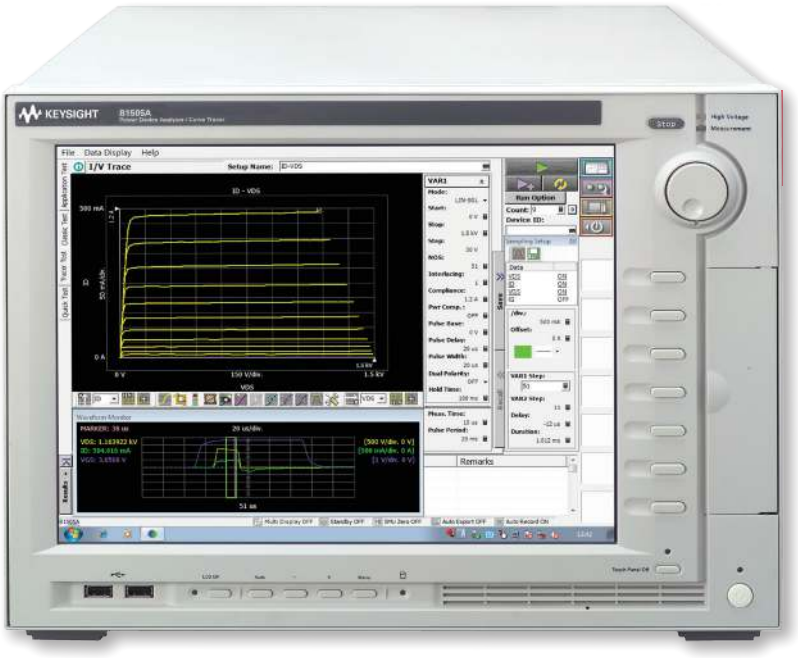
Keysight Technologies
B1505A Power Device Analyzer/Curve Tracer

Data Sheet



KEYSIGHT TECHNOLOGIES

Introduction

The Keysight Technologies, Inc. B1505A Power Device Analyzer/Curve Tracer is a single-box solution with next-generation curve tracer functionality that can accurately evaluate and characterize power devices at up to 10 kV and 1500 amps. The B1505A is capable of handling all types of power device evaluation, with features that include a wide voltage and current range, fast pulsing capability (10 µs), µΩ level on-resistance measurement resolution and sub-pA level current measurement capability. In addition, an oscilloscope view permits visual verification of both current and voltage pulsed waveforms.

Two independent analog-to-digital (A/D) converters on each channel support a 2 µs sampling rate for accurate monitoring of the critical timings that can affect device behavior.

IIt can also perform fully automated capacitance measurements (such as Ciss, Coss and Crss) at high voltage biases (up to 3 kV). Moreover, it can evaluate gate charge (which is an important parameter for high frequency switching converter efficiency) at up to 3 kV as well. The B1505A with EasyEXPERT software includes a curve tracer mode that combines familiar curve tracer functionality with the convenience of a PC-based instrument; this makes it easy for traditional curve-tracer users to become productive quickly. Module selector, device capacitance selector and Quick Test feature enable fully automated measurement on multiple parameters without the need to recable. The net result is improved ease of use, better data analysis and simplified data management for the measurement of power devices and power circuitry.

Basic features

Precision measurement across a wide range of operating conditions
- All-in-one solution for power device characterization up to 1500 A / 10 kV
- Medium current measurement with high voltage bias (e.g. 500 mA at 1200 V).
- μΩ resistance measurement capability
- Accurate sub-picoamp level current measurement at high voltage bias
- Fully automated thermal test from -50 °C to +250 °C

Extensive device evaluation capabilities
- Fully automated Capacitance (Ciss, Coss, Crss, etc.) measurement at up to 3000 V of DC bias
- High power pulsed measurements down to 10 μs
- Gate charge measurement covering IGBT/FET both in package and on wafer
- High voltage/high current fast switch option to characterize GaN current collapse effect
- Up to 5 high voltage (3 kV) source/measure unit channels for reliability applications
- Perform both hot and cold temperature dependency testing in an interlock equipped test fixture

Improved measurement efficiency
- Switch between high-voltage and high-current measurements without the need to recable
- Automated reconfiguration of test circuitry for transistor capacitance measurement (Ciss, Coss, Crss, Cgs, Cgd, Cds, etc.) for both packaged and on-wafer devices
- Standard test fixtures with interlock for safe packaged power device testing
- Supported and secure on-wafer high-power testing over 200 A and up to 10 kV
- Oscilloscope view allows verification of applied voltage and current waveforms
- MS Windows-based EasyEXPERT software facilitates data management and simplifies data analysis

Upgradable and scalable hardware architecture
- A wide selection of measurement modules
- Support for high power devices with up to 6 pins

GPIB, USB, LAN interfaces and VGA video output port
Self-test, self-calibration, diagnostics

Specification conditions

The measurement and output accuracy are specified under the conditions listed below. Note: The SMU measurement and output accuracies are specified at the SMU connector terminals, using the Zero Check terminal as a reference.

1. Temperature: 23 °C ± 5 °C
2. Humidity: 20% to 70%
3. Self-calibration after a 40 minute warm-up is required.
4. Ambient temperature change less than ±1 °C after self-calibration execution. (Note: This does not apply to the MFCMU).
5. Measurement made within one hour after self-calibration execution. (Note: This does not apply to the MFCMU).
6. Calibration period: 1 year
7. SMU integration time setting:
   1 PLC (1 nA to 1 A range, voltage range), 200 μs (20 A range)
   Averaging of high-speed ADC:
   128 samples per 1 PLC
8. SMU filter: ON (for HPSMU and MPSMU)
9. SMU measurement terminal connection: Kelvin connection (for HPSMU, MPSMU, HCSMU and MCSMU), non-Kelvin (for HVSMU)

Note: This document lists specifications and supplemental characteristics for the B1505A and its associated modules. The specifications are the standards against which the B1505A and its associated modules are tested. When the B1505A or any of its associated modules are shipped from the factory, they meet the specifications. The “supplemental” characteristics described in the following specifications are not guaranteed, but provide useful information about the functions and performance of the instrument.

