

# Semiconductor Test



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# 4200-SCS



- **Intuitive, point-and-click Windows®-based environment**
- **Unique Remote PreAmps extend the resolution of SMUs to 0.1fA**
- **C-V instrument makes C-V measurements as easy as DC I-V**
- **Ultra low frequency C-V measurement capability**
- **Ultra-fast I-V module for transient and Pulse I-V capabilities**
- **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 leading analytical probers**

## Semiconductor Characterization System

### DC I-V, C-V, and Pulse in One Test Environment

The easy-to-use Model 4200-SCS Semiconductor Characterization System performs lab grade DC I-V, C-V, 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. 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 I-V, C-V, 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, C-V, and pulse 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 nine source measurement units (SMUs) in any combination of medium and high power SMUs. A high-power SMU provides 1A/20W capability. Also available are the C-V option and the ultra-fast I-V modules. The C-V option includes the C-V Power package, which supports high power C-V measurements up to 400V and 300mA, up to 60V of differential DC bias, and quasistatic C-V measurements.

#### 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. (Note: Requires optional Model 4200-Compiler.)
- 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.

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# 4200-SCS

## 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

4210-CVU Integrated C-V Instrument

4225-PMU Ultra-Fast I-V Module

4225-RPM Remote Amplifier/Switch

4220-PGU High Voltage Pulse Generator

4200-SMU Medium Power Source-Measure Unit

4210-SMU High Power Source-Measure Unit

4200-PA Remote PreAmp Option for 4200-SMU and 4210-SMU

4210-MMPC/X Multi-measurement Performance Cables

## Related Products

707B Semiconductor Switching Matrix Mainframe

708B Single Slot Switching Matrix Mainframe

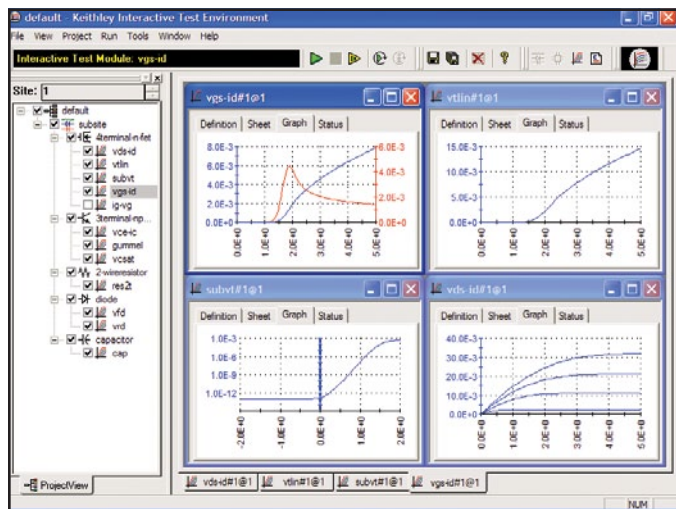
7072 8x12 Semiconductor Matrix Card

7072-HV 8x12 High Voltage Semiconductor Matrix Card

7174A 8x12 High Speed, Low Current Matrix

# Semiconductor Characterization System

## DC I-V, C-V, and Pulse in One Test Environment



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.

## 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. One sequence can include DC I-V, C-V, and pulse tests.

## 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.

(Note: KULT requires the optional Model 4200-Compiler.)

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# 4200-SCS

## Semiconductor Characterization System DC I-V, C-V, and Pulse in One Test Environment

### Model 4200-SMU Medium Power and 4210-SMU High Power SMUs

Precision DC I-V measurements are the cornerstone of device and materials electrical characterization. The SMUs in the 4200-SCS can source either voltage or current, and can simultaneously measure both the voltage and current. Typically, the DC I-V measurements performed by these SMUs are used for very precise (0.01%) or very sensitive (1fA, 1 $\mu$ V) measurements in the time frame of milliseconds to seconds. The SMUs can also provide continuous power output, allowing tests to run for hours, or even weeks, without interruption.

The SMUs in the 4200-SCS are fully integrated in the 4200-SCS chassis and incorporate the latest measurement technologies including:

- 24-bit A/D converters on every SMU
- Full remote sense (Kelvin) capability
- Broadest dynamic range of current, from <1fA to 1A
- Broadest dynamic range of voltage from <1 $\mu$ V to 200V
- Up to 9 medium or high power SMUs can source/measure simultaneously

The 4200-SCS has been used by thousands of engineers and researchers around the world to

electrically characterize their devices and materials. This has resulted in the largest library of standard tests available. More than 400 different libraries are supplied, demonstrating precision DC I-V tests on:

- CMOS MOSFETS and devices
- Bipolar devices
- Diodes and pn junctions
- Solar cells
- Nanotech devices
- And nearly every other material and device imaginable

Additional capabilities include:

- Data for most types of tests can be acquired and plotted in real time with a resolution of milliseconds to seconds
- Wide variety of standard sweep types are available, including linear and log sweeps, voltage and current sweeps, and even arbitrary custom sweeps
- Up to nine SMUs can be installed in a single chassis, and all nine can be used simultaneously or independently.

### Model 4210-CVU C-V Instrument

C-V measurements are as easy to perform as I-V measurements with the integrated C-V instrument. This optional capacitance-voltage instrument performs capacitance measurements from femtoFarads (fF) to microFarads ( $\mu$ F) at frequencies from 1kHz to 10MHz. Also available is the 4200-CVU-PWR option that supports:

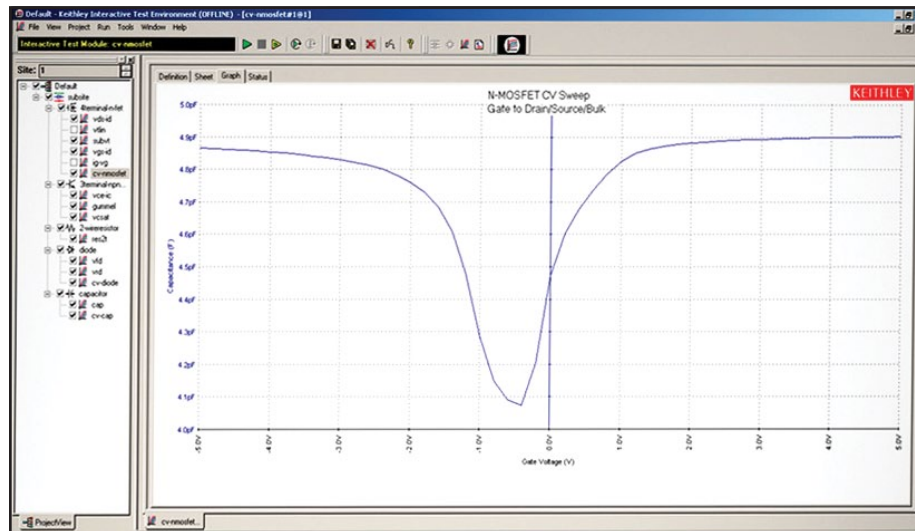
- High power C-V measurements up to 400V (200V per device terminal)—for testing high power devices, such as MEMs, LDMOS devices, displays, etc.
- DC currents up to 300mA—for measuring capacitance when a transistor is on.

The innovative design of the 4210-CVU has eight patents pending and is complemented by the broadest C-V test and analysis library available in any commercial C-V measurement solution. It also supplies diagnostic tools that ensure the validity of your C-V test results.

With this system, you can configure linear or custom C-V and C-f sweeps with up to 4096 data points. In addition, through the open environment of the 4200-SCS, you can modify any of the included tests, such as:

- C-V, C-t, and C-f measurements and analysis of:
  - New! Complete solar cell libraries, including DLCP
  - High and low  $\kappa$  structures
  - MOSFETs
  - BJTs
  - Diodes
  - III-V compound devices
  - Carbon nanotube (CNT) devices
- Doping profiles,  $T_{OX}$ , and carrier lifetime tests
- Junction, pin-to-pin, and interconnect capacitance measurements

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



C-V curve from a MOSFET transistor measured with the 4210-CVU.

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## Semiconductor Characterization System DC I-V, C-V, and Pulse in One Test Environment

### Model 4225-PMU Ultra-Fast I-V Module

The Model 4225-PMU Ultra Fast I-V Module is the latest addition to the growing range of instrumentation options for the Model 4200-SCS Semiconductor Characterization System. It integrates ultra-fast voltage waveform generation and signal observation capabilities into the Model 4200-SCS's already powerful test environment to deliver unprecedented I-V testing performance, expanding the system's materials, device, and process characterization potential dramatically. Just as important, it makes ultra-fast I-V sourcing and measurement as easy as making DC measurements with a traditional high-resolution source measurement unit (SMU).

Three types of measurements are necessary to characterize a device, material, or process thoroughly. The first two are precision DC I-V measurements (usually made with the Model 4200-SCS's SMUs) and AC impedance measurements (which can be made with the Model 4210-CVU C-V Instrument). The Model 4225-PMU represents the last segment of this characterization triangle—ultra-fast I-V or transient I-V measurements.

Some of the functionality provided by the Model 4225-PMU includes:

- Voltage outputs with programmable timing from 60ns to DC in 10ns steps
- Measuring I and V simultaneously, at acquisition rates of up to 200 megasamples/second (MS/s)
- Choosing from two voltage source ranges ( $\pm 10V$  or  $\pm 40V$ ) and four current measurement ranges (800mA, 200mA, 10mA, 100 $\mu A$ )
- Also, each module provides two channels of integrated simultaneous I-V sourcing and measurement; plug in up to six modules in a single chassis for twelve synchronized channels.

Two optional instruments offer additional functionality:

- The optional Model 4220-PGU Pulse Generator Unit offers a voltage-sourcing-only alternative to the 4225-PMU.
- The optional Model 4225-RPM Remote Amplifier/Switch expands current ranges (10mA, 1mA, 100 $\mu A$ , 10 $\mu A$ , 1 $\mu A$ , 100nA), switches sourcing/measurement between the Model 4225-PMU, Model 4210-CVU, Model 4200-SMU, and 4210-SMU.

Each plug-in 4225-PMU module provides two channels of integrated sourcing and measurement but occupies only a single slot in the Model 4200-SCS's nine-slot chassis. Unlike competitive solutions, each channel of the 4225-PMU combines high speed voltage outputs (with pulse widths ranging from 60 nanoseconds to DC) with simultaneous current and voltage.

### Model 4225-PMU Applications

- Ultra-fast general-purpose I-V measurements
- Pulsed I-V and transient I-V measurements
- Flash, PCRAM, and other non-volatile memory tests
- Isothermal testing of medium-sized power devices
- Materials testing for scaled CMOS, such as high- $\kappa$  dielectrics
- NBTI/PBTI reliability tests



Each Model 4200-SCS chassis can accommodate up to six Model 4225-PMU modules to provide up to twelve ultra-fast source and measure channels.



Cascade probe station with a Model 4225-RPM Remote Amplifier/Switch

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# 4200-SCS

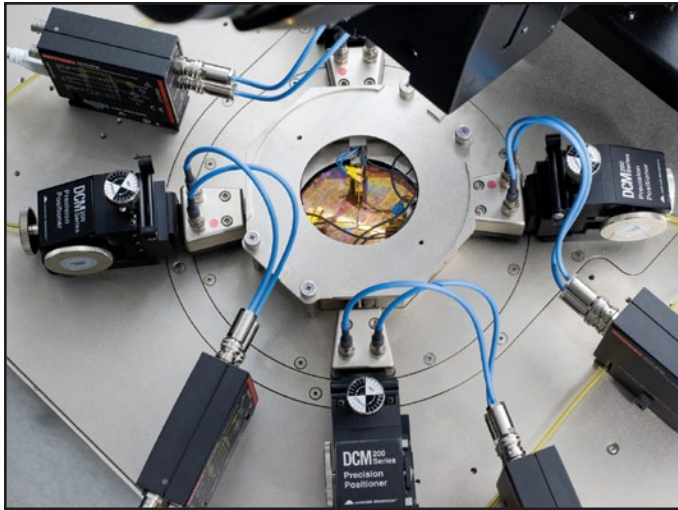
## Semiconductor Characterization System DC I-V, C-V, and Pulse in One Test Environment

### Multi-Measurement Cables

Keithley offers the only prober cable kits that support I-V, C-V, and Ultra-Fast I-V signals. These high performance cable kits simplify switching between DC I-V, C-V, and Ultra-Fast I-V testing configurations by eliminating the need for re-cabling when you change from one type of measurement to another. Their patent-pending design also eliminates the need to lift the probe needles for each cable change. The results of using these triaxial cables are that you:

- Save time by avoiding the laborious process of re-cabling the connections from the test instruments to the prober every time a new measurement type is required.
- Prevent the cabling errors that often occur during difficult cable changes, which in turn prevents the measurement errors produced from faulty cabling.
- Reduce wafer pad damage by making setup changes while the probe needles remain in contact with the wafer. This also allows you to maintain the same contact impedance for each type of measurement.

Two versions of the cable kits are available: the Model 4210-MMPC-C for Cascade Microtech probes and the Model 4210-MMPC-S for SUSS Microtec probes. Contact factory for other supported probes.



The 4210-MMPC cable kits include a provision for connecting the shields/grounds of all the probes together near the probe tips, providing the best high frequency performance.

### How to Use

When changing between I-V and C-V measurements:

- DO NOT lift the probe needles
- DO NOT replace any cables

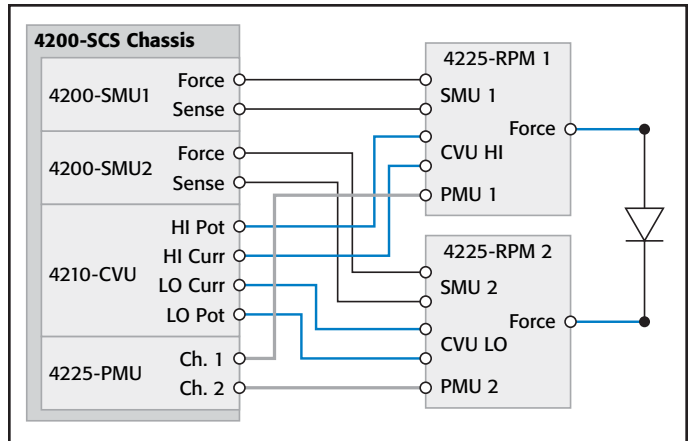
Simply reposition the cable at the bulkhead to access the appropriate instrument.

