIN	ASINH
ATAN	ATAN2	ATANH	AVERAGE	COS
COSH	EXP	FIXED	IF	LN
LOG	LOG10	LOOKUP	MATCH	MAX
MIN	NOW	PI	PRODUCT	ROUND
SIGN	SIN	SINH	SQRT	STDEVP
SUM	SUMSQ	TAN	TANH	VARP

Settings Sheet

The Settings sheet stores the test setup so that when the Sheet tab is exported as a workbook, users can refer to the test configuration. The test setups for multiple appends are also stored.

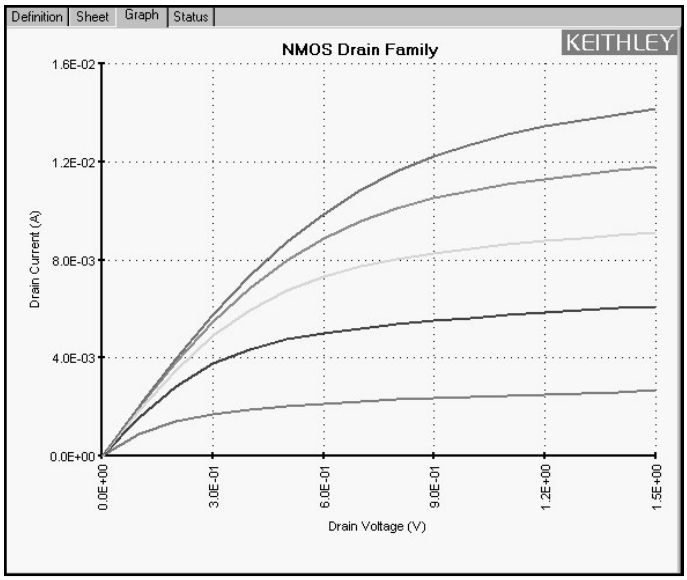
Append Sheet

Append sheets store test results when the Append button is clicked. Data in Append sheets can be automatically plotted on the graph. Test modules support up to 40 Append sheets.

Graph Tab—Plotting

The Graph Tab is a full-featured plotting tool for creating report-ready graphs. It allows real-time X-Y plotting of acquired and extracted data with one or two Y axes.

- Dual graphs per tab.
- Linear, Semilog, and Log/Log graphs.
- Real-time auto scaling, end of test auto scaling, or manual scaling.
- Six cursors with X-Y readout.
- Graphical line fitting.
- Plot overlay of multiple test executions.
- Four data variable readouts.
- User-formatted comment box, title, and axis labels.
- Choice of engineering units on axes: V (volts), A (amps), s (seconds), S (Siemens), F (farads), Hz (Hertz).
- Choice of engineering symbols on axes: m, μ, n, etc.



Output

Files

- Sheet tab test results can be saved as a Microsoft Excel Workbook or a delimited ASCII text file.
- Plots can be saved as bit map image (.bmp), JPEG (.jpg), or TIFF (.tif) files.

Display

- Flat Panel: 1024 × 768 resolution.
- External SVGA: Up to 1920 × 1200 resolution.

Printers

Windows printer drivers are used to support a wide variety of print and plot devices.

Example Projects

The 4200-SCS includes the following KITE projects to facilitate rapid start-up and provide examples for common semiconductor lab applications.

Default Project

Default—The default project includes standard tests for MOSFETs, BIPOLAR transistors, resistors, and diodes. This project helps users get started quickly.

Memory Projects

These projects test floating gate FLASH and embedded NVM memory. They test up to four independent, multi-level pulse channels with up to ±40V pulsing on the gate. The waveforms can be predefined or custom. These projects also offer three types of DUT setups: NAND, NOR, and switch based.

Flash-NOR, Flash-NAND, Flash-Switch: These projects provide the ability to send n pulses to the DUT, then perform a V_T sweep. The tests in these projects support four- and eight-terminal testing and allow investigation into program and erase state dependencies on pulse parameters using three types of waveforms: program, erase, and fast program erase. Flash-Switch also includes automatic control of Keithley's Model 707B or Model 708B Switch Matrix.

FlashDisturb-NOR, FlashDisturb-NAND, FlashDisturb-Switch: The Disturb tests pulse stress a device in an array test structure, then perform a measurement, such as V_T, on a device adjacent to the pulsed device. The goal is to measure the amount of V_T shift in adjacent cells, either in the programmed or erased states, when a nearby device is pulsed with either program, erase, or program+erase waveforms. FlashDisturb-Switch also includes automatic control of Keithley's Model 707B or Model 708B Switch Matrix.

FlashEndurance-NOR, FlashEndurance-NAND, FlashEndurance-Switch: These projects pulse stress the DUT with a number of Program+Erase waveform cycles, then periodically measure the V_T. The purpose of these projects is to determine the lifetime of the DUT, based on the number of program+erase cycles withstood by the device before a certain amount of shift, or degradation, in the V_T or other measurement. They also control in-line solid-state relays for the erase waveform cycle. FlashEndurance-Switch also includes automatic control of Keithley's Model 707B or Model 708B Switch Matrix.

PMU-Flash-NAND: Demonstrates the FLASH memory testing capabilities of the Model 4225-PMU.

PRAM: Tests a Phase Change Random Access Memory (PRAM or PCRAM) device using the Model 4225-PMU. Includes set, reset, I-V, and RI tests.

RRAM: Tests Resistive Random Access Memory (RRAM, Memristor) devices using the Model 4225-PMU. Includes conditioning, set, reset, I-V, and other tests.

CMOS Project

CMOS-default: The tests in this project include the most common CMOS device tests that a typical user might perform on a daily basis.

BJT Project

BJT-default: The tests in this project represent the most common BJT tests that a typical user might perform on a daily basis.

Reliability Projects

EM_const_I: Tests electromigration using constant current. It also controls a hot chuck.