Note: Module upgrades to existing B1505A systems must be carried out at a Keysight Technologies, Inc. service centre. In order to ensure system specifications the new modules need to be installed and the complete unit calibrated. Contact your nearest Keysight Technologies office to arrange the installation and calibration of new B1505A modules.

B1505A Specifications

Supported plug-In modules

The B1505A supports ten slots for plug-in modules.

Part number	Description	Slots occupied	Range of operation	Measure resolution
B1510A	High Power Source Monitor Unit (HPSMU)	2	-200 V to 200 V, -1 A to 1 A	2 µV, 10 fA
B1511B	Medium Power Source Monitor Unit (MPSMU)	1	-100 V to 100 V, -100 mA to 100 mA	0.5 µV, 10 fA
B1512A	High Current Source Monitor Unit (HCSMU)	2	-40 V to 40 V, -1 A to 1 A -20 V to 20 V, -20 A to 20 A (Pulse only)	200 nV, 10 pA
B1513C	High Voltage Source Monitor Unit (HVSMU)	2	-3000 V to 3000 V, -4 mA to 4 mA -1500 V to 1500 V, -8 mA to 8 mA	200 µV, 10 fA
B1514A	Medium Current Source Monitor Unit (MCSMU)	1	-30 V to 30 V, -100 mA to 100 mA -30 V to 30 V, -1 A to 1 A (Pulse only)	200 nV, 10pA
B1520A[1]	Multi Frequency Capacitance Measurement Unit (MFCMU)	1	1 kHz to 5 MHz	0.035 fFrms[2]

1. N1300A-100 SMU CMU Unify Unit (SCUU) is not supported for the B1505A.
2. Valid when connecting a 10 pF capacitor to the measurement terminals under the following measurement conditions: a frequency of 1 MHz, a signal level of 250 mV AC, and a measurement time of 1 PLC. The display resolution is 0.000001 fF at 1 fF order by 6 digits display.

Maximum module configuration

The total power consumption of all modules cannot exceed 84 W. Under this rule, the B1505A can contain any combination of the following SMUs:

- Up to 4 dual-slot HPSMUs[1]
- Up to 10 single-slot MPSMUs
- Up to 2 dual-slot HCSMUs[1]
- Up to 6 single-slot MCSMUs
- Up to 5 dual-slot HVSMU

In addition, up to 1 single-slot MFCMU can be installed per B1505A mainframe for any of the above listed SMU configurations.

The installation order of the modules is: HPSMU, MPSMU, MFCMU, MCSMU, HCSMU and HVSMU starting from the bottom of the B1505A mainframe.

Maximum voltage between Common and Ground

≤ ± 42 V

Ground unit (GNDU) specifications

The GNDU is furnished with the B1505A mainframe.

Output voltage: 0 V ± 100 µV
Maximum sink current: ± 4.2 A
Output terminal/connection:
Triaxial connector, Kelvin (remote sensing)

GNDU supplemental characteristics

Load capacitance: 1 µF
Cable resistance:
For $I_S \leq 1.6$ A: Force line R < 1 Ω
For 1.6 A < $I_S \leq 2.0$ A: Force line R < 0.7 Ω
For 2.0 A < $I_S \leq 4.2$ A: Force line R < 0.35 Ω
For all cases: Sense line R ≤ 10 Ω
Where I_S is the current being sunk by the GNDU.

1. The total number of installed HPSMU and HCSMU modules cannot exceed 4.

HPSMU Module Specifications

Voltage range, resolution, and accuracy (high resolution ADC)

Voltage range	Force resolution	Measure resolution	Force accuracy [1] ±(% + mV)	Measure accuracy [1] ±(% + mV)	Maximum current
±2 V	100 µV	2 µV	±(0.018 + 0.4)	±(0.01 + 0.14)	1 A
±20 V	1 mV	20 µV	±(0.018 + 3)	±(0.009 + 0.9)	1 A
±40 V	2 mV	40 µV	±(0.018 + 6)	±(0.01 + 1)	500 mA
±100 V	5 mV	100 µV	±(0.018 + 15)	±(0.012 + 2.5)	125 mA
±200 V	10 mV	200 µV	±(0.018 + 30)	±(0.014 + 2.8)	50 mA

1. ± (% of reading value + offset value in mV)

Current range, resolution, and accuracy (high resolution ADC)