When performing Ultra-Fast I-V, one or more of the probes may need to be attached to the shield/ground of the pulse source. The cables facilitate this easily with supplied shorting caps.

Occasionally, two or more probes need to be connected in parallel. The patented design of the 4210-MMPC cable sets support this functionality.

### For Even More Simplicity

You can eliminate the need to reposition cables at the bulkhead when switching between I-V, C-V and Ultra-Fast I-V measurements with Keithley's Model 4225-RPM Remote Amplifier/Switch. All instrument connections at the bulkhead are fed into the switch, which automatically connects the desired instrument to the positioner.



This closeup of two Model 4225-RPMs highlights the DC SMU, C-V, and ultra-fast I-V cable connections.

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# 4200-SCS

# Semiconductor Characterization System

## DC I-V, C-V, and Pulse in One Test Environment

### SERVICES AVAILABLE

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

### PIV, PULSE, SCOPE, C-V, AND FLASH OPTIONS

4200-FLASH-3Y-CAL	3 calcs within 3 years of purchase of the 4200-FLASH. Requires purchase of 4200-3Y-CAL.
4200-FLASH-3Y-EW	1-year factory warranty on the 4200-FLASH extended to 3 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-3Y-EW.
4200-PIV-A-3Y-CAL	3 calcs within 3 years of purchase of the 4200-PIV-A Package. Requires purchase of 4200-3Y-CAL.
4200-PIV-A-3Y-EW	1-year factory warranty on the 4200-PIV-A Package extended to 3 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-3Y-EW.
4200-PIV-Q-3Y-CAL	3 calcs within 3 years of purchase of the 4200-PIV-Q. Requires purchase of 4200-3Y-CAL.
4200-PIV-Q-3Y-EW	1-year factory warranty on the 4200-PIV-Q extended to 3 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-3Y-EW.
4200-SCP2-3Y-CAL	3 calcs within 3 years of purchase of the 4200-SCS Scope Card (Standard or HR version). Requires purchase of 4200-3Y-CAL.
4200-SCP2-3Y-EW	1-year factory warranty on the 4200-SCS Scope Card (Standard or HR version) extended to 3 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-3Y-EW.
4205-PG2-3Y-EW	1-year factory warranty on the 4205-PG2 Pulse Generator Card extended to 3 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-3Y-EW.
4205-PG2-3Y-CAL	3 calcs within 3 years of purchase of the 4205-PG2 Pulse Generator Card. Requires purchase of 4200-3Y-CAL.
4210-CVU-3Y-EW	1-year factory warranty on the 4210-CVU C-V Measurement Unit extended to 3 years from date of shipment. Includes calibration and return shipping. Requires purchase of 4200-3Y-EW.
4210-CVU-3Y-CAL	3 calcs within 3 years of purchase of the 4210-CVU C-V Measurement Unit. Requires purchase of 4200-3Y-CAL.

### 4200-SCS Condensed Specifications

Note: see the 4200 Technical Data Sheet for complete specifications.

#### 4200-SCS CHASSIS CORE CAPABILITIES

Integrate Intel Core2Duo processor, 2Gb Ram, 500Gb HDD, 1024X768 LCD, 9 slots, USB, Ethernet, GPIB, external monitor, over 200W of measurement power.

#### 4200-SMU MEDIUM POWER SOURCE-MEASURE UNIT (2.1 watts max.)

**MAXIMUM NUMBER OF UNITS PER CHASSIS:** 9.  
**VOLTAGE RANGE:**  $\pm 200V$ , 4 ranges from 200mV to 200V full scale.  
**BASIC VOLTAGE ACCURACY:** 0.01% measure, 0.02% source.  
**VOLTAGE RESOLUTION:** 0.1 $\mu V$  to 100 $\mu V$ .  
**CURRENT RANGE:**  $\pm 100mA$ , 7 ranges from 100nA to 100mA full scale.  
**BASIC CURRENT ACCURACY:** 0.03% measure, 0.04% source.  
**CURRENT RESOLUTION:** 0.1pA to 100pA.  
**WITH OPTIONAL 4200-PA:** Adds 5 low current ranges with resolution down to 0.1fA.

#### 4210-SMU HIGH POWER SOURCE-MEASURE UNIT (21 watts max.)

**MAXIMUM NUMBER OF UNITS PER CHASSIS:** 9.  
**VOLTAGE RANGE:**  $\pm 200V$ , 4 ranges from 200mV to 200V full scale.  
**BASIC VOLTAGE ACCURACY:** 0.01% measure, 0.02% source.  
**VOLTAGE RESOLUTION:** 0.1 $\mu V$  to 100 $\mu V$ .  
**CURRENT RANGE:**  $\pm 1A$ , 8 ranges from 100nA to 1A full scale.  
**BASIC CURRENT ACCURACY:** 0.03% measure, 0.04% source.  
**CURRENT RESOLUTION:** 0.1pA to 100pA.  
**WITH OPTIONAL 4200-PA:** adds 5 low current ranges with resolution down to 0.1fA.

#### 4210-CVU MULTI-FREQUENCY CAPACITANCE-VOLTAGE UNIT

**MAXIMUM NUMBER OF UNITS PER CHASSIS:** 1 (consult factory for more).  
**MEASUREMENT PARAMETERS:** Cp, Cs, G, R, D, Z, theta.  
**FREQUENCY RANGE:** 1kHz to 10MHz variable.  
**MEASUREMENT RANGES:** 100fF to 100 $\mu F$  typical full scale.  
**TYPICAL RESOLUTION:** 1aF, InanoSiemens, 0.001 degree.  
**AC SIGNAL:** 10mV to 100mV programmable.  
**DC BIAS:**  $\pm 30V$  on either High or Low outputs ( $\pm 60V$  differential), 10mA max current.  
**OPTIONAL 4200-CVU-PWR-PKG:** Utilizes SMUs for  $\pm 200V$  (400V differential) up to 300mA.

#### RAMP RATE QUASISTATIC C-V

**MAXIMUM NUMBER OF UNITS PER CHASSIS:** Requires two SMUs per channel.  
**MEASUREMENT PARAMETERS:** Cp, DCV, timestamp.  
**RANGING:** 1pF to 1nF.  
**RAMP RATES:** 0.1V/s to 1V/s.  
**DCV:**  $\pm 200V$ .  
**TYPICAL ACCURACY:** 5% at 1V/s ramp rate.

#### VERY LOW FREQUENCY C-V (VLF-CV)

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

#### 4225-PMU ULTRA-FAST I-V UNIT

**MAXIMUM NUMBER OF UNITS PER CHASSIS:** 6.  
**CHANNELS PER UNIT:** 2 independent or synchronized.  
**VOLTAGE RANGE:**  $\pm 40V$ , 2 ranges of 10V and 40V.  
**BASIC VOLTAGE ACCURACY:** 0.25%.  
**VOLTAGE RESOLUTION:** 250 $\mu V$ , 750 $\mu V$ .  
**CURRENT RANGE:**  $\pm 800mA$ , 4 ranges from 100 $\mu A$  to 800mA.  
**BASIC CURRENT ACCURACY:** 0.25%.  
**CURRENT RESOLUTION:** 14 bits, 10nA to 10mA.  
**WITH OPTIONAL 4225-RPM REMOTE AMPLIFIER/SWITCH:** Adds 3 low current ranges 100nA, 1 $\mu A$ , 10 $\mu A$ .  
**CORE A/D CONVERTER:** Two per channel, 4 per unit, 5ns, 200MHz, 14 bits, 1GB memory.  
**CORE VOLTAGE SLEW RATE:** 1V/ns.  
**BEST VOLTAGE PULSE WIDTH:** 20ns to 10V.  
**TYPICAL CURRENT MEASURE PULSE WIDTH:** 60ns.



# 4200-SCS

# Semiconductor Characterization System

## DC I-V, C-V, and Pulse in One Test Environment

### OPTIONAL INSTRUMENTATION AND ACCESSORIES

#### SUPPLIED ACCESSORIES

##### ACCESSORIES SUPPLIED WITH EACH MODEL 4210-CVU:

CA-447A	SMA Cables, male to male, 100Ω, 1.5m (5 ft.) (4)
CS-1247	Female SMA to Male BNC Adapters (4)
CS-701	BNC Tee Adapters (2)
TL-24	SMA Torque Wrench

##### ACCESSORIES SUPPLIED WITH EACH MODEL 4200-SMU OR 4210-SMU:

4200-MTRX-2	Two Ultra Low Noise SMU Triax Cables, 2m (6.6 ft). Not included with SMUs configured with a 4200-PA Remote PreAmp.
4200-TRX-2	Ultra Low Noise PreAmp Triax Cable, 2m (6.6 ft). Two supplied for Ground Unit. Two supplied in replacement of 4200-MTRX-2 cables for each SMU configured with a 4200-PA.
4200-RPC-2	Remote PreAmp Cable, 2m (6.6 ft). One supplied for each PreAmp.
236-ILC-3	Interlock Cable, 3m (10 ft)
Line Cord	NEMA 5-15P for 100-115VAC or CEE 7/7 (Continental European) for 240VAC

##### ACCESSORIES SUPPLIED WITH EACH MODEL 4225-PMU OR 4220-PGU:

SMA to SMA 50Ω cables, 2m (4 ea.)
SMA to SSMC Y-Cable Assembly, 6 in (2 ea.)

##### ACCESSORIES SUPPLIED WITH EACH MODEL 4225-RPM:

SMA to SMA 50Ω cable, 20 cm (1 ea.)
Triax to BNC Adapter (1 ea.)
BNC to SMA Adapter (1 ea.)
RPM Cable, 2.1 m (1 ea.)

#### OPTIONAL INSTRUMENTATION

4200-BTI-A	Hardware and software ultra-fast package for complete NBTI/PBTI reliability testing
4210-CVU	Integrated C-V Instrument
4200-SMU	Medium Power Source-Measure Unit for 4200-SCS. 100mA to 100fA, 200V to 1μV, 2 Watt
4210-SMU	High Power Source-Measure Unit for 4200-SCS. 1A to 100fA, 200V to 1μV, 20 Watt
4200-PA	Remote PreAmp Option for 4200-SMU and 4210-SMU, extends SMU to 0.1fA resolution
4220-PGU	High Voltage Pulse Generator
4225-PMU	Ultra-Fast I-V Module
4225-RPM	Remote Amplifier/Switch

#### OPTIONAL SWITCHING SYSTEMS AND CARDS

707B	6-slot Switching Matrix Mainframe
708B	Single-slot Switching Matrix Mainframe

#### CARDS

7072	8×12, Semiconductor Matrix Card
7072-HV	8×12, High Voltage, Semiconductor Matrix Card
7173-50	4×12, Two-Pole, High Frequency, Matrix Card
7174A	8×12, High Speed, Low Leakage Current, Matrix Card

#### OPTIONAL ACCESSORIES

##### CONNECTORS AND ADAPTERS

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

##### CABLES AND CABLE SETS

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

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

##### FIXTURES

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

##### CABINET MOUNTING ACCESSORIES

4200-RM	Fixed Cabinet Mount Kit
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#### OPTIONAL ACCESSORIES (continued)

##### 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

##### COMPUTER ACCESSORIES

4200-MOUSE	Microsoft Ambidextrous 2 Button Mouse (Note: A pointing device is integrated with the 4200-SCS keyboard.)
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##### SOFTWARE

ACS-BASIC	Component Characterization Software
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##### DRIVERS

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

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

##### 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 probes
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

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# 4200-BTI-A

- **Best-in-class test speed allows faster, more complete device characterization**
  - Begin measuring BTI degradation as soon as 30ns after stress is removed
  - Measure transistor  $V_T$  in less than 1 $\mu$ s using  $I_D$ - $V_G$  sweep method
- **Model 4225-RPM Remote Amplifier/Switch**
  - Switches automatically between low-level precision DC I-V (via standard SMUs) and ultra-fast I-V measurements with no need for re-cabling
  - Improves single-pulse source and measurement performance by minimizing cable parasitic effects and increasing low current sensitivity
- **Best high-speed, low-current measurement sensitivity available in a single-box integrated solution**
  - Supports sub-microsecond pulse characterization of drain current at reduced drain voltage, minimizing drain-to-source fields that could otherwise skew test results
  - Ensures the source/measure instrumentation won't be the limiting factor when making low-level measurements
  - Detects degradation trends sooner during the test, reduces the time needed to perform process reliability monitoring
- **Simple, predictable interconnect scheme prevents measurement problems due to incorrect DUT connections**

## Ultra-Fast NBTI/PBTI Package for the Model 4200-SCS



The Model 4200-BTI-A Ultra-Fast BTI 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. The 4200-BTI-A package, which builds on the Model 4200-SCS semiconductor parameter analyzer's powerful test environment, includes all the instruments, interconnects, and software needed to make the most sophisticated NBTI and PBTI measurements on leading-edge silicon CMOS technology:

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

### APPLICATIONS

- **Single-Pulse Charge Trapping/ high- $\kappa$  dielectric characterization**
- **Silicon-On-Insulator testing**
- **LDMOS/GaAs isothermal characterization**
- **Flash RTS ID**
- **Phase-change random access memory (PCRAM) testing**
- **Ultra-fast NBTI characterization**
- **Charge pumping measurements**
- **Thermal impedance characterization**
- **MEMs capacitor testing**
- **Random telegraph signal (RTS) CMOS**
- **Charge-based capacitance measurement (CBCM) Materials testing for scaled CMOS, such as high- $\kappa$  dielectrics**
- **NBTI/PBTI reliability tests**

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# 4200-BTI-A

- **Optional Multi-Measurement Performance Cables (MMPC) optimize measurement performance of configurations that combine DC I-V, C-V, and ultra-fast I-V capabilities**
- **ACS software supports building complex test sequences including up to 20 measurement sequences and full prober integration**
  - DC I-V and ultra-fast I-V measurements can be easily integrated into a stress-measure sequence
  - Degradation and recovery behaviors can be characterized using either AC or DC stress
  - Combine spot measurements with precision SMU sweeps in pretesting and posttesting
  - Incorporate single pulse charge trapping (SPCT) measurements into longer stress-measure sequences
- **Support for handling large data sets required in device reliability modeling and process monitoring applications**
- **Support for hot chucks and fully and semi automatic probers, including wafer maps, wafer- and cassette-level sample plans**

# Ultra-Fast NBTI/PBTI Package for the Model 4200-SCS

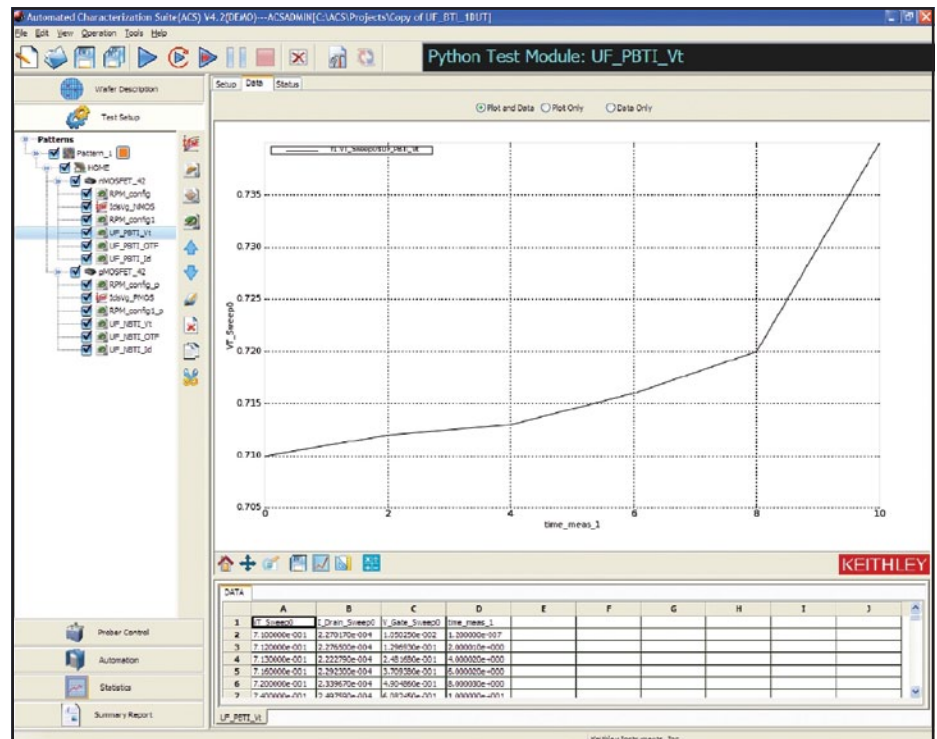
## Model 4225-PMU Ultra-Fast I-V Module

This module is the hardware core of the ultra-fast I-V measurement capability essential for characterizing NBTI and PBTI degradation in microseconds, allowing for more accurate lifetime measurements for Designed-In Reliability (DIR) that support modeling for device and circuit design. It integrates a sophisticated two-channel waveform generator with high-speed voltage and current measurement capabilities, a deep measurement buffer, and a real-time test execution engine.

Unlike traditional pulse generation solutions, the Model 4225-PMU can be programmed to output the complex waveforms required in ultra-fast BTI testing. And, unlike traditional Arbitrary Waveform Generators (AWGs), the waveforms' duration and complexity aren't limited by bitmap or memory depth. Instead, the 4225-PMU employs a high-level waveform description language that uses the concept of segments, segment libraries, and looping. In addition, the waveform description specifies exactly when measurements must be made during the waveform and the type of measurement to be made.

Spot, step sweep, smooth sweep, and sample measurement types are supported and multiple measurement types can be linked to form a test sequence. The programmable sample period can be set as fast as 5ns, so most measurements will include multiple samples. The system's real-time test execution engine automatically calculates the mathematical mean of the samples, which reduces the volume of data that must be transferred and parsed during the course of the test. The resulting measurements are streamed back to the high-level test module for near-real-time analysis and test termination.

For additional information on this module's capabilities and specifications, consult the Model 4225-PMU data sheet.



The Model 4225-PMU/4225-RPM's combination of superior speed and sensitivity allow characterizing voltage threshold ( $V_T$ ) directly with high-speed  $I_D$ - $V_G$  sweeps. Measuring  $V_T$  directly makes it unnecessary to correlate the single-point  $I_D$  measurement to actual  $V_T$  levels.

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# 4200-BTI-A

## Ordering Information

### 4200-BTI-A

**Ultra-Fast BTI Package for the Model 4200-SCS (includes one Model 4225-PMU Ultra-Fast I-V Module, two Model 4225-RPM Remote Amplifier/Switches, Ultra-Fast BTI Test Project Module, and one copy of the Automated Characterization Suite (ACS) software**

### Accessories Supplied

#### For the 4225-PMU:

**SMA to SMA 50Ω cables, 2m (4 ea.)**

**SMA to SSMC Y-Cable Assembly, 6 in (2 ea.)**

## ACCESSORIES AVAILABLE

- 4210-MMPC-C Multi Measurement Performance Cables for Cascade probe stations using SSMC probe pin connections. One kit required per manipulator.
- 4210-MMPC-S Multi Measurement Performance Cables for Suss probe stations using SSMC probe pin connections. One kit required per manipulator.
- 4225-PMU Extra Ultra-Fast I-V Module
- 4225-RPM Extra Remote Amplifier/Switch. Up to two of these units can be used with a single 4225-PMU module.
- 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.

# Ultra-Fast NBTI/PBTI Package for the Model 4200-SCS

## Model 4225-RPM Remote Amplifier/Switch

This module is designed to maximize the Model 4225-PMU's current measurement sensitivity. The 4225-RPM's independent force and sense connections to the DUT maximize its pulse, DC, and C-V performance. Its built-in switching capabilities allow the Model 4200-SCS to switch automatically between making ultra-fast I-V measurements with the 4225-PMU and DC I-V measurements with the system's 4200-SMU and 4210 source-measure units (SMUs).

Model 4225-RPM modules are required for ultra-fast BTI testing; if the 4225-PMU module is used without them, it employs a recursive technique to compensate for cable influences such as load line effects and is typically used for isothermal I-V testing. This recursive technique is inappropriate for use in BTI reliability applications in which measurements must be both as short as possible and highly temporally deterministic in order to minimize the relaxation effects.

By making it possible to locate the pulse source close to the device under test (DUT), the 4225-RPM helps minimize the cable length and corresponding cable parasitic effects. The shorter cables result in reduced cable capacitance, reduced load-line effects, and reduced source overshoot. Placing the pulse source and high speed measurement circuits near the DUT allows the cable length to be reduced so that the round-trip propagation delay is shorter than the rise or fall time of the desired pulse.

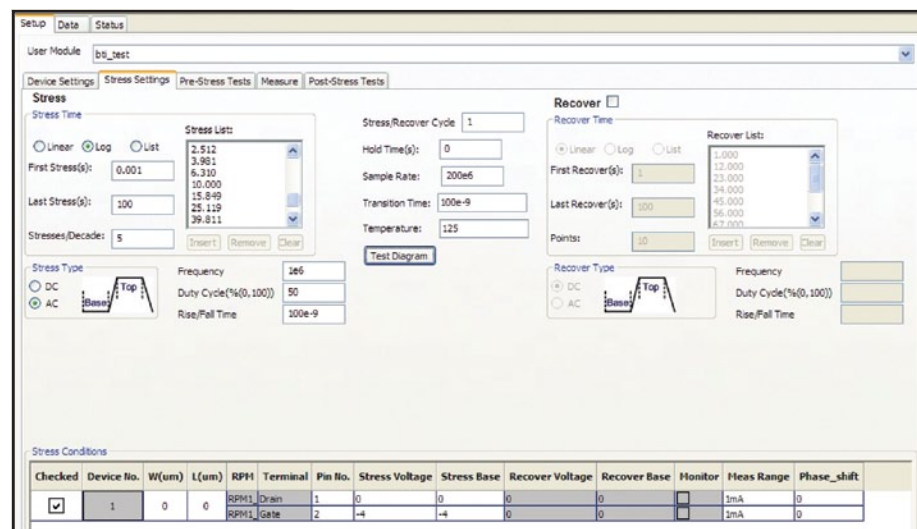
For additional details and specifications on the Model 4225-RPM, consult the Model 4225-PMU data sheet.

## Speed and Sensitivity

Bias temperature instability is a highly dynamic phenomenon that requires sensitive, high-speed measurements for accurate characterization. Assuming all other factors are constant, measurement physics largely defines the relationship between measurement speed and sensitivity. When making sub-millisecond measurements, all sources of noise must be taken into account; for sub-microsecond applications, quantum effects can't be ignored. The 4200-BTI-A package provides the optimal combination of measurement speed and sensitivity for ultra-fast BTI testing because it's engineered to approach the limits of measurement physics while ensuring high ease of use. The package is optimized to provide accurate ultra-fast results without the use of RF structures and interconnects.

## Reduce Unwanted Source-Drain Fields

To eliminate hot carrier injection effects or unwanted charge displacement during BTI testing, minimizing drain-to-source fields is critical. All BTI characterization techniques involve measuring drain current with a voltage applied to the drain. Given that the drain current is proportional to the



**Define stress timing and stress conditions easily using familiar parameters like timing – log, linear, custom list; measurements per decade; AC or DC stress; optional recovery test sequence; and test sample rate (speed).**

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# 4200-BTI-A

## Ultra-Fast NBTI/PBTI Package for the Model 4200-SCS

### Disadvantages of BTI systems developed in house

Until now, some researchers have been forced to configure their own ultra-fast BTI test systems. These in-house-developed systems typically combine a pulse generator or arbitrary waveform generator with an oscilloscope equipped with current probes or some type of transimpedance amplifier to help measure low current. Although it is possible to build a BTI system that is suitable for a very specific set of electrical conditions if the instruments and interconnect are carefully selected, several major technical challenges remain:

- **Waveform generation.** Standard pulse generators and arbitrary waveform generators are designed to generate a waveform on a fixed recurring interval, rather than the Log(time) scale required for most reliability tests, including NBTI and PBTI testing.
- **Measurement timing and data storage.** Although oscilloscopes can be configured to trigger based on a waveform feature (such as a falling edge, for example), they are not designed to store samples selectively for specific portions of the waveform. This makes it necessary to store very large data sets for postprocessing. Only the most expensive oscilloscopes or those with costly memory expansion options can store enough data to compensate for these shortcomings.
- **Precision, accuracy, and sensitivity.** Oscilloscopes, current probes, and transimpedance amplifiers all have independently defined performance specifications and they are not necessarily optimized to work together. It is often very difficult to combine these components in a way that provides optimal performance across a wide dynamic range in order to achieve precise and accurate current measurements at high speeds.
- **Interconnect.** Systems built in house typically use splitters and bias tees, which limit the performance of the test setup. For example, a bias tee might limit bandwidth from 100ns to 10 $\mu$ s. Although this is suitable for high speed measurements, it prevents making any meaningful prestress and poststress DC measurements as part of the stress–measure sequence. It also prevents making measurements in the intermediate range of 10 $\mu$ s to DC.
- **Test control and data management.** Traditional oscilloscopes don't support data streaming, so results transfer must wait until the test ends. Once the test is complete, massive amounts of data must be transferred to the control computer for postprocessing, which requires parsing complex waveforms into individual test results, followed by further reduction of the data into actual measurements.
- **Test termination.** Given that the test results can't be analyzed until the data is transferred from the oscilloscope, the test duration must be determined prior to test initiation. This makes it impossible to terminate the test based in parametric shifts or to detect catastrophic failures in real time.
- **Automation.** Wafer- or cassette-level automation requires control of both the test instruments and the wafer probe station, which systems built in house typically wouldn't provide. Also, incorporating sophisticated features like conditional test termination would add considerable complexity to the custom software necessary to run a system of this type.
- **Higher channel count.** Even for an in-house-built system that works well, pressures to increase the channel or test system count may arise. Typical test system maintenance issues such as calibration, operation, and correlation related to these custom setups can easily consume a disproportionate amount of the available resources.

drain-to-source field, the more sensitive the drain current measurement is, the lower the required drain voltage must be. The 4200-BTI-A package's superior low current measurement capability allows the use of lower drain voltages to produce more accurate results.

### Reduced Relaxation Time

The 4225-BTI-A package's superior speed and sensitivity allow making degradation measurements faster than any other commercial test system available. Single-point ID spot measurements can be completed in less than 1 $\mu$ s and ten-point ID-VG step sweeps can be made in less than 10 $\mu$ s. A sub-microsecond smooth sweep can be performed in less than 1 $\mu$ s.

### Software

The Ultra-Fast BTI test software module brings together the measurement capabilities of the Model 4225-PMU and 4225-RPM through an intuitive interface that doesn't compromise test flexibility. It makes it easy to define stress timing, stress conditions, and a wide range measurement sequences from spot  $I_D$ , On-The-Fly (OTF), or  $I_D$ - $V_G$  sweeps. The test module allows measuring recovery effects as well as degradation. It also offers prestress and poststress measurement options that incorporate the Model 4200-SCS's DC SMUs for high-precision low-level measurements.

### Stress Settings

The Ultra-Fast BTI Test Module employs familiar parameter setting for building stress–measure timing sequences. The stress set-up screen makes defining log or linear timing or building a custom list of time intervals to trigger intra-stress measurements both easy and quick.

### Intuitive Test Sequence Development

The Ultra-Fast BTI Test Module makes creating a powerful test sequence as uncomplicated as selecting one or more measurement types, then entering the appropriate values for voltage levels and measurement parameters in the intuitive interface. No coding or script writing is required. Select from four measurement types and chain up to 20 measurements together to form a ready-to-run measurement sequence:

- **Spot.** The spot measurement is a single measurement made while the gate and drain are pulsed. The measurement result is the mean value of the samples taken after the drain settles and before the pulse ends.
- **Step Sweep.** The step sweep is very similar to a conventional DC SMU sweep, in which

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# Ultra-Fast NBTI/PBTI Package for the Model 4200-SCS

each step in the sweep includes a settling period and an integration (or averaging) period.

- **Smooth Sweep.** The smooth sweep does not include settling times, and the signal is sampled continuously throughout the sweep.
- **Sample.** A sample measurement is much like the smooth sweep measurement, except that it is performed at a constant set of voltage conditions on the gate and drain.

## Test Automation Speeds Data Sample Acquisition

The ability to acquire large, statistically significant samples of data quickly is key to reliability modeling. Advances in ultra thin film transistors have further increased the required sample size due to the increasingly random nature of the defects in these devices. As a result, it's critical to use a test environment that supports wafer- and cassette-level automation. This environment must also be capable of handling the extremely large data sets associated with reliability testing. The test environment provided with the Automated Characterization Suite software supports full automation capabilities compatible with both semi and fully automatic probe stations.

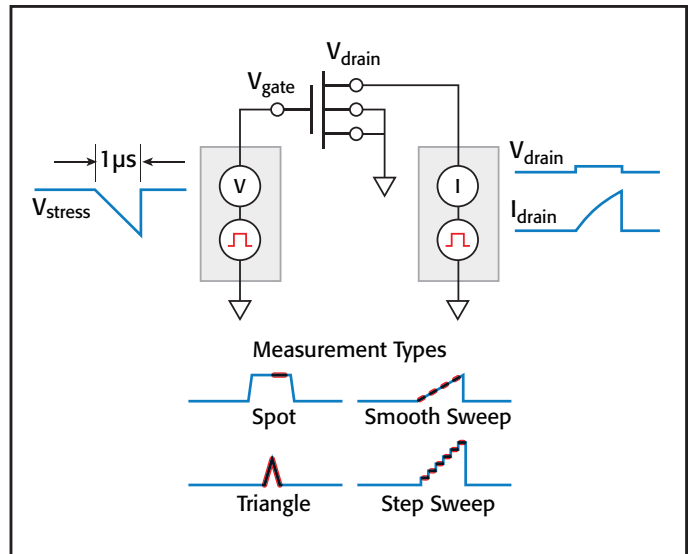
## Interconnect

The 4200-BTI-A package provides all the cabling and connectors required to connect to standard coaxial probe manipulators. For enhanced measurement accuracy, many users add an optional multi-measurement performance cable kit that connects the Model 4200-SCS to a prober manipulator, simplifying switching between DC I-V, C-V, and ultra-fast I-V testing configurations. This kit eliminates the need for re-cabling, as well as maximizing signal fidelity by eliminating the measurement errors that often result from cabling errors. Versions engineered for Cascade Microtech and SUSS MicroTec probers are available. There's also a general-purpose kit for connecting the 4225-PMU to other triaxial and coaxial probe stations.

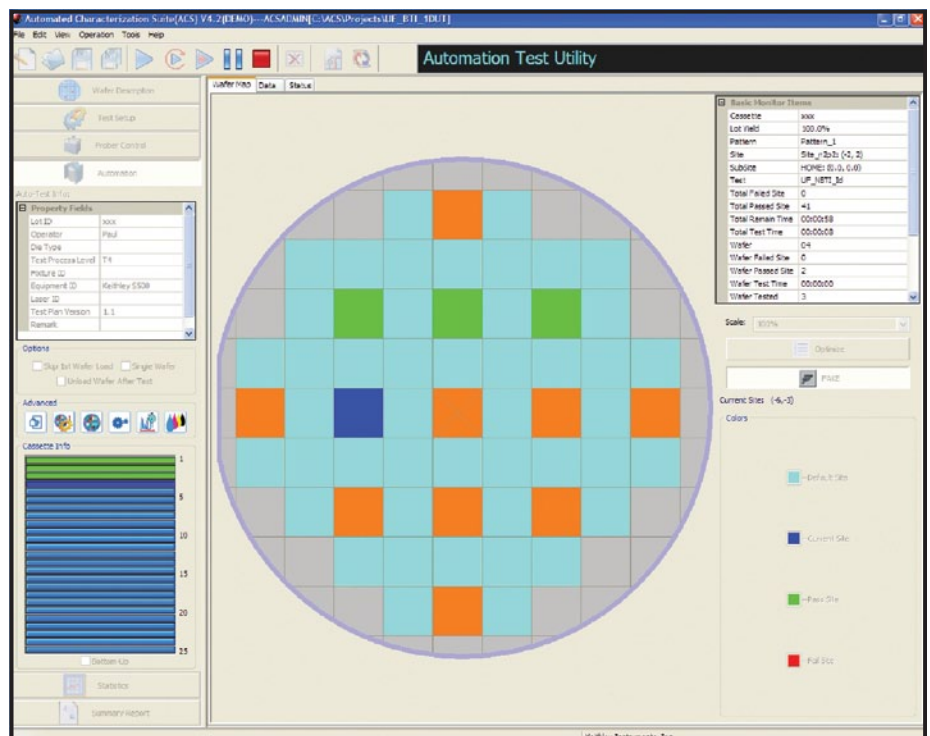
## Additional Applications

The Model 4225-PMU's ultra-fast I-V capabilities are not limited to low-voltage pMOS and nMOS reliability testing. It can drive up to 800mA or 40V with pulse widths from 30ns to several seconds in length. This remarkable dynamic range is suitable for a wide variety of other applications.

Keithley's Model 4200-SCS replaces a variety of electrical test tools with a single, tightly integrated characterization solution that's ideal for a wide variety of applications. To assure customers of the ongoing viability of their systems, Keithley has continually enhanced the system's hardware and software. This ongoing commitment ensures a cost-effective system upgrade path to address new testing needs as they arise. That means Model 4200-SCS users will never have to buy a new parametric analyzer because the old one is obsolete. The Model 4200-SCS is engineered to adapt readily to the industry's changing test needs—making our customers' capital investments stretch further and improving ROI.



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.



ACS software provides wafer- and cassette-level automation capabilities compatible with semi and fully automatic probe stations.

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# 4200-BTI-A

## Ultra-Fast NBTI/PBTI Package for the Model 4200-SCS

### Specifications

#### 4225-RPM REMOTE AMPLIFIER/SWITCH Optional Accessory for the 4225-PMU

The 4225-RPM provides lower current measurement ranges to the 4225-PMU.

- Low current measure ranges supports wide range of measurements, from nanotechnology to BTI (Bias Temperature Instability) on leading-edge CMOS devices
- This is a single-channel accessory; order two Model 4225-RPMs to support the two channels of the Model 4225-PMU.
- Supports switching to the Model 4200-SCS's SMUs or 4210-CVU, allowing for a wide range of tests without re-cabling.
- Built-in bypass mode allows access to the Model 4225-PMU's higher current measurement ranges.

#### PULSE/LEVEL <sup>1</sup>

	4225-PMU with 4225-RPM
V <sub>OUT</sub>	-10 V to +10 V
Accuracy <sup>2</sup> into open load	±(0.5% ±10 mV)
Resolution	< 0.5 mV
Output Connectors	Triaxes, source and sense
Baseline Noise	±(0.39% + 1 mV) RMS typical
Overshoot/Pre-shoot/Ringing <sup>3</sup>	±2% of amplitude ±20 mV

#### 4225-RPM REMOTE AMPLIFIER/SWITCH (must be used in conjunction with 4225-PMU)

##### TYPICAL MINIMUM TIMING PARAMETER FOR CURRENT MEASUREMENT

Range	100 nA	1 μA	10 μA	100 μA	1 mA	10 mA
Recommended Minimum Pulse Width <sup>4,5</sup>	134 μs	20.4 μs	8.36 μs	1.04 μs	370 ns	160 ns
Recommended Minimum Measure Window <sup>5</sup>	10 μs	1.64 μs	1 μs	130 ns	40 ns	20 ns
Accuracy (DC)	±(0.5% + 1nA)	±(0.5% + 1nA)	±(0.5% + 30nA)	±(0.5% + 100nA)	±(0.5% + 1μA)	±(0.5% + 10μA)
Recommended Minimum Transition Time <sup>5,6</sup>	1 μs	360 ns	360 ns	40 ns	30 ns	20 ns
Noise <sup>5,7</sup>	200 pA	2 nA	5 nA	50 nA	300 nA	1.5 μA
Settling Time <sup>5,8</sup>	100 μs	15 μs	6 μs	750 ns	250 ns	100 ns

#### VOLTAGE MEASURE

±10V

RECOMMENDED MINIMUM PULSE WIDTH<sup>4,5</sup>: 160ns.

RECOMMENDED MINIMUM MEASURE WINDOW<sup>5</sup>: 20ns.

ACCURACY (DC): 0.25% + 10mV.

RECOMMENDED MINIMUM TRANSITION TIME<sup>5,6</sup>: 20ns.

NOISE<sup>5,7</sup>: 1mV.

SETTLING TIME<sup>5,8</sup>: 100ns.

#### NOTES

1. Performance at the triax output connectors of the 4225-RPM when using a 2m RPM interconnect cable between the 4225-PMU and 4225-RPM Remote Pulse Measure unit.
2. 100mV to 10V.
3. Typical, with transition time of 100ns (0-100%).
4. Recommended minimum pulse width = (Setting Time)/0.75
5. Typical values, into an open.
6. Recommended rise/fall time to minimize overshoot.
7. RMS noise measured over the Recommended Minimum Measure Window for the given voltage or current range, typical.
8. Time necessary for the signal to settle to the DC accuracy level. (Example: the 10mA measurement range's settling time refers to the period required for the signal to settle to within 0.35% of the final value. Calculated as Accuracy = 0.25% + 10μA = 0.25% + (10μA/10mA) = 0.25% + 0.1% = 0.35%).

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

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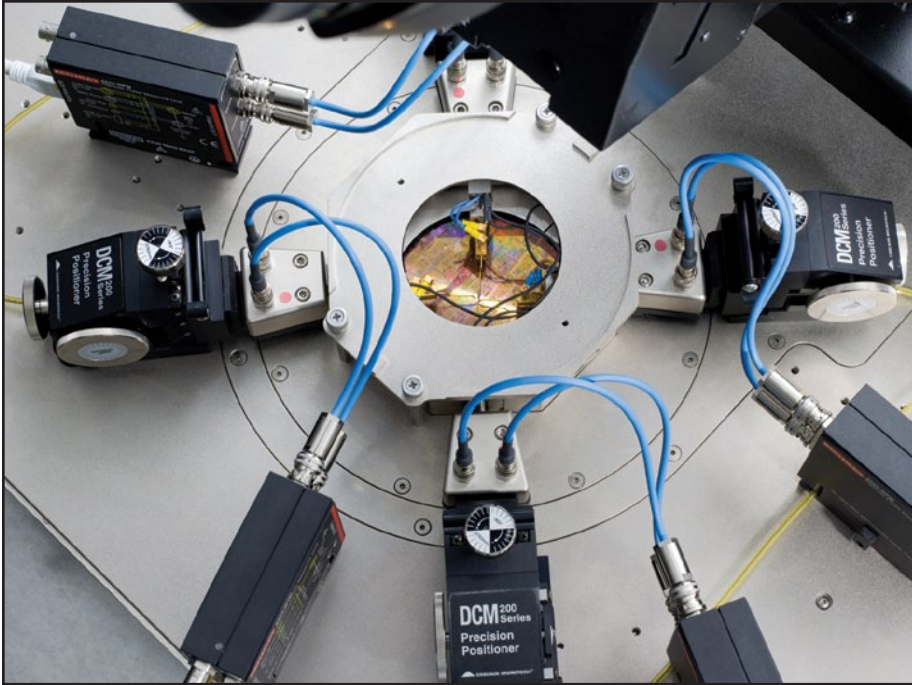
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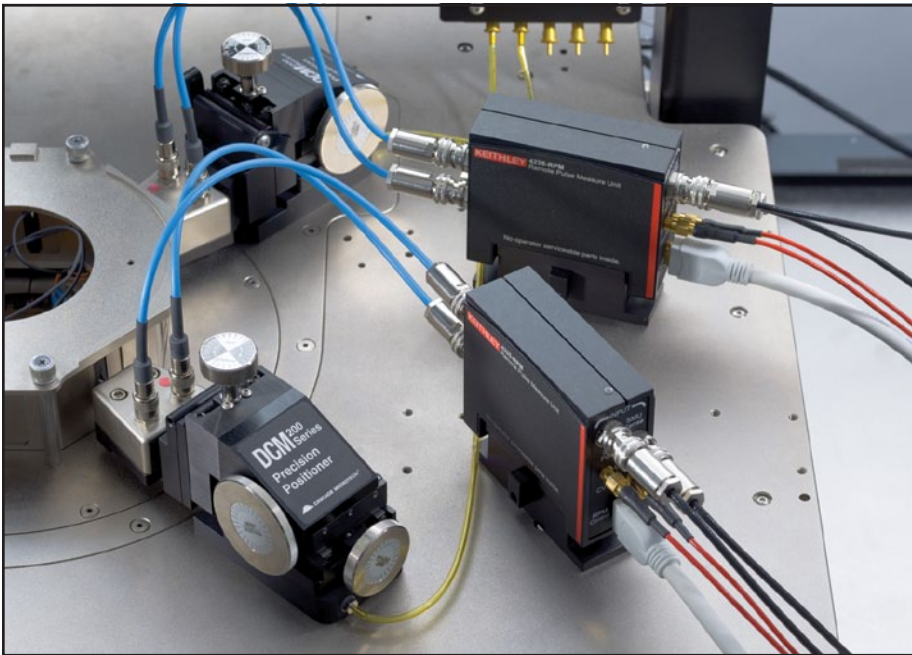
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# 4200-BTI-A

## Ultra-Fast NBTI/PBTI Package for the Model 4200-SCS



This top-down view of a Cascade Microtech analytical probe station illustrates best practices for interconnecting the Model 4225-RPM Remote Amplifier/Switch to the prober using the blue Multi-Measurement Performance cables.



This closeup of two Model 4225-RPMs highlights the DC SMU, C-V, and ultra-fast I-V cable connections.

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# S530

- Semiconductor industry's most cost-effective fully automatic parametric testers
- Optimized for use in environments with a broad mix of products, where high flexibility and system speed are critical
- Choice of low current or high voltage system configurations
  - Low current configuration supports measurement of low current characteristics such as sub-threshold leakage, gate leakage, etc.
  - High voltage configuration is optimized for monitoring processes used for GaN, SiC, and Si LDMOS power devices
- Compatible with popular fully automatic probe stations
- All systems configured with high power 20W SMUs: 1A@20V, 100mA@200V, 20mA@1000V (1000V range available only on high voltage S530 systems)
- Cabled-out tester configuration maximizes prober interface flexibility and expands voltage range
  - Compatible with Keithley's Model 9139A Probe Card Adapter
  - Supports reuse of existing five-inch probe card libraries
- Proven instrumentation technology ensures high measurement accuracy and repeatability in both the lab and the fab

## Parametric Test Systems



Keithley's S530 Parametric Test Systems can address all the DC and C-V measurements required in process control monitoring, process reliability monitoring, and device characterization because they are built on proven sourcing and measurement technology.

### Optimized for High-Mix Test Environments

S530 Parametric Test Systems are designed for production and lab environments that must handle a broad range of devices and technologies, offering industry-leading test plan flexibility, automation, probe station integration, and test data management capabilities. Keithley has brought more than 30 years of expertise in delivering a wide range of standard and custom parametric testers to customers around the world to the design of these test solutions.

### Simple Software Migration and High Hardware Reuse

S530 systems are designed with capabilities that speed and simplify system startups and maximize reuse of your existing test resources. For example, the software that controls these systems is compatible with many new and legacy automatic probe stations, so you may be able to eliminate the cost of a new one. In addition, the S530's cabled-out configuration typically allows continued use of your existing probe card library. Several optional applications services can help you keep getting the full value of your existing prober and probe card investments. Keithley can also provide assistance to speed the development, conversion, or repurposing of your existing test recipes for use with S530 systems.

### Semiconductor Industry's Most Powerful Standard Parametric Test System

Two different system configurations are available to address different parametric test application environments. The S530 Low Current System, which is configurable from two to eight source measurement unit (SMU) channels, provides sub-picoamp measurement resolution and low current guarding all the way to the probe card, which makes it ideal for characterizing sub-micron silicon MOS technologies. The S530 High Voltage System, configurable from three to seven SMU channels, can source up to 1000V for use in the difficult breakdown and leakage tests that automotive electronics and power management devices demand.

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Table 1. S530 System Selector Guide

	Description	Typical Use Cases/Settings	Key Range and Offset Performance
<b>S530 Low Current System</b>	Ideal for both mature and emerging technologies that demand pico-amp current measurement capability	<ul style="list-style-type: none"> <li>Source up to 200V or 1A</li> <li>Measure current with atto-amp resolution with pico-amp offset</li> <li>Measure voltage with microvolt resolution and millivolt offset</li> </ul>	
<b>S530 High Voltage System</b>	Optimized for power electronics and display technologies that require testing at high voltages	<ul style="list-style-type: none"> <li>Source up to 1000V or 1A</li> <li>Measure current with atto-amp resolution with pico-amp offset<sup>1</sup></li> <li>Measure voltage with microvolt resolution and millivolt offset</li> </ul>	

1. Using 200V SMU. The 1000V SMU provides 10pA resolution with nanoamp-level offset.

All Series S530 systems are equipped with Keithley’s proven high power SMUs, which provide up to 20W source or sink capability on both the 200V and 20V ranges. This level of power is essential for complete characterization of the high power devices and circuits prevalent in today’s mobile devices. Whether the application is testing LDMOS Si or GaN BJTs, this higher power capability provides greater visibility into device performance. That means S530 systems can handle high power device testing without compromising the low current sub-picoamp sensitivity needed to monitor mainstream device processes. In contrast, competitive parametric test systems are limited to medium power 2W SMUs, so they cannot match the S530 systems’ range of applications.

**Full Kelvin Standard Configurations**

All too often, currents higher than a few milliamps lead to measurement errors as a result of voltage drops across the interface cables and pathways. To prevent this drop in measurement integrity, both the low current and high voltage S530 systems provide full Kelvin measurements (also known as remote voltage sense) at the probe card. Full Kelvin measurements are particularly critical to ensuring measurement accuracy given the 20W capability of the high power SMUs used in S530 systems. For test environments in which minimizing system cost is of higher importance than absolute accuracy, S530 testers can be configured as non-Kelvin systems.

**Industry’s Most Powerful High Voltage Parametric Test System**

The S530 High Voltage Semiconductor Parametric Test System is the only parametric tester available that’s capable of full Kelvin high voltage performance on up to 24 pins, a capability that’s invaluable for characterizing today’s higher power devices. The system incorporates a high voltage SMU that sources up to 1000V at 20mA (20W max.). Two high voltage pathways allow making either direct high-side current measurements (in which a single SMU is used to both source and measure the high side of the DUT) or higher sensitivity low-side low current measurements (in which one SMU is used to source high voltage to the high side of the DUT and a different SMU is used to force 0V and measure the current of the low side).

**System Architecture**

Each S530 system configuration is made up of five layers:

- Instruments layer – This layer includes the SMUs, the capacitance-voltage instrumentation (CVU), and any auxiliary instruments configured into the system.
- Pathways layer – S530 systems provide high fidelity signal pathways that can be dynamically reconfigured to allow any instrument to be connected to any pin or set of pins during test.
- Cable interface layer – All system interconnects are constructed of fully shielded and guarded triaxial low leakage, high voltage cables to ensure higher measurement integrity.
- Probe card adapter (PCA) layer – This layer extends the shield and guard to the probe card to ensure measurement integrity. Also, the PCA provides auxiliary inputs for instruments that require direct access to the probe card and must bypass the signal path switch matrix.
- Probe card layer – This layer includes the custom cards supplied by your probe card vendors.

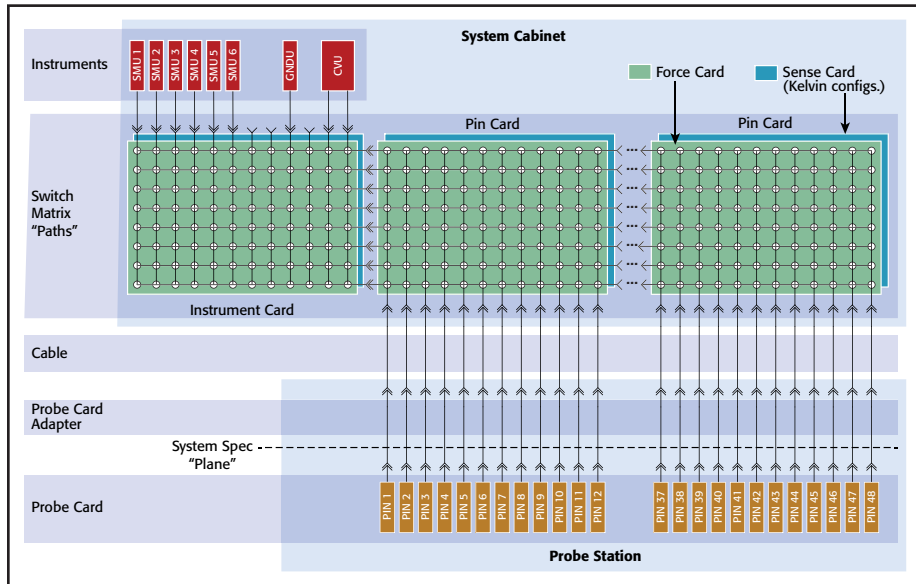
## Signal Pathways

The core of each S530 test system is a set of high fidelity signal pathways that direct signals between instruments and test pins. The performance of these pathways directly influences the performance of the test system as a whole by setting upper current and voltage ranges, and limiting low-level measurements due to current offsets. The S530 has eight high fidelity pathways that can be used to route instruments to pins dynamically. For example, up to eight SMUs can be routed to any pin (or number of pins) at one time. The S530 Low Current System delivers uniform performance across all eight pathways; the S530 High Voltage System provides two high voltage/low leakage pathways, four general-purpose pathways, and two C-V pathways. Both system options support C-V measurements up to 1MHz.

**Table 2. S530 Pathway Performance**

Pathway Type	Key Characteristics	Maximum Voltage	Maximum Current	Comments
Low Current I-V <sup>1</sup>	Ultra low leakage	200V	1A	Limited to 200V max. Provides best low-level signal performance and excellent C-V performance.
High Voltage I-V <sup>2</sup>	1300V	1300V	1A	Supports low-level measurements but not quite as low as the Low Current pathway.
General-Purpose I-V <sup>2</sup>		200V	1A	Suitable for the majority of parametric tests, except for very low current and/or high voltage tests.
C-V <sup>2</sup>		200V	1A	Excellent C-V performance but not suitable for DC I-V measurements.

1. Available only on low current system.  
2. Available only on high voltage system.



Every S530 system is made up of five layers: instruments, pathways, cable interface, probe card adapter, and probe card.

## Proven SMU Technology

All source measurement units (SMUs) built into S530 Parametric Test Systems are based on Keithley's production-qualified instrument technology to ensure high measurement accuracy and repeatability and extended hardware life. The SMUs are four-quadrant sources, so they can source or sink current or voltage. In addition to precision sourcing circuits, they include programmable limits (compliance) across all ranges, which helps protect both devices and probe tips from damage due to device break-

down. Each SMU also measures both voltage and current while sourcing, which ensures that parameter calculations reflect actual conditions rather than simply the programmed conditions.

## Capacitance-Voltage (C-V) Unit

All S530 systems can be equipped with an optional high speed capacitance-voltage measurement unit for C-V measurements up to 1MHz to any pin. This C-V unit can measure a 10pF capacitor at 1MHz with 1% accuracy.

## Ground Unit (GNDU)

All source measurement units are referenced to the ground unit or GNDU. During a test, the GNDU provides both a common reference and a return path for current sourced by the SMUs. The GNDU signal is formed by combining all the Source LO and Sense LO signals and referencing them to system ground. The system can easily be configured for a range of ground system configurations to accommodate various probe station ground schemas.

**Table 3. System Capabilities Comparison**

	S530 Low Current	S530 High Voltage
Pin Count	Up to 60*	Up to 60*
SMU Channels	2 to 8	3 to 7
Vmax	200V	1000V
Imax	1A	1A
Vmin Resolution	1μV	1μV
Imin Resolution	1fA	1fA (100pA at 1000V)
CVU	1kHz to 1MHz	1kHz to 1MHz

\*Maximum of 24 pins with full-Kelvin option.

## Standard 9139A Probe Card Adapter

The standard probe card adapter (PCA) for the S530 parametric test systems is the proven Model 9139A. Several key features and performance advantages have made it the industry's leading choice of PCA for more than 20 years:

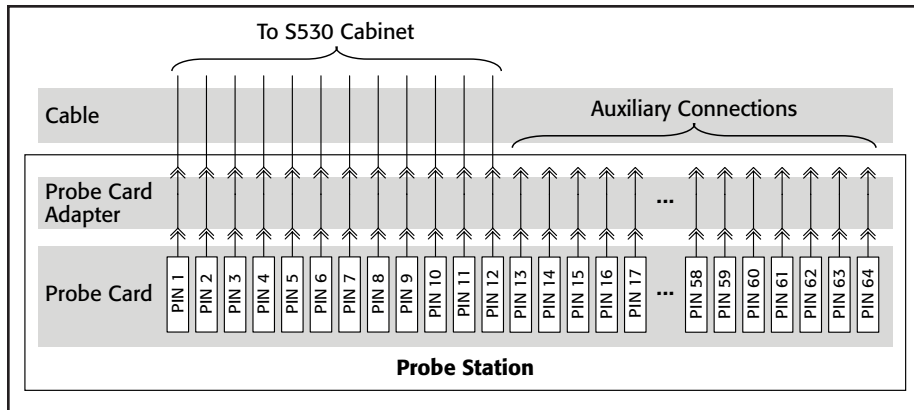
- Low offset currents that maximize low current performance.
- Low noise performance that helps ensure the integrity of low-level voltage measurements.
- Minimally invasive, low profile design that allows easy camera integration.
- 64 inputs – Configurable to support both standard cable connections from the tester and auxiliary inputs for instruments that bypass the pathway matrix.
- 500V pin-to-pin isolation (1000V when connecting only to every other pin).

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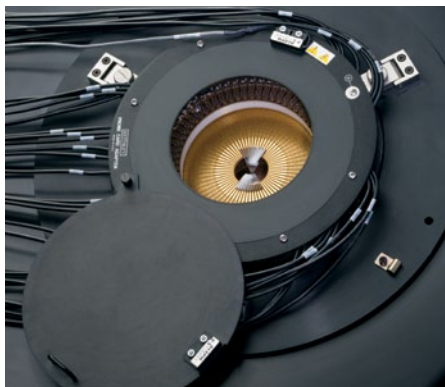
The Model 9139A PCA can be configured for auxiliary I/O connections, allowing instruments to be connected to it directly, bypassing the switch matrix signal paths. This provides for maximum bandwidth to the test structure with a minimum number of variables.

### High flexibility cabled-out configuration

S530 systems are “cabled-out” configurations to provide the broad interconnect flexibility that high-mix fab and lab environments demand. These systems can be interfaced to a variety of probing solutions, including high performance circular probe cards, cost-effective rectangular edge-conductor probe cards, and even special high performance cards for applications that involve extreme temperatures or demand high durability.

**Table 4. S530 System Cabling Options**

Cabling Options	Probe Card Type	Features	Benefits
Standard Keithley 9139A PCA (S400-type)	Circular ceramic	Extends driven guard to probe pin	Superior low current measurements. Supports up to 64 pins; easily configured for auxiliary inputs for additional instrument options
Custom Cabled to Existing PCA Type	Typically for five-inch rectangular probe cards using edge card connectors	Compatible with existing probe card library	Reduces migration cost by reusing existing probe cards
Unterminated Cables	Cables connected to pathway output with unterminated cable ends	Ready to cable to existing interface or fixture	Provides recommended cable to optimize system performance
No Cables	Custom probe card	No need to purchase a cable solution	Use cable system provided by custom probe card vendor



### Alternative Probe Card Adapters (PCAs)

Optional probe card adapters are available for all S530 configurations. In the simplest form, the edge connector used to interface to a rectangular probe card (typically referred to as five-inch probe cards) is a PCA. This type of PCA provides the most cost-effective solution for applications involving mid-range signal levels. If desired, the Model 9139A PCA can be configured into any S530 system as an option. This PCA is designed for interfacing the system to circular probe cards (from Keithley-approved vendors)

The Model 9139A Probe Card Adapter has been trusted by the industry for more than 10 years. Its combination of low current performance and high voltage capability makes it the ideal companion to the S530 Parametric Test Systems.

via pogo pin connections. Probe-station-specific adapter plates can be specified during ordering to ensure the Model 9139A's compatibility with a variety of popular probe stations.

### Probe Cards

Unlike testhead-based systems, S530 systems are easily adaptable for use with a wide range of probe card types, so you likely won't need to replace your existing (and expensive) probe card library. Although Keithley recommends the use of the Model 9193A PCA and approved probe card vendors, we recognize you have made a major investment in your current cards. If probe card reuse is critical to your capital equipment strategy, consult an applications team member to learn about connection options that can protect your probe card investment.

### System Software

Keithley's S530 system software maximizes the efficiency and flexibility of our system hardware, bringing together all the key elements for automated parametric testing in a single integrated package. Measurement routines and test plans can be easily written, converted, or re-used, helping you get up and running faster. That simplifies using your S530 system effectively in conjunction with existing test systems. S530 software includes all the key system software operations:

- Wafer description
- Test macro development
- Test plan development
- Limits setting
- Wafer or cassette level testing with automatic prober control
- Test data management

### Engineer and Operator User Modes

S530 system software gives engineers full system capability and software flexibility for creating test plans. The tools provided help engineers develop, validate, and debug core measurement routines, test macros, and comprehensive test plans. System software administration and log-in capabilities make specified tools and capabilities accessible only to the engineers you designate. A separate user interface is supplied exclusively for system operators for test execution, blocking access to core system set-up files. Alternatively, the S530 system software provides a command line interface so you can customize your own operator interface.

### System Diagnostics and Reliability Tools

Diagnostics can be performed routinely to ensure the system is performing as expected and won't generate false failures or false passes. The S530 systems' diagnostics capability verifies system functionality quickly and easily. Key steps in the diagnostics process include configuration verification, communications pathway tests, signal pathway testing, and SMU source-measure tests. Even the cable interface and PCA are included in the diagnostics process to ensure complete system functionality. This diagnostics process is designed to detect and localize a wide range of system problems, speed troubleshooting, and maximize uptime.

### High Voltage Instrument Protection Modules

Some S530 instrumentation can produce high voltages that other system instruments are not designed to withstand. If a test sequence or a failed DUT presents too much voltage at the inputs to a low voltage instrument, serious instrument damage is possible. To minimize the potential for these problems, Keithley engineers have developed protection modules that prevent damaging voltages from harming sensitive instruments without compromising their low-level measurement capabilities. In addition to the system's SMUs, these modules protect the system's optional capacitance-voltage instrumentation against high voltage damage.

### Industrial PC with RAID Mirror Drive

Even the highest quality disk drives are subject to routine failures, so regular system backups are critical. S530 systems incorporate a high reliability industrial controller including the RAID (Redundant Array of Independent Disks) option, designed to maintain a mirror of the master drive at all times. In the event of a drive failure, the mirror drive becomes the master and the user is notified that a drive replacement should be scheduled immediately. With a RAID mirror drive, a failed drive represents a scheduled repair rather than a downed system.

### Support Services and Contracts

Keithley's worldwide network of service and applications professionals provides expert support services ranging from initial installation and calibration to repairs and test plan migration services. These services maximize system utilization and uptime while reducing your overall cost of ownership.

- *Installation and Probe Station Integration Services* – Includes the setup and verification of the system, as well as probe station integration. This includes setting up probe station communications and installing the probe card adapter.
- *Calibration Services* – All S530 Parametric Test Systems are calibrated onsite by a certified Keithley field service engineer.<sup>1</sup> Keithley provides a range of internationally recognized accredited calibration services, including A2LA (American Association for Laboratory Accreditation) accredited calibration.<sup>2</sup>
- *Repair Services* – Repair services ranging from on-site service contracts to self-service module-swaps are available.

- *Test Plan Migration Services* – Keithley's experienced applications engineers are skilled at converting your existing test plans to the S530 system software environment. This includes conversion of data objects like user test libraries, wafer description files, cassette plans, etc.
- *Correlation Studies* – Keithley applications engineers can perform correlation studies, comparing your existing parametric test system's capability to the S530's and analyzing the underlying performance differences.

1. While most components of the system are calibrated on site, certain components are calibrated at one of Keithley's worldwide network of service facilities.
2. A2LA accredited calibration services are available in the United States and Germany.

### Documentation

A comprehensive manual set is pre-installed on the system; it is also provided on CD:

- *S530 Administrative Guide* – Information on site preparation, installation, etc.
- *Users Reference Manual* – A detailed reference and instruction manual on the operation of the ACS software.
- *Programmers Guide* – Provides a detailed reference to developing test scripts, using standard libraries, building and maintaining custom libraries, etc.
- *Prober Manual* – Assists in automatic probe station setup and programming. It includes driver details and usage instructions.

### System Performance Specifications

All system specifications are to the system reference plane, which is located between the pogo pins of the Model 9139A PCA and the probe card.

### Customization in Layers

The S530 provides a number of hardware and software customization layers for adapting the system to a wide range of test needs:

- Instrumentation – Standard Options
- Custom instrumentation
- Auxiliary instrument connections on PCA
- Customizable load board in PCA
- User Access Points (to customize test sequence framework)

### User Access Points (UAPs) for Added Flexibility

User Access Points or UAPs can be used to modify the operational flow of the test sequence at key events like "load wafer," "start test," "end cassette," etc. They are useful for adding system capabilities like reading wafer cassette RFID tags or reading wafer IDs using an OCR system. During test operation, an enabled UAP triggers the execution of one or more custom operations defined in a script or executable program.

## Specification Conditions

23°C ±5°C, 1 year.

RH between 5% and 60% after 1 hour warm-up.

All specs assume 4-wire (Kelvin) option.

V/A errors can be eliminated when used as a 4-wire system.

All specs are based on 1 year calibration cycle for individual instruments.

Measurement Specifications @ 1 PLC (Power Line Cycle) unless otherwise noted.

Capacitance Specifications are typical @ quiet mode.

## General I/V Source Specifications

**MAXIMUM OUTPUT POWER PER SMU:** 20W (four quadrant source or sink operation).

**COMPLIANCE:** Compliance resolution and accuracy are determined by the corresponding range used.

## Condensed Specifications

### Low Current System

Current Range	Max. Voltage	MEASURE		SOURCE	
		Resolution	Accuracy	Resolution	Accuracy
1 A	200 V	10 μA	0.03% + 1.5 mA + 1.3 pA/V	20 μA	0.05% + 1.8 mA + 1.3 pA/V
100 mA	200 V	1 μA	0.02% + 20.0 μA + 1.3 pA/V	2 μA	0.03% + 30.0 μA + 1.3 pA/V
10 mA	200 V	100 nA	0.02% + 2.5 μA + 1.3 pA/V	200 nA	0.03% + 6.0 μA + 1.3 pA/V
1 mA	200 V	10 nA	0.02% + 200.0 nA + 1.3 pA/V	20 nA	0.03% + 300.0 nA + 1.3 pA/V
100 μA	200 V	1 nA	0.02% + 25.0 nA + 1.3 pA/V	2 nA	0.03% + 60.0 nA + 1.3 pA/V
10 μA	200 V	100 nA	0.03% + 1.5 nA + 1.3 pA/V	200 pA	0.03% + 5.0 nA + 1.3 pA/V
1 μA	200 V	10 pA	0.03% + 500.6 pA + 1.3 pA/V	20 pA	0.03% + 800.6 pA + 1.3 pA/V
100 nA	200 V	1 pA	0.06% + 100.6 pA + 1.3 pA/V	2 pA	0.06% + 100.6 pA + 1.3 pA/V
10 nA	200 V	100 fA	0.15% + 3.6 pA + 1.3 pA/V	200 fA	0.15% + 5.6 pA + 1.3 pA/V
1 nA	200 V	10 fA	0.15% + 880.0 fA + 1.3 pA/V	20 fA	0.15% + 2.6 pA + 1.3 pA/V
100 pA	200 V	1 fA	0.15% + 760.0 fA + 1.3 pA/V		

Voltage Range	Max. Current	MEASURE		SOURCE	
		Resolution	Accuracy	Resolution	Accuracy
200 V	100 mA	1 mV	0.02% + 50 mV	5 mV	0.02% + 50 mV
20 V	1 A	100 μV	0.02% + 5 mV	500 μV	0.02% + 5 mV
2 V	1 A	10 μV	0.02% + 480 μV	50 μV	0.02% + 730 μV
200 mV	1 A	1 μV	0.02% + 355 μV	5 μV	0.02% + 505 μV

Capacitance	10kHz	100kHz	1MHz
10 pF	0.50%	0.50%	1.00%
100 pF	0.50%	0.50%	1.00%
1 nF	0.50%	0.50%	4.00%
10 nF	0.50%	0.50%	5.00%
100 nF	1.00%	1.00%	5.00%

### High Voltage System

Current Range	Max. Voltage	MEASURE		SOURCE	
		Resolution	Accuracy	Resolution	Accuracy
1 A <sup>1</sup>	200 V	10 μA	0.08% + 3.8 mA + 2.4 pA/V	20 μA	0.13% + 4.5 mA + 2.4 pA/V
100 mA <sup>1</sup>	200 V	1 μA	0.05% + 50.0 μA + 2.4 pA/V	2 μA	0.08% + 75.0 μA + 2.4 pA/V
20 mA <sup>1</sup>	1100 V	100 μA	0.09% + 3.0 μA + 2.4 pA/V	500 nA	0.11% + 10.0 μA + 2.4 pA/V
10 mA <sup>1</sup>	200 V	100 μA	0.05% + 6.3 μA + 2.4 pA/V	200 nA	0.08% + 15.0 μA + 2.4 pA/V
1 mA <sup>1</sup>	1100 V	10 nA	0.07% + 500.0 nA + 2.4 pA/V	50 nA	0.09% + 750.1 nA + 2.4 pA/V
100 μA <sup>1</sup>	1100 V	1 nA	0.06% + 63.0 nA + 2.4 pA/V	5 nA	0.08% + 150.0 nA + 2.4 pA/V
10 μA <sup>1</sup>	1100 V	100 nA	0.07% + 3.8 nA + 2.4 pA/V	500 pA	0.08% + 12.5 nA + 2.4 pA/V
1 μA <sup>1</sup>	1100 V	10 pA	0.07% + 1.3 nA + 2.4 pA/V	50 pA	0.09% + 2.0 nA + 2.4 pA/V
100 nA <sup>2</sup>	200 V	1 pA	0.15% + 260.0 pA + 2.4 pA/V	2 pA	0.15% + 260.4 pA + 2.4 pA/V
10 nA <sup>2</sup>	200 V	100 fA	0.38% + 17.9 pA + 2.4 pA/V	200 fA	0.38% + 22.9 pA + 2.4 pA/V
1 nA <sup>2</sup>	200 V	10 fA	0.38% + 11.0 pA + 2.4 pA/V	20 fA	0.38% + 15.4 pA + 2.4 pA/V
100 pA <sup>2</sup>	200 V	1 fA	0.38% + 10.7 pA + 2.4 pA/V		

<sup>1</sup> Using general purpose signal paths.

<sup>2</sup> Using high performance signal paths.

Capacitance	10kHz	100kHz	1MHz
10 pF	0.50%	0.50%	3.00%
100 pF	0.50%	0.50%	2.00%
1 nF	0.50%	0.50%	7.00%
10 nF	0.50%	0.50%	5.00%
100 nF	1.00%	1.00%	5.00%

Voltage Range	Max. Current	MEASURE		SOURCE	
		Resolution	Accuracy	Resolution	Accuracy
1000 V	20 mA	10 mV	0.04% + 126 mV	50 mV	0.05% + 251 mV
200 V	100 mA	1 mV	0.04% + 125 mV	5 mV	0.05% + 125 mV
20 V	1 A	100 μV	0.04% + 13 mV	500 μV	0.05% + 12.7 mV
2 V	1 A	10 μV	0.05% + 935 μV	50 μV	0.05% + 1.7 mV
200 mV	1 A	1 μV	0.04% + 810 μV	5 μV	0.05% + 1.7 mV

# S500

- Highly configurable, instrument-based system
- Ideal for SMU-per-pin Wafer Level Reliability (WLR) testing, high speed parallel test, die sorting and binning, NBTI, Process Control Monitoring (PCM)
- Intuitive test setup, data gathering and analysis with ACS software
- Keithley's TSP-Link® backplane provides high speed measurement throughput
- Flexible solution to meet emerging and mature testing needs
- Full control of automated and semi-automated probers
- Develop and execute tests at the device, site, wafer, and cassette level

## Integrated Test System

### Versatile Systems with the Instrument Advantage

S500 Integrated Test Systems are highly configurable, instrument-based systems for semiconductor characterization at the device, wafer, or cassette level. Built on our proven instrumentation, S500 Integrated Test Systems provide innovative measurement features and system flexibility, scalable to your needs. The unique measurement capability, combined with the powerful and flexible Automated Characterization Suite (ACS) software, provides a comprehensive range of applications and features not offered on other comparable systems on the market. Specific capabilities and system configurations include:

- Full-range source measurement unit (SMU) instrument specifications, including sub-femtoamp measurement, ensure a wide range of measurements on almost any device.
- Pulse generation and ultra-fast I-V for memory characterization, charge pumping, single-pulse PIV (charge trap analysis), and PIV sweeps (self-heating avoidance).
- Low or high channel-count systems, including parallel test, with Keithley's system-enabling and scalable SMUs.
- High voltage, current, and power source-measure instrumentation for testing devices such as power MOSFETs and display drivers.
- Switching, probe cards, and cabling take the system all the way to your DUT.

### Flexibility Combined with Applications Experience

S500 Integrated Test Systems are designed around three standard Keithley principles: configuration, integration, and customization. What this means to you is that you will receive a comprehensive test system for semiconductor characterization with both industry-leading Keithley hardware and highly configurable ACS software applications that include device characterization, reliability/WLR, parametric, and component functional test. With Keithley's proven instrumentation and user-friendly ACS software, the S500 is configured, integrated, and customized with the applications experience that only Keithley can provide.

### Value-Focused Systems and Service

- Assessment of individual application needs for customization
- Proposal of integrated system configuration
- Installation and system user support
- Management of system-out cabling and probe card adaptation
- Implement training, test code development, and applications services
- Assurance of turnkey solutions for future applications



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## Key System Components

- **4200-SCS lab-grade parameter analyzer characterizes devices using unique instrumentation modules such as sub-femtoamp SMUs, capacitance-voltage units, pulse generators, and ultra-fast I-V units**
- **Series 2600A family of SMUs offering a wide dynamic range of 1fA to 10A and 1 $\mu$ V to 200V, combines into a high channel-count system via the Keithley TSP-Link interface**
- **Model 707B high speed switch matrix integrates seamlessly with Series 2600A SMUs via the Keithley TSP-Link interface for a complete multipoint test solution**
- **Model 2410 High Voltage 20W SourceMeter Unit sources up to 1100V, 1A**
- **Model 2651A High Power SourceMeter Unit offers 2000W pulsed power, 200W DC power, and up to 50A @ 40V with pA and  $\mu$ V resolution**
- **ACS software provides intuitive test setup, data gathering and analysis for parametric characterization from single die to full cassette**
- **Full control of automated and semi-automated probers, as well as other test instruments, further simplifies device test and characterization**

## Flexible and User-Friendly Software Environment

Each comprehensive S500 test system includes advanced components and productivity features to make workflow smooth and easy. The ACS application software is designed to perform complex functions, such as:

- Wafer description
- Test setup
- Prober control
- Test execution
- Real-time and post-test analysis

The integrated test plan and wafer description function allows the user to set up single or multiple test plans on one wafer and selectively execute them later, either manually or automatically. Additionally, the user has maximum flexibility for performing applications—easily switching between lab use (manual) and production (fully automated) using the same test plan.

## High Throughput WLR

SMU-per-pin configuration is especially beneficial in scaled CMOS reliability testing.

- Ideal for DC “on-the-fly” NBTI testing
- High speed measurements produce lifetime predictions from two to five times faster than conventional WLR solutions
- Embedded Test Script Processor (TSP®) technology and deep measurement buffers ensure deterministic timing on all pins
- Up to 200V stress and picoamp measurements provide a wide range of capabilities and technologies
- Real-time plotting provides visibility into tests as they occur

## Automated Device Characterization

Exceptional balance of high precision testing and automated data gathering.

- Flexible configurations to meet current and emerging test needs
- Powerful analysis, presentation, and reporting tools
- Control full and semi-automatic probers with intuitive setup and operation



## Parametric Die Sort

Uniquely suited for multi-site parallel testing for die sort and other high throughput applications.

- Multi-group testing allows groups of SMUs to execute in parallel on different devices, structures, or dies
- True parallel test is enabled through distributed processing with embedded Test Script Processor (TSP®) technology in each SMU.
- High voltage and high current capabilities provide capabilities across a wide range of technologies
- Large library of ready-to-use tests and parameter extractions





# ACS

- Supports a wide array of instruments and probers
- Intuitive GUI simplifies I-V tests, analysis and results from bench-top to fully automated parametric testers
- Develop and execute tests at the device, site, wafer and cassette level
- Intuitive GUI for test plan development and interactive operation
- Interactive and real-time data plotting
- Highly portable test projects with minimal or no modifications
- Supports multiple SMUs for parallel testing
- Flexible, modular software accommodates evolving and mature test requirements

## APPLICATIONS

Compatible with emerging and mature testing needs for:

- Component test
- Component characterization
- Device characterization
- Parametric test
- Reliability test
- Die sort

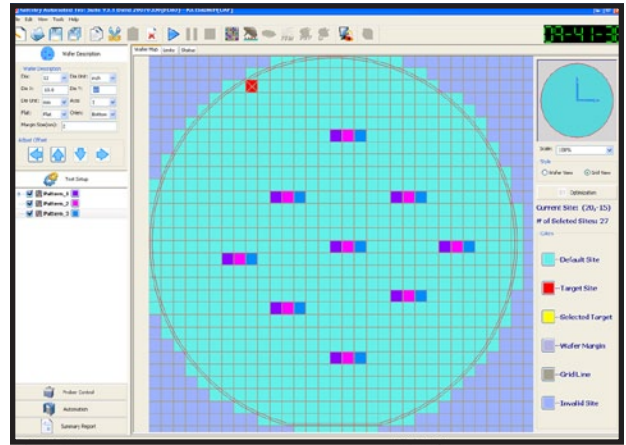
## Ordering Information

ACS Component Characterization Suite Software

# Automated Characterization Suite Software

## One Powerful Software Solution—A Wide Range of Hardware Configurations

Keithley's Automated Characterization Suite (ACS) is a flexible, interactive software test environment designed for device characterization, parametric test, reliability test and even simple functional tests. ACS supports a wide array of Keithley instrumentation and systems, hardware configurations, and test settings, from a few bench-top instruments for use in a QA lab to fully integrated and automated rack-based parametric testers.



ACS offers exceptional testing and analysis flexibility, plus its intuitive GUI helps novice users be productive almost immediately, regardless of their level of programming experience. The GUI simplifies configuring test instrumentation, making I-V measurements, getting results, and analyzing them quickly because no coding is required. Even if you're an infrequent user, you can go from creating a new test setup to characterizing new devices in a fraction of the time older test development approaches require. Just as important, ACS provides all the tools you need to set up tests, analyze data, and export your results—without ever leaving the ACS environment.

## ACS – From Lab to Fab

Series 2600A

Multiple Series 2600As

Model 4200-SCS, 707B

S500

S530

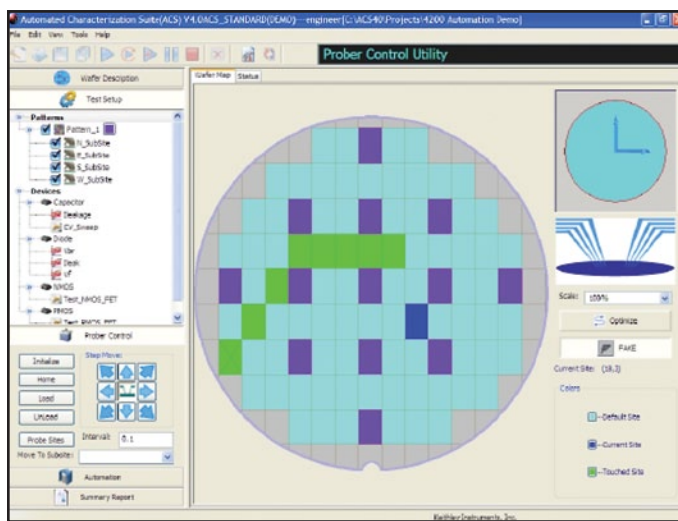
## Choose ACS for What It Gives You that Others Don't

There are many alternatives on the market for creating characterization applications, but ACS offers major advantages that competitive solutions can't match, such as a choice of three powerful project development options. With ACS, you can create the tests you need in the way that best suits your application's requirements and your own programming preferences.

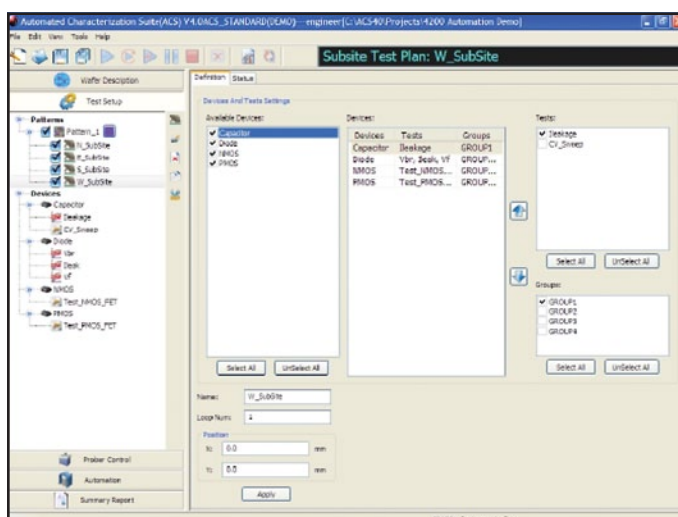
- You say you're a researcher and you just need to make a quick test of common parameters and properties on a single device? We've packaged the same tests that our semiconductor customers use to verify their

products into **easy-to-use applications libraries**. These libraries help you get the data you need to validate your work quickly so you can get back to your research sooner.

- Need more test development flexibility? Our **interactive test development GUI** lets you select bias and sweep conditions, acquire raw data, then use the built-in Formulator tool to extract meaningful results—all without writing code.
- For the ultimate test development flexibility, modify one of the existing test scripts in our applications libraries using the **embedded script editing and debugging tools**.



**Interactive probe station control speeds and simplifies test development and debugging by combining interactive testing with manual probe station control.**



**ACS lets you map devices and tests to sites and subsites, so there's no need to duplicate each test for each subsite, reducing your test development time significantly.**

## Automate Your Data Gathering Processes

Need the throughput advantages of a semi-automatic or fully automatic wafer probe station to get lots of data fast? The wafer prober automation option for ACS makes it easy to interface a variety of popular probe stations into your test setup. This option includes a wafer description utility (for creating a virtual wafer to use in creating wafer-level sampling plans), real-time wafer maps with binning capabilities (for designating a device's disposition before it's packaged, in die sorting, etc.), a cassette sample plan utility (for designating which wafers are to be tested), and a post-test cassette and wafer review utility (for exploring and comparing test results from multiple wafers interactively).

Many of the tools and capabilities built into ACS enhance automated device characterization:

- Wafer- and cassette-level automation
- Limits file generation tool
- Test results binning, including interactive binning plot
- Test map—map device and tests to sites and subsites
- Interactive probe station control mode
- Real-time plotting
- Single or per-wafer Keithley data file
- SQLite™ database and binning file output options
- Lot summary report generator
- Integrated support for Keithley Series 2600A and 2400 SourceMeter families
- Integrated scripting editor and GUI builder
- Integrated support for C (with 4200-SCS only), Python, and Lua (for Series 2600A) programming languages

## Share Test Projects and Results

ACS offers a common set of key elements that work across a wide range of hardware configurations, which saves time and increases productivity. Systems perform consistently from one hardware implementation to another, so, for example, it's easy to transfer your knowledge of an ACS-based system used in single-device component characterization to another designed for wafer level testing.

Similarly, test projects and sequences you create for one Keithley ACS hardware configuration will run on compatible setups in other test settings

with little or no modification. This portability across a range of configurations reduces the effort involved in transferring a new device from one lab or department to another and simplifies comparing results obtained in various test settings. This is possible because ACS employs common open-standard file interfaces for projects, wafer maps, output files, etc. as well as common test libraries and instrument drivers, which also means you can be confident of high results correlation whether your tests are run on a system with a single Series 2600A instrument or a fully automated custom die sort tool with dozens of these instruments.

### Maximize the Productivity of Your Keithley Hardware

The tools in ACS simplify test development and maximize the speed of each Keithley instrument linked into the system. For example, ACS builds on the throughput advantages inherent in Keithley's newest family of high performance source measurement units, the Series 2600A System SourceMeter instruments. These advantages include:

- The on-board Test Script Processor (TSP®) in each instrument that allows each 2600A to operate independently of the ACS system's controller
- The TSP-Link® high speed communications bus used to network multiple 2600A instruments together
- True parallel test execution
- Precision timing

Together, ACS and Keithley TSP-based hardware offer the highest throughput in the industry to lower the cost of test without requiring you to spend time learning new programming concepts or languages before getting the data needed to accomplish your goals.

### Add More Hardware to Adapt to Changing Needs

High scalability and a flexible architecture simplify configuring an ACS system to match your specific testing requirements or to upgrade an existing system to handle new test needs as they evolve. Our wide range of source-measure and switching capabilities provides a solid foundation for configuring customized applications because ACS software can control virtually any instrument or peripheral with a standard hardware interface. For example, third-party LCR meters can be easily integrated into any ACS system and drivers are available for popular instruments. Also, ACS's integrated scripting environment can control any GPIB instrument the application may require, such as a hot chuck controller.

Many ACS systems are configured using one or more of Keithley's innovative Series 2600A System SourceMeter instruments, which are optimized for precision sourcing and measurement synchronization to capture high speed events. These systems offer unmatched testing speed and accuracy because they provide an SMU-per-pin architecture. ACS system configurations can support any number from two to more than 40 SMUs in a single rack for true parallel characterization applications.

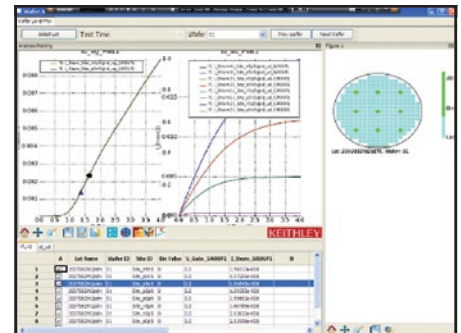
ACS also makes it easy to integrate other types of Keithley hardware into your system, such as instruments to meet specialized test requirements, such as:

- High channel count switching—Model 707B Six-slot Switch Mainframe
- Combination of switching and measurement—Series 3700A Switch/Multimeters
- High voltage sourcing—Model 237 High Voltage Source-Measure Unit
- Higher resolution, lower current, or other capabilities such as C-V or pulse testing—Model 4200-SCS
- Wider dynamic range—Series 2400 SourceMeter instruments

### Broad Range of Applications

ACS-based Integrated Test Systems are complete solutions for applications such as parametric die sort and wafer level reliability testing. When paired with appropriate semi-automatic and fully automatic probe stations, their hardware configurations and test project development can be easily optimized for specific tasks. ACS leverages the on-board test script processors in Series 2600A System SourceMeter instruments into a multi-processor environment that's ideal for true parallel test in both single- and multi-site configurations. This multi-processor environment provides high parallel throughput while speeding and simplifying test project development. Multi-site testing capabilities are embedded throughout ACS from the wafer description utility to the test results output file or binning file, for example:

- Multi-site parallel testing brings the highest possible throughput for both parametric die sort and WLR applications
- Configurable for special applications like MEMS testing
- Easily customize test flows with User Access Points (UAPs) that execute scripts or call custom utilities



**Wafer and binning map tools allow you to browse through the test results on either a wafer-by-wafer or site-by-site basis. You can also overlay traces from multiple sites to make quick comparisons.**

# ACS Basic Edition

## Semiconductor Parametric Test Software for Component and Discrete Devices



- **Designed for packaged devices (MOSFETs, BJTs, IGBTs, diodes, resistors, etc.)**
- **Rich set of test libraries for fast and easy test setup and execution without programming**
- **Built-in data analysis tools for quick analysis of parametric data**
- **Supports Keithley's Series 2600A, Series 2400, and Model 2651A SourceMeter® instruments and Model 237 Source-Measure Unit (SMU)**
- **FREE optional off-line version for developing test setups on a different PC**
- **Windows® 7 and XP compatible**

### Ordering Information

**ACS-BASIC** Component Characterization Software

**ACS-BASIC-UPGRADE** (available for existing ACS Basic customers)

Optimized for parametric testing of component and discrete (packaged) semiconductor devices, ACS Basic Edition maximizes the productivity of technicians and engineers in research and development. The versatile architecture of this software allows it to meet the wide ranging and ever changing requirements of semiconductor device testing. It supports all of Keithley's source and measure instrument products, including Series 2600A, Series 2400, and Model 2651A SourceMeter instruments and the Model 237 SMU.

This powerful, yet cost effective solution includes Keithley's rich set of proven parametric libraries. Simply choose the desired test and begin running it to immediately start gathering data and analyzing it. Users also have the option of customizing any test with the embedded script editor.

The built-in data analysis tools allow users to quickly analyze the parametric data. For example, place device curves developed from newly collected data over "golden" curves for fast comparisons. To perform specialized calculations on raw data, use the mathematical formulator tool to create customized parameter calculations. Data can be easily saved in graphical and/or tabular formats.

ACS Basic offers three modes of operation:

- **Single Test Mode**—for single device, single test operations
- **Multi Test Mode**—for multiple test operations on a single device
- **Trace Mode**—for mapping out the operating range and characteristics of a semiconductor device while minimizing the risk of damage to it. This mode offers an interactive method of controlling the voltage level of a sweep with a slide bar or the arrow keys on the PC keyboard.

### Related Products

For applications requiring wafer level testing, use ACS Integrated Test Systems or ACS Wafer Level Reliability Systems. These systems supply a wafer map, prober automation capabilities, and analysis options for yield monitoring as well as related statistical calculations for maximizing productivity in wafer level test environments.

### ACCESSORIES AVAILABLE

2600-FIX-TRX	Grounded Phoenix-to-Triax Cable Adapter
8101-4TRX	Leaded Component Test Fixture
ACS-COMP	PC for Installed and Bench-top ACS Systems
KUSB-488A	IEEE-488.2 USB-to-GPIB Interface Adapter for USB Port
LR-8028	DIP Component Test Fixture

### KEY APPLICATIONS

- **Materials and device development**
- **Quality assurance**
- **Device inspection**

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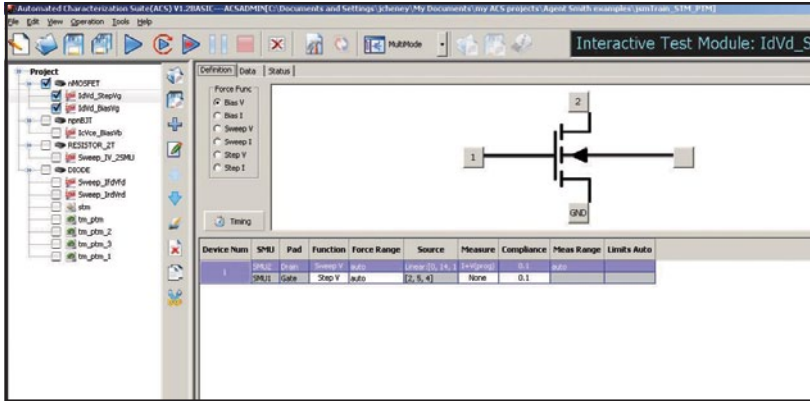
[www.keithley.com](http://www.keithley.com)

**KEITHLEY**

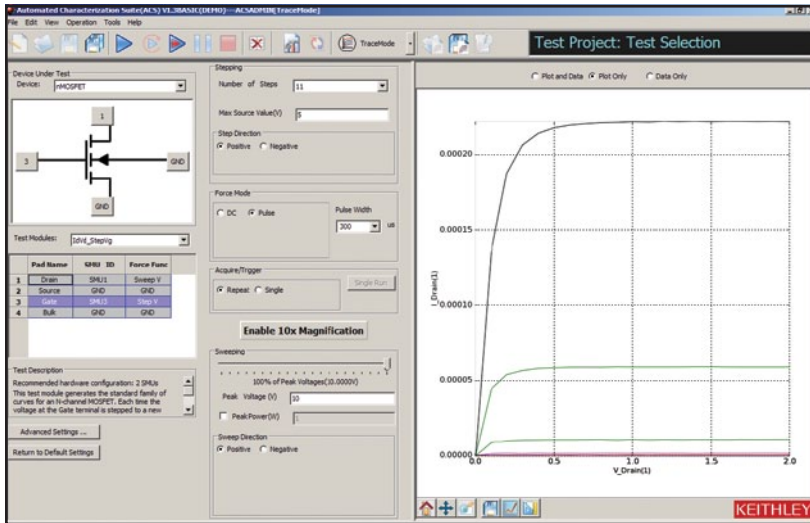
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# ACS Basic Edition

# Semiconductor Parametric Test Software for Component and Discrete Devices



Multi Test Mode allows multiple tests to be performed on a device.



Trace Mode supports interactive testing of a device.

## SUMMARY OF TYPICAL TESTS

Device	Leakage	Breakdown	Gain	On-State
Bipolar Junction Transistor	IEBO, IECO, IEVEB, ICVCB	BVCBO, BVCEI, BVCEO, BVCEV, BVEBO, BVECO	HFE	IBCO, IBEO, IBICVBE, IBVBE, ICBO, ICEV, ICVCE_BiasIB, ICVCE_StepIB, ICVCE_StepVB, VBCO, VCE
MOSFET	IDL, IDS_ISD, IGL, ISL	BVDSS, BVDSV, BVGDO, BVGDS, BVGSO	GM	IDVD_BiasVG, IDVD_StepVG, IDVG_BiasVD, IDVG_StepVD, IDVG_StepVSUB, IGVG, VTCl, VTEXT, VTEXT_IISQ
Diode	IRDVRD	VBRIRD	NA	DYNAMICZ, IFDVFED, VFDIFD, VRDIRD
Resistor	NA	NA	NA	IV
Capacitor	IV	NA	NA	

## FORMULATOR FUNCTION SUMMARY

Type	Functions
Math	ABS, AVG, DELTA, DIFF, EXP, LN, LOG, LOG10, SQRT
Parametric Extractions	GMMAX, RES, RES_4WIRE, RES_AVG, SS, SSVTCI, TTF_DID_LGT, TTF_LGDID_T, TTF_DID_T, TTF_LGDID_LGT, VTCl, VTILINGM, VTSATGM
Fitting	EXPFIT, EXPFITA, EXPFITB, LINFIT, LINFITSLP, LINFITXINT, LINFITYINT, REGFIT, REGFITSLP, REGFITXINT, REGFITXINT, REGFIT_LGX_LGY, REGFIT_LGX_Y, REGFIT_X_LGY, TANFIT, TANFITSLP, TANFITXINT, TANFITYINT
Manipulation	AT, FINDD, FINDLIN, FINDU, FIRSTPOS, JOIN, LASTPOS, MAX, MAXPOS, MIN, MINPOX, POW, SMOOTH

# ACS-2600-RTM

- Leverages unique strengths of Keithley Series 2600A SourceMeter® instruments – including system scalability and measurement speed
- System configurations from 2 to 44 channels
- Comprehensive JEDEC-compliant test suite
- Optimized for both emerging and mature technologies
- Supports both sequential and parallel testing
- Fully automatic single-site and multi-site capability
- Compatible with all popular wafer probe stations
- Real-time plotting and wafer mapping

## APPLICATIONS

- **Device reliability**
  - HCI, NBTI, PBTI
- **Gate oxide integrity**
  - TDDB,  $V_{RAMP}$ ,  $J_{RAMP}$
- **Metal interconnect**
  - Isothermal electromigration
  - Poly heater
  - Constant current
  - ILD TDDB

## Ordering Information

ACS-2600-RTM  
Wafer Level Reliability  
Option to ACS

# Wafer Level Reliability Option to ACS



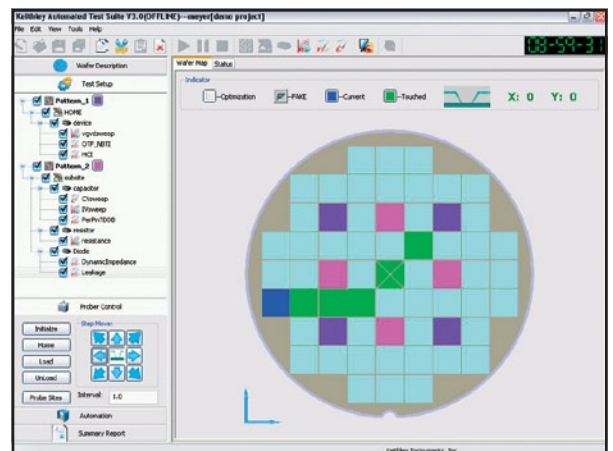
Keithley has taken the power of its Automated Characterization Suite (ACS) software and focused it on wafer level reliability (WLR) testing. ACS-2600-RTM is an option to ACS that leverages the measurement speed and system integration capabilities of Keithley's Series 2600A System SourceMeter instruments. The result—you can produce lifetime predictions from two to five times faster than you can with conventional WLR test solutions, allowing you to accelerate your technology development, process integration, and process monitoring for faster time to market.

With the ACS-2600-RTM option, ACS offers comprehensive single- and parallel-device WLR testing capability. Integrated with our innovative 2600A SourceMeter instruments, your WLR system will provide unmatched testing speed and accuracy via an SMU-per-pin architecture. A single 2600A dual-channel source measurement unit (SMU) is suitable for single-device reliability testing. Or take advantage of the TSP-Link® bus on the 2600A instruments for systems with as many as 44 SMU channels (2 for each 2600A) for testing large numbers of devices in parallel and increasing overall system productivity. In addition

to precise low-level measurements, the 2600A instruments can supply high voltage (200V) and high current (1.5A) sourcing and measurement to every test structure pad. This maximizes system flexibility, so you don't need one solution for gate oxide integrity and a different system for metal interconnect reliability. Looking for a complete system solution? Keithley offers ACS with its highly configurable S500 Integrated Test Systems and application development services.

## Extensive Software Capabilities

No coding is required to take full advantage of the source-measure capability of the 2600As or the tools included in the ACS software environment. The ACS-2600-RTM option provides a powerful stress/measure sequencing tool with an interactive interface for testing device reliability, gate oxide integrity, and metal interconnects (EM). Its flexible test sequencing capabilities support pre- and post-testing, as well as intra-stress testing and stress monitoring. During testing, you can log raw reliability data into the database and/or plot it in real time. This real-time plotting provides a “sneak peek” at a test's outcome to let you know whether time-consuming tests are on track to deliver meaningful results. After testing, use the easy point-and-click analysis offered by the integrated Formulator, which is populated with standard parametric extraction calculations. In addition, a variety of modeling, line fitting, and standard math functions allow custom data manipulation without programming.



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