S530/S530-HV Parametric Test Systems

Datasheet

Keithley's S530 and S530-HV 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

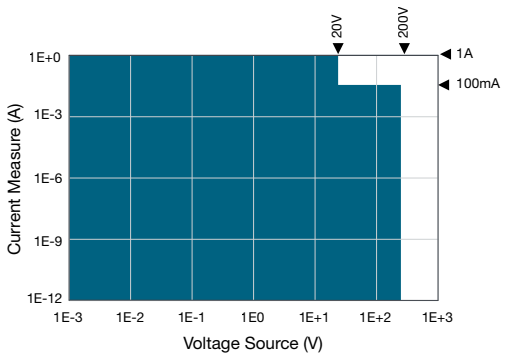
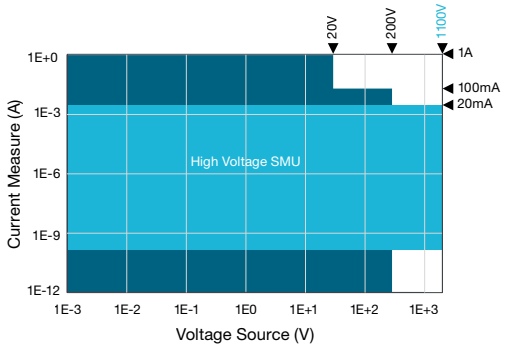
The S530 and S530-HV Parametric Test Systems are designed for production and lab environments that must handle a broad range of devices and technologies, offering industry-leading test plan flexibility, automation, probe station integration, and test data management capabilities. Keithley has brought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

Key Features

- 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 (1100 V) system configurations
  - Low current 64 pin configuration supports measurement of low current characteristics such as sub-threshold leakage, gate leakage, etc.
  - New high voltage 64 pin configuration is optimized for monitoring processes used for GaN, SiC, and Si LDMOS power devices
- Compatible with popular fully automatic probe stations
- Instrument options for sourcing pulses, frequency measurements, and low voltage measurements
- Cabled-out tester configuration maximizes prober interface flexibility and expands voltage range
- Compatible with 9139B-PCA Probe Card Adapter that supports 1100 V on each of the Kelvin pins
- Proven instrumentation technology ensures high measurement accuracy and repeatability in both the lab and the fab
- SECS/GEM option for 300 mm applications

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.

	System Capabilities	Key Range and Offset Performance
S530 **Low Current System**	• Source up to 200 V or 1 A • Measure current with femto-amp resolution and sub pico-amp offset • 2 to 8 SMU channels [1] • Options for C-V, pulse sourcing, frequency measurements, and low-voltage measurements • Up to 64 pins full Kelvin plus connection for chuck	
S530-HV **High Voltage System**	• Source up to 1100 V or 1 A • Use 200 V SMU to measure current with femto-amp resolution and pico-amp offset • Use 1100 V SMU to measure current with ten pico-amp resolution and nano-amp offset • 3 to 7 SMU channels [1] • Options for C-V, pulse sourcing, frequency measurements, and low-voltage measurements • Up to 64 pins full Kelvin plus connection for chuck	

1. Depending on instrument options within the system.

Table 1. S530 and S530-HV System Selector Guide

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 measure unit (SMU) channels and up to 64 test pins, 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, also with up to 64 test pins, is configurable from three to seven SMU channels, can source up to 1100 V for use in the difficult breakdown and leakage tests that automotive electronics and power management devices demand.

All Series S530 systems are equipped with Keithley's proven high power SMU instruments, 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 SMU instruments, so they cannot match the S530 systems' range of applications.