HCI_1_DUT: This is a Hot Carrier Injection (HCI) project on one 4-terminal N-MOSFET. No switch matrix is involved in the measurement. Parameters monitored between two successive stresses include I_{Doff}, I_{Don}, I_G, V_T, and G_m. Those parameters are measured on both forward (normal operation condition) and reverse (reverse source and drain bias) conditions. If only a subset of these parameters is needed, it is possible to deselect the test(s) that include the unwanted parametric measurements. It is also possible to add custom tests that will be monitored between successive stresses.

HCI_4_DUT: This is a Hot Carrier Injection (HCI) project on two 4-terminal N-MOSFETs and two 4-terminal p-MOSFETs with a switch matrix. Parameters monitored between two successive stresses include I_{Doff}, I_{Don}, I_G, V_T, and G_m. Those parameters are measured on both forward (normal operation condition) and reverse (reverse source and drain bias) conditions. If only a subset of these parameters is needed, it is possible to deselect the test(s) that include the unwanted parametric measurements. It is also possible to add custom tests that will be monitored between successive stresses. Also, if less than four devices are tested, it is possible to deselect the unwanted device plan in the project tree or modify it for more devices.

HCI_PULSE: This Hot Carrier Injection (HCI) project tests one 4-terminal N-MOSFET using AC stress. It is similar to HCI_1_DUT.

NBTI_1_DUT: This is a Negative Bias Temperature Instability (NBTI) project on one 4-terminal P-MOSFET. Parameters monitored between two successive stresses include I_{Doff}, I_{Don}, I_G, V_T, and G_m. If only a subset of these parameters is needed, it is possible to deselect the test(s) that include the unwanted parametric measurements. It is also possible to add custom tests that will be monitored between successive stresses.

Qbd: This charge-to-breakdown project consists of two Q_{BD} tests on gate dielectrics (V-Ramp and J-Ramp). Those two tests follow JEDEC Standard 35-A. An additional test performs an I-V measurement under normal work conditions to obtain input parameters for the V-Ramp and J-Ramp tests.

Pulse Projects

Chargepumping: This project consists of Charge Pumping (CP) tests that characterize interface and charge-trapping phenomena. There are a variety of tests, including base sweep, amplitude sweep, rise time linear sweep, fall time linear sweep, frequency linear sweep, and frequency log sweep.

ChargeTrapping: The Charge Trapping project uses a single pulse technique to look at device charge trapping and de-trapping behavior within a single, well-configured gate pulse. During the rise and fall times of the voltage ramp, the corresponding drain current response is captured, allowing appropriate V_{GS}–I_D curves to be formed.

ivpgswitch_340x: The tests in this project demonstrate automated device testing using a 4200-SCS, a Keithley Model 3402 pulse generator, and a switch matrix.

ivpgswitch: The tests in this project demonstrate automated device testing using a 4200-SCS, an HP8110A/81110A pulse generator, and a switch matrix.

PMU-DUT-Examples: Contains example test modules to test a MOSFET using the Model 4225-PMU.

PMU-MOSFET: Contains test modules for performing measurements on a MOSFET, including generating DC and pulsed I-V drain families of curves and gate voltage vs. drain current measurements.

PMU-Switch: Provides examples for switching between the Model 4225-PMU, 4200-SMU, and 4200-CVU to the DUT.

PulseIV-Complete: This project provides PIV (pulse IV) tests, including tests that generate I_D vs. V_D graphs and I_D vs. V_G graphs as well as tests that show the effect of self-heating on devices due to DC voltages. (This is the primary sample project included in the 4200-PIV-A package.)

QPulseIV-Complete: This project includes PIV-Q tests that generate I_D vs. V_D and I_G vs. V_D graphs for a FET as well as calibration routines. This project is used to run characterization curves on III-V and LDMOS high power devices using the pulse technique and a non-zero quiescent point.

Solar Cell Project

SolarCell: This project is designed for photovoltaic cells of all types, including crystalline, amorphous, and thin film. I-V, C-V, and resistivity tests are included.

Nanotechnology Project

NanoDevices: This project is designed specifically for Nanotechnology applications and includes the most common tests for nanowires, nanotubes, molecular and CNT transistors, and biocomponents.

C-V Projects

CVU_BJT: Measures capacitance (at 0V bias) between terminals, including C_{be}, C_{bc}, and C_{ec}.

CVU_Capacitor: Performs both a C-V sweep and a C-f sweep on a Metal-Insulator-Metal (MIM) capacitor and calculates standard deviation.

CVU_highV: Performs C-V and C-T sweeps using the Model 4200-CVU-PWR C-V Power Package up to 400V.

CVU_InterconnectCap: Measures C-V of small interconnect capacitance on wafer.

CVU_ivcvswitch: Demonstrates using DC SMUs, 4210-CVU, and 707B/708B (switch matrix) in one project. Switches back and forth between DC and C-V tests and connections to the DUT.

CVU_Lifetime: Determines generation velocity and lifetime testing (Zerbst plot) of MOS capacitors.

CVU-MobileIon: Determines mobile charge using the bias-temperature stress method. Extracts flatband voltage. Includes built-in control of a hot chuck to test a sample at room temperature, heated, then tested again at room temperature to determine flatband shift.

CVU_MOScap: Measures C-V on a MOS capacitor. Extracted parameters include oxide capacitance, oxide thickness, doping density, depletion depth, Debye length, flatband capacitance, flatband voltage, bulk potential, threshold voltage, metal-semiconductor work function difference, and effective oxide charge.

CVU_MOSFET: Makes a C-V sweep on a MOSFET device. Extracted/calculated parameters include oxide thickness, oxide capacitance, flatband capacitance, flatband voltage, threshold voltage, and doping concentration as a function of depletion depth.

CVU_nanowire: Makes a C-V sweep on a two-terminal nanowire device.

CVU_PNjunction: Measures the capacitance of a p-n junction or Schottky diode as a function of the DC bias voltage across the device.