Current range	Force resolution	Measure resolution	Force accuracy [1] ±(% + A + A)	Measure accuracy [1] ±(% + A + A)	Maximum voltage
±1 nA	50 fA	10 fA	±(0.1 + 3E-13 + Vo x 1E-15)	±(0.1 + 2E-13 + Vo x 1E-15)	200 V
±10 nA	500 fA	10 fA	±(0.1 + 3E-12 + Vo x 1E-14)	±(0.1 + 1E-12 + Vo x 1E-14)	200 V
±100 nA	5 pA	100 fA	±(0.05 + 3E-11 + Vo x 1E-13)	±(0.05 + 2E-11 + Vo x 1E-13)	200 V
±1 µA	50 pA	1 pA	±(0.05 + 3E-10 + Vo x 1E-12)	±(0.05 + 1E-10 + Vo x 1E-12)	200 V
±10 µA	500 pA	10 pA	±(0.05 + 3E-9 + Vo x 1E-11)	±(0.04 + 2E-9 + Vo x 1E-11)	200 V
±100 µA	5 nA	100 pA	±(0.035 + 15E-9 + Vo x 1E-10)	±(0.03 + 3E-9 + Vo x 1E-10)	200 V
±1 mA	50 nA	1 nA	±(0.04 + 15E-8 + Vo x 1E-9)	±(0.03 + 6E-8 + Vo x 1E-9)	200 V
±10 mA	500 nA	10 nA	±(0.04 + 15E-7 + Vo x 1E-8)	±(0.03 + 2E-7 + Vo x 1E-8)	200 V
±100 mA	5 µA	100 nA	±(0.045 + 15E-6 + Vo x 1E-7)	±(0.04 + 6E-6 + Vo x 1E-7)	200 V [2]
±1 A	50 µA	1 µA	±(0.4 + 3E-4 + Vo x 1E-6)	±(0.4 + 15E-5 + Vo x 1E-6)	200 V [2]

1. ± (% of reading value + fixed offset in A + proportional offset in A), Vo is the output voltage in V.)
2. 200 V (Io ≤ 50 mA), 100 V (50 mA < Io ≤ 125 mA), 40 V (125 mA < Io ≤ 500 mA), 20 V (500 mA < Io ≤ 1 A), Io is the output current in Amps.

Voltage range, resolution, and accuracy (high speed ADC)

Voltage range	Force resolution	Measure resolution	Force accuracy [1] ±(% + mV)	Measure accuracy [1] ±(% + mV)	Maximum current
±2 V	100 µV	100 µV	±(0.018 + 0.4)	±(0.01 + 0.7)	1 A
±20 V	1 mV	1 mV	±(0.018 + 3)	±(0.01 + 4)	1 A
±40 V	2 mV	2 mV	±(0.018 + 6)	±(0.015 + 8)	500 mA
±100 V	5 mV	5 mV	±(0.018 + 15)	±(0.02 + 20)	125 mA
±200 V	10 mV	10 mV	±(0.018 + 30)	±(0.035 + 40)	50 mA

1. ±(% of reading value + offset value in mV). Averaging is 128 samples in 1 PLC.

Current range, resolution, and accuracy (high speed ADC)

Current range	Force resolution	Measure resolution	Force accuracy [1] ±(% + A + A)	Measure accuracy [1] ±(% + A + A)	Maximum voltage
±1 nA	50 fA	50 fA	±(0.1 + 3E-13 + Vo x 1E-15)	±(0.25 + 3E-13 + Vo x 1E-15)	200 V
±10 nA	500 fA	500 fA	±(0.1 + 3E-12 + Vo x 1E-14)	±(0.25 + 2E-12 + Vo x 1E-14)	200 V
±100 nA	5 pA	5 pA	±(0.05 + 3E-11 + Vo x 1E-13)	±(0.1 + 2E-11 + Vo x 1E-13)	200 V
±1 µA	50 pA	50 pA	±(0.05 + 3E-10 + Vo x 1E-12)	±(0.1 + 2E-10 + Vo x 1E-12)	200 V
±10 µA	500 pA	500 pA	±(0.05 + 3E-9 + Vo x 1E-11)	±(0.05 + 2E-9 + Vo x 1E-11)	200 V
±100 µA	5 nA	5 nA	±(0.035 + 15E-9 + Vo x 1E-10)	±(0.05 + 2E-8 + Vo x 1E-10)	200 V
±1 mA	50 nA	50 nA	±(0.04 + 15E-8 + Vo x 1E-9)	±(0.04 + 2E-7 + Vo x 1E-9)	200 V
±10 mA	500 nA	500 nA	±(0.04 + 15E-7 + Vo x 1E-8)	±(0.04 + 2E-6 + Vo x 1E-8)	200 V
±100 mA	5 µA	5 µA	±(0.045 + 15E-6 + Vo x 1E-7)	±(0.1 + 2E-5 + Vo x 1E-7)	200 V [2]
±1 A	50 µA	50 µA	±(0.4 + 3E-4 + Vo x 1E-6)	±(0.5 + 3E-4 + Vo x 1E-6)	200 V [2]

1. ±(%of reading value + fixed offset in A + proportional offset in A), Vo is the output voltage in V.)
2. 200 V (Io ≤ 50 mA), 100 V (50 mA < Io ≤ 125 mA), 40 V (125 mA < Io ≤ 500 mA), 20 V (500 mA < Io ≤ 1 A), Io is the output current in Amps.