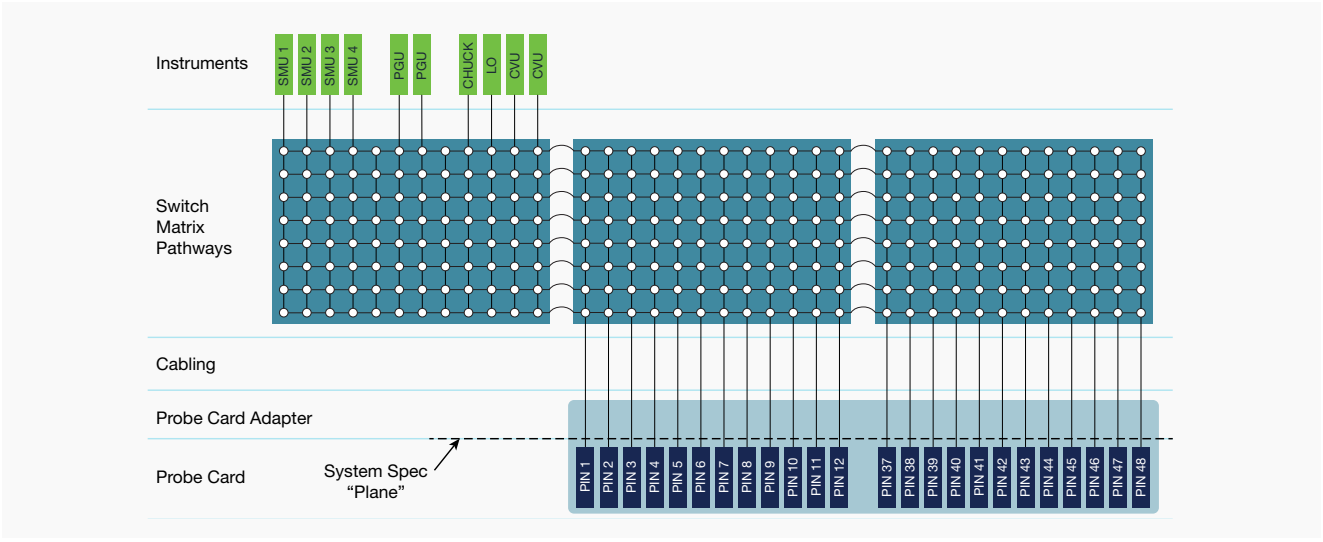
Full Kelvin Standard Configurations

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 20 W capability of the high power SMU instruments used in S530 systems.

System Architecture

Each S530 system configuration is made up of five layers:

- Instruments Layer – In addition to SMU instruments, the S530 systems offer options for sourcing pulses or making C-V, frequency, or low voltage measurements.
- 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.



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

Signal Pathways

The core of each S530 test system is a set of high fidelity signal pathways through the system switch that direct signals between instruments and test pins. The S530 has eight high fidelity pathways that can be used to route instruments to pins dynamically. For example, up to eight SMU instruments can be routed to any pin (or number of pins) at one time. The S530 Low Current System uses switch matrices that deliver uniform performance across all eight pathways. The S530 High Voltage System uses switch matrices with specific pathways for high voltage/low leakage measurements and also for C-V. Refer to 7174A and 7072-HV data sheets for more details.

Pathway Type	Key Characteristics	Maximum Voltage	Maximum Current	Comments
Low Current I-V [1]	Ultra low leakage	200 V	1 A	Limited to 200 V max. Provides best low-level signal performance and excellent C-V performance.
High Voltage I-V [2]	1100 V	1100 V	1 A	Supports low-level measurements but not quite as low as the Low Current pathway.
General-Purpose I-V [2]		200 V	1 A	Suitable for the majority of parametric tests, except for very low current and/or high voltage tests.
C-V [2]		200 V	1 A	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.

Table 2. S530 and S530-HV Pathway Performance

Proven SMU Technology

All source measurement units (SMU instruments) 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 SMU instruments 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 breakdown. Each SMU also measures both voltage and current while sourcing, which ensures that parameter calculations reflect actual conditions rather than simply the programmed conditions.

System Measurement Options

For a wider range of test structures and measurements, the S530 can be equipped with several measurement options:

- Capacitance-Voltage (C-V) Unit – Capable of measuring a 10 pF capacitor at 1 MHz with a typical accuracy of 1%.
- Pulse Generator Unit – The optional pulse generator unit supports open load pulse amplitudes from ±100 mV to ±40 V, with pulse widths from 100ns to 1s and pulse transitions from 50 ns to 200 ms. Up to six pulse channels can be added (in increments of two channels). Add one to three dual-channel units for applications such as flash memory testing.
- Frequency Measurements – For measuring test structures such as ring oscillators, a frequency measurement option is available for the S530. This option uses one port on the switch matrix and is intended to allow the user to measure ring oscillator structures. The option has a frequency range of 10 kHz to 20 MHz and can measure signals from 10 mV rms to 1 V rms.
- Low-voltage Measurements – An optional 7½-digit digital multimeter (DMM) augments the voltage measurement capabilities to allow both differential and non-differential voltage measurements from sub-500 µV to 400 V (up to 1100 V in S530 High Voltage system) for measuring structures including van der Pauw, contact chains, metal resistors and other devices where small voltages must be measured accurately.

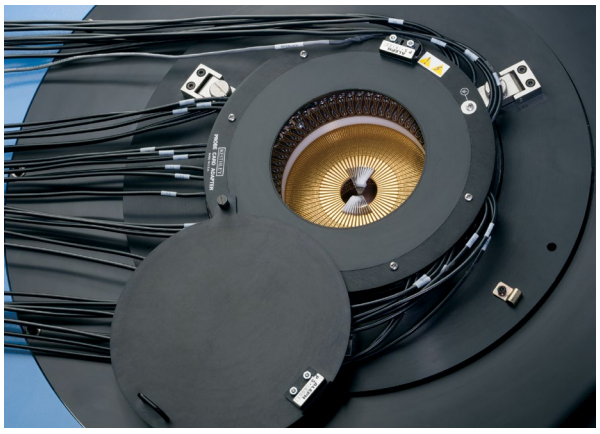
Ground Unit (GNDU)

All SMU instruments 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 SMU instruments. 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.

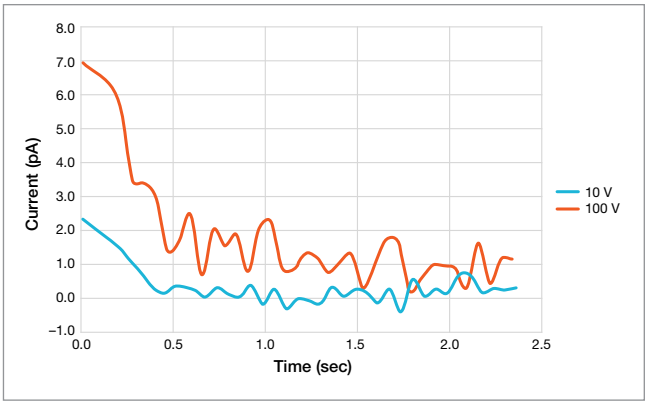
Standard 9139B-PCA Probe Card Adapter

The standard probe card adapter (PCA) for the S530 parametric test systems is the proven 9139B. 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.
- 1100 V pin-to-pin isolation.



The 9139B-PCA Probe Card Adapter.



At 10 V the settling time to sub 1 pA is less than 0.5 secs (10 V @ 1 PLC measurement speed)

At 100 V the settling time to sub 3 pA is less than 0.5 secs (100 V @ 1 PLC measurement speed)

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-connector probe cards, and even special high performance cards for applications that involve extreme temperatures or demand high durability.

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 9139B-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) via pogo pin connections. Probe-station-specific adapter plates can be specified during ordering to ensure the 9139B'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 9193B-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.

Cabling Options	Probe Card Type	Features	Benefits
Standard Keithley 9139B-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

Table 4. S530 System Cabling Options

System Software

Keithley's S530 system relies on the Keithley Test Environment (KTE) v5.8.2 software for test development and execution. KTE v5.8.2 delivers system-level speed improvements of up to 30% compared to KTE v5.5. Hosted a standard industrial PC with a Linux OS, KTE incorporates decades of Keithley parametric test experience into its latest generation test system. 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
- Adds support for Random Wafer Testing mode enabled on a TEL P8 Prober, allowing the prober error-handler routine to get called every time.
- Adds support for the Keithley Recipe Manager (KRM) for conversion of legacy systems

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.

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

The S530 and S530-HV High Voltage System contains a 1kV SMU that might be used on one terminal of a DUT while applying a 200V SMU or the CVU to another terminal. If a test sequence or a failed DUT presents too much voltage to one of these lower voltage instruments, serious instrument damage is possible. To minimize the potential for these problems, Keithley engineers have developed protection modules that prevent damaging voltages from harming the 200V SMU instruments and CVU without compromising their low-level measurement capabilities.

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.[1] Keithley provides a range of internationally recognized accredited calibration services, including A2LA (American Association for Laboratory Accreditation) accredited calibration.[2]
- **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.

Specification Conditions

23 °C ±5 °C, 1 year.

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

System-level specifications are to the end of the Keithley PCA.

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	20 W (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	20 V	1 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	0.1 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	10 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	1 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	0.1 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	10 pA	0.03% + 1.5 nA + 1.3 pA/V	200 pA	0.03% + 5.0 nA + 1.3 pA/V
1 µA	200 V	1 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	0.1 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	10 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	1 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	0.1 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	10 kHz	100 kHz	1 MHz
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%

Maximum Signal Level	100 mV
DC Voltage Range	±30 V

High Voltage System [1]

Current Range	Max. Voltage	MEASURE		SOURCE	
		Resolution	Accuracy	Resolution	Accuracy
1 A	20 V	1 µA	0.03% +1.5 mA + 0.94 pA/V	20 µA	0.05% +1.8 mA + 0.94 pA/V
100 mA	200 V	0.1 µA	0.02% + 20.0 µA + 0.94 pA/V	2 µA	0.03% + 30.0 µA + 0.94 pA/V
20 mA	1100 V	100 nA	0.04% +1.2 µA + 0.94 pA/V	500 nA	0.05% + 4.0 µA + 0.94 pA/V
10 mA	200 V	10 nA	0.02% + 2.5 µA + 0.94 pA/V	200 nA	0.03% + 6.0 µA + 0.94 pA/V
1 mA	1100 V	10 nA	0.03% + 200.0 nA + 0.94 pA/V	50 nA	0.03% + 300.0 nA + 0.94 pA/V
100 µA	1100 V	1 nA	0.03% + 25.0 nA + 0.94 pA/V	5 nA	0.03% + 60.0 nA + 0.94 pA/V
10 µA	1100 V	100 pA	0.03% +1.5 nA + 0.94 pA/V	500 pA	0.03% + 5.0 nA + 0.94 pA/V
1 µA	1100 V	10 pA	0.03% + 504.1 pA + 0.94 pA/V	50 pA	0.04% + 804.1 nA + 0.94 pA/V
100 nA	200 V	0.1 pA	0.06% +104.1 pA + 0.94 pA/V	2 pA	0.06% +104.1 pA + 0.94 pA/V
10 nA	200 V	10 fA	0.15% + 7.1 pA + 0.94 pA/V	200 fA	0.15% + 9.1 pA + 0.94 pA/V
1 nA	200 V	1 fA	0.15% + 4.4 pA + 0.94 pA/V	20 fA	0.15% + 6.1 pA + 0.94 pA/V
100 pA	200 V	0.1 fA	0.15% + 4.3 pA + 0.94 pA/V		

1. Specifications using high peprformance pathways. When the general purpose pathways are used:
   – Maximum voltage is limited to 200 V.
   – Leakage increases by 3.6 pA/V.
   – Less accuracy in lower ranges (100 pA through 1 µA).

Voltage Range	Max. Current	MEASURE		SOURCE	
		Resolution	Accuracy	Resolution	Accuracy
1000 V[2]	20 mA	10 mV	0.015% + 50.2 mV	50 mV	0.02% +100.2 mV
200 V	100 mA	1 mV	0.015% + 50.0 mV	5 mV	0.02% + 50.1 mV
20 V	1 A	100 µV	0.015% + 5.0 mV	500 µV	0.02% + 5.1 mV
2 V	1 A	10 µV	0.02% + 374.0 µV	50 µV	0.02% + 680.0 mV
200 mV	1 A	1 µV	0.015% + 324.0 µV	5 µV	0.02% + 680.0 mV

2. Maximum voltage is 1100 V with 10% over range.

Capacitance	10 kHz	100 kHz	1 MHz
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%

Using dedicated C-V paths.

Maximum Signal Level	100 mV
Dc Voltage Range	±30 V

Keithley SECS/GEM Interface

Keithley's SECS/GEM interface for KTE software fully supports SEMI automation standards E5(SECS-II), E30(GEM), E37(HSMS), E39(OSS), E40(PMS), E87(CMS), E90(STS), and E94(CJM). This optional software package is customized based on specific user requirements in 300 mm applications.

Pulse Generator Unit Option

Number of Channels per PGU	2
Maximum Voltage	±40 V
Typical Pulse Width Range	100 ns to 1s
Typical Pulse Transitions	50 ns to 200 ms

Frequency Analysis Option

Typical Frequency Measurement Range	10 kHz to 20 MHz
Typical Amplitude Measurement Range	10 mV_{RMS} to 1 V_{RMS}

Low-voltage DMM Option

	7.5 digit resolution
Lowest Ranges	100 mV with 10 nV resolution. 1 V with 100 nV resolution.

General Specifications

System Cabinet Size	60.0 cm wide × 91.5 cm deep × 190.5 cm high (23.7 in. × 36.0 in. × 75.0 in.)
Nominal Line Power	100 V, 115 V, 220 V, 240 V (50 Hz, 60 Hz)
Power Consumption	Rated at 2.4 kVA for the 2 kW power distribution unit
Recommended Operating Conditions	
Temperature	23° ±5°C (73.4°F ±9°F)
Humidity	30% to 60% relative humidity, non-condensing, after a two hour warm up time.

Refer to S530 Administrative Guide for more system and facilities details.