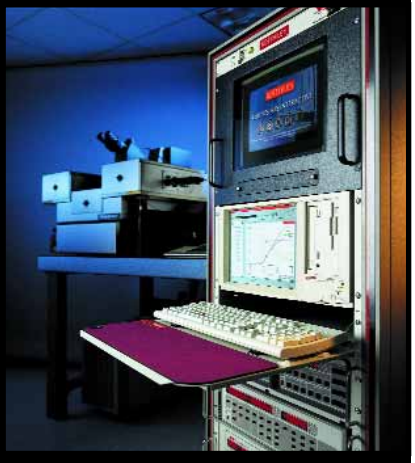
Lab grade DC device characterization

SEMICONDUCTOR TEST

# 4200-SCS

# Semiconductor Characterization System



- **Intuitive, point-and-click Windows®-based environment**
- **Unique Remote PreAmps extend the resolution of SMUs to 0.1fA**
- **New pulse and pulse I-V capabilities for advanced semiconductor testing**
- **New scope card provides integrated scope and pulse measure functionality**
- **Self-contained PC provides fast test setup, powerful data analysis, graphing and printing, and on-board mass storage of test results**
- **Unique browser-style Project Navigator organizes tests by device type, allows access to multiple tests, and provides test sequencing and looping control**
- **Built-in stress/measure, looping, and data analysis for point-and-click reliability testing, including five JEDEC-compliant sample tests**
- **Integrated support for a variety of LCR meters, Keithley switch matrix configurations, and both Keithley Series 3400 and Agilent 81110 pulse generators**
- **Includes software drivers for Cascade Microtech Summit 12K Series, Karl Suss Model PA-200 and Model PA-300, Micromanipulator Model 8860, Signatone CM500 Prober, and manual probers**
- **Advanced semiconductor modeling support including Keithley supplied IC-CAP device modeling package driver and support for Cadence BSIMProPlus/Virtuoso and Silvaco UTMOST device modeling tools**

The easy-to-use Model 4200-SCS Semiconductor Characterization System performs lab grade DC and pulse device characterization, real-time plotting, and analysis with high precision and sub-femtoamp resolution. The 4200-SCS offers the most advanced capabilities available in a fully integrated characterization system, including a complete, embedded PC with Windows operating system and mass storage. Its self-documenting, point-and-click interface speeds and simplifies the process of taking data, so users can begin analyzing their results sooner. Additional features enable stress-measure capabilities suitable for a variety of reliability tests.

The powerful test library management tools included allow standardizing test methods and extractions to ensure consistent test results. The Model 4200-SCS offers tremendous flexibility with hardware options that include four different switch matrix configurations and a variety of LCR meters and pulse generators. A variety of customer support packages are also available, including applications support, calibration, repair, and training.

## A Total System Solution

The Model 4200-SCS provides a total system solution for DC and pulse characterization and reliability testing of semiconductor devices, test structures, and materials. This advanced parameter analyzer provides intuitive and sophisticated capabilities for a wide variety of semiconductor tests. The Model 4200-SCS combines unprecedented measurement speed and accuracy with an embedded Windows-based PC and the Keithley Interactive Test Environment (KITE) to provide a powerful single-box solution. KITE allows users to gain familiarity quickly with tasks such as managing tests and results and generating reports. Sophisticated and simple test sequencing and external instrument drivers simplify performing automated device and wafer testing with combined I-V and C-V measurements. The exceptional low current performance of the Model 4200-SCS makes it the perfect solution for research studies of single electron transistors (SETs), molecular electronic devices, and other nanoelectronic devices that require I-V characterization. The Model 4200-SCS can be used to make four-probe van der Pauw resistivity and Hall voltage measurements, eliminating the need for a switch matrix and user-written code. With remote preamps added, resistances well above $10^{12}\Omega$ can be measured.

The Model 4200-SCS is modular and configurable. The system supports up to eight Source-Measure Units, including up to four high-power SMUs with 1A/20W capability. Also available are new pulse and scope pulse measure modules.

## Pulse I-V Package

The optional Pulse I-V package provides dual-channel pulse generation and measurement. Pulsed I-V testing offers a new approach to characterization testing. Its high-speed pulses allow you to characterize materials and devices in applications like charge trapping for high $\kappa$ gates and devices that have self-heating effects.

## Extended Measurement Resolution

An optional Remote PreAmp, the Model 4200-PA, extends the system's measurement resolution from 100fA to 0.1fA 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 Model 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.

## KTE Interactive Software Tools

KTE Interactive includes four software tools for operating and maintaining the Model 4200-SCS in addition to the Windows operating system:

- 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. Built-in looping, stress-measure capabilities, and data management enable many types of reliability testing.
- Keithley User Library Tool (KULT)—Allows test engineers to integrate custom algorithms into KITE using Model 4200-SCS or external instruments.

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# 4200-SCS

# Semiconductor Characterization System

## Ordering Information

**4200-SCS/F**
Flat Panel Display

**4200-SCS/C**
Composite Front Bezel; requires an external SVGA display

### Accessories Supplied

Reference and User Manual on CD-ROM

236-ILC-3 Interlock Cable, 3m

Note: All 4200-SCS systems and instrument options are supplied with required cables of 2m length.

### Additional Instrumentation

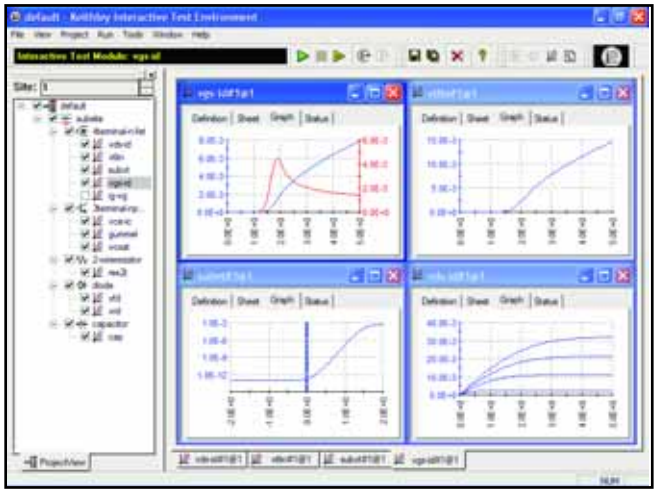
**4200-PG2**
Dual-Channel Pulse Generator

**4200-SCP2**
Dual-Channel Digital Oscilloscope

**4200-PIV**
Complete Pulse I-V Package

## Related Products

| | |
|---|---|
| 707A | Semiconductor Switching Matrix Mainframe |
| 708A | Single Slot Switching Matrix Mainframe |
| 4200-SCP2-ACC | 70MHz Scope Probe |
| 7071 | 8×12 General Purpose Matrix Card |
| 7072 | 8×12 Semiconductor Matrix Card |
| 7072-HV | 8×12 High Voltage Semiconductor Matrix Card |
| 7174A | 8×12 High Speed, Low Current Matrix |



**The Keithley Interactive Test Environment (KITE) 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.**

- Keithley Configuration Utility (KCON)—Allows test engineers to define the configuration of GPIB instruments, switch matrices, and analytical probers connected to the Model 4200-SCS. It also provides system diagnostics functions.
- Keithley External Control Interface (KXCI)—The Model 4200-SCS application for controlling the Model 4200-SCS from an external computer via the GPIB bus.

### 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.
- 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.

### 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.

### Test Sequencing

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.

### Keithley User Library Tool (KULT)

The Keithley User Library Tool is an open environment that provides you with the flexibility to create your own custom routines as well as use existing Keithley and third-party C-language subroutine libraries. 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 Model 4200-SCS to control an entire test rack from a single user interface. KULT is derived from the Keithley S600 and Series S400 Parametric Test Systems. This simplifies migration of test libraries between the Model 4200-SCS and Keithley parametric test systems.