Power consumption

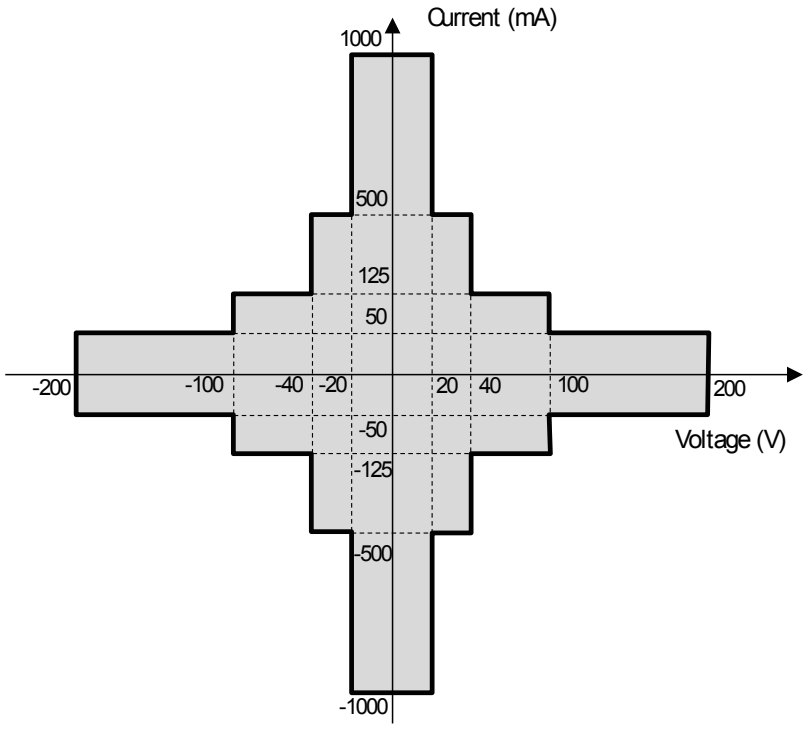
Voltage source mode:	
Voltage range	**Power**
2 V	20 x Ic (W)
20 V	20 x Ic (W)
40 V	40 x Ic (W)
100 V	100 x Ic (W)
200 V	200 x Ic (W)

Where Ic is the current compliance setting.

Current source mode:	
Voltage compliance	**Power**
Vc ≤ 20	20 x Io (W)
20 < Vc ≤ 40	40 x Io (W)
40 < Vc ≤ 100	100 x Io (W)
100 < Vc ≤ 200	200 x Io (W)

Where Vc is the voltage compliance setting and Io is output current.

HPSMU measurement and output range



MPSMU Module Specifications

Voltage range, resolution, and accuracy (high resolution ADC)

Voltage range	Force resolution	Measure resolution	Force accuracy [1] ±(% + mV)	Measure accuracy [1] ±(% + mV)	Maximum current
±0.5 V	25 µV	0.5 µV	±(0.018 + 0.15)	±(0.01 + 0.12)	100 mA
±2 V	100 µV	2 µV	±(0.018 + 0.4)	±(0.01 + 0.14)	100 mA
±5 V	250 µV	5 µV	±(0.018 + 0.75)	±(0.009 + 0.25)	100 mA
±20 V	1 mV	20 µV	±(0.018 + 3)	±(0.009 + 0.9)	100 mA
±40 V	2 mV	40 µV	±(0.018 + 6)	±(0.01 + 1)	[2]
±100 V	5 mV	100 µV	±(0.018 + 15)	±(0.012 + 2.5)	[2]

1. ± (% of reading value + offset value in mV)
2. 100 mA (Vo ≤ 20 V), 50 mA (20 V < Vo ≤ 40 V), 20 mA (40 V < Vo ≤ 100 V), Vo is the output voltage in Volts.

Current range, resolution, and accuracy (high resolution ADC)

Current range	Force resolution	Measure resolution	Force accuracy [1] ±(% + A + A)	Measure accuracy [1] ±(% + A + A)	Maximum voltage
±1 nA	50 fA	10 fA	±(0.1 + 3E-13 + Vo x 1E-15)	±(0.1 + 2E-13 + Vo x 1E-15)	100 V
±10 nA	500 fA	10 fA	±(0.1 + 3E-12 + Vo x 1E-14)	±(0.1 + 1E-12 + Vo x 1E-14)	100 V
±100 nA	5 pA	100 fA	±(0.05 + 3E-11 + Vo x 1E-13)	±(0.05 + 2E-11 + Vo x 1E-13)	100 V
±1 µA	50 pA	1 pA	±(0.05 + 3E-10 + Vo x 1E-12)	±(0.05 + 1E-10 + Vo x 1E-12)	100 V
±10 µA	500 pA	10 pA	±(0.05 + 3E-9 + Vo x 1E-11)	±(0.04 + 2E-9 + Vo x 1E-11)	100 V
±100 µA	5 nA	100 pA	±(0.035 + 15E-9 + Vo x 1E-10)	±(0.03 + 3E-9 + Vo x 1E-10)	100 V
±1 mA	50 nA	1 nA	±(0.04 + 15E-8 + Vo x 1E-9)	±(0.03 + 6E-8 + Vo x 1E-9)	100 V
±10 mA	500 nA	10 nA	±(0.04 + 15E-7 + Vo x 1E-8)	±(0.03 + 2E-7 + Vo x 1E-8)	100 V
±100 mA	5 µA	100 nA	±(0.045 + 15E-6 + Vo x 1E-7)	±(0.04 + 6E-6 + Vo x 1E-7)	[2]

1. ± (% of reading value + fixed offset in A + proportional offset in A), Vo is the output voltage in V.)
2. 100 V (Io ≤ 20 mA), 40 V (20 mA < Io ≤ 50 mA), 20 V (50 mA < Io ≤ 100 mA), Io is the output current in Amps.

Voltage range, resolution, and accuracy (high speed ADC)

Voltage range	Force resolution	Measure resolution	Force accuracy [1] ±(% + mV)	Measure accuracy [1] ±(% + mV)	Maximum current
±0.5 V	25 µV	25 µV	±(0.018 + 0.15)	±(0.01 + 0.25)	100 mA
±2 V	100 µV	100 µV	±(0.018 + 0.4)	±(0.01 + 0.7)	100 mA
±5 V	250 µV	250 µV	±(0.018 + 0.75)	±(0.01 + 2)	100 mA
±20 V	1 mV	1 mV	±(0.018 + 3)	±(0.01 + 4)	100 mA
±40 V	2 mV	2 mV	±(0.018 + 6)	±(0.015 + 8)	[2]
±100 V	5 mV	5 mV	±(0.018 + 15)	±(0.02 + 20)	[2]

1. ±(% of reading value + offset value in mV). Averaging is 128 samples in 1 PLC.
2. 100 mA (Vo ≤ 20 V), 50 mA (20 V < Vo ≤ 40 V), 20 mA (40 V < Vo ≤ 100 V), Vo is the output voltage in Volts.

Current range, resolution, and accuracy (high speed ADC)

Current range	Force resolution	Measure resolution	Force accuracy [1] ±(% + A + A)	Measure accuracy [1] ±(% + A + A)	Maximum voltage
±1 nA	50 fA	50 fA	±(0.1 + 3E-13 + Vo x 1E-15)	±(0.25 + 3E-13 + Vo x 1E-15)	100 V
±10 nA	500 fA	500 fA	±(0.1 + 3E-12 + Vo x 1E-14)	±(0.25 + 2E-12 + Vo x 1E-14)	100 V
±100 nA	5 pA	5 pA	±(0.05 + 3E-11 + Vo x 1E-13)	±(0.1 + 2E-11 + Vo x 1E-13)	100 V
±1 µA	50 pA	50 pA	±(0.05 + 3E-10 + Vo x 1E-12)	±(0.1 + 2E-10 + Vo x 1E-12)	100 V
±10 µA	500 pA	500 pA	±(0.05 + 3E-9 + Vo x 1E-11)	±(0.05 + 2E-9 + Vo x 1E-11)	100 V
±100 µA	5 nA	5 nA	±(0.035 + 15E-9 + Vo x 1E-10)	±(0.05 + 2E-8 + Vo x 1E-10)	100 V
±1 mA	50 nA	50 nA	±(0.04 + 15E-8 + Vo x 1E-9)	±(0.04 + 2E-7 + Vo x 1E-9)	100 V
±10 mA	500 nA	500 nA	±(0.04 + 15E-7 + Vo x 1E-8)	±(0.04 + 2E-6 + Vo x 1E-8)	100 V
±100 mA	5 µA	5 µA	±(0.045 + 15E-6 + Vo x 1E-7)	±(0.1 + 2E-5 + Vo x 1E-7)	[2]

1. ±(% of reading value + fixed offset in A + proportional offset in A), Vo is the output voltage in V.)
2. 100 V (Io ≤ 20 mA), 40 V (20 mA < Io ≤ 50 mA), 20 V (50 mA < Io ≤ 100 mA), Io is the output current in Amps.

Power consumption

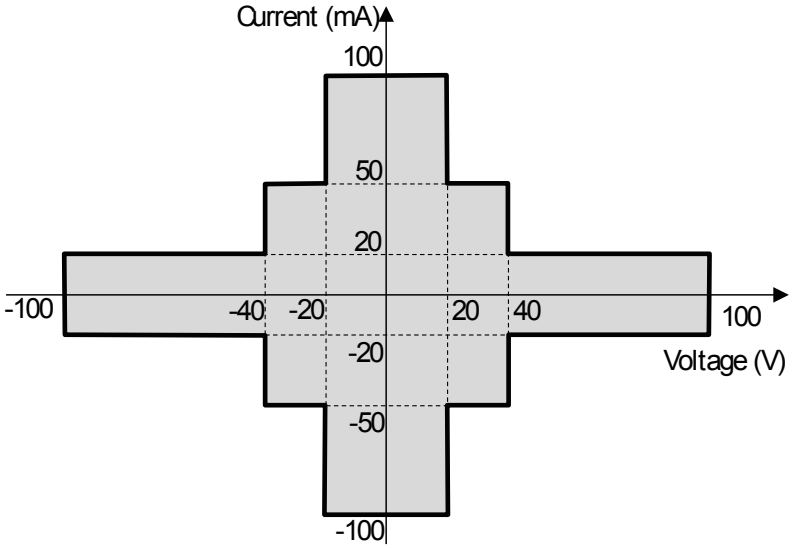
Voltage source mode:	
Voltage range	**Power**
0.5 V	20 x Ic (W)
2 V	20 x Ic (W)
5 V	20 x Ic (W)
20 V	20 x Ic (W)
40 V	40 x Ic (W)
100 V	100 x Ic (W)

Where Ic is the current compliance setting.

Current source mode:	
Voltage compliance	**Power**
Vc ≤ 20	20 x Io (W)
20 < Vc ≤ 40	40 x Io (W)
40 < Vc ≤ 100	100 x Io (W)

Where Vc is the voltage compliance setting and Io is output current.

MPSMU measurement and output range



HCSMU Module Specifications

Voltage range, resolution, and accuracy					
Voltage range	Force resolution	Measure resolution	Force accuracy[1] ±(% + mV + mV)	Measure accuracy[1] (% + mV + mV)	Maximum current
±0.2 V	200 nV	200 nV	±(0.06 + 0.14 + Io x 0.05)	±(0.06 + 0.14 + Io x 0.05)	20 A
±2 V	2 µV	2 µV	±(0.06 + 0.6 + Io x 0.5)	±(0.06 + 0.6 + Io x 0.5)	20 A
±20 V	20 µV	20 µV	±(0.06 + 3 + Io x 5)	±(0.06 + 3 + Io x 5)	20 A
±40 V	40 µV	40 µV	±(0.06 + 3 + Io x 10)	±(0.06 + 3 + Io x 10)	1 A

1. ±(% of reading value + fixed offset in mV + proportional offset in mV). Note: Io is the output current in A.

Current range, resolution, and accuracy					
Current range	Force resolution	Measure resolution	Force accuracy[1] (% + A + A)	Measure accuracy[1] (% + A + A)	Maximum voltage
±10 µA	10 pA	10 pA	±(0.06 + 2E-9 + Vo x 1E-10)	±(0.06 + 2E-9 + Vo x 1E-10)	40 V
±100 µA	100 pA	100 pA	±(0.06 + 2E-8 + Vo x 1E-9)	±(0.06 + 2E-8 + Vo x 1E-9)	40 V
±1 mA	1 nA	1 nA	±(0.06 + 2E-7 + Vo x 1E-8)	±(0.06 + 2E-7 + Vo x 1E-8)	40 V
±10 mA	10 nA	10 nA	±(0.06 + 2E-6 + Vo x 1E-7)	±(0.06 + 2E-6 + Vo x 1E-7)	40 V
±100 mA	100 nA	100 nA	±(0.06 + 2E-5 + Vo x 1E-6)	±(0.06 + 2E-5 + Vo x 1E-6)	40 V
±1 A	1 µA	1 µA	±(0.4 + 2E-4 + Vo x 1E-5)	±(0.4 + 2E-4 + Vo x 1E-5)	40 V
±20 A[2]	20 µA	20 µA	±(0.4 + 2E-3 + Vo x 1E-4)	±(0.4 + 2E-3 + Vo x 1E-4)	20 V

1. ±(% of reading value + fixed offset in A + proportional offset in A), Vo is the output voltage in V.
2. Pulse mode only. The maximum value of the base current during pulsing is ±100 mA.

Power consumption

Voltage source mode:	
Voltage range	Power
0.2 V	40 x Ic (W)
2 V	40 x Ic (W)
40 V	40 x Ic (W)

Where Ic is the current compliance setting.
For pulse current, Ic = (duty) x Ipulse

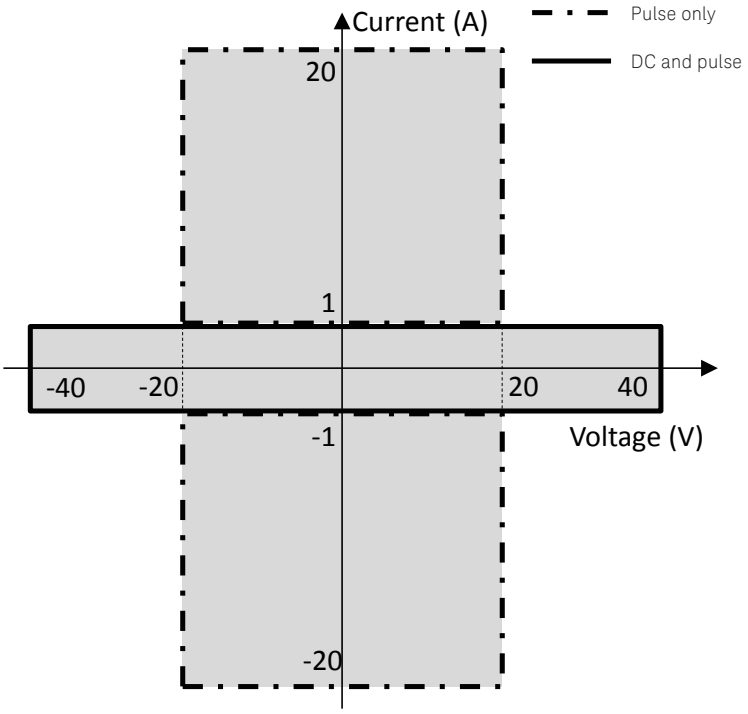
Current source mode:	
Voltage compliance	Power
Vc ≤ 0.2	40 x Io (W)
0.2 < Vc ≤ 2	40 x Io (W)
2 < Vc ≤ 40	40 x Io (W)

Where Vc is the voltage compliance setting and Io is output current.
For pulse current, Io = (duty) x Ipulse

Current range expansion

If two HCSMUs are combined using the Dual HCSMU combination adapter or the Dual HCSMU Kelvin combination adapter, then the maximum current ranges are 40A (Pulsed) and 2A (DC).

HCSMU measurement and output range



HVSMU Module Specifications

Voltage range, resolution, and accuracy					
Voltage range	**Force resolution**	**Measure resolution**	**Force accuracy [1] ±(% + mV)**	**Measure accuracy [1] ±(% + mV)**	**Maximum current**
±200 V	200 µV	200 µV	±(0.03 + 40)	±(0.03 + 40)	8 mA
±500 V	500 µV	500 µV	±(0.03 + 100)	±(0.03 + 100)	8 mA
±1500 V	1.5 mV	1.5 mV	±(0.03 + 300)	±(0.03 + 300)	8 mA
±3000 V	3 mV	3 mV	±(0.03 + 600)	±(0.03 + 600)	4 mA

1. ±(% of reading value + offset voltage V)

Current range, resolution, and accuracy						
Current range	**Force resolution**	**Measure resolution**	**Force accuracy [1] ±(% + A + A)**	**Measure accuracy [1] ±(% + A + A)**	**Maximum voltage**	**Minimum set current [2]**
±1 nA	10 fA	10 fA	±(0.1 + 6E-13 + Vo x 1E-15)	±(0.1 + 6E-13 + Vo x 1E-15)	3000 V	1pA
±10 nA	100 fA	100 fA	±(0.1 + 25E-13 + Vo x 1E-15)	±(0.1 + 25E-13 + Vo x 1E-15)	3000 V	1pA
±100 nA	100 fA	100 fA	±(0.05 + 25E-12 + Vo x 1E-13)	±(0.05 + 25E-12 + Vo x 1E-13)	3000 V	100 pA
±1 µA	1 pA	1 pA	±(0.05 + 1E-10 + Vo x 1E-13)	±(0.05 + 1E-10 + Vo x 1E-13)	3000 V	100 pA
±10 µA	10 pA	10 pA	±(0.04 + 2E-9 + Vo x 1E-11)	±(0.04 + 2E-9 + Vo x 1E-11)	3000 V	10 nA
±100 µA	100 pA	100 pA	±(0.03 + 3E-9 + Vo x 1E-11)	±(0.03 + 3E-9 + Vo x 1E-11)	3000 V	10 nA
±1 mA	1 nA	1 nA	±(0.03 + 6E-8 + Vo x 1E-10)	±(0.03 + 6E-8 + Vo x 1E-10)	3000 V	100 nA
±10 mA	10 nA	10 nA	±(0.03 + 2E-7 + Vo x 1E-9)	±(0.03 + 2E-7 + Vo x 1E-9)	1500 V	1 µA

1. ±(%of reading value + fixed offset in A + proportional offset in A), Vo is the output voltage in V.)
2. Output current needs to be set more than current shown in the table.

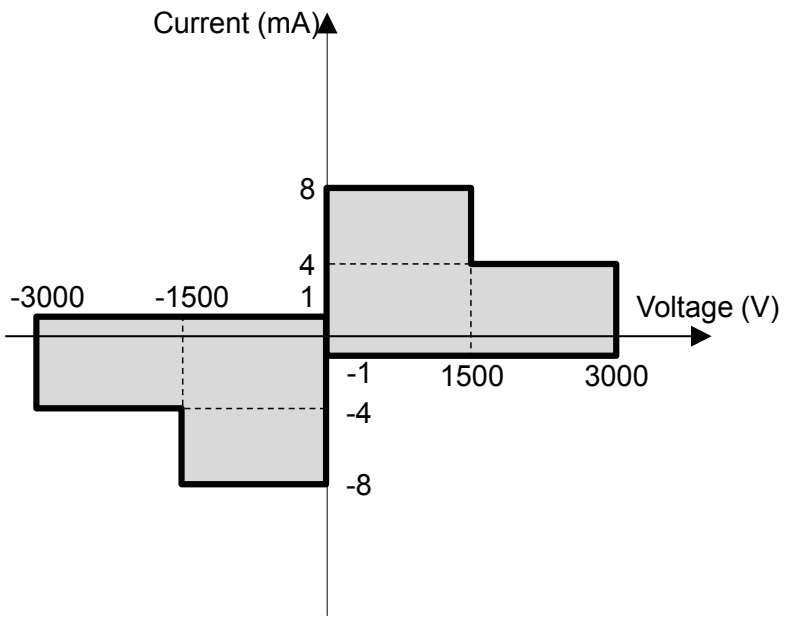
Power consumption

Voltage source mode:	
Current compliance	**Power**
Ic ≤ 4m	3000 x Ic + 12 (W) [1]
4m < Ic ≤ 8m	1500 x Ic + 12 (W) [1]
Where Ic is the current compliance setting.	

Current source mode:	
Voltage compliance	**Power**
Vc ≤ 1500	1500 x Io (W) + 12 [1]
1500 < Vc ≤ 3000	3000 x Io (W) + 12 [1]
Where Vc is the voltage compliance setting and Io is output current.	

1. The "+ 12" factor does not apply to the first installed HVSMU; it only applies to the second thru fifth installed HVSMUs.

HVSMU measurement and output range



HVSMU has 3 output range settings, which are "0 to +3 kV", "-1500 V to +1500 V", and "0 to -3 kV". If more than one HVSMU is installed in the B1505A, all of the HVSMUs must use the same output range setting.

MCSMU Module Specifications

Voltage range, resolution, and accuracy

Voltage range	Force resolution	Measure resolution	Force accuracy [1] ±(% + mV)	Measure accuracy [1] (% + mV + mV)	Maximum current
±0.2 V	200 nV	200 nV	±(0.06 + 0.14)	±(0.06 + 0.14 + Io x 0.05)	1 A
±2 V	2 µV	2 µV	±(0.06 + 0.6)	±(0.06 + 0.6 + Io x 0.5)	1 A
±20 V	20 µV	20 µV	±(0.06 + 3)	±(0.06 + 3 + Io x 5)	1 A
±40 V [2]	40 µV	40 µV	±(0.06 + 3)	±(0.06 + 3 + Io x 10)	1 A

1. ±(% of reading value + fixed offset in mV + proportional offset in mV). Note:Io is the output current in A.
2. Maximum output voltage is 30 V.

Current range, resolution, and accuracy

Current range	Force resolution	Measure resolution	Force accuracy [1] (% + A + A)	Measure accuracy [1] (% + A + A)	Maximum voltage
±10 µA	10 pA	10 pA	±(0.06 + 2E-9 + Vo x 1E-10)	±(0.06 + 2E-9 + Vo x 1E-10)	30 V
±100 µA	100 pA	100 pA	±(0.06 + 2E-8 + Vo x 1E-9)	±(0.06 + 2E-8 + Vo x 1E-9)	30 V
±1 mA	1 nA	1 nA	±(0.06 + 2E-7 + Vo x 1E-8)	±(0.06 + 2E-7 + Vo x 1E-8)	30 V
±10 mA	10 nA	10 nA	±(0.06 + 2E-6 + Vo x 1E-7)	±(0.06 + 2E-6 + Vo x 1E-7)	30 V
±100 mA	100 nA	100 nA	±(0.06 + 2E-5 + Vo x 1E-6)	±(0.06 + 2E-5 + Vo x 1E-6)	30 V
±1 A [2]	1 µA	1 µA	±(0.4 + 2E-4 + Vo x 1E-5)	±(0.4 + 2E-4 + Vo x 1E-5)	30 V

1. ±(% of reading value + fixed offset in A + proportional offset in A), Vo is the output voltage in V.
2. Pulse mode only. The maximum value of the base current during pulsing is ±50 mA.

Power consumption

Voltage source mode:

Voltage range	Power
0.2 V	40 x Ic (W)
2 V	40 x Ic (W)
40 V	40 x Ic (W)

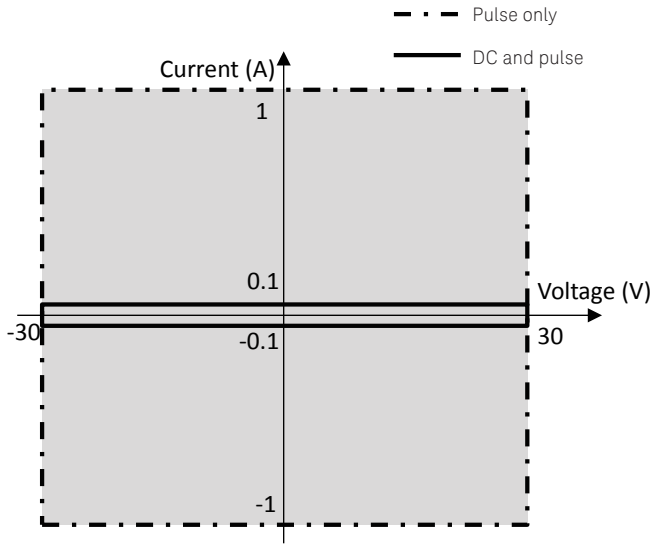
Where Ic is the current compliance setting.

Current source mode:

Voltage compliance	Power
Vc ≤ 0.2	40 x Io (W)
0.2 < Vc ≤ 2	40 x Io (W)
2 < Vc ≤ 40	40 x Io (W)

Where Vc is the voltage compliance setting and Io is output current.

MCSMU measurement and output range



SMU source measurement mode

For HPSMU and MPSMU:
VFIM, IFVM
For HCSMU, MCSMU and HVSMU:
VFIM, VFVM, IFVM, IFIM

Output terminal/connection:

For HPSMU and MPSMU:
Dual triaxial connector, Kelvin (remote sensing)

For HCSMU:
Triaxial connector (for sense) and coaxial connector (for force) Kelvin (remote sensing)

For MCSMU:
Dual triaxial connector, Kelvin (remote sensing)

For HVSMU:
High voltage triaxial connector, non-Kelvin

Voltage/current compliance (limiting)

The SMU can limit output voltage or current to prevent damaging the device under test.

Voltage:
0 V to ±200 V (HPSMU)
0 V to ±100 V (MPSMU)
0 V to ±40 V (HCSMU)
0 V to ±30 V (MCSMU)
0 V to ±3000 V (HVSMU)

Current:
±1 pA to ±1 A (HPSMU)
±1pA to ±100 mA (MPSMU)
±10 nA to ±20 A (HCSMU)
±10 nA to ±1 A (MCSMU)
±1 pA to ±8 mA (HVSMU)

Compliance accuracy:
Same as the current or voltage set accuracy.

Power compliance

For HPSMU:
Power: 0.001 W to 20 W
Resolution: 0.001 W

For MPSMU:
Power: 0.001 W to 2 W
Resolution: 0.001 W

For HCSMU:
Power: 0.001 W to 40 W (DC)
0.001 W to 400 W (Pulse)
Resolution: 0.001 W

For MCSMU:
Power: 0.001 W to 3 W (DC)
0.001 W to 30 W (Pulse)
Resolution: 0.001 W"

For HVSMU:
No power compliance

SMU pulse measurement

Pulse width, period, and delay:

For HPSMU and MPSMU:
Pulse width: 500 µs to 2 s
Pulse width resolution: 100 µs
Pulse period: 5 ms to 5 s
Period ≥ delay + width + 2 ms (when delay + width ≤ 100 ms)
Period ≥ delay + width + 10 ms (when delay + width > 100 ms)
Pulse period resolution: 100 µs
Pulse delay: 0 s

For HCSMU:
Pulse width:
50 µs to 1 ms (20 A range)
50 µs to 2 s (10 µA to 1 A range)
Pulse width resolution: 2 µs
Pulse period: 5 ms to 5 s
Pulse period resolution: 100 µs
Pulse duty:
For 20 A range: ≤ 1%
For 10 µA to 1 A range
Period ≥ delay + width + 2 ms (when delay + width ≤ 100 ms)
Period ≥ delay + width + 10 ms (when delay + width > 100 ms)
Pulse delay: 0 to (Period–width)

For MCSMU:
Pulse width:
10 µs to 100 ms (1 A range)
10 µs to 2 s (10 µA to 100 mA range)
Pulse width resolution: 2 µs
Pulse period: 5 ms to 5 s
Pulse period resolution: 100 µs
Pulse duty:
For 1 A range: ≤ 5%
For 10 µA to 100m A range
Period ≥ delay + width + 2 ms (when delay + width ≤ 100 ms)
Period ≥ delay + width + 10 ms (when delay + width > 100 ms)
Pulse delay: 0 to (Period–width)

For HVSMU:
Pulse width: 500 µs to 2 s
Pulse width resolution: 2 µs
Pulse period: 5 ms to 5 s
Period ≥ delay + width + 2 ms (when delay + width ≤ 100 ms)
Period ≥ delay + width + 10 ms (when delay + width > 100 ms)
Pulse period resolution: 100 µs
Pulse delay: 0 to (Period – width)
Pulse output limitation:
When the pulