4200A-SCS Parameter Analyzer

Datasheet

See your innovations come to life. The 4200A-SCS is a customizable and fully-integrated parameter analyzer that provides synchronized insight into current-voltage (I-V), capacitance-voltage (C-V), and ultra-fast pulsed I-V characterization. The highest performance parameter analyzer, the 4200A-SCS accelerates semiconductor, materials, and process development.

The 4200A-SCS Clarius™ GUI-based Software provides clear, uncompromised measurement and analysis capability. Furnished with embedded measurement expertise and hundreds of ready-to-use application tests, Clarius Software enables you to dig deeper into your research with speed and confidence.

The 4200A-SCS Parameter Analyzer is completely customizable and fully upgradable, so you can add the instruments you need now – or later. With the 4200A-SCS Parameter Analyzer, making connections to your bold discoveries has never been easier.

Key Performance Specifications

I-V Source Measure Unit (SMU)

- ± 210 V/100 mA or ± 210 V/1 A modules
- 100 fA measure resolution
- 10 aA measure resolution with optional preamp
- 10 mHz – 10 Hz very low frequency capacitance measurements
- 4-quadrant operation
- 2 or 4-wire connections

C-V Multi-frequency Capacitance Unit (CVU)

- AC impedance measurements (C-V, C-f, C-t)
- 1 kHz – 10 MHz frequency range
- ± 30 V (60 V differential) built-in DC bias, expandable to ± 210 V (420 V differential)
- Simple switching between I-V and C-V measurements with the optional CVIV Multi-Switch

Pulsed I-V Ultra-fast Pulse Measure Unit (PMU)

- Two independent or synchronized channels of high-speed pulsed I-V source and measure
- 200 MSa/sec, 5 ns sampling rate
- ±40 V (80 V p-p), ±800 mA
- Transient waveform capture mode
- Arbitrary waveform generator Segment ARB® mode for multi-level pulse waveform with 10 ns programmable resolution

High Voltage Pulse Generator Unit (PGU)

- Two channels of high-speed pulsed V source
- ±40 V (80 V p-p), ± 800 mA
- Arbitrary waveform generator Segment ARB® mode for multi-level pulse waveform with 10 ns programmable resolution

I-V/C-V Multi-Switch Module (CVIV)

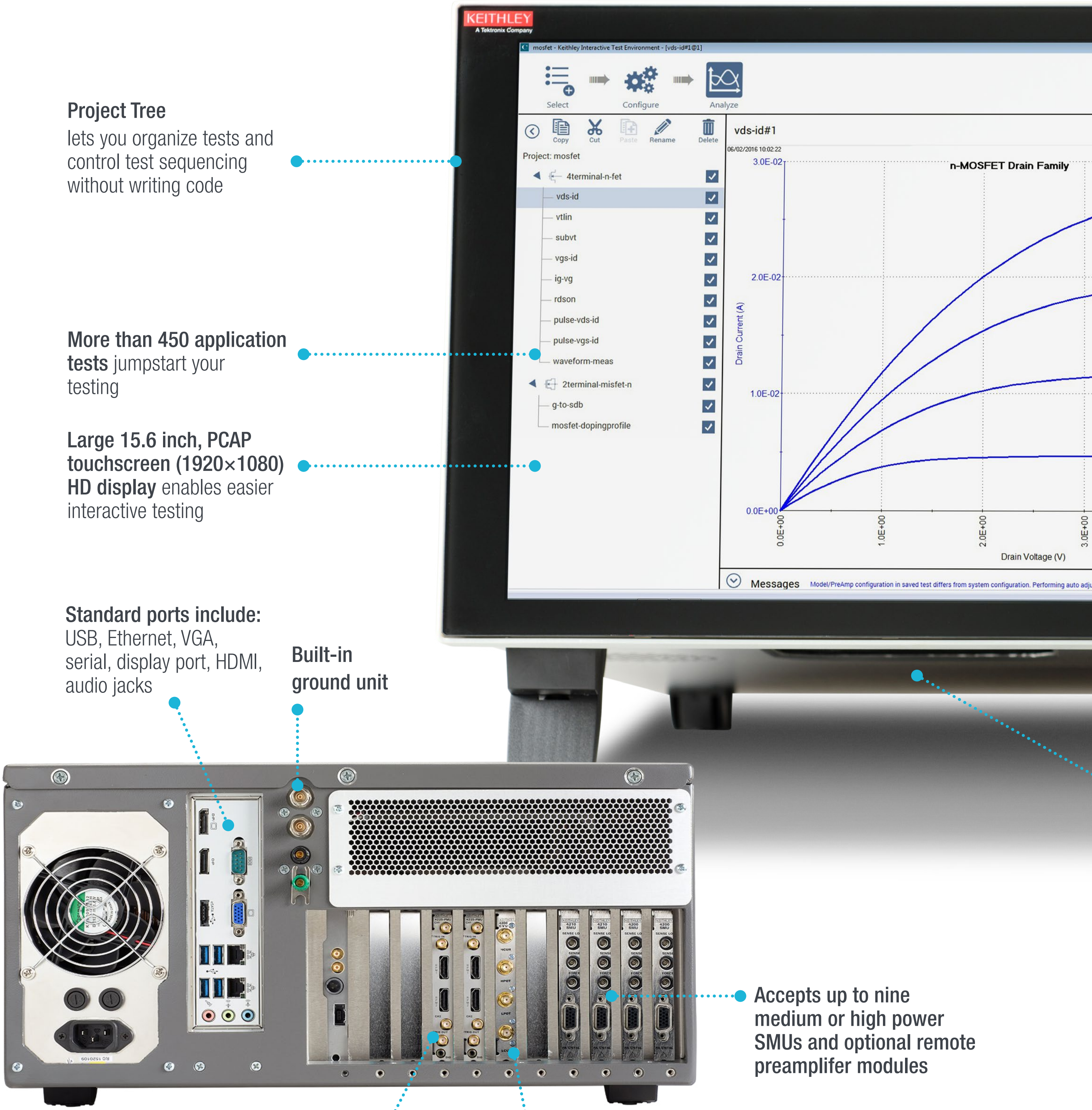
- Easily switch between I-V and C-V measurements without re-cabling or lifting prober needles
- Move the C-V measurement to any terminal without re-cabling or lifting prober needles

Remote Preamplifier/Switch Module (RPM)

- Automatically switches between I-V, C-V, and ultra-fast pulsed I-V measurements
- Extends current sensitivity of the 4225-PMU to tens of picoamps
- Reduces cable capacitance effects

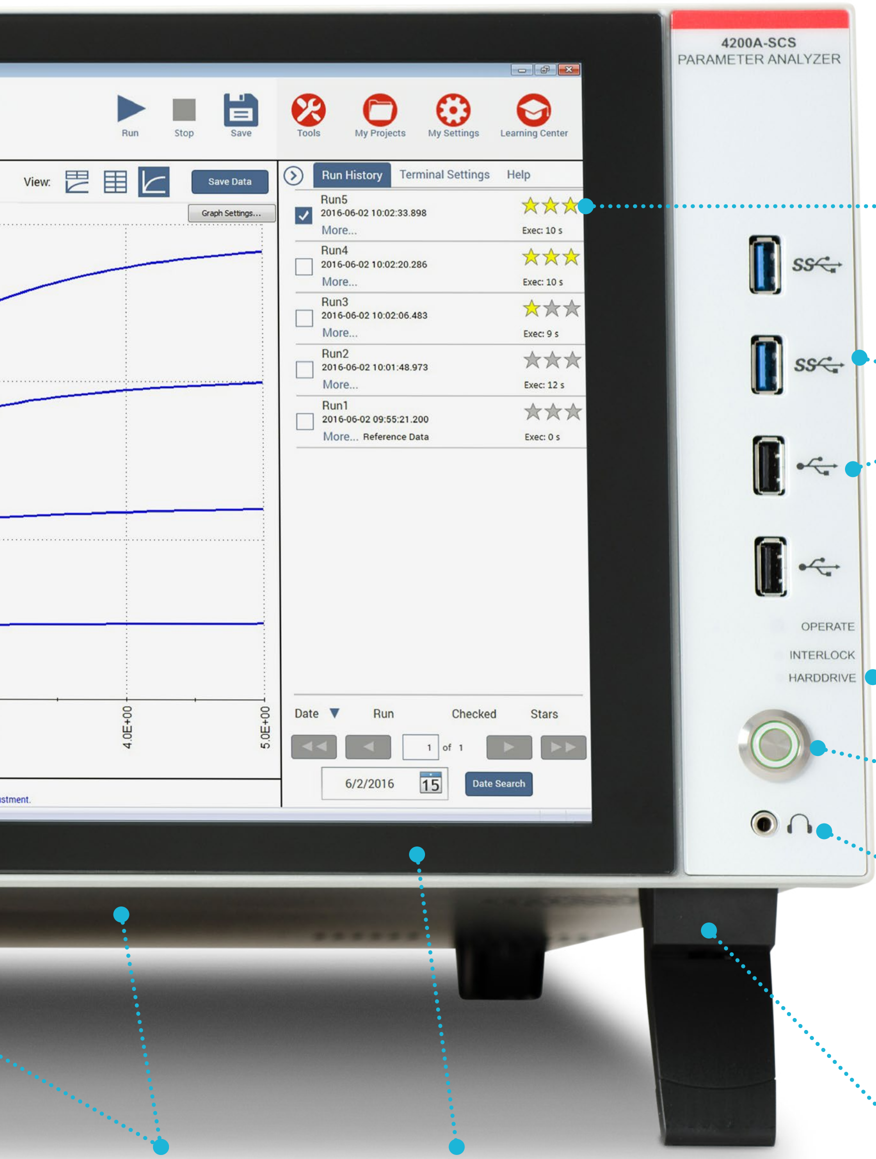
The Ultimate Parameter Analyzer for Materials, Semi

Perform I-V, C-V and pulsed I-V characterization with speed, clarity and confide



conductor Devices and Process Development

nce with the powerful Clarius software.



Tag and organize test results

USB 3.0 and 2.0 ports for use with keyboards, mouse and flashdrives

Solid-state hard drive facilitates fast start-ups and data storage/transfer

Power on

Headphone jack to listen to instructional measurement videos

Built-in audio speakers

Context-sensitive embedded videos for measurement and troubleshooting guidance

4200A-SCS can be rack mounted or installed on a bench

4200A-SCS Instruments and Modules

Model	Description	Key Measurements	Range	Measure Resolution
4200-SMU	Medium Power Source-Measure Unit	- DC I-V - Very Low Frequency C-V - QSCV	±100 mA, ±210 V	0.2 µV, 100 fA
4210-SMU	High Power Source-Measure Unit		±1 A, ±210 V	0.2 µV, 100 fA
4200-PA	Remote Preamplifier Module		Extends current ranges for all SMUs	0.2 µV, 10 aA
4210-CVU	Capacitance-Voltage Unit	- AC Impedance - C-V, C-f, C-t	1 kHz – 10 MHz ±30 V built-in DC bias (60 V differential) ±210 V DC bias with SMUs	—
4200A-CVIV	I-V/C-V Multi-Switch Module	DC I-V and C-V with Automatic Switching	—	—
4225-PMU	Ultra-Fast Pulse Measure Unit	- Pulsed I-V - SegmentARB® Multi-level pulsing - Transient Waveform Capture	±40 V (80 V p-p), ±800 mA 200 MSa/s simultaneous I and V measure 2048 unique segments 20 ns PW source only 60 ns PW source/measure	75 nA
4225-RPM	Remote Preamplifier/ Switch Module	DC I-V, C-V, Pulsed I-V with Automatic Switching	Extends current range of 4225-PMU unit	200 pA
4220-PGU	High Voltage Pulse Generator Unit	- Pulsed Voltage Source - SegmentARB® multi-level pulsing	±40 V (80 V p-p) 2048 unique segments	—
Ground Unit	Built-in, Low Noise Ground Unit	—	Triaxial connection: 2.6 A Binding post: 9.5 A	—

Example List of Extracted or Measured Parameters

CMOS transistor	Id-Vg, Id-Vd, Ig-Vg, Vth, Vtlin, Sub-Vt, Rds-on, breakdown, capacitance, QSCV, Low-frequency CV, self-heating reduction and more
BJT	Ic-Vc, Vcsat, Gummel plot, capacitance, βF, αF
Non-volatile Memory	Vth, endurance test, capacitance
Nanoscale	Resistance, Id-Vg, Id-Vd, Ic-Vc
Discrete components	Id-Vg, Id-Vd, Ic-Vc, V_{fdiode}, V_{rdiode}, capacitance
Materials	Van der Pauw, 4-point collinear resistivity Hall Effect
Photovoltaics	$I_{forward}$, $I_{reverse}$, HiR, LoR
Power device	Pulsed Id-Vg, pulsed Id-Vd, breakdown
Reliability	NBTI/PBTI, charge pumping, hot carrier injection, V-Ramp, J-Ramp, TDDB

1. Clarius Software

Take your research to new levels of understanding with the new Clarius Software user interface. The 4200A-SCS includes the Clarius+ software package, which allows peforming nearly any type of I-V, C-V, and pulsed I-V characterization test. The Clarius Software user interface provides touch-and-swipe or point-and-click control for advanced test definition, parameter analysis, graphing, and automation capabilities for modern semiconductor, materials, and process characterization.