# 4200-SCS Semiconductor Characterization System

Lab grade DC device characterization

## Dual-Channel Pulse Generator

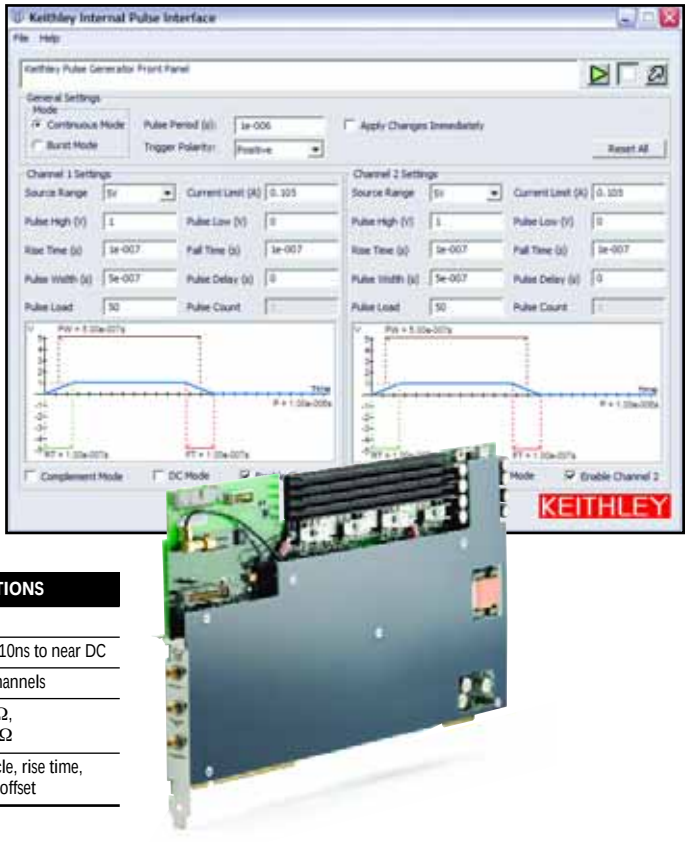
The optional, integrated dual-channel pulse generator adds pulsing to the Model 4200-SCS's DC source and measure capabilities. It supports voltage pulses as short as 10ns in high speed mode or up to ±20V (into 50Ω) in high voltage mode. Two pulse generators on one card provides you with the flexibility to apply pulses to two points on a DUT, such as the gate and the drain, simultaneously.

Using a supplied User Test Module, it is simple to incorporate pulse generation into KITE test sequences. The pulse generator can also be used as a stand-alone pulse generator using the pulse generator's Window's GUI. This GUI can control a wide range of variables, including pulse frequency, duty cycle, rise/fall time, amplitude, offset, and the ability to trigger single pulses and/or pulse chains.

The dual-channel pulse generator has a wide range of uses. Typical applications include:

- Charge pumping to characterize interface state densities in MOSFET devices
- Using AC stress pulses of varying frequencies to simulate real-world AC signals applied to clocked devices
- Basic clock generation for test vectoring and failure analysis
- Digital triggering

The pulse generator can be purchased as an upgrade to existing systems (KTEI version 6.0 or above required) or as an option for new systems.

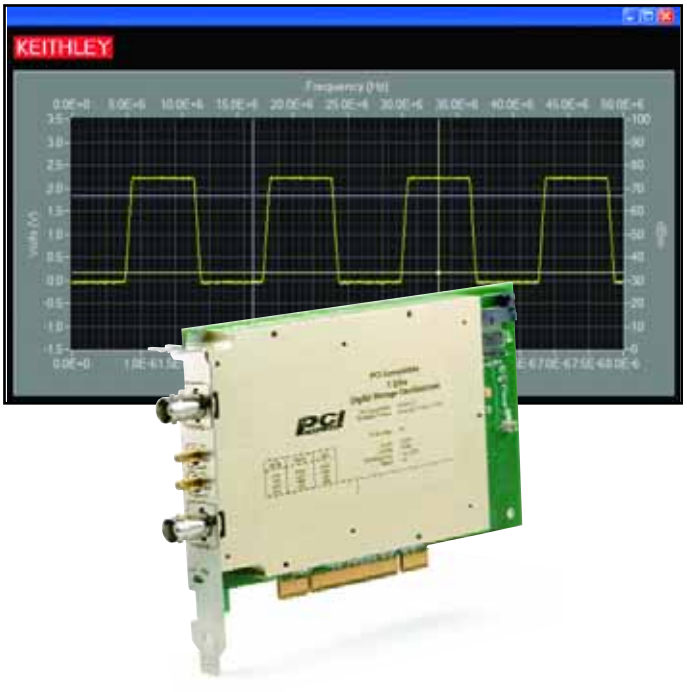



| KEY PULSE GENERATOR SPECIFICATIONS | |
|---|---|
| **Frequency Range** | 1Hz–50MHz |
| **Pulse Width** | Programmable from 10ns to near DC |
| **Channels** | Dual independent channels |
| **Pulse Amplitude Range** | 100mV–20V into 50Ω,<br>100mV–40V into 1MΩ |
| **Programmable Parameters** | Pulse width, duty cycle, rise time, fall time, amplitude, offset |

## Dual-Channel Digital Oscilloscope

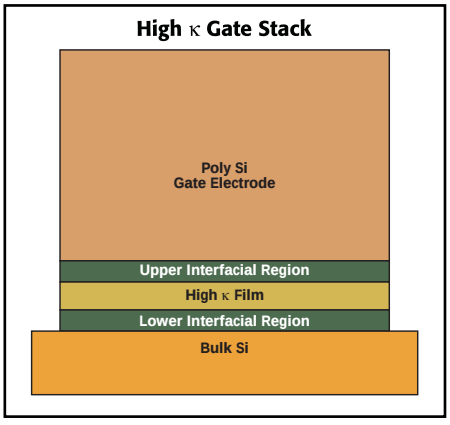
The optional dual-channel digital oscilloscope places more than the performance of a bench-top oscilloscope into your 4200-SCS. It also supports time-domain measurements of pulse waveforms and monitors the reactions of devices under test to those pulses. Some of the features of this oscilloscope include: a broad selection of acquisition modes, triggers, measurements, calculations, and up to four reference waveforms.

The dual-channel oscilloscope integrates directly into the Model 4200-SCS chassis. It can be purchased as an upgrade to existing systems (KTEI version 6.0 or above required) or as an option for new systems.




| KEY OSCILLOSCOPE SPECIFICATIONS | |
|---|---|
| **Bandwidth** | DC to 750MHz |
| **Channels** | 2 |
| **Maximum Sample Rate** | 1.25 giga-samples per second per channel |

# 4200-SCS Semiconductor Characterization System




**Pulse I-V measurement capabilities are increasingly critical for high κ gate stack characterization and isothermal testing of new devices.**


**To minimize the signal reflections due to poor impedance matching that often plague "do-it-yourself" pulse testing systems, Keithley's Pulse I-V package includes a system interconnect setup that provides AC/DC coupling to connect the pulse generator and the DC instrumentation.**

## Pulse I-V Solution Package

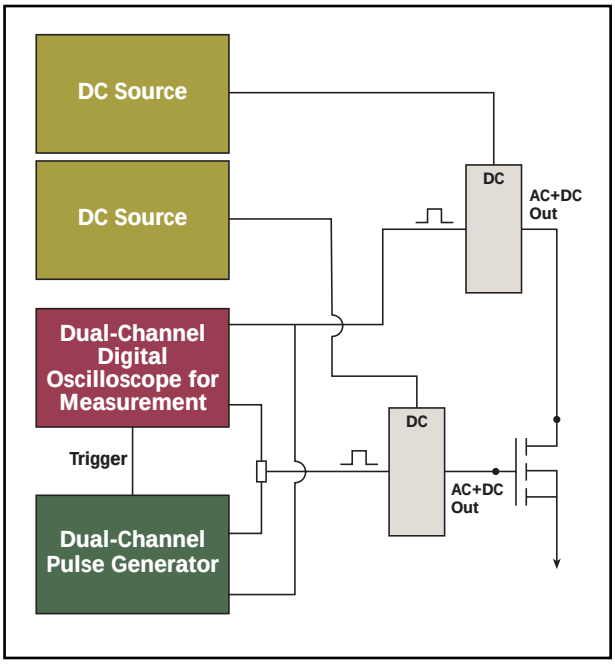
The Pulse I-V package provides a turnkey pulse I-V solution. It is a comprehensive package of hardware and software, designed to integrate seamlessly with the Model 4200-SCS workstation. It combines the dual-channel pulse generator, dual-channel digital oscilloscope, specialized interconnect, and patented Pulse I-V software.

The Pulse I-V software controls sourcing (from the pulse generator) and data acquisition (from the oscilloscope) to automate a variety of Pulse I-V tests. Running in the Model 4200-SCS's proven interface, the Pulse I-V software provides instrument setup and control, data storage, and presentation. The innovative software includes both cable compensation and a solution to the load-line effect, producing pulsed-based I-V transistor curves, such as the $V_{DS}$-$I_D$ family of curves and $V_{GS}$-$I_D$ for voltage threshold extraction.

The Pulse I-V bundle allows the Model 4200-SCS to support a wide range of applications, such as charge trapping for high κ dielectric characterization, isothermal testing of devices and materials subject to self-heating effects, charge pumping, AC stress testing, clock generation, and mixed signal device testing.

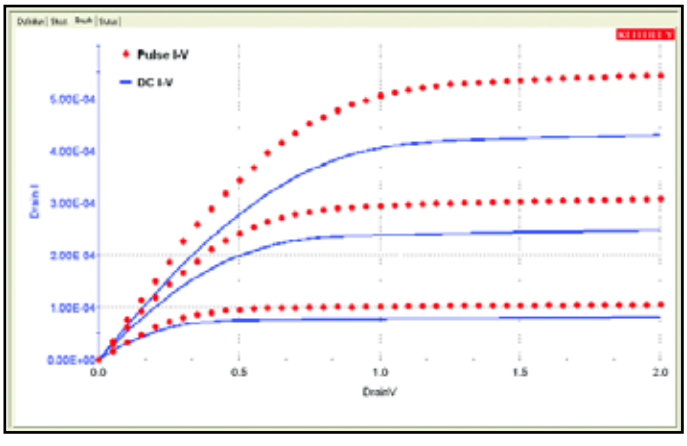
The specialized interconnect solves most of the problems encountered in high speed pulse testing, such as:

- Combining pulse and DC sources to a single DUT pin to permit both DC and pulse characterization without recabling or switching
- Impedance matching for pulse integrity to minimize reflection
- Straightforward cabling and connection to the DUT for easy setup




**The Pulse I-V package includes everything needed to implement a turnkey system for pulsed I-V testing of leading-edge devices and materials. Pieces included in the package are:**

- **Integrated dual-channel pulse generator**
- **Dual-channel digital oscilloscope**
- **Pulse I-V control software (patent pending)**
- **Interconnect designed to minimize the signal reflections common to pulse I-V testing (patent pending)**
- **All required connectors and cables**
- **Sample projects for:**
  - **Pulse I-V isothermal testing of FinFETs, SOI devices, and other devices with self-heating problems**
  - **Charge-trap testing for high κ gate stack characterization**




**Pulse testing can characterize a device with little to no isothermal degradation.**

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SEMICONDUCTOR TEST

# 4200-SCS Semiconductor Characterization System

## ACCESSORIES AVAILABLE

### COMPUTER OPTIONS

| | |
|---|---|
| 4200-FPD-RM | 1V 17˝ TFT Display with keyboard and pointing device |
| 4200-MOUSE | Microsoft 2 Button Mouse |

### REMOTE PREAMP MOUNTING OPTIONS

| | |
|---|---|
| 4200-MAG-BASE | Magnetic Base for mounting 4200-PA on a prober platen |
| 4200-VAC-BASE | Vacuum Base for mounting 4200-PA on a prober platen |
| 4200-TMB | Triaxial mounting bracket for mounting 4200-PA on a triaxial mounting panel |

### OTHER ACCESSORIES

| | |
|---|---|
| 4000-CASE | Wheeled Carrying Case |
| 4200-MAN | Printed Manual Set |
| 4200-CART | Roll-Around Cart |

### SWITCH MATRIX OPTIONS

| | |
|---|---|
| Ultra Low Current | 100fA offset, 30µV offset, remote or local sense |
| Low Current | 1pA offset, 40µV offset, 12–360 pins, local sense only |
| General Purpose | 100pA offset, 5µV offset, 12–360 pins, remote sense |

### DRIVER OPTIONS

| | |
|---|---|
| 4200-ICCAP-6.0 | IC-CAP Driver and Source Code for 4200-SCS: UNIX/Windows |

### CABINETS AND MOUNTING ACCESSORIES

| | |
|---|---|
| 4200-CAB-20UX | 20U Cabinet (35˝) |
| 4200-CAB-25UX | 25U Cabinet (44˝) |
| 4200-CAB-34UX | 34U Cabinet (60˝) |
| 4200-RM | Slide Rack Mounting Kit for 4200-SCS/F and 4200-SCS/C |
| 4200-CRT-RM | Fixed Rack Mounting Kit for external CRT |
| 4200-KEY-RM | Slide Rack Mounting Kit for standard keyboard and pointing device |