CVU_PVcell: Measures both forward and reverse biased DC characteristics of an illuminated solar cell and extracts parameters such as max power, max current, max voltage, short-circuit current, open-circuit voltage, and efficiency. Also performs characteristic C-V and C-f sweeps.

default: Standard C-V sweeps for generic MOSFETs, diodes, and capacitors.

ivcvswitch: The tests in this project demonstrate the 4200-SCS's integrated I-V, C-V, switching, and probing capabilities.

lifetime: The lifetime project performs high frequency C-t measurements using the Keithley System 82 on MOS capacitors. The minority carrier recombination lifetime and surface velocity are extracted using a Zerbst Plot.

QSCV: Performs Quasistatic C-V using the 4200's SMUs and PAs using the Ramp Rate method.

SIMCV: This project provides routines for simultaneous C-V measurement using the Keithley System 82. Typical MOS device parameters, such as doping profile, flat band voltage, threshold voltage, interface trap density, and band bending are extracted.

STVS: This project uses the Keithley System 82 to perform an STVS (Simultaneous Triangular Voltage Sweep) measurement at high temperature. Mobile ion density is extracted.

Miscellaneous Projects

FourPtProbe: This project enables users to make four-point collinear probe measurements on semiconductor materials.

ivswitch: The ivswitch project integrates control of a Keithley Model 707B or Model 708B external switch matrix with device testing.

probesites: The probesites project illustrates how KITE controls semi-automatic probe stations for automated probing of one subsite per site on a single wafer.

probesubsites: The probesubsites project illustrates how KITE controls semi-automatic probe stations when testing multiple subsites per site on a single wafer.

vdp_resistivity: This project enables users to make Van der Pauw measurements on semiconductor materials.

LowCurrent: This project demonstrates sub-10fA performance on four SMUs.

Demonstration Projects

Demo-Default: The tests in this project demonstrate the most common DC tests on an FET. Also, new features that were recently introduced are demonstrated, including pulse SMU, dual sweep, and selecting Engineering labels for the axes.

Demo-ALL: This project collects more than 400 different test libraries in one convenient location.

Automation

Test Sequencing

The Keithley Interactive Test Environment (KITE) provides "point and click" test sequencing on a device, a group of devices (subsite, module, or test element group), or a user-programmable number of probe sites on a wafer.

Prober Control

Keithley provides integrated prober control for supported analytical probers when test sequencing is executed on a user-programmable number of probe sites on a wafer. Contact the factory for a list of supported analytical probers. A "manual" prober mode prompts the operator to perform prober operations during the test sequence.

Supported Probers

Manual Prober

Use the manual prober driver to test without utilizing automatic prober functionality. Manual prober replaces all computer control of the prober with that of the operator. At each prober command, a dialog box appears, instructing the operator what operation is required.

Fake Prober

The Fake prober is useful when prober actions are not desired, such as when debugging, without having to remove prober commands from a sequence.

Supported Semi-automatic (Analytical) Probers

Cascade Microtech Summit™ 12K Series, verified with Nucleus UI

Karl Suss Model PA-200, verified with Wafermap for ProberBench NT, NI-GPIB Driver for ProberBench NT, PBRS232 Interface for ProberBench NT, Navigator for ProberBench NT, Remote Communicator for ProberBench NT

MicroManipulator 8860 Prober, verified with pcBridge, pcLaunch, pcIndie, pcWfr, pcNav, pcRouter

Signatone CM500 driver also works with other Signatone probers with interlock controller such as the WL250 and S460SE

Optional Software

Automated Characterization Suite (ACS) V4.2 for reliability testing, general characterization, and lab automation. For more information on these capabilities, refer to the Model 4200-BTI-A data sheet.

Keithley User Library Tool (KULT)

(Requires optional Model 4200-COMPILER)

The Keithley User Library Tool supports creating and integrating C-language subroutine libraries with the test environment. User library modules are accessed in KITE through User Test Modules. Factory supplied libraries provide up and running capability for supported instruments. Users can edit and compile subroutines, then integrate libraries of subroutines with KITE, allowing the 4200-SCS to control an entire test rack from a single user interface.

Standard User Libraries

The 4200-SCS includes the following subroutine libraries, which provide "out of the box" integration and control of Keithley switch matrix systems and other common device characterization equipment. Users access these libraries with the UTM definition tab described on page 15.

chargepumping

This library can be used to study charge trapping and new charge creation on a high κ–Si interface and within high κ film.

hotchuck-temptronics-3010b

This user library controls the temperature of Temptronics 3010b hotchucks. This library sets the target temperature and waits until the target is reached before exiting.

hotchuck_triotek

The hotchuck_triotek user library controls the temperature of TrioTek hot chucks. This library sets the target temperature and waits until the target is reached before exiting.

hp4284ulib

The hp4284ulib user library performs capacitance measurements and C-V sweeps using the Agilent 4284A or 4980 LCR meter.

hp4294ulib

The hp4294ulib user library performs capacitance measurements, C-V sweeps, and frequency sweeps using the Agilent 4294 LCR meter. This library also includes calibration routines to perform phase, open, short, and load calibrations.

hp8110ulib

The hp8110ulib user library performs initialization, setup, and triggering for the Agilent HP8110A (or 81110A) pulse generator.

ki42xxulib

The ki42xxulib user library provides an example subroutine for performing a MOSFET ON resistance (R_{ON}) test routine using the 4200-SCS LPTLIB interface.

ki82ulib

The ki82ulib user library performs simultaneous C-V, C-t, and Q/t measurements and cable compensation for the Keithley System 82 Simultaneous C-V System.

ki340xulib

For use with Keithley Series 3400 pulse/pattern generators.

ki590ulib

The ki590ulib user library performs conductance measurements and 100kHz or 1MHz capacitance measurements, C-V sweeps, C-V pulse sweeps, C-t sweeps, and cable compensation for the Keithley Model 590 C-V Analyzer.

ki595ulib

The ki595ulib user library performs Q/t sweeps and C-V sweeps using the Keithley Model 595 Quasistatic C-V Meter.

kipulseulib

The kipulseulib UTMs control the Model 4205-PG2, 4220-PGU, or 4225-PMU pulse card.

kiscopeulib

The kiscopeulib UTMs control either the Model 4200-SCP2HR or 4200-SCP2 oscilloscope.

matrixulib

The matrixulib user library connects instrument terminals to output pins using a Keithley 707B or 708B switch system when configured as a general-purpose (Model 4200-GP-RS-XX), low current (Model 4200-LC-LS-XX) or ultra-low current (Model 4200-UL-RS-XX or Model 4200-UL-LS-XX) matrix.

parlib

The parlib user library is used for extracting device parameters on bipolar and MOSFET transistors. Extracted parameters include Beta, resistance, threshold voltage, and V_{DS}–I_D sweeps and V_{GS}–I_D sweeps for MOSFETs.

prbgen

The prbgen user library provides test modules to initialize the prober driver, move to the next site or subsite in the prober's wafer map, make or break contact between the probes and the wafer, and obtain the X position and Y position of the prober. Contact the factory for supported probers.

winulib

The winulib user library provides user interface routines for operator inputs and prompts, such as the abort, retry, and ignore decision prompts.

wlrlib

The wlrlib user library includes routines for performing linear regression and charge-to-breakdown tests (Q_{BD}) on gate dielectrics. Included modules are qbd_rmpv (V-Ramp method) and qbd_rmpj (J-Ramp method).

C language

Microsoft Visual Studio Professional (optional Model 4200-COMPILER) provides the compiler for the Keithley User Library Tool (KULT). Users can develop test subroutine libraries using the full capabilities of C-language programming.

LPTLIB Control

The LPTLIB provides an application programming interface for developing C-language test routines that control integrated test hardware and supported external instruments and switches. This simple connect/source/measure approach eliminates the need for low-level programming and allows the user to focus on creating new test routines quickly.

System Configuration and Diagnostics (KCON)

The Keithley Configuration Utility (KCON) simplifies programming and maintaining a fully integrated test station. KCON provides a single interface for configuring external instruments, switch matrices, and analytical probers, and for executing system diagnostics.

External Instrument Configuration

KCON allows lab managers to integrate external instruments with the 4200-SCS and a supported switch matrix. After the user configures the GPIB addresses for supported instruments, Keithley-supplied libraries will function and test modules can be transferred between 4200-SCS systems without any user modification. In addition to the standard supported instruments, the General Purpose Instrument allows users to develop subroutines and control switches for a generic two-terminal or four-terminal instrument. For the widest possible system extensibility, users can develop their own test libraries for general purpose instruments.

Switch Matrix Configuration

Users define the connection of 4200-SCS instruments and external instruments to device under test (DUT) pins through a supported switch matrix configuration. (See Switch Matrix Support and Configurations). Once connections are defined, users need only enter the instrument terminal name and pin number to establish connections. The 4200-SCS applications and standard user libraries manage the routing of test signals between instrument terminals and DUT pins. The user doesn't need to remember and program row and column closures. Test modules can transfer between 4200-SCS systems without re-entering connection information.

4200-SCS Instrument Diagnostics

Users can confirm system integrity of SMUs, C-V measurement unit, pulse generator, oscilloscopes, and Remote PreAmps by running a system self-test. For more complex problems, the system's configuration analysis tool can generate reports that assist Keithley's Technical Support staff in diagnosing problems.

Keithley External Control Interface (KXCI)

With KXCI, you can use an external computer to control the SMUs and CVU modules in the Model 4200-SCS directly. KXCI also provides you with indirect control of the Ultra-fast I-V and Oscilloscope modules using UTMs via either the built-in GPIB or Ethernet. For the SMUs, the KXCI command set includes an HP 4145 compatibility mode, allowing many programs already developed for the HP4145 to use the 4200-SCS instead.

Support Contracts

Note: ISO-17025/2540.3 accredited calibrations are also available for the base system. Call Keithley for more information.

On-Site Services

Our field service engineers can perform some calibrations and repair services at your facility. Call Keithley to ask about on-site services for the 4200-SCS.

Off-Site Services

Base System

4200-3Y-EW	1-year factory warranty on the **base 4200-SCS (including all SMUs and PAs)** extended to 3 years from date of shipment. Includes calibration (reports compliant to ANSI Z540-1) and return shipping.
4200-5Y-EW	1-year factory warranty on the **base 4200-SCS (including all SMUs and PAs)** extended to 5 years from date of shipment. Includes calibration (reports compliant to ANSI Z540-1) and return shipping.
4200-3Y-CAL	3 calibrations within 3 years of purchase of the **base 4200-SCS (including all SMUs and PAs)**. Before and after data reports compliant with ANSI/NCSL Z540-1. Does not cover CVU Scope or Pulse Generator Cards.
4200-5Y-CAL	5 calibrations within 5 years of purchase of the **base 4200-SCS (including all SMUs and PAs)**. Before and after data reports compliant with ANSI/NCSL Z540-1. Does not cover CVU Scope or Pulse Generator Cards.

Oscilliscope Option

4200-SCP2-3Y-EW	1-year factory warranty on the 4200-SCS Scope Card (Standard or HR version) extended to 3 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-3Y-EW.
4200-SCP2-5Y-EW	1-year factory warranty on the 4200-SCS Scope Card (Standard or HR version) extended to 5 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-5Y-EW.
4200-SCP2-3Y-CAL	3 calibrations within 3 years of purchase of the 4200-SCS Scope Card (Standard or HR version). Requires purchase of 4200-3Y-CAL.

Support Contracts

Off-Site Services

Oscilliscope Option (continued)

4200-SCP2-5Y-CAL	5 calibrations within 5 years of purchase of the 4200-SCS Scope Card (Standard or HR version). Requires purchase of 4200-5Y-CAL.

Pulse Generator Option

4220-PGU-3Y-EW	1-year factory warranty on the 4220-PGU Dual-Channel Pulse Generator extended to 3 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-3Y-EW.
4220-PGU-5Y-EW	1-year factory warranty on the 4220-PGU Dual-Channel Pulse Generator extended to 5 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-5Y-EW.
4220-PGU-3Y-CAL	3 calibrations within 3 years of purchase of the 4220-PGU Dual-Channel Pulse Generator. Requires purchase of 4200-3Y-CAL.
4220-PGU-5Y-CAL	5 calibrations within 5 years of purchase of the 4220-PGU Dual-Channel Pulse Generator. Requires purchase of 4200-5Y-CAL.

Ultra-Fast I-V Module Option

4225-PMU-3Y-EW	1-year factory warranty on both the 4225-PMU Ultra-Fast I-V Module and the 4225-RPM Remote Amplifier/Switch extended to 3 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-3Y-EW.
4225-PMU-5Y-EW	1-year factory warranty on both the 4225-PMU Ultra-Fast I-V Module and the 4225-RPM Remote Amplifier/Switch extended to 5 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-5Y-EW.
4225-PMU-3Y-CAL	3 calibrations within 3 years of purchase of both the 4225-PMU Ultra-Fast I-V Module and the 4225-RPM Remote Amplifier/Switch. Requires purchase of 4200-3Y-CAL.
4225-PMU-5Y-CAL	5 calibrations within 5 years of purchase of both the 4225-PMU Ultra-Fast I-V Module and the 4225-RPM Remote Amplifier/Switch. Requires purchase of 4200-5Y-CAL.

Value-Add Services

APPS SERVICE Customized applications assistance. Examples include:

- Software services – KULT/UTM development and customization
- Applications assistance – test plan development, test process optimization, measurement troubleshooting
- System development – integration of a 4200-SCS with other elements of a test system, such as a switch matrix or a C-V meter

Training services are available. Please contact Keithley for information.

Visit Keithley's Technical Support Web Forums to get answers to your product support and applications questions 24/7.

Other Upgrades

Besides adding the instrument modules listed on page 27, there are other upgrades available for the 4200-SCS/x.

4200-KTEI-x.x	4200-SCS Keithley Test Environment Interactive (KTEI) complete software test suite (latest version). Includes installation CD and instructions. Not available for Version 1 (Windows NT) chassis.
4200-Upgrade	Required installation and calibration service when any instrument module is added to any 4200-SCS chassis. Only one 4200-Upgrade required per instrument module upgrade order. Not required for 4200-Chassis-Refurb or the 4200-Complete-Refurb.
4200-Complete-Refurb	This upgrade service will bring any 4200-SCS chassis (including Version 1 Windows NT systems) up to the latest CPU and instrument capability.

Note: 4200-Complete-Refurb restores the 4200-SCS to factory conditions, including re-formatting the hard drive. All existing data and programs will be lost. Be sure to create a backup of all data and projects prior to ordering either of these upgrades.

Embedded PC Policy

Caution: Keithley Instruments warrants the performance of the Model 4200-SCS only with the factory-approved Windows Operating System and applications software pre-installed on the 4200-SCS by Keithley Instruments. Systems that have been modified by the addition of un-approved third-party application software (software that is not explicitly approved and supported by Keithley Instruments) are not covered under the product warranty. Model 4200-SCS systems with unapproved software may need to be restored to factory approved condition before any warranty service can be performed (e.g., calibration, upgrade, technical support). Services provided by Keithley Instruments to restore systems to factory approved condition will be treated as out-of-warranty services with associated time and material charges. Approved software is listed in the Reference Manual and under "Approved Third-Party Software" on page 25 of this document.

CAUTION: DO NOT reinstall or upgrade the Windows operating system (OS) on any Model 4200-SCS. This action should only be performed at an authorized Keithley service facility. Violation of this precaution will void the Model 4200-SCS warranty and may render the Model 4200-SCS unusable. Any attempt to reinstall or upgrade the Windows operating system will require a return-to-factory repair and will be treated as an out-of-warranty service, including time and material charges.

Warranty Information

Warranty Summary

This section summarizes the warranties of the 4200-SCS. For complete warranty information, refer to the 4200-SCS Reference Manual. Any portion of the product that is not manufactured by Keithley is not covered by this warranty and Keithley will have no duty to enforce any other manufacturer's warranties.

Hardware Warranty

Keithley Instruments, Inc. warrants the Keithley manufactured portion of the hardware for a period of one year from defects in materials or workmanship; provided that such defect has not been caused by use of the Keithley hardware which is not in accordance with the hardware instructions. The warranty does not apply upon any modification of Keithley hardware made by the customer or operation of the hardware outside the environmental specifications.

Software Warranty

Keithley warrants for the Keithley produced portion of the software or firmware will conform in all material respects with the published specifications for a period of ninety (90) days; provided the software is used on the product for which it is intended in accordance with the software instructions. Keithley does not warrant that operation of the software will be uninterrupted or error-free, or that the software will be adequate for the customer's intended application. The warranty does not apply upon any modification of the software made by the customer.

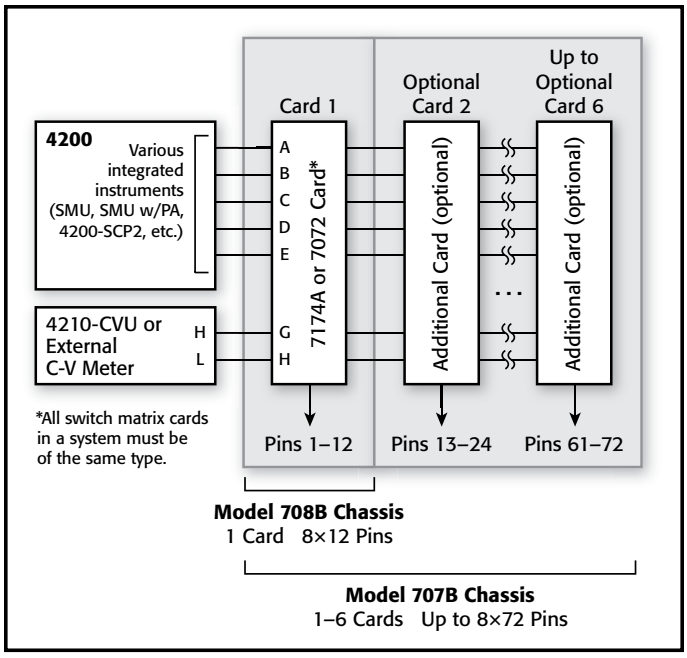
Approved Third-Party Software:

Acronis True Image (OEM)
Adobe Acrobat 8.0 or later
Adobe Acrobat Reader 8.0 or later
Diskeeper 9.0 or later
Kaspersky Anti-Virus 2009 or later
McAfee Virus Scan Plus 2009 or later
Microsoft Excel
Microsoft Internet Explorer 7.0 or later
Microsoft Word
Norton AntiVirus 2000 6.0 or later
Symantec pcAnywhere 11.0
TrendMicro Anti-Virus 2008 or later
Visual C++ .net
Visual Studio 2010 Professional Edition
Windows XP Professional

Switch Matrix Support and Configurations

Overview

A number of useful standard switch matrix configurations are available for the 4200-SCS. Each standard configuration includes all components, cabling, and instructions for the user to assemble the switch matrix and add the matrix configuration to the 4200-SCS test environment. Once a supported configuration is added to the test environment, the 4200-SCS standard user library (matrixulib) connects instrument terminals to output pins through a simple "fill-in-the-blank" interface.



Basic block diagram of 4200-SCS configurations

Ultra-Low Current/Local Sense Configuration (4200-UL-LS-XX)

The Ultra-Low Current/Local Sense switch configuration is built using the Keithley Model 7174A Low Current Matrix Card (with the Model 707B or 708B Switch Matrix), which is designed for semiconductor research, development, and production applications requiring high quality, high performance switching of I-V and C-V signals. This configuration provides eight instrument inputs with up to 72 output pins at only 10fA typical offset current.

4200-UL-LS-12/B (or -12/707B)

1 708B (or 707B) Switch Mainframe
1 7174A Switch Card
12 4200-TRX-3 Cable for each 12 pins
1 7007-1 IEEE-488 Cable
2 7078-TRX-BNC Adapter

4200-UL-LS-24B, -36B, -48B, -60B, -72B

1 707B Switch Mainframe
1 7174A Switch Card for each 12 pins
12 4200-TRX-3 Cable for each 12 pins
1 7007-1 IEEE-488 Cable
2 7078-TRX-BNC Adapter

Connector Type: 3-lug triax.
Maximum Signal Level: 200V, 2A.
Offset Current: 100fA max, 10fA typical.
Maximum Leakage: 0.01pA/V.
3dB Bandwidth: 30MHz typical.

Low Current/Local Sense Configuration (4200-LC-LS-XX)

The Low Current/Local Sense switch configuration is built using the Keithley Model 7072 Semiconductor Matrix Card, which is designed for semiconductor applications requiring good quality I-V and C-V signals. The configuration provides eight instrument inputs with up to 72 output pins with less than 1pA offset current.

4200-LC-LS-12/B (or -12/707B)

1 708B (or 707B) Switch Mainframe
1 7072 Matrix Switch Card
12 4200-TRX-3 Cable
1 7007-1 IEEE-488 Cable
2 7078-TRX-BNC Adapter

4200-LC-LS-24/B, -36/B, -48/B, -60/B, -72/B

1 707B Switch Mainframe
1 7072 Matrix Switch Card for each 12 pins
12 4200-TRX-3 Cable for each 12 pins
1 7007-1 IEEE-488 Cable
2 7078-TRX-BNC Adapter

Connector Type: 3-lug triax.
Maximum Signal Level: 200V, 1A.
Offset Current: <1pA (Rows A–B).
Maximum Leakage: 0.1pA/V.
3dB Bandwidth: 5MHz typical (Rows G–H).

4200-SCS Parameter Analyzer Supplied Accessories

Mainframe	Description	Supplied Accessories
4200-SCS	Parameter Analyzer Mainframe	(1) 236-ILC-3 Interlock Cabe, 3m (10 ft) (2) 4200-TRX-2 Ultra Low Noise Triax Cables, 2m (6.6 ft)
Instrument Modules	**Description**	**Supplied Accessories**
4200-SMU	Medium Power Source-Measure Unit for 4200-SCS, 100mA to 100fA, 200V to 1μV, 2 Watts	*If configured with a preamp:* All cables are provided with the 4200-PA. See 4200-PA below. *If configured without a preamp:* (2) 4200-MTRX-2 Mini Ultra Low Noise Triax Cables, 2m (6.6 ft.)
4210-SMU	High Power Source-Measure Unit for 4200-SCS, 1A to 100fA, 200V to 1μV, 20 Watts	*If configured with a preamp:* All cables are provided with the 4200-PA. See 4200-PA below. *If configured without a preamp:* (2) 4200-MTRX-2 Mini Ultra Low Noise Triax Cables, 2m (6.6 ft.)
4200-PA	Remote PreAmp Option for 4200-SMU and 4210-SMU, extends SMU to 10aA resolution	(1) 4200-RPC remote preamp cable, 2m (6.6 ft) (2) 4200-TRX-2 Ultra Low Noise Triax Cables, 2m (6.6 ft)
4210-CVU	Capacitance-Voltage (C-V) Module	(4) CA-447A SMA Cables, male to male, 100Ω, 1.5m (5 ft) • (4) CS-1247 Female SMA to Male BNC Adapters (2) CS-701 BNC Tee Adapters • (1) TL-24 SMA Torque Wrench
4225-PMU	Ultra-Fast I-V Module	(4) SMA-to-SMA 50Ω cables, 2m (6.6 ft) (2) SMA-to-SSMC Y-Cable Assembly, 6 in.
4225-RPM	Remote Amplifier/Switch	(1) SMA-to-SMA 50Ω Cable, 20cm (7.9 in), (1) Triax-to-BNC Adapter, (1) BNC-to-SMA Adapter, (1) RPM Cable, 2.1m (6.9 ft)
4220-PGU	High Voltage Pulse Generator	(4) SMA-to-SMA 50Ω cables, 2m (6.6 ft), (2) SMA-to-SSMC Y-Cable Assembly, 6 in.
Switching Systems and Cards	**Description**	**Supplied Accessories**
707B	6-slot Switching Matrix Mainframe	CA-180-4A CAT 5 Ethernet Crossover Cable, 1m (3.3 ft) • CA-179-2A CAT 5 Ethernet Cable 3m (10 ft) CO-7 Line Cord • Rear Fixed Rack Mount Hardware
708B	Single-slot Switching Matrix Mainframe	CA-180-4A CAT 5 Ethernet Crossover Cable, 1m (3.3 ft) • CA-179-2A CAT 5 Ethernet Cable 3m (10 ft) • CO-7 Line Cord
7072	8×12, Semiconductor Matrix Card	
7072-HV	8×12, High Voltage, Semiconductor Matrix Card	
7173-50	4×12, Two-Pole, High Frequency, Matrix Card	
7174A	8×12, High Speed, Low Leakage Current, Matrix Card	

OPTIONAL ACCESSORIES

CONNECTORS AND ADAPTERS

CS-565	Female BNC to Female BNC Adapter
CS-701	BNC Tee Adapter (female, male, female)
CS-719	3-lug Triax Jack Receptacle
CS-1247	SMA Female to BNC Male Adapter
CS-1249	SMA Female to SMB Plug Adapter
CS-1251	BNC Female to SMB Plug Adapter
CS-1252	SMA Male to BNC Female Adapter
CS-1281	SMA Female to SMA Female Adapter
CS-1382	Female MMBX Jack to Male SMA Plug Adapter
CS-1390	Male LEMO Triax to Female SMA Adapter
CS-1391	SMA Tee Adapter (female, male, female)
CS-1479	SMA Male to BNC Male Adapter
237-BAN-3A	Triax Cable Center Conductor terminated in a safety banana plug
237-BNC-TRX	Male BNC to 3-lug Female Triax Adapter
237-TRX-BAR	3-lug Triax Barrel Adapter (female to female)
237-TRX-T	3-slot Male to Dual 3-lug Female Triax Tee Adapter
7078-TRX-BNC	3-Slot Male Triax to BNC Adapter
7078-TRX-GND	3-Slot Male Triax to Female BNC Connector (guards removed)

TEST FIXTURES

8101-4TRX	4-pin Transistor Fixture
8101-PIV	Pulse I-V Demo Fixture
LR8028	Component Test Fixture

CABINET MOUNTING ACCESSORIES

4200-RM	Fixed Cabinet Mount Kit

CABLES AND CABLE SETS

NOTE: All 4200-SCS systems and instrument options are supplied with required cables, 2m (6.5 ft.) length.

CA-19-2	BNC to BNC Cable, 1.5m
CA-404B	SMA to SMA Coaxial Cable, 2m
CA-405B	SMA to SMA Coaxial Cable, 15cm
CA-406B	SMA to SMA Coaxial Cable, 33cm
CA-446A	SMA to SMA Coaxial Cable, 3m
CA-447A	SMA to SMA Coaxial Cable, 1.5m
CA-451A	SMA to SMA Coaxial Cable, 10.8cm
CA-452A	SMA to SMA Coaxial Cable, 20.4cm
236-ILC-3	Safety Interlock Cable, 3m
237-ALG-2	Low Noise Triax Input Cable terminated with 3 alligator clips, 2m
4210-MMPC-C	Multi-Measurement (I-V, C-V, Pulse) Prober Cable Kit for Cascade Microtech 12000 prober series
4210-MMPC-S	Multi-Measurement (I-V, C-V, Pulse) Prober Cable Kit for SUSS MicroTec PA200/300 prober series
4200-MTRX-*	Ultra Low Noise SMU Triax Cable: 1m, 2m, and 3m options
4200-PRB-C	SMA to SSMC Y Cable with local ground
4200-RPC-*	Remote PreAmp Cable: 0.3m, 2m, 3m, 6m options
4200-TRX-*	Ultra Low Noise PreAmp Triax Cable: 0.3m, 2m, 3m options
7007-1	Double-Shielded Premium GPIB Cable, 1m
7007-2	Double-Shielded Premium GPIB Cable, 2m

ADAPTER, CABLE, AND STABILIZER KITS

4200-CVU-PWR	CVU Power Package for ±200V C-V
4200-CVU-PROBER-KIT	Accessory Kit for connection to popular analytical probers
4200-PMU-PROBER-KIT	General Purpose Cable/Connector Kit. For connecting the 4225-PMU to most triax and coax probe stations. One kit required per 4225-PMU module.
4200-Q-STBL-KIT	Addresses oscillation when performing pulse I-V tests on RF transistors

REMOTE PREAMP MOUNTING ACCESSORIES

4200-MAG-BASE	Magnetic Base for mounting 4200-PA on a probe platen
4200-TMB	Triaxial Mounting Bracket for mounting 4200-PA on a triaxial mounting panel
4200-VAC-BASE	Vacuum Base for mounting 4200-PA on a prober platen

SOFTWARE

ACS-BASIC	Component Characterization Software

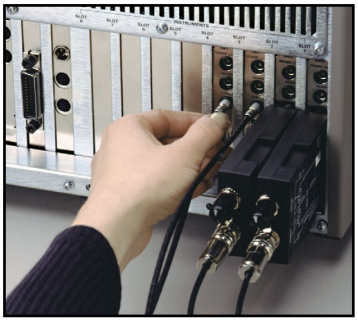
DRIVERS

4200ICCAP-6.0	IC-CAP Driver and Source Code for 4200-SCS: UNIX/Windows (shareware only)

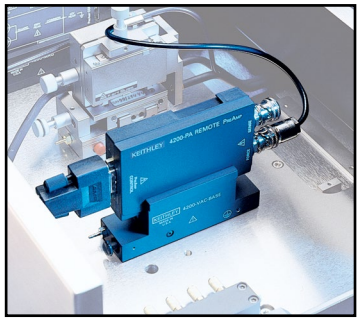
OTHER ACCESSORIES

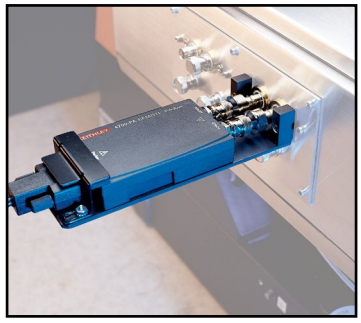
EM-50A	Modified Power Splitter
TL-24	SMA Torque Wrench
4200-CART	Roll-Around Cart for 4200-SCS
4200-CASE	Transport Case for 4200-SCS
4200-MAN	Printed Manual Set

PreAmp Mounting and Cabling

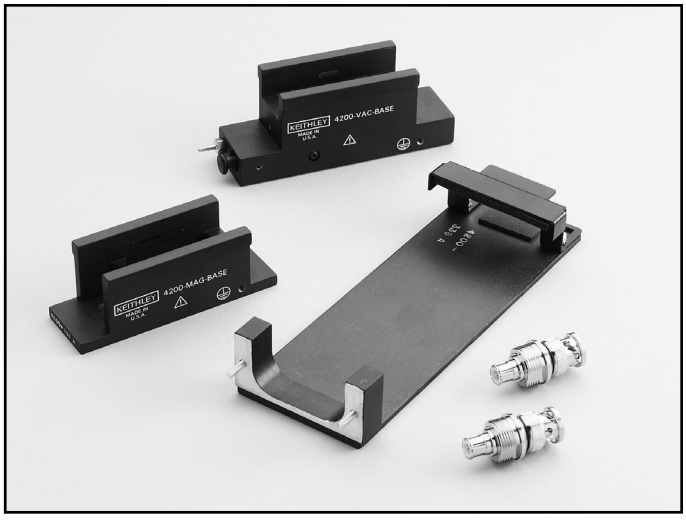


It's easy to connect the Model 4200-SCS to a probe station or a switch matrix with standard triax cables.





DC 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, which provides more accurate low-level measurements.



An optional vacuum (Model 4200-VAC-BASE) or magnetic (Model 4200-MAG-BASE) platen mounting base allows the PreAmp to be located next to manipulators on the chuck platen, eliminating measurement problems caused by long cable lengths when performing ultra-low current measurements.

If platen space is not available, the triax mounting bracket (Model 4200-TMB) allows users to locate the DC PreAmp on dual triaxial connectors that may already be installed for HP4156 Kelvin triax cables. This mounting option reduces problems caused by long cables without occupying platen space.

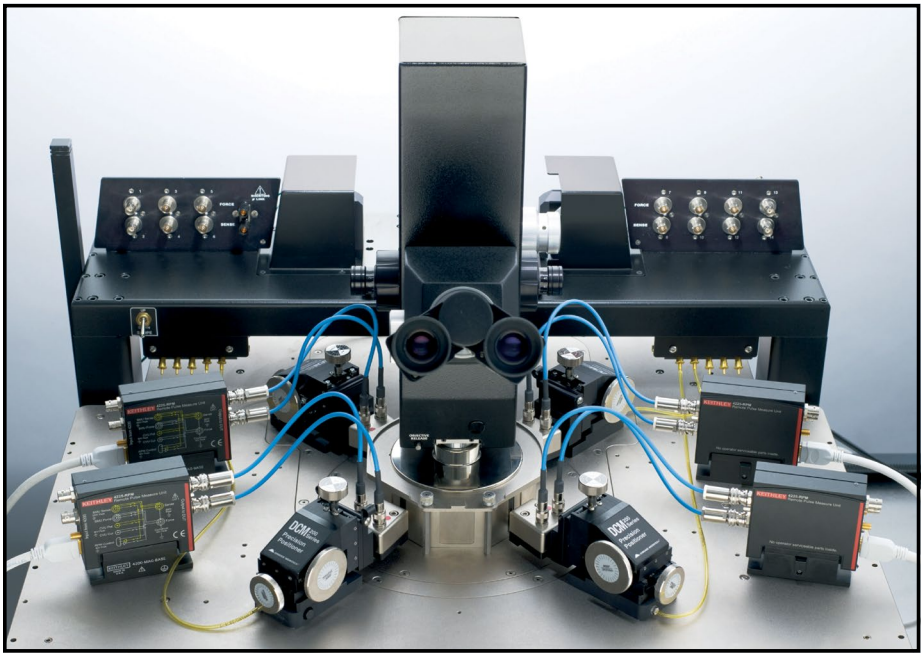
The Model 4225-RPM Remote Amplifier/Switch can be mounted close to the probe needles to reduce the cable effects when performing pulse or other ultra-fast I-V measurements.

4200-SCS Accessories

Model 4200-CART
Roll-around cart

Model 4200-CASE
Transport case

Model 4200-KEY-RM
Keyboard rack mount



Each Model 4220-SCS chassis can accommodate up to four Model 4225-PMU modules to provide up to eight ultra-fast source and measure channels. Pictured are four 4225-RPM modules connected to a 4-pin prober.

4200-SCS Parameter Analyzer Technical Data

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