Key Features

- Ready-to-use, modifiable application tests, projects and devices that reduce test development time
- Industry's first instrument with built-in measurement videos from world-wide Application engineers, in four languages, to reduce learning curve
- Pin to pad contact check ensures reliable measurements
- Multiple measurement functions
- Data display, analysis and arithmetic functions

Reduce Characterization Complexity with Expert Videos

Engage quickly with your application and reduce your learning curve by watching built-in videos from Keithley worldwide application engineers. Hours of expert measurement expertise help will guide you when unexpected results occur or questions arise on how to set up your test. Localized in four languages (English, Chinese, Japanese and Korean), Clarius Software short expert videos enable quick insight to your bold discoveries.

Select from Ready-to-Use Application Tests

With over 450 furnished application tests in the Clarius library, select or modify the pre-defined application tests to accelerate your characterization or easily create custom tests from the beginning. With three easy steps, Clarius Software guides even the new user through parameter analysis like an expert.

Real-time Results and Parameters

Accelerate your time to insight with automated data display, arithmetic functions, analysis and real-time parameter extraction. Never worry about losing your data since all test history is stored.

Verify Pulse Measurements without an Oscilloscope

Pulse timing preview mode provides an easy view of your pulse timing parameters that confirm your pulsed I-V test will execute as desired. Use the Transient I-V or waveform capture mode to make time-based current or voltage measurements without the need of an external oscilloscope.

Typical Applications

MOSFET, BJT Transistors

Materials Characterization

Non-volatile Memory Devices

Resistivity & Hall Effect Measurements

NBTI/PBTI

III-V Devices

Failure Analysis

Nanoscale Devices

Diodes and pn Junctions

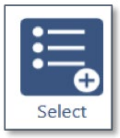
Solar Cells

Sensors

MEMS Devices

Electrochemistry

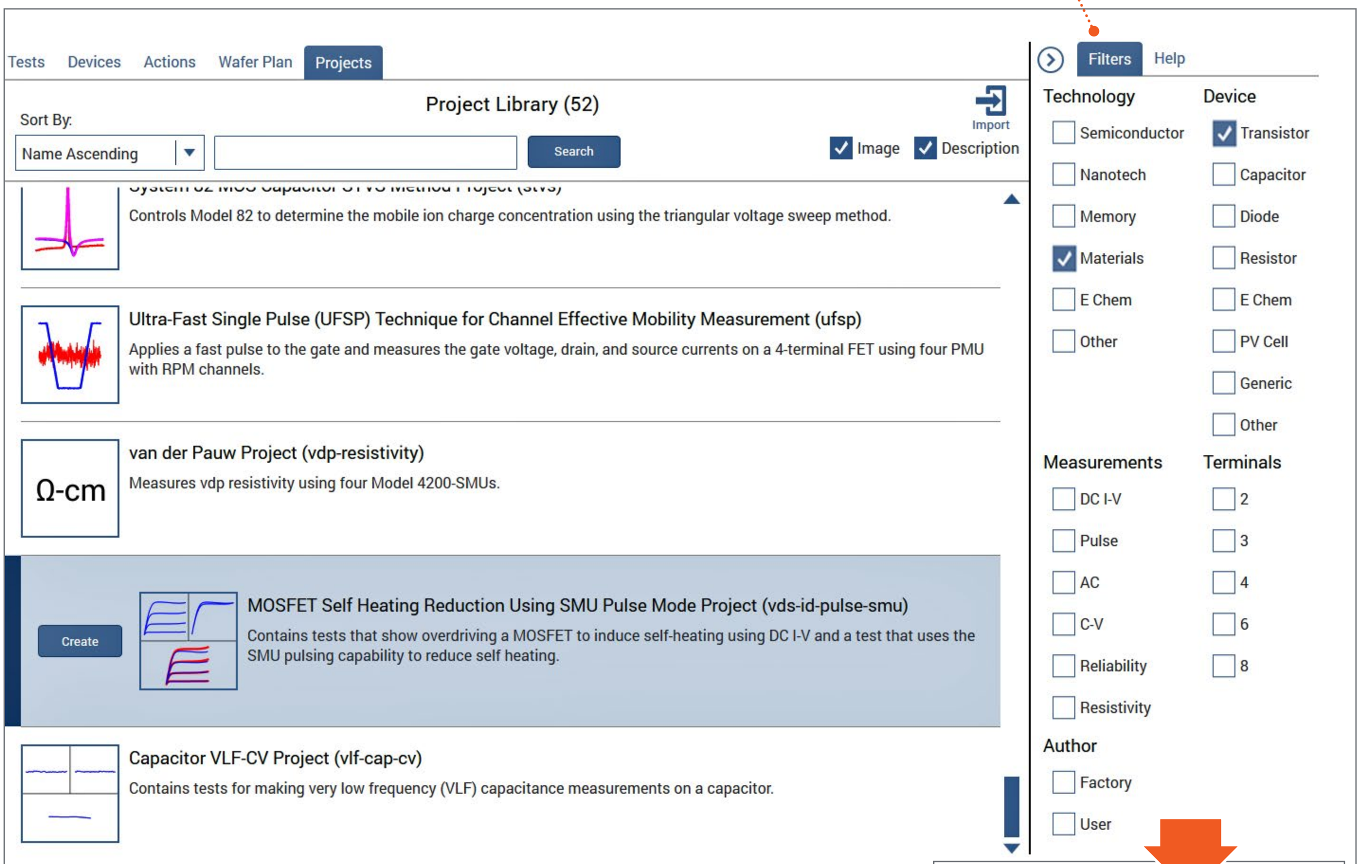
LED and OLED



Step 1 - Build your Test Plan

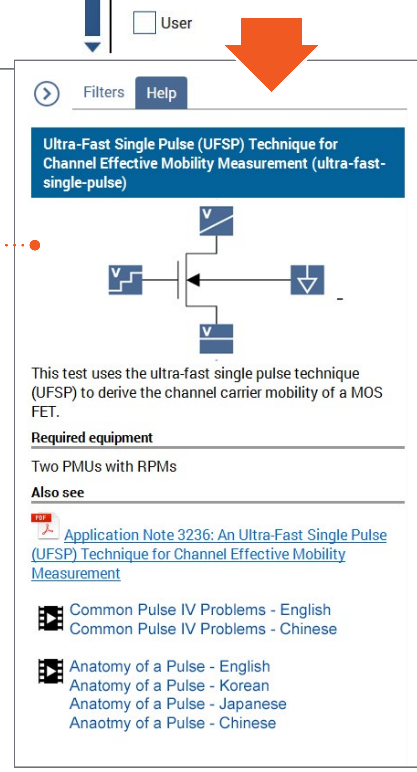
Search, filter and select from more than 450 pre-defined application tests, projects, and devices from the Clarius library.

Filter test, device or project libraries for quick selection



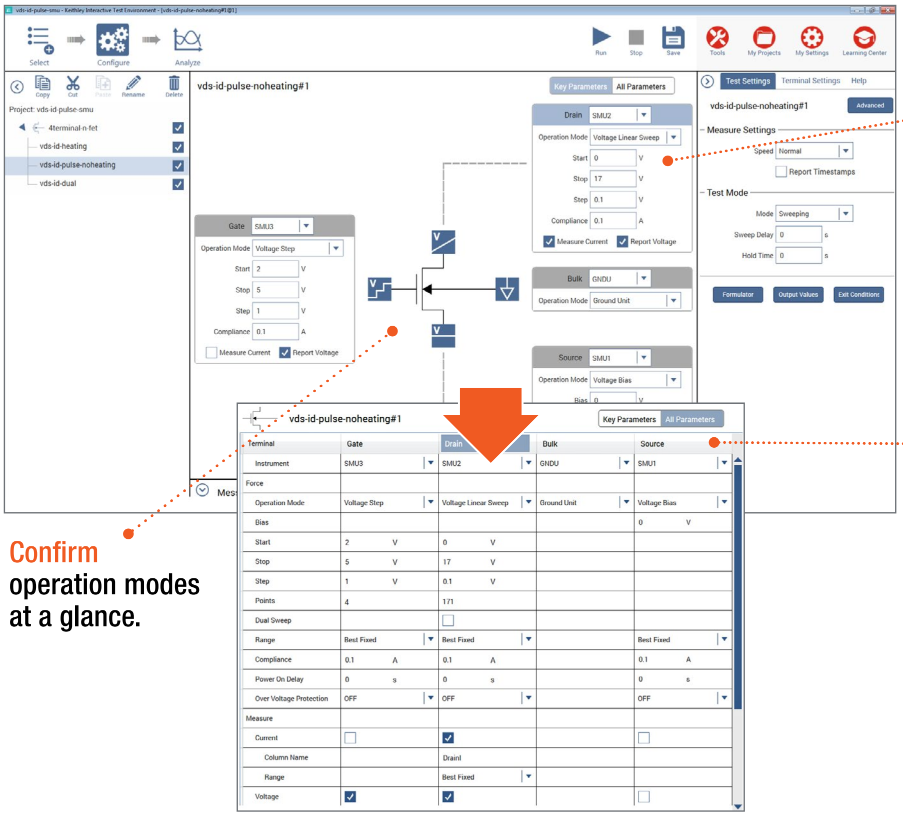
Learn about each test with more detailed information including:

- Comprehensive test descriptions
- Schematic view of test
- Required equipment
- Short videos and application notes



Step 2 – Configure Your Tests

Quickly modify the test parameters using the Key Parameters View or All Parameters View.



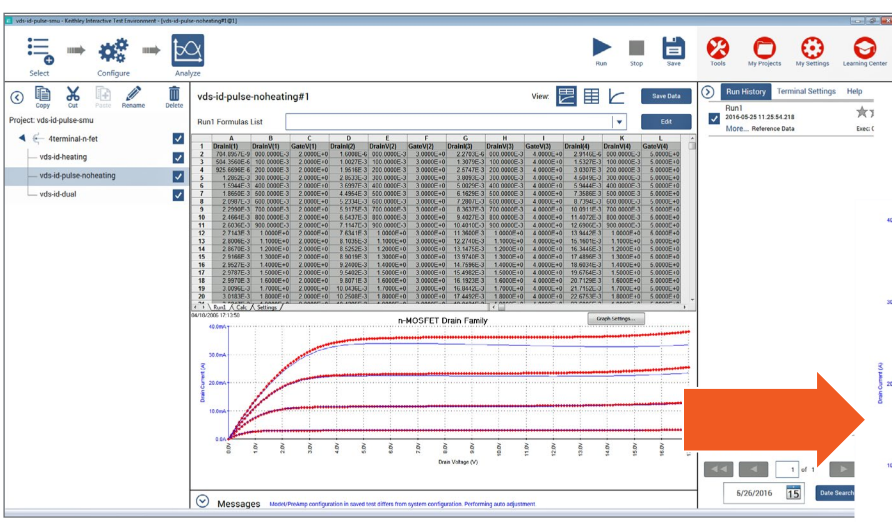
Key Parameters View provides a visual perspective on each test and device and helps to reduce the learning curve.