### PULSE GENERATOR, OSCILLOSCOPE, AND ACCESSORIES

| | |
|---|---|
| 4200-PG2 | Dual-Channel Pulse Generator |
| 4200-SCP2 | Dual Channel Digital Oscilloscope |
| 4200-PIV | Complete Pulse I-V Package |
| 4200-SCP2-ACC | Dual-Channel Digital Oscilloscope Accessory Kit (70MHz probe) |
| 8101-4TRX | 4-Pin Transistor Fixture |
| 8101-PIV | Pulse I-V Demo Fixture |

### ADDITIONAL CABLES AND CONNECTORS

| | |
|---|---|
| 4200-RPC-0.3 | Remote PreAmp Cable, 0.3m (for use inside prober shield) |
| 4200-RPC-2 | Remote PreAmp Cable, 2m (for remote location of 4200-PA, one included with each 4200-PA) |
| 4200-RPC-3 | Remote PreAmp Cable, 3m (for remote location of 4200-PA) |
| 4200-RPC-6 | Remote PreAmp Cable, 6m (for remote location of 4200-PA) |
| 4200-TRX-0.3 | Ultra Low Noise PreAmp Triax Cable, 0.3m (Triax-Triax, connects 4200-PA to a test fixture, recommended for remote location of the 4200-PA) |
| 4200-TRX-1 | Ultra Low Noise PreAmp Triax Cable, 1m (Triax-Triax, connects 4200-PA to a test fixture) |
| 4200-TRX-2 | Ultra Low Noise PreAmp Triax Cable, 2m (Triax-Triax, connects 4200-PA to a test fixture, two included with each 4200-PA) |
| 4200-TRX-3 | Ultra Low Noise PreAmp Triax Cable, 3m (Triax-Triax, connects 4200-PA to a test fixture) |
| 4200-MTRX-1 | Ultra Low Noise SMU Triax Cable, 1m (Mini Triax-Triax, connects 4200 SMUs to a test fixture) |
| 4200-MTRX-2 | Ultra Low Noise SMU Triax Cable, 2m (Mini Triax-Triax, connects 4200 SMUs to a test fixture, two included with each 4200 SMU that is not configured with a Remote PreAmp) |
| 4200-MTRX-3 | Ultra Low Noise SMU Triax Cable, 3m (Mini Triax-Triax, connects 4200 SMUs to a test fixture) |
| 236-ILC-3 | Interlock Cable, 3m (one included with each 4200-SCS) |
| 7007-1 | Shielded IEEE-488 Cable (1m) |
| 7007-2 | Shielded IEEE-488 Cable (2m) |
| 7078-TRX-BNC | Coaxial connector for connecting coax instruments to a triax matrix |

## 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 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 | 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.

## 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.

## 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.

| | % Relative Humidity | |
|---|---|---|
| Temperature | 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).

**OUTPUT TERMINAL CONNECTION:** Dual triaxial connectors for 4200-PA, dual mini-triaxial connectors for 4200-SMU and 4210-SMU.

**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.

## 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.

### 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:** 500VA.

**REGULATORY COMPLIANCE:**
**Safety:** Low Voltage Directive 73/23/EEC.
**EMC:** Directive 89/336/EEC.

**DIMENSIONS:** 43.6cm wide × 22.3cm high × 56.5cm deep (17⁵⁄₃₂ in × 8¾ in × 22¼ in).

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

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

### 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-SCS Semiconductor Characterization System

## 4200-PG2 Specifications[1]

### PULSE/LEVEL[2]

| | | HIGH SPEED | HIGH VOLTAGE |
|---|---|---|---|
| $V_{OUT}$ | 50 Ω into 50 Ω | –5 V to +5 V | –20 V to +20 V |
| | 50 Ω into 1 MΩ | –10 V to +10 V | –40 V to +40 V |
| | Accuracy | ±(3% + 50 mV) | ±(3% + 100 mV) |
| AMPLITUDE/LEVEL RESOLUTION | 50 Ω into 50 Ω | 1 mV | 5 mV |
| | 50 Ω into 1 MΩ | 2 mV | 10 mV |
| OUTPUT CONNECTORS | | SMA | SMA |
| SOURCE IMPEDANCE | | 50 Ω nominal | 50 Ω nominal |
| | Accuracy | ±0.5% | ±0.5% |
| SHORT CIRCUIT CURRENT | | ±200 mA | ±800 mA peak |
| CURRENT INTO 50Ω LOAD AT FULL SCALE | | ±100 mA typical | ±400 mA typical |
| BASELINE NOISE | | ±(0.1 % + 5 mV) RMS typical | ±(0.1 % + 5 mV) RMS typical |
| OVERSHOOT/PRE-SHOOT/RINGING | | ±5% of amplitude ±20 mV | ±5% of amplitude ±80 mV |
| OUTPUT LIMIT | | Programmable limit to protect the DUT | |