All Parameters View is ideal for entering test parameters.

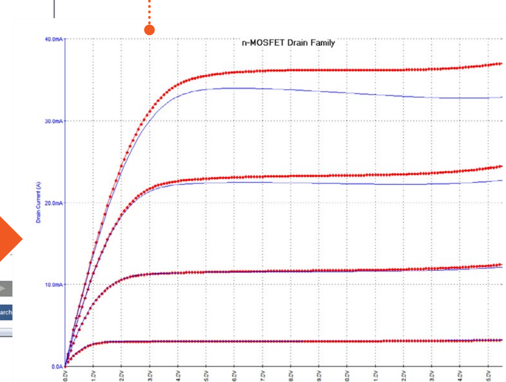
Confirm operation modes at a glance.

Step 3 – Analyze Results

View results in either graphical and numerical results, filter your test data, and tag data for easy identification.



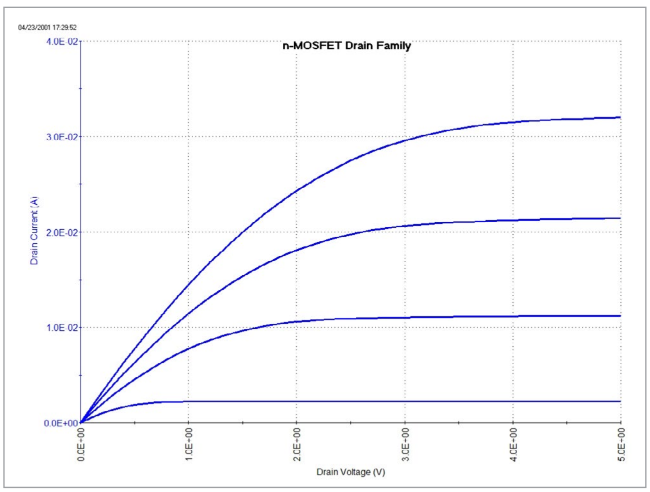
Parameter extractions and data analysis are displayed automatically.



2. Source Measure Units (SMU)

Precision DC current vs. voltage (I-V) measurements are the cornerstone of device and materials characterization. World-class source measure unit (SMU) instruments are at the core of the 4200A-SCS Parameter Analyzer. A source measure unit can source either voltage or current and can simultaneously measure both voltage and current with high resolution and accuracy. The SMU integrates the voltage source, current source, ammeter and voltmeter in one instrument card for tight synchronization of I-V measurements.

A source measure unit has four-quadrant capability, which means it can not only source but also sinks current, as when taking current from a device under test (DUT), such as a charged capacitor or solar cell.



I-V sweep measurement.

The 4200A-SCS Parameter Analyzer can be configured with up to nine SMUs. Two SMU models are available: a medium power SMU that has a range up to 210 V/100 mA and a high power SMU that has a range up to 210 V/1 A. Each 4200-SMU medium power SMU or the 4210-SMU high power SMU occupies one slot in the mainframe and can be used together in the 4200A-SCS system.

All 4200A-SCS SMUs have shielded triaxial connections with active guarding for low current and high impedance measurements and 4-wire (Kelvin) force and sense connections.

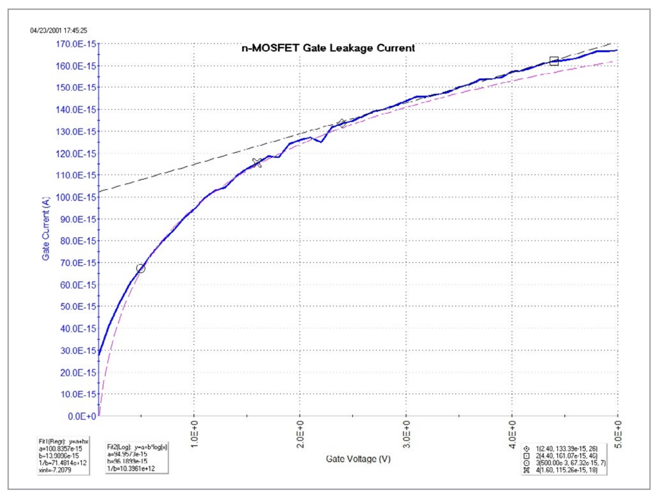
Spot, Sweep and Pulse Measurements

Built-in 4200A-SCS SMU features offer a variety of measurement capabilities, such as sweep measurement operation, linear and logarithmic staircase, list sweep, single spot averaging, etc.

Extend Measurement Resolution to 10 aA

Many critical applications demand the ability to measure very low currents – such as determining the gate leakage current of FETs, testing sensitive nano-scale devices, and measuring leakage current of insulators and capacitors.

When the SMUs are configured with the optional 4200-PA Remote Preamp, they are capable of exceptionally low current measurements. The 4200-PA provides 10 aA resolution by adding additional current ranges to either SMU model. To the user, the SMU simply appears to have additional measurement resolution available.

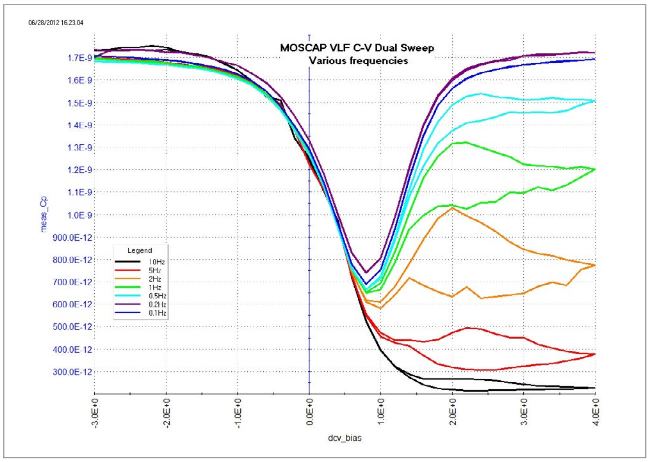


Sub-fA measurements with optional 4200-PA preamplifier module.

The preamplifier is shipped installed on the back of the 4200A-SCS mainframe. This installation allows for standard cabling to a prober, test fixture or switch matrix. The preamplifier can be removed from the back panel and placed in a remote location (such as in a light-tight enclosure or on a prober platen) to eliminate measurement problems due to long cables. Platen mounts and triax panel mount accessories are available.

Very-low Frequency C-V Technique with SMUs

The 4200A-SCS offers the unique ability to perform very-low frequency capacitance-voltage measurements without an LCR meter or capacitance module. Low frequency C-V measurements are used to characterize the slow trapping and de-trapping phenomenon in some materials.



Very low frequency C-V measurements with SMUs and preamps.

The 4200A-SCS uses a new narrow-band technique that takes advantage of the low current measurement capability of the integrated SMU instruments to perform C-V measurements at specified low frequencies in the range of 10 mHz to 10 Hz. This approach uses the 4200A-SCS's SMUs with preamplifiers; no additional hardware or software is required.

Local Switching Options

To accommodate switching between I-V and other measurement types, the 4200A-SCS offers several options for switching easily between measurement types:

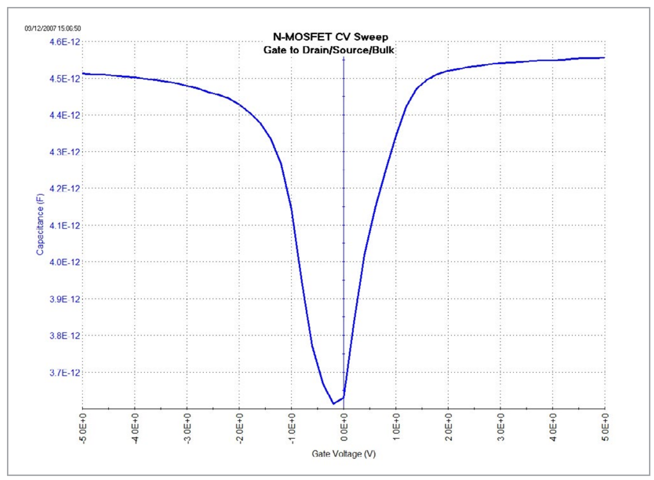
- 4200A-CVIV Multi-Switch Module – up to four channels that effortlessly switch between I-V and C-V measurements. In addition, the C-V measurements can be moved around the device under test without lifting the prober needles or changing the test setup.
- 4225-RPM Remote Preamplifier/Switch Module acts as a multiplexer switch that automatically switches between precision DC SMUs, C-V, and the ultra-fast pulsed I-V instruments. In addition, the RPM extends the low current measurement capability of the 4225-PMU Ultra-fast Pulsed I-V Instrument Module.

3. Capacitance-Voltage Unit (CVU)

Capacitance-voltage (C-V) measurements are often used to characterize a MOSFET's gate oxide thickness, oxide defect density, doping profiles, etc. In this measurement, as the gate voltage varies, the capacitance of the gate to the drain and source changes. Capacitance measurements are typically made using an AC technique. The multi-frequency C-V instrument module measures AC impedance by applying a DC bias voltage and sourcing an AC voltage across the device under test (DUT) and then measuring the resultant AC current and phase angle.

AC Measurements from 1 kHz – 10 MHz

The 4210-CVU instrument module performs multi-frequency capacitance measurements from femtofarads (fF) to microfarads (µF) at test frequencies from 1 kHz to 10 MHz and while providing a DC bias voltage of up to ±30 V or 60 V differential.



Capacitance-Voltage sweeps.

With up to 4096 measurement points, the CVU instrument can be used to measure capacitance vs. voltage (C-V), capacitance vs. frequency (C-f) and capacitance vs. time (C-t) to extract many important parameters such as:

- Doping profiles
- T_{OX}
- Carrier lifetime tests
- Junction, pin-to-pin, and interconnect capacitance measurements

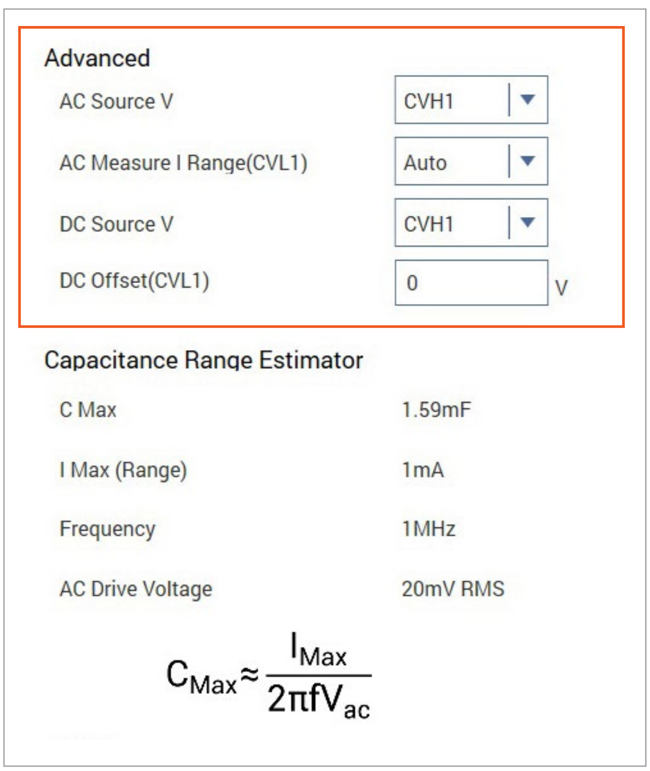
The 4200-CVU PWR option is also available to support:

- High power C-V measurements up to 400 V (200 V per device terminal) for testing high power devices, such as MEMs devices, LDMOS devices, and displays.
- DC currents up to 300 mA for measuring capacitance when a transistor is turned on.

Ensure Validity of your Results

Unlike other C-V modules on the market, the 4210-CVU is designed with unique, patented circuitry to support features and diagnostic tools that ensure the validity of your results.

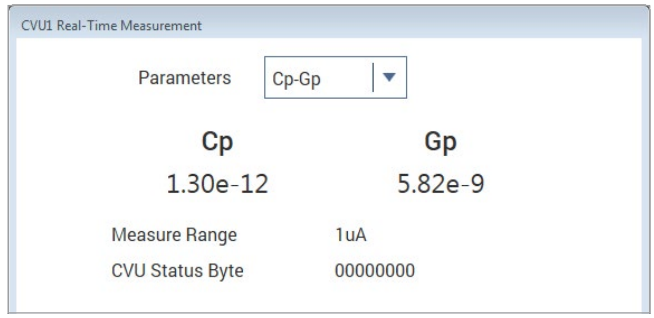
- **Switch the AC ammeter in software.** This simple feature ensures that you are measuring the AC signal on the least noisy terminal, which will provide a more useful measurement. Without having to manually change cables, lift the prober needles, or change the test setup, you have easily eliminated potential mistakes.



Change AC and DC sources to least noisy terminal with a simple click of the mouse.

- **Move the DC bias to the terminal of choice.** With just a click in the Clarius Software, you can change the terminal to which the DC bias is applied to ensure proper control of the electric field.

- **Real-time C-V meter.** The real-time C-V meter displays quick and accurate capacitance measurements with no need to run a pre-programmed test. This is especially useful to ensure you have an open and short circuit before you perform a measurement compensation. Additionally, you can use the real-time C-V meter for troubleshooting your test setup and device under test.



Real-time capacitance measurements.

- **Confidence Check.** This diagnostic tool allows users to check the integrity of open and short connections and the connections to the DUT. When performing an open or short test, an impedance and noise measurement is made on the high and low sides of the test circuit. This is especially useful to confirm that contact has been made with the pads on a wafer or that the switch matrix is connected properly. If the Confidence check diagnostic test fails, additional troubleshooting guidance is given.

Local Switching Options

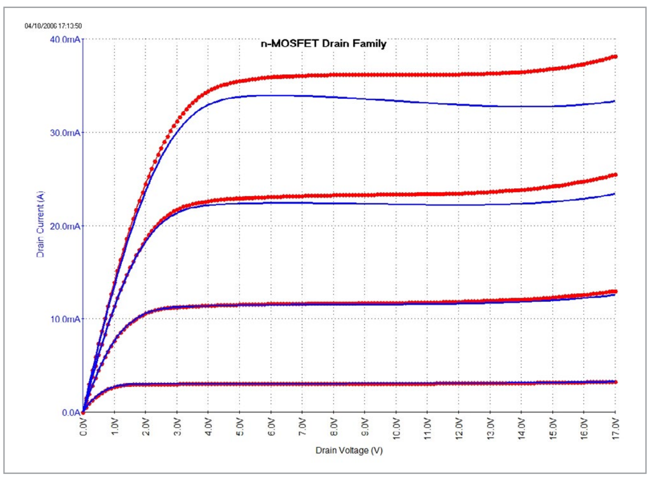
Because it can be difficult to switch between C-V and other measurement types, the 4200A-SCS offers several options to switch easily between measurement types:

- **4200A-CVIV Multi-Switch Module** – Up to four channels that effortlessly switch between I-V and C-V measurements. In addition, the C-V measurements can be moved around the DUT without lifting the prober needles or changing the test setup.
- **4225-RPM Remote Preamplifier/Switch Module** This acts as a multiplexer switch that automatically switches between precision DC SMUs, C-V, and the ultra-fast pulsed I-V instruments. In addition, the RPM extends the low current measurement capability of the 4225-PMU Ultra-fast Pulsed I-V Instrument Module.

4. Ultra-fast Pulse Measure Unit (PMU)

Ultra-fast I-V sourcing and measuring have become increasingly important capabilities for many technologies, including compound semiconductors, medium power devices, non-volatile memory, MEMS devices and more.

The 4225-PMU instrument card integrates ultra-fast voltage waveform generation and signal observation capabilities into the already-powerful 4200A-SCS test environment to deliver unprecedented I-V testing performance, expanding the system's materials, device, and process characterization dramatically. It replaces traditional pulse/measure hardware configurations, which typically included an external pulse generator, a multi-channel oscilloscope, specially designed interconnect hardware, and integrated software.



Minimize self-heating effects with ultra-fast pulsed I-V.

Each module has two independent channels. Each channel can measure both voltage and current simultaneously with parallel 14-bit A/D converters with deep memory, allowing up to one million samples at 5 ns per sample (200 MSa/sec).

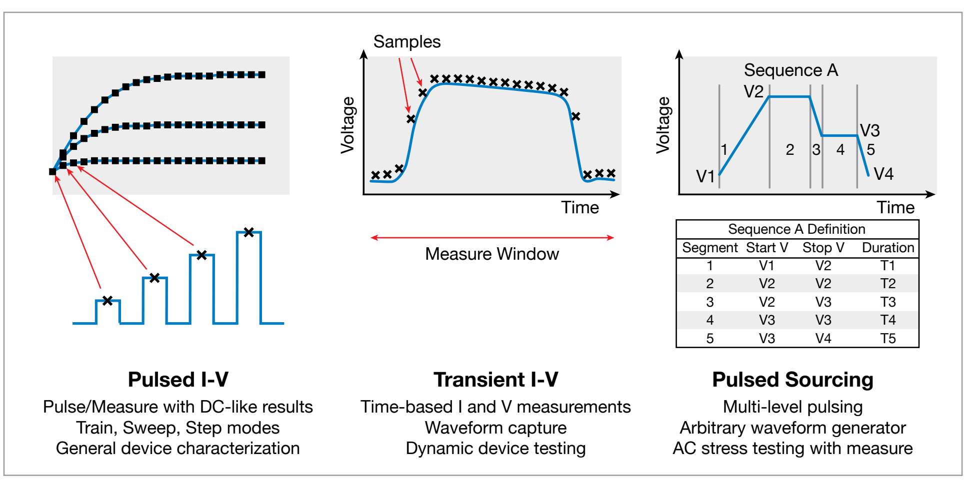
Three Operating Modes for Complete Characterization

The 4225-PMU can be used to perform three types of ultra-fast I-V tests: pulsed I-V, transient I-V, and pulsed sourcing.

Pulsed I-V refers to any test with a pulsed source and a corresponding high speed, timed-based measurement that provides DC-like results. Using pulsed I-V signals to characterize devices rather than DC signals makes it possible to study or reduce the effects of self-heating (Joule heating) or to minimize current drift or degradation in measurements due to trapped charge.

Transient I-V or waveform capture is a time-based current and/or voltage measurement that is typically the capture of a pulsed waveform. A transient test is typically a single pulse waveform that is used to study time-varying parameters, such as the drain current degradation versus time due to charge trapping or self-heating. Transient I-V measurements can be made to test a dynamic test circuit or can be used as a diagnostic tool for choosing the appropriate pulse settings in the pulsed I-V mode.

Pulsed Sourcing involves outputting user-defined two-level or multi-level pulses using the built-in Segment ARB® function or outputting an arbitrarily defined waveform. When the instrument's Segment ARB mode is used for multi-level pulsing, individual voltage segments can be as short as 20 ns and waveforms can have up to 2048 unique segments per channel, which provides the flexibility necessary to build waveforms for characterizing flash devices and other non-volatile memory technologies.



4225-PMU Operating Modes.

5. Switching Solutions

Tie it all together with your choice of high speed, high integrity switching solutions from Keithley.

4200A-CVIV Multi-Switch

One of the most difficult problems associated with integrating various measurements into device characterization is that the cabling required for each measurement type is fundamentally different.

4200A-CVIV Multi-Switch.

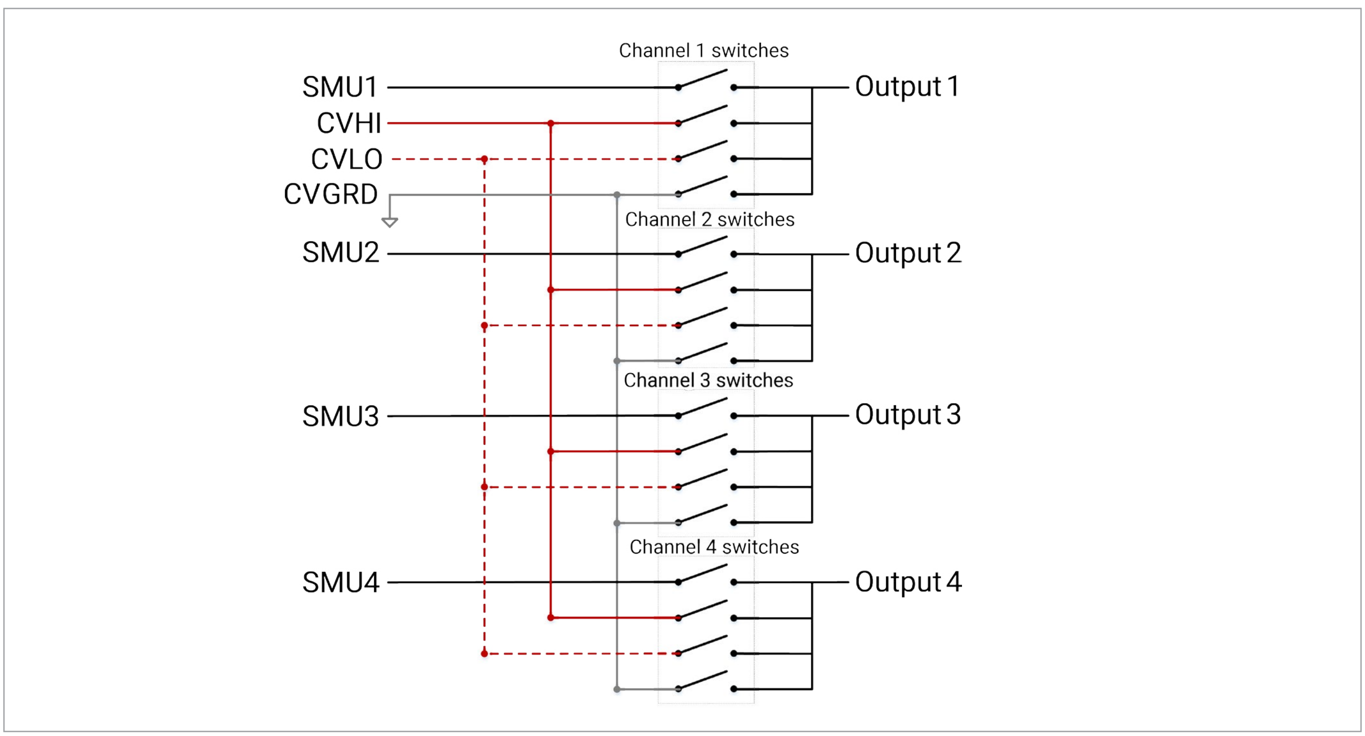
Matching cabling to the measurement type enhances measurement integrity. However, changing cables for each measurement type is so time-consuming many users simply tolerate the sub-optimal results. Moreover, whenever cables are rearranged, users run the risk of reconnecting them improperly, thereby causing errors and demanding extra troubleshooting time. Worse still, these errors may go unnoticed for a long time.