### TIMING

| | | HIGH SPEED | HIGH VOLTAGE |
|---|---|---|---|
| FREQUENCY RANGE | | 1 Hz to 50 MHz | 1 Hz to 2 MHz |
| TIMING RESOLUTION | | 10 ns | 10 ns |
| RMS JITTER (period, width) | | 0.01 % + 200 ps typical | |
| PERIOD RANGE | | 20 ns to 1s (See Figure 1.) | 500 ns to 1 s |
| | Accuracy | ±1% | ±1% |
| PULSE WIDTH RANGE | | 10 ns to (period – 10 ns) | 250 ns to (period – 100 ns) |
| | Accuracy | ±(3% + 200 ps) | ±(3% + 5 ns) |
| PROGRAMMABLE TRANSITION TIME | (0–100%) | 10 ns – 1 s | 100 ns – 1 s |
| TRANSITION SLEW RATE[3] | Accuracy | ±1% for transition time ≥100 ns | ±1% for transition time ≥1 µs |
| | Linearity | 3% for transition time ≥100 ns | 3% for transition time ≥500 ns |
| TYPICAL MIN. TRANSITION TIME (10–90%) | | < 15 ns | < 150 ns |
| | | Pulse period and width are variable in 10ns steps without any output glitches or dropouts. | |

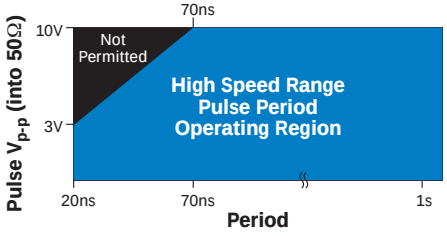


**Figure 1. Permitted area of operation.**

### NOTES

1. Unless stated otherwise, all specifications assume a 50Ω termination.
2. Level specs are valid after 50ns typical settling time (after slewing) for the high speed mode and after 500ns typical settling time (after slewing) for the high voltage mode into a 50Ω load.
3. Specifications apply to a 10–90% transition, typical.

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

## 4200-SCP2 Specifications[1]

### ANALOG INPUT[1]

**NO. OF CHANNELS:** 2.
**BANDWIDTH (50Ω):** DC to 750MHz.
**BANDWIDTH (1MΩ):** DC to 500MHz.
**FULL SCALE INPUT RANGE (50Ω):** 0.05, 0.1, 0.25, 0.5, 1, 2, 5, 10 (Vp-p).
**FULL SCALE INPUT RANGE (1MΩ):** 0.1, 0.2, 0.5, 1, 2.5, 5, 10, 20, 50, 100 (Vp-p).
**DC GAIN ACCURACY:** <±1% of full scale.
**IMPEDANCE:** 1MΩ || 12pF or 50Ω.
**IMPEDANCE ACCURACY:** ±1%.
**COUPLING:** DC or AC.
**OFFSET ADJUST:** ±(full scale range/2).
**OFFSET ACCURACY:** ±(1% offset + 1% full scale).
**INPUT CONNECTOR:** BNC.
**ABSOLUTE MAXIMUM INPUT (50Ω):** ±5VDC.
**ABSOLUTE MAXIMUM INPUT (1MΩ):** ±150 DC, derated 20dB/decade above 1MHz.

### ANALOG-TO-DIGITAL CONVERTER

**RESOLUTION:** 8-bit.
**SAMPLE RATE:** 2.5kS/s to 1.25GS/s in 1, 2.5, 5 steps. 2.5GS/s (1 channel interleaved).
**MEMORY DEPTH:** 1M samples/channel (2M using 1 channel interleaved).
**ACQUISITION TIME RANGE:** 50ns to 419 seconds.
**ACQUISITION MODES:** Normal, Average, Envelope, and Equivalent-Time.

### TRIGGER

**TRIGGER SOURCE:** Channels 1 to 2, External, Pattern, Software.
**POST-TRIGGER DELAY:** 0 to 655 seconds.
**PRE-TRIGGER DELAY:** 0 to waveform time.
**TRIGGER HOLD OFF RANGE:** 0 to 655 seconds.
**TRIGGER MODES:** Edge or Pulse Width.
**EDGE TRIGGER MODE:** Rising or Falling Edge.
**PULSE WIDTH RANGE:** 20ns to 655 seconds, 10ns resolution.
**EXTERNAL TRIGGER INPUT:** TTL compatible, 10kΩ input impedance.
**CONNECTOR:** SMB.

### OPTIONAL SCOPE PROBE: 4200-SCP2-ACC

**BANDWIDTH:** 70MHz.
**ATTENUATION:** 1×.
**MAX. DC:** 300V DC rated.
**LOADING:** 100pF and 1MΩ.
**LENGTH:** 1 meter.
**CONNECTOR:** BNC.

### NOTES

1. 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-PIV Typical Specifications[1]

**CHANNELS:** Two.

**TYPICAL PULSE PERFORMANCE:**

| | With 4200 Remote Bias Tee[4] (Figure 2) | Without 4200 Remote Bias Tee (Figure 3) |
|---|---|---|
| **Measurement Accuracy** | <4% of signal ±1mV | N/A |
| **Max. Current Measure** | 100 mA | 400 mA |
| **Resolution** | Maximum 5µA, 250µV<br>8-bit A/D converter | Maximum 5µA, 250µV<br>8-bit A/D converter |
| **Sample Rate** | 1.25 Gsample/s | 1.25 Gsample/s |
| **Duty Cycle** | <0.1% | See PG2 specs |
| **DC Offset** | ±200 V | N/A |
| **Min. Transition Time** | 10 ns[2] | See PG2 specs |
| **Pulse Source Voltage Range** | 0 to ±5V into gate[2] | 0 to ±5V into gate, 40$V_{pp}$ into drain |
| **Pulse Width** | 40 ns to 150 ns | See PG2 specs |

**SMU TYPICAL DC PERFORMANCE (with 4200 Remote Bias Tee):**

**Leakage:** 1–10nA/V[3]
**Noise:** 1–10nA RMS.
**Max. Voltage:** 200V (>40V requires safety interlock and related precautions).
**Max. Current:** 0.5A.

**4200 REMOTE BIAS TEE TYPICAL PERFORMANCE:**

**Band Pass:** 10kHz–300MHz (3dB).
**Power Divider Max. Power Input:** 0.125W DC.

### NOTES

1. Unless stated otherwise, all specifications assume a 50Ω termination.
2. 4200 Remote Bias Tee supports the 4200-PG2 high speed range only.
3. Leakage measured after a five-second settling time.
4. All typical specs apply to the AC+DC output connector of the 4200 Remote Bias Tee interconnect box and after system compensation.

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

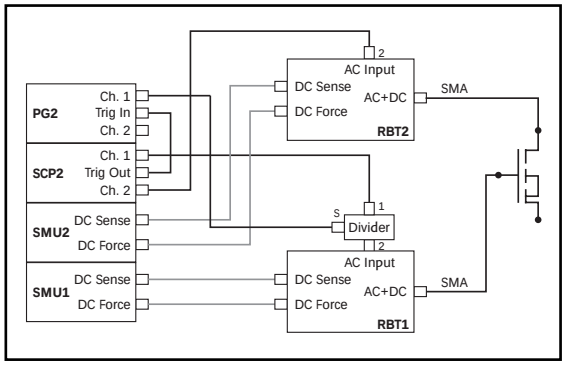


**Figure 2. Interconnect for pulse I-V (high κ charge trapping and isothermal testing). Pulse voltage on gate with DC bias on drain.**

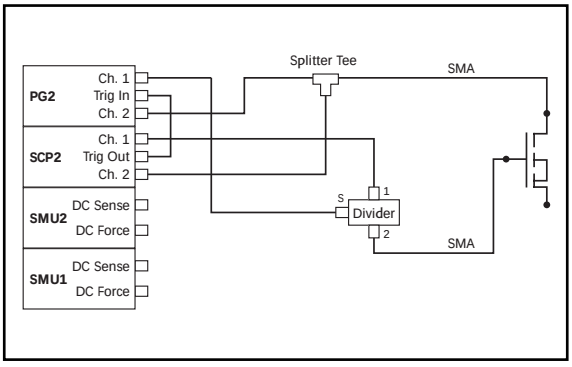


**Figure 3. Interconnect for single pulse charge trapping.**