One alternative is to use a remote switch capable of handling I-V and C-V signals, such as Keithley's 4200A-CVIV Multi-Switch.

The new 4200A-CVIV Multi-Switch automatically switches between I-V and C-V measurements. In addition, C-V measurements can be moved to any output channel without re-cabling. This four-channel switch allows the user to maintain the same impedance during the I-V and C-V tests by keeping the probe needles on the wafer test site. Additionally, the test setup and cables don't need to be changed to enhance the measurement.

The built-in display provides exceptional, clear test information where you need it, near the device under test.

- View real-time test status
- Personalize output naming convention via Clarius software
- Rubber bumpers allow 2-way orientation on probe station
- Ability to rotate text allows user to orient the module as needed
- Turn off display to reduce light near DUT



4200A-CVIV Multi-Switch connection schematic.

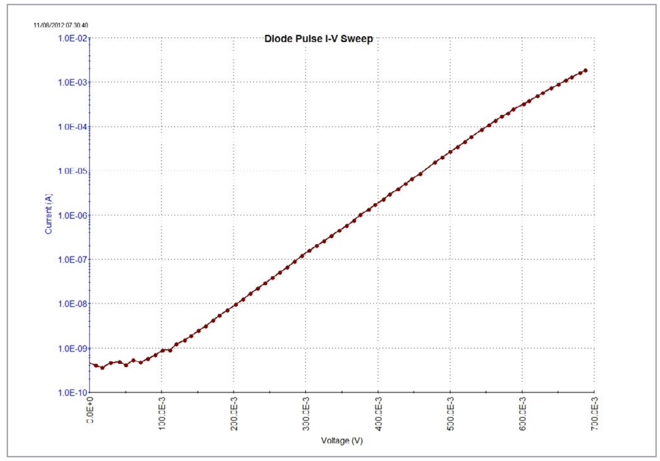
4225-RPM Remote Preamplifier/Switch Module

For some devices, multiple types of electrical measurements are required, such as pulsed I-V, DC I-V, and C-V tests. This usually requires an external switch matrix capable of switching the various types of signals to the device under test. However, the optional 4225-RPM Remote Preamplifier/Switch Module allows for switching automatically between DC I-V, C-V, and pulsed I-V measurements, greatly simplfying the connections to the device.

4225-RPM Remote Preamplifier/Switch Module.

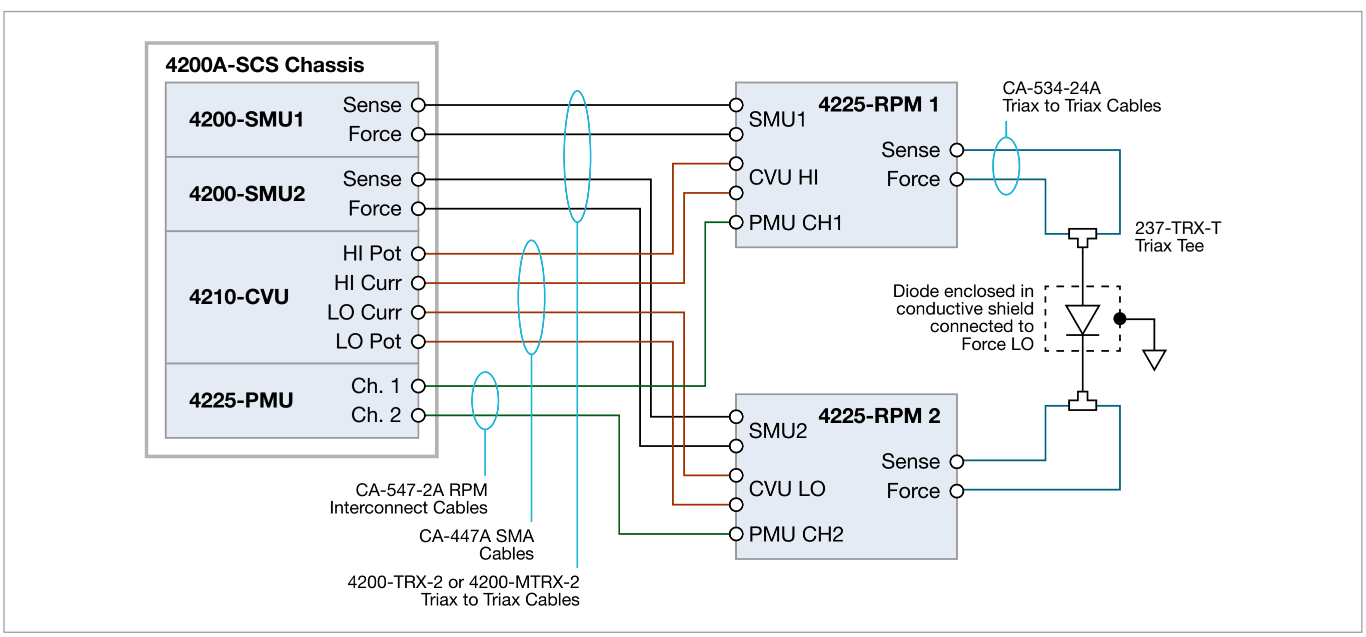
Users can perform all the electrical measurements on the device without having to disconnect and reconnect cabling for each test, which ultimately saves valuable test time and reduces frustration.

The 4225-RPM also serves as a preamp to extend the lower current ranges on the PMU. This is especially important for devices, such as diodes, that have I-V characteristics that extend over several decades of current. The pulsed I-V measurements of the diode through the 4225-RPM Remote Preamplifier/Switch are shown below. Its unique auto-range feature enables automatic range selection while the pulsed I-V sweep is in progress, so the user isn't forced to select a fixed range, which can reduce measurement resolution.



4225-RPM provides lower current ranges for pulse applications.

The optional Multi-measurement Performance Cable Kit (4210-MMPC) connects the 4200A-SCS Parameter Analyzer to a prober manipulator. In addition to eliminating the need for re-cabling, this kit helps maximize signal fidelity by eliminating the measurement errors that often result from cabling errors.



Connection diagram when using 4225-RPM Remote Preamplifier/Switch Module.

Switch Matrices

A number of switch matrix configurations are available for the 4200A-SCS.

The six-slot 707B and single-slot 708B Semiconductor Switch Matrix mainframes slash the time from command to connection, offering significantly faster test sequences and overall system throughput than earlier mainframe designs.

708B and 707B Switch Matrix mainframes.

They are specifically designed for the requirements of both semiconductor lab and production test environments, delivering ultra-low current switching performance using standard triaxial connectors and cables.

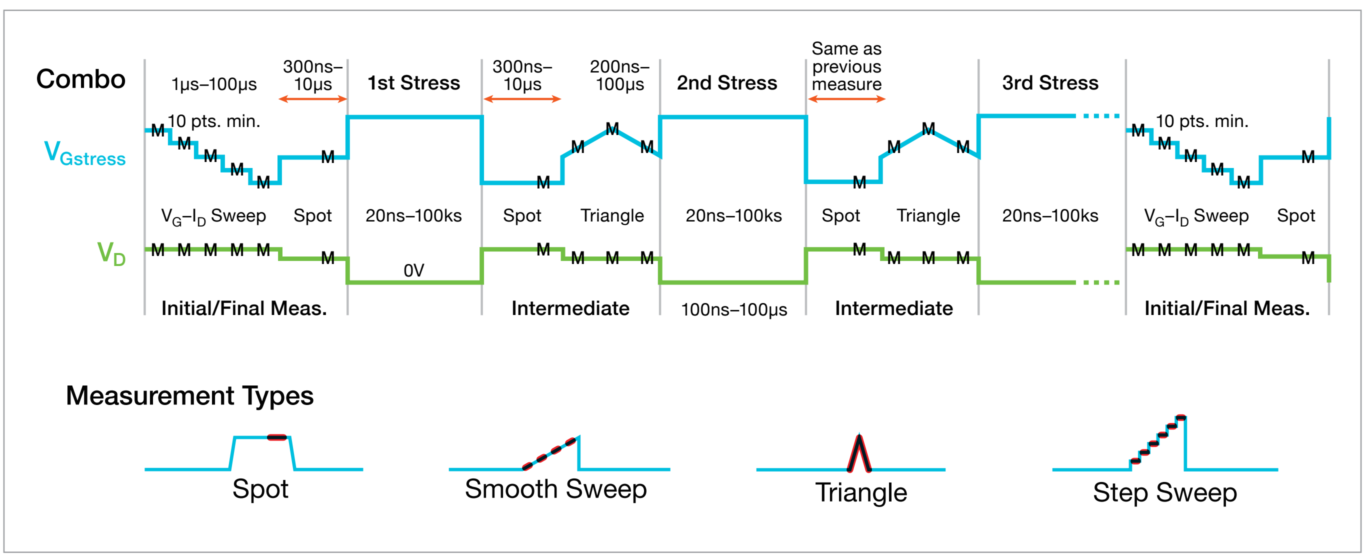
6. NBTI/PBTI Package

Modeling negative/positive bias temperature instability (NBTI/PBTI) is a challenge when developing deeply scaled silicon CMOS transistor designs. Over time, NBTI effects cause a transistor's threshold voltage (V_T) to shift and its sub-threshold drain current to increase significantly, severely limiting transistor lifetime and circuit performance.

These effects must be accurately modeled during device development and monitored during process integration and production. During BTI characterization, the transistor is alternately stressed and characterized. However, the BTI mechanism is susceptible to relaxation effects, which means that the instant the stress is removed, the transistor starts to recover and the degradation fades. Characterizing the degradation prior to relaxation demands the use of ultra-fast I-V techniques.

The 4200-BTI-A Ultra-Fast BTI Package is the industry's most advanced NBTI/PBTI test platform, with everything needed to make sophisticated NBTI and PBTI measurements on leading-edge silicon CMOS technology: a 4225-PMU Ultra-Fast I-V Module, two 4225-RPM Remote Preamplifier/Switches, Automated Characterization Suite (ACS) software, an Ultra-Fast BTI Test Project Module, and cabling. The test software module makes it easy to define stress timing, stress conditions, and a wide range of measurement sequences from spot I_D, On-The-Fly (OTF), or I_D-V_G sweeps. It allows measuring recovery effects as well as degradation and offers pre-stress and post-stress measurement options that incorporate the 4200A-SCS's DC SMUs for precision low-level measurements.

The Ultra-Fast BTI test software module supports spot, step sweep, smooth sweep, and sample measurement types. Each type's timing is defined by the test sample rate and the individual measurement settings. The software module also provides control over the voltage conditions between each element in the test sequence, for maximum flexibility and ease of use, even when defining complex test sequences.



Ultra-fast BTI package supports spot, smooth sweep, triangle, and step sweep measurement types.

Specifications

All specifications are guaranteed unless noted otherwise. All specifications apply to all models unless noted otherwise.

1. Source Measure Units

	4200-SMU Medium Power	4210-SMU High Power	Optional 4200-PA Remote Preamplifier
Current, maximum	100 mA	1 A	extends low current measure range of all SMUs
Voltage, maximum	210 V	210 V	
Power	2.1 W	21.0 W	

General Information

	Four-quadrant source/sink operation
	A/D converter on every SMU
	Full remote sense capability
	Log and linear measurement sweeps
	4200A-SCS mainframe can accept up to nine medium or high power SMU instruments
Output connectors	Three mini-triaxial (f) on each SMU for Force, Sense and Sense Lo One custom, 15-pin, D-Sub (f) for connection to 4200-PA
Optional accessory	4200-PA remote preamplifier module

SMU Current Measurement [4]

		Current Range [1]	Max. Voltage	Measure Resolution [3]	Measure Accuracy ±(% rdg + amps)	Source Resolution [3]	Source Accuracy ±(% rdg + amps)
4210-SMU High Power SMU [2]		1 A	21 V	1 µA	0.100% + 200 µA	50 µA	0.100% + 350 µA
4210-SMU High Power SMU [2]		100 mA	210 V	100 nA	0.045% + 3 µA	5 µA	0.050% + 15 µA
4210-SMU High Power SMU [2]	**4200-SMU Medium Power SMU [2]**	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.

Notes

1. All ranges extend to 105% of full scale.
2. Specifications apply on these ranges with or without a 4200-PA.
3. Display resolution is limited by fundamental noise limits. Measured resolution is 6½ digits on each range. Source resolution is 4½ digits on each range.
4. 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 warmup.
   - Speed set to NORMAL.
   - Guarded Kelvin connection.

SMU Voltage Measurement[3]

Voltage Range[1]	Max. Current		Measure		Source	
	4200-SMU	4210-SMU	Resolution[2]	Accuracy ±(% rdg + volts)	Resolution[2]	Accuracy ±(% rdg + volts)
200 V	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.						

Notes

1. All ranges extend to 105% of full scale.
2. Specifications apply on these ranges with or without a 4200-PA.
3. 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 warmup.
    - Speed set to NORMAL.
    - Guarded Kelvin connection.

Voltage Monitor Mode

High impedence voltmeter mode set at 0 Amps.

Accuracy & Resolution

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} Ω
Input Leakage Current	<30 pA
Measurement Noise	0.02% of measure range (rms).
Differential Voltage Monitor	Use two SMUs in VMU mode or use the low sense terminal provided with each SMU.

SMU Supplemental Information

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

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	1 mA step, R_L = 10 kΩ, 20 V range
Range Change Transient	
Voltage Ranging	<200 mV
Current Ranging	<200 mV

Temperature and Humidity Effect on Accuracy

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

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

Remote Sense	<10 Ω in series with FORCE terminal not to exceed a 5 V difference between FORCE and SENSE terminals ±30 V maximum between COMMON and SENSE LO.
Maximum Load Capacitance	10 nF
Maximum Guard Offset Voltage	3 mV from FORCE
Guard Output Impedance	100 kΩ
Maximum Guard Capacitance	1500 pF
Maximum Shield Capacitance	3300 pF
4200-SMU and 4210-SMU Shunt Resistance (Force to Common)	>10^{12} Ω (100 nA–1 µA ranges)
4200-PA Shunt Resistance (Force to Common)	>10^{16} Ω (1 pA and 10 pA ranges), >10^{13} Ω (100 pA–100 nA 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	0.2 V/µs
DC Floating Voltage	Common can be floated ±32 V from chassis ground

2. SMU Preamplifier Module

The low current measurement capabilities of any SMU can be extended by adding an optional 4200-PA preamplifier. The preamplifier provides 10 aA 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.

4200-PA General information

Installation	
Local	The preamplifier is shipped installed on the back panel of the 4200A-SCS for local operation.
Remote	Users can remove the preamplifier 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.
Input Connectors	One custom, 15 pin, D-Sub (m)
Output Connectors	Two triaxial (f)
Dimensions	.078 in. wide x 4.4 in. deep x 2.2 in. tall (2 cm wide x 11.3 cm deep x 5.6 cm tall)
Weight	4.8 oz. (136 g)

SMU Current Measurement with 4200-PA Preamplifier [4]

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

Notes

1. All ranges extend to 105% of full scale.
2. Specifications apply on these ranges with or without a 4200-PA.
3. Display resolution is limited by fundamental noise limits. Measured resolution is 6½ digits on each range. Source resolution is 4½ digits on each range.
4. 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 warmup.
   - Speed set to NORMAL.
   - Guarded Kelvin connection.

3. Multi-Frequency Capacitance-Voltage Unit

4210-CVU General Information

Measurement configuration	Four-terminal pair, High POT, High CUR, Low POT, Low CUR
Output connectors	Four SMA (f)
Supplied cable	100 Ω, SMA (m) to SMA (m), 1.5 m, 4 each
Optional cables	100 Ω, SMA (m) to SMA (m), 3 m

Measurement Functions

Measurement parameters	C_P–G, C_P–D, C_S–R_S, C_S–D, R–jX, Z-theta
Ranging	Auto and fixed
Integration time	Fast, Normal, Quiet, and Custom

Test Signal

Frequency range	1 kHz to 10 MHz
Minimum resolution	1 kHz, 10 kHz, 100 kHz, 1 MHz depending on frequency range
Source frequency accuracy	±0.1%
Signal output level range	10 mV rms to 100 mV rms
Resolution	1 mV rms
Accuracy	±(10.0% + 1 mV rms) unloaded (at rear panel)
Output impedance	100 Ω, typical

DC Bias Function

DC voltage bias range	±30 V (60 V differential)
DC voltage bias resolution	1.0 mV
DC voltage bias accuracy	±(0.5% + 5.0 mV) unloaded
Maximum DC current	10 mA

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

Notes

1. The capacitance and conductance measurement accuracy is specified under the following conditions: $D_X < 0.1$.
2. Conductance accuracy is specified as the maximum conductance measured on the referenced capacitor.
3. These specs are typical, non-warranted, apply at 23°C, and are provided solely as useful information.
4. Integration time: 1 s or 10 s below 10 kHz. Test signal level: 30 mV 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.

CVU Supplemental Cable Specification [3]

These specifications are typical, non-warranted, apply at 23°C, and are provided solely as useful information.

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: $D_X < 0.1$.
2. Conductance accuracy is specified as the maximum conductance measured on the referenced capacitor.
3. These specs are typical, non-warranted, apply at 23°C, and are provided solely as useful information.
4. Integration time: 1 s or 10 s below 10 kHz. Test signal level: 30 mV 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.

4. CV-IV Multi-Switch Module

The I-V/C-V Multi-Switch automatically switches between I-V and C-V measurements. In addition, C-V measurements can be moved to any output channel without recabling. Each channel is user configurable for low current measurement capabilities using the 4200-PA preamplifier or standard current resolution with a SMU Pass Thru 4200A-CVIV-SPT.

4200A-CVIV General Information

Input connectors	**4200-PA Preamplifier:** Custom, 15-pin, D-Sub (m) **4200-CVIV-SPT SMU Pass-thru module:** Two triaxial (f) per module **CVU:** Four SMA (f)	
Output connectors	Eight triaxial (f)	
Dimensions	19.8 cm wide x 14.2 cm high x 11.1 cm deep (7.8 in. wide x 5.6 in. tall x 4.4 in. deep)	
Weight	3.3 lbs.	
Power	From 4200A-SCS mainframe via USB cable	
Output channels	Configurable up to 4 channels	
Voltage, max.	210 V	
Current, max.	1 A	
SMU Path	**With 4200-PA**	**With 4200A-CVIV-SPT**
Offset current	<100 fA	< 1pA
Offset voltage	<100 µV	<100 µV
Shunt resistance	>1e15 Ω	>1e14 Ω
DC output resistance (2-wire)	1.5 Ω	1.5 Ω
DC output resistance (4-wire)	<100 mΩ	<100 mΩ
CVU Path		
AC output impedance	100 Ω, typical (center pin to outer shield)	
Accuracy, typical	Refer to chart below	
CVU DC bias function		
Range	±30V at 10 mA max. (±60V Differential)	
Resolution	1 mV	
Additional errors (for CVU bias)	<50 µV	
DC output resistance (4 wire)	<100 mΩ	

Typical Accuracy of 4210-CVU through the 4200A-CVIV Multi-Switch, 2-wire mode unless otherwise noted [1,3]

Measured Capacitance	1 kHz	10 kHz	100 kHz	1 MHz
1 pF	Not Specified	±9.0%	±2.2%	±0.7%
10 pF	Not Specified	±1.0%	±0.5%	±0.5%
100 pF	Not Specified	±0.5%	±0.5%	±0.5%
1 nF	±0.8%	±0.5%	±0.5%	±0.5% [2]
10 nF	±0.5%	±0.5%	±0.5%	±0.75% [2]
100 nF	±0.5%	±0.5%	±0.5%	±1.25% [2]
1 µF	±0.5%	±0.5%	Not Specified	Not Specified

Notes

1. Valid when CVU compensation is applied from a <1 month old compensation acquisition.
2. Specified in 4-wire mode; 4-wire always recommended for low impedance devices
3. The specifications above are typical, non-warranted, apply at 25°C, and are provided solely as useful information.

5. Ultra-fast Pulse Measure Unit

The two-channel 4225-PMU provides the combination of ultra-fast voltage waveform generation with fast simultaneous voltage and current measurements.

4225-PMU General Information

Output connectors	Four SMA (f) and two HDMI
Suppled cables	SMA (m) to SMA (m), 2m, 4 each (CA-404B) SMA to SSMC Y-cable, 6 inch (15 cm), 2 each (4200-PRB-C)
Optional accessory	4225-RPM single-channel, remote preamplifier/switch module

PMU Current Measurement

Timing parameters, typical [1] with or without the 4225-RPM Remote Preamplifier/Switch Module

	10 V Range		40 V 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

Notes

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: 10 mA settling time on the PMU 10 V range is defined when the signal is within 1.25% of the final value. This calculation: Accuracy = 0.25% + 100 µA = 0.25% + (100 µA/10 mA) = 0.25% + 1% = 1.25%).

Timing parameters, typical [1] with the 4225-RPM Remote Preamplifier/Switch Module

	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

Notes

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: 10 mA settling time on the PMU 10 V range is defined when the signal is within 1.25% of the final value. This calculation: Accuracy = 0.25% + 100 µA = 0.25% + (100 µA/10 mA) = 0.25% + 1% = 1.25%).

PMU Current Measurement Accuracy

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-PMU and RPM Combined

	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)

PMU Voltage Measurement

Timing parameters, typical [1]

	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

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: 10 mA settling time on the PMU 10 V range is defined when the signal is within 1.25% of the final value. This calculation: Accuracy = 0.25% + 100 µA = 0.25% + (100 µA/10 mA) = 0.25% + 1% = 1.25%).

PMU Voltage Accuracy

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

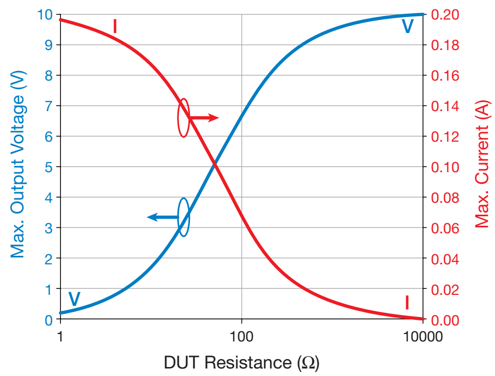
Voltage and Current, Maximum [1]

Resistance [2]	10V Range		40V Range	
	Maximum V [2]	Maximum I [2]	Maximum V [2]	Maximum I [2]
1 Ω	0.196 V	196 mA	0.784 V	784 mA
5 Ω	0.909 V	182 mA	3.64 V	727 mA
10 Ω	1.67 V	167 mA	6.67 V	667 mA
25 Ω	3.33 V	133 mA	13.3 V	533 mA
50 Ω	5.00 V	100 mA	20.0 V	400 mA
100 Ω	6.67 V	66.7 mA	26.7 V	267 mA
250 Ω	8.33 V	33.3 mA	33.3 V	133 mA
1 kΩ	9.52 V	9.5 mA	38.1 V	38.1 mA
10 kΩ	9.95 V	995 µA	39.8 V	3.98 mA

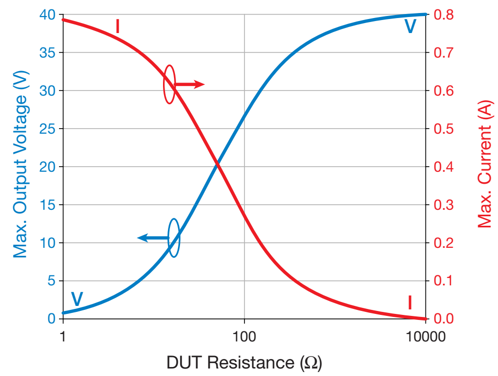
Notes

1. To calculate the approximate maximum current and voltage for any resistance
   I_{MAX} = V range/(50 Ω + Resistance)
   $V_{MAX} = I_{MAX} \cdot$ Resistance
   where Resistance is the total resistance connected to the PMU or PGU channel and V range is either 10 or 40.
   Example: 10 V range using R = 10 Ω (for DUT + interconnect)
   $V_{MAX} = I_{MAX} \cdot R = 0.167 \cdot 10 = 1.67$ V
2. Typical maximum at pulse output connector. Resistance is the total resistance connected to the pulse output connector, including device and interconnect.

10V Range: Max. Output vs. DUT Resistance



40V Range: Max. Output vs. DUT Resistance



PMU Pulse/Level [1,2]

		10 V Range	40 V 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 limit		Programmable limit to protect the device under test	

Notes

1. Unless stated otherwise, all specifications assume a 50 Ω termination.
2. Level specifications are valid after 50 ns typical settling time (after slewing) for the 10 V source range and after 500 ns typical settling time (after slewing) for the 40 V source range into a 50 Ω load.
3. With transition time of 20 ns (0%–100%) for the 10 V source range and 100 ns (0%–100%) for the 40 V source range.

PMU Pulse 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 [1]	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

Notes

1. 40V range minimum programmable transition time (source only) is 30ns for voltage <10 V and 100 ns for voltages >10 V.

Voltage Source, Best Performance

When the 4225-PMU is used as a voltage source only (no measurements of voltage or current), the timing performance is improved. The following is provided to offer a clearer idea of best performance when used as a voltage source, as achievable under optimal conditions. This should not be interpreted as a guarantee.

	10V Range	40V Range
Rise time	<10 ns	50 ns to 10 V, 100 ns to 40 V
Pulse width	10 ns (FWHM)	50 ns (FWHM)
Period	20 ns	100 ns
Overshoot/ preshoot/ringing	±(2% + 20 mV)	±(0.5% + 40 V)

Trigger

Trigger output impedance	50 Ω
Trigger output level	TTL
Trigger in impedance	10 kΩ
Trigger in level	TTL
Trigger in transition timing, maximum	<100 ns
Trigger in to pulse output delay	400 ns
Trigger synchronization/jitter[1]	<2 ns

Segment ARB® and Timing

Segment ARB capabilities are available with the 4225-PMU and 4220-PGU, with or without the 4225-RPM Remote Preamplifier/Switch Module.

Max. Number of Segments[2]	2048
Max. Number of Sequences[2]	512
Max. Number of Sequence Loops	10^{12}
Time per Segment	20 ns to 40 s
Segment Timing Resolution	10 ns
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

1. For multiple 4225-PMU or 4220-PGU cards in a single 4200A-SCS chassis
2. Per channel

6. Pulse Generator Unit

The two-channel, voltage-only pulse generator is an economical alternative to the 4225-PMU Ultra-fast Pulse Measure Unit if pulse measurement is not needed.

4220-PGU General Information

Output connectors	Four SMA (f)
Supplied cables	SMA (m) to SMA (m), 2 m, 4 each (CA-404B) SMA (m) to SSMC 4-cable, 6 inch (15 cm), 2 each (4200-PRB-C)

Pulse/Level [1,2]

		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 50 Ω load (at full scale)	—	±100 mA typical	±400 mA typical
Short circuit current	—	±200 mA	±800 mA
Output limit	—	Programmable limit to protect the device under test	

Notes

1. Unless stated otherwise, all specifications assume a 50 Ω termination.
2. Level specifications are valid after 50 ns typical settling time (after slewing) for the 10 V source range and after 500 ns typical settling time (after slewing) for the 40 V source range into a 50 Ω load.
3. With transition time of 20 ns (0%–100%) for the 10 V source range and 100 ns (0%–100%) for the 40 V source range.

Pulse Timing

	10 V Range Source Only	40 V Range Source Only
Frequency range	1 Hz to 50 MHz	1 Hz to 10 MHz
Timing resolution	10 ns	10 ns
RMS jitter (period, width), typical	0.01% + 200 ps	0.01% + 200 ps
Period range	20 ns to 1 s	100 ns to 1s
Accuracy	±1%	±1%
Pulse width range	10 ns to (Period–10 ns)	50 ns to (Period–10 ns)
Accuracy	±(1% + 200 ps)	±(1% + 5 ns)
Programmable transition time (0%–100%)	10 ns to 33 ms	30 ns to 33 ms [1]
Transition slew rate accuracy	±1% (transitions > 100 ns)	±1% (transitions > 1 µs)
Solid state relay open/close time	25 µs	25 µs

Notes

1. 40V range minimum programmable transition time (source only) is 30ns for voltage <10 V and 100 ns for voltages >10 V.

Voltage Source, Best Performance

When the 4225-PMU is used as a voltage source only (no measurements of voltage or current), the timing performance is improved. The following is provided to offer a clearer idea of best performance when used as a voltage source, as achievable under optimal conditions. This should not be interpreted as a guarantee.

	10 V Range	40 V Range
Rise Time	<10 ns	50 ns to 10 V, 100 ns to 40 V
Pulse Width	10 ns (FWHM)	50 ns (FWHM)
Period	20 ns	100 ns
Overshoot/ Preshoot/Ringing	±(2% + 20 mV)	±(0.5% + 40 mV)

Trigger

Trigger output impedance	50 Ω
Trigger output level	TTL
Trigger in impedance	10 kΩ
Trigger in level	TTL
Trigger in transition timing, maximum	<100 ns
Trigger in to pulse output delay	400 ns
Trigger synchronization/jitter[1]	<2 ns

Segment ARB® and Timing

Segment ARB capabilities are available with the 4225-PMU and 4220-PGU, with or without the 4225-RPM Remote Preamplifier/Switch Module.

Max. Number of Segments	2048 per PMU channel
Max. Number of Sequences	512 per PMU channel
Max. Number of Sequence Loops	10^{12}
Time per Segment	20 ns to 40 s
Segment Timing Resolution	10 ns
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

1. For multiple 4225-PMU or 4220-PGU cards in a single 4200A-SCS chassis

7. Remote Preamplifier/Switch Module

The 4225-RPM enables automatic switching between I-V, C-V and Pulsed I-V measurements, allowing you to choose the appropriate measurement without recabling your test setup. Additionally, the RPM expands the range of the 4225-PMU Pulse Measure Module.

4225-RPM General Information

Inputs	Three inputs. SMU Force, SMU Sense, CVU Pot, CVU Cur, RPM Control
Outputs	One channel
Input connector	Triaxial (f), two SMA (f), two HDMI
Output connector	Triaxial (f), two
Dimensions	1.34 in. wide x 4.9 in. deep x 3.0 in. tall (3.4 cm wide x 12.5 cm deep x 7.6 cm tall)
Dimensions with base	1.34 in. wide x 4.9 in. deep x 3.8 in. tall (3.4 cm wide x 12.5 cm deep x 9.6 cm tall)
Weight	8.6 oz. (245 g) (with base: 13.4 oz. (381 g))
Optional Accessories	Magnetic base Vacuum base

RPM Current Measurement

Timing parameters, typical[1] with the 4225-PMU and 4225-RPM Remote Preamplifier/Switch Module

	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

Notes

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: 10 mA settling time on the PMU 10 V range is defined when the signal is within 1.25% of the final value. This calculation: Accuracy = 0.25% + 100 µA = 0.25% + (100 µA/10 mA) = 0.25% + 1% = 1.25%).

Current Measurement Accuracy

4225-PMU and RPM Combined

	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)

Pulse/Level [1]

Pulse/Level[1]	4225-PMU with 4225-RPM
V_{OUT}	–10 V to +10 V
Accuracy[2] into open load	±(0.5% ± 10 mV)
Resolution	< 0.5 mV
Baseline noise	±(0.39% ± 1 mV) RMS typical
Overshoot/Pre-shoot/Ringing[3]	± 2% of amplitude ± 20 mV

Notes

1. Performance at the triax output connection of the 4225-RPM when using a 2m RPM interconnect cable between the 4225-PMU and 4225-RPM Remote Preamplifier/Switch Module.
2. 100mV to 10V.
3. Typical, with transistion time of 100ns (0% - 100%).

RPM Voltage Measurement with the 4225-PMU

Timing parameters, typical [1]

	4225-RPM
Voltage measure range	10 V
Recommended minimum pulse width [2]	160 ns
Recommended minimum measure window [2]	20 ns
Recommended minimum transition time [3]	20 ns
Noise [4]	1 mV
Settling time [5]	100 ns

Notes

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: 10 mA settling time on the PMU 10 V range is defined when the signal is within 1.25% of the final value. This calculation: Accuracy = 0.25% + 100 µA = 0.25% + (100 µA/10 mA) = 0.25% + 1% = 1.25%).

8. Switch Matrix Configurations

General Information

Connector type	3-lug triaxial
Maximum signal level	200 V, 1 A
Offset current	<1 pA (rows A–B)
Maximum leakage	0.1 pA/V
3 dB bandwidth	5MHz typical (rows G–H)

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 or -36B, -48B, -60B, -72B

	(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

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

9. NBTI/PBTI Package

The 4200-BTI-A package combines Keithley's advanced DC I-V and ultra-fast I-V measurement capabilities with automatic test executive software to provide the most advanced NBTI/PBTI test platform available in the semiconductor test industry.

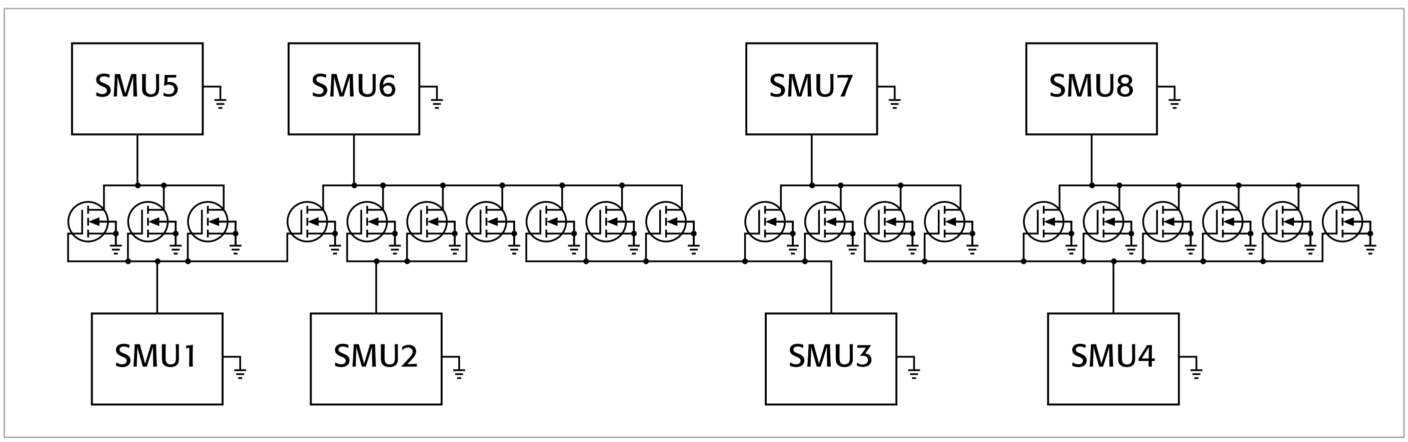
4200-BTI-A Ultra-fast NBTI/PBTI

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.

Model 4200-BTI-A

Offers the best high-speed, low-current measurement sensitivity available in a single-box integrated solution.

	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-BTI-A Ultra-fast NBTI/PBTI includes:	
	(1) 4225-PMU Ultra-Fast I-V Module
	(2) 4225-RPM Remote Preamplifier/Switch Modules
	Automated Characterization Suite (ACS) Software
	Ultra-Fast BTI Test Project Module
	Cabling



Example of using eight SMUs to stress 20 devices in parallel for HCI and NBTI. A separate ground unit (GNDU) is used for common terminals.

10. Clarius+ Software

Clarius+ software provides a variety of tools for operating and maintaining the 4200A-SCS parameter analyzer.

Furnished Software Modules

Clarius	The graphical user interface for testing and characterizing your devices, materials and processes. Clarius software provides a unified measurement interface that guides you through complex characterization tests, enabling you to focus on your research or development projects.
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 4200A-SCS to control an entire test rack from a single user interface. Requires optional 4200-Compiler.
Keithley External Control Interface (KXCI)	Controls the 4200A-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 4200A-SCS. It also provides diagnostic functions.
KPulse	A graphical user interface that is a non-programming alternative to configure and control the installed 4225-PMU or 4220-PGU pulse generator modules. It is used for quick tests requiring minimal interaction with other 4200A-SCS test resources.

Clarius User Interface Software

	Clarius is the resident user interface software running on the 4200A-SCS. Clarius runs on the embedded Windows 7 operating system. It provides test plan selection and development, advanced test configurations, parameter analysis and graphing, and automation capabilities required for modern semiconductor device, materials and process characterization.
Data Analysis	Two methods of parameter extraction are available. The Formulator executes data transformations for performing automated line fits and parameter extraction. A spreadsheet offers standard spreadsheet analysis tools. Many of the sample libraries include parameter extraction examples.

Formulator

Formulator	The Formulator supports mathematical functions, conversion functions, search functions, common industry constants and line fit/parameter extraction functions. 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 (Boltzmann'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/A2 (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 × 10^{+8} m/s (Speed of light) KT/Q = 0.02568 V (Thermal Voltage)

Automation

Test Sequencing	Clarius 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

Keithley User Library Tool (KULT)

(Requires optional 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 Clarius 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 Clarius, allowing the 4200A-SCS to control an entire test rack from a single user interface.

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 4200A-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 4200A-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 4200A-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 4200A-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 4200A-SCS systems without re-entering connection information.
4200A-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 4200A-SCS directly. KXCI also provides you with indirect control of the Ultra-fast I-V Pulse Measure Unit, 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 4200A-SCS instead.

11. Supplied Accessories

4200-SMU	**Medium Power Source-Measure Unit for 4200A-SCS, 100 mA to 100 fA, 200 V to 0.2 µV, 2 Watts**
If configured with a preamp:	(4) 4200-TRX-2 Ultra Low Noise Triax Cables, 2m (6.6 ft)
	(1) 236-ILC-3 Interlock Cable, 3m (10 ft)
If configured without a preamp:	(2) 4200-TRX-2 Ultra Low Noise Triax Cables, 2m (6.6 ft)
	(2) 4200-MTRX-2 Mini Ultra Low Noise Triax Cables, 2m (6.6 ft)
	(1) 236-ILC-3 Interlock Cable, 3m (10 ft)

4210-SMU	**High Power Source-Measure Unit for 4200A-SCS, 1 A to 100 fA, 200 V to 0.2 µV, 20 Watts**
If configured with a preamp:	(4) 4200-TRX-2 Ultra Low Noise Triax Cables, 2m (6.6 ft)
	(1) 236-ILC-3 Interlock Cable, 3m (10 ft)
If configured without a preamp:	(2) 4200-TRX-2 Ultra Low Noise Triax Cables, 2m (6.6 ft)
	(2) 4200-MTRX-2 Mini Ultra Low Noise Triax Cables, 2m (6.6 ft)
	(1) 236-ILC-3 Interlock Cable, 3m (10 ft)

4200-PA	**Remote PreAmp Option for 4200-SMU and 4210-SMU, extends SMU to 0.1 fA resolution**
	(1) 4200-RPC remote preamp cable, 2m (6.6 ft)

4210-CVU	**Capacitance-Voltage (C-V) Module**
	(4) CA-447A SMA Cables, male to male, 100 Ω, 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 Pulse Measure Unit
	(4) CA-404B SMA-to-SMA 50 Ω cables, 2m (6.6 ft)
	(2) 4200-PRB-C SMA-to-SSMC Y-Cable Assembly, 6 in

4225-RPM	Remote Preamplifier/Switch Module
	(1) CA-452A SMA-to-SMA 50 Ω Cable, 20cm (7.9 in)
	(1) 7078-TRX-BNC Triax-to-BNC Adapter
	(1) CS-1247 BNC-to-SMA Adapter
	(1) CA-547-2A RPM Cable, 2.1m (6.9 ft)

4220-PGU	High Voltage Pulse Generator
	(4) CA-404B SMA-to-SMA 50 Ω cables, 2m (6.6 ft)
	(2) 4200-PRB-C SMA-to-SSMC Y-Cable Assembly, 6 in.

4200A-CVIV	I-V, C-V Multi-switch Module
	(2) 4200A-CVIV-SPT SMU Pass-Thru Modules
	(2) 214543500 Slot Blockers
	(1) 174691500 USB Cable
	NOTE: For each SMU connected through the 4200A-CVIV, one 4200A-CVIV-SPT or one 4200-PA is required.

Switching Systems and Cards

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

12. 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

4200A-RM	Fixed Cabinet Mount Kit for 4200A-SCS

Cables and Cable Sets

NOTE: All 4200A-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, 0.7m, 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 4200A-SCS: UNIX/Windows (shareware only)

Other Accessories

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

13. General Specifications

Mainframe display	15.6 inch LCD, capacitive touchscreen 1920 × 1080 full HD 10 point touch
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 2000 m **Storage:** 0 to 4600 m
Power requirements	100 V to 240 V, 50 to 60 Hz
Maximum VA	1000 VA
Regulatory compliance	**Safety:** European Low Voltage Directive **EMC:** European EMC Directive
Dimensions	43.6 cm wide × 22.3 cm high × 56.5 cm deep (17⁵⁄₃₂ in × 8¾ in × 22¼ in)
Weight (approx.)	29.7 kg (65.5 lbs) for typical configuration of four SMUs
I/O ports	USB, SVGA, printer, RS-232, GPIB, Ethernet, mouse, keyboard
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 ≤ 1 Ω, SENSE ≤ 10 Ω
LCD Display Pixel Guideline	LCD displays are made up of a matrix of pixels, with each pixel consisting of red, green, and blue sub-pixels. These pixels and sub-pixels can become fixed in an unchanging state resulting in permanently black, white, or colored spots on the display. These are typically categorized as Bright or Black pixel (or dot) defects. **Bright Dot Defect:** A dot that is always lit, either as a white or colored dot, visible on a black check pattern. **Black Dot Defect:** A dot that appears as either black or purple (magenta) on red, green, and/or blue check patterns. The LCD display used in the 4200A-SCS is permitted to have a maximum of 6 (six) Bright Dot Defects upon receipt of a new instrument. A maximum of three Bright Dot Defect pairs (adjacent defective dots) are permitted. Three adjacent Bright Dots are not permitted under the pixel guideline. The LCD display is permitted to have a maximum of 5 (five) black dot defects. Two adjacent Black Dot Defects are to be counted as a single Black Dot Defect. A maximum of three Black Dot Defect pairs (adjacent defective dots) are permitted. Three adjacent Black Dot Defects are not permitted under the pixel guideline.

14. Ordering Information

Mainframes	
4200A-SCS	Parameter Analyzer with 15.6” LCD display
4200A-SCS/NFP	Parameter Analyzer without LCD display

Instruments/Modules	
4200-SMU	Medium Power Source Measure Unit
4210-SMU	High Power Source Measure Unit
4200-PA	Remote SMU Preamplifier Module
4210-CVU	Multi-frequency C-V Unit
4225-PMU	Ultra-fast Pulsed I-V Unit
4220-PGU	Pulse Generator Unit
4225-RPM	Remote Preamplifier/Switch Module
4200A-CVIV	CVIV Multi-Switch Module
4200-CVU-PWR	C-V Power Package

15. Configured Packages

4200A-SCS-PK1 High Resolution I-V	
4200A-SCS	Parameter analyzer mainframe
4200-SMU	Two medium power SMU
4200-PA	One preamplifier
8101-PIV	One test fixture with sample devices

4200A-SCS-PK2 High Resolution I-V and C-V	
4200A-SCS	Parameter analyzer mainframe
4200-SMU	Two medium power SMU
4200-PA	One preamplifier
4210-CVU	One multi-frequency C-V
8101-PIV	One test fixture with sample devices

4200A-SCS-PK3 High Power I-V and C-V	
4200A-SCS	Parameter analyzer mainframe
4200-SMU	Two medium power SMU
4210-SMU	Two high power SMU
4200-PA	Two preamplifier
4210-CVU	One multi-frequency C-V
8101-PIV	One test fixture with sample devices

16. Upgrading the 4200A-SCS Parameter Analyzer

Besides adding instrument modules to your parameter analyzer, there are other upgrade options available to keep your parameter analyzer up-to-date with the latest technologies and applications tests.

4200A-MF-UP	This upgrade service will convert any 4200-SCS mainframe to the 4200A-SCS widescreen mainframe with Clarius+ software. Any instrument modules in the 4200-SCS will be moved to the 4200A-SCS mainframe and the system will receive a factory calibration and a one year warranty on the mainframe.
4200A-IFC	Required installation and factory calibration service when any instrument module is added to the 4200A-SCS mainframe. Only one 4200A-IFC is required per instrument module upgrade order. Not required when ordering the 4200A-MF-UP.

17. Warranty Information

Warranty Summary	This section summarizes the warranties of the 4200A-SCS. For complete warranty information, refer to the 4200A-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.

18. Embedded PC Policy

CAUTION: Keithley Instruments warrants the performance of the Model 4200A-SCS only with the factory-approved Windows Operating System and applications software pre-installed on the 4200A-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 4200A-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.

CAUTION: DO NOT reinstall or upgrade the Windows operating system (OS) on any Model 4200A-SCS. This action should only be performed at an authorized Keithley service facility. Violation of this precaution will void the Model 4200A-SCS warranty and may render the Model 4200A-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.

Contact Information:

Australia* 1 800 709 465
Austria 00800 2255 4835
Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777
Belgium* 00800 2255 4835
Brazil +55 (11) 3759 7627
Canada 1 800 833 9200
Central East Europe / Baltics +41 52 675 3777
Central Europe / Greece +41 52 675 3777
Denmark +45 80 88 1401
Finland +41 52 675 3777
France* 00800 2255 4835
Germany* 00800 2255 4835
Hong Kong 400 820 5835
India 000 800 650 1835
Indonesia 007 803 601 5249
Italy 00800 2255 4835
Japan 81 (3) 6714 3010
Luxembourg +41 52 675 3777
Malaysia 1 800 22 55835
Mexico, Central/South America and Caribbean 52 (55) 56 04 50 90
Middle East, Asia, and North Africa +41 52 675 3777
The Netherlands* 00800 2255 4835
New Zealand 0800 800 238
Norway 800 16098
People's Republic of China 400 820 5835
Philippines 1 800 1601 0077
Poland +41 52 675 3777
Portugal 80 08 12370
Republic of Korea +82 2 6917 5000
Russia / CIS +7 (495) 6647564
Singapore 800 6011 473
South Africa +41 52 675 3777
Spain* 00800 2255 4835
Sweden* 00800 2255 4835
Switzerland* 00800 2255 4835
Taiwan 886 (2) 2656 6688
Thailand 1 800 011 931
United Kingdom / Ireland* 00800 2255 4835
USA 1 800 833 9200
Vietnam 12060128

*** European toll-free number. If not accessible, call:** +41 52 675 3777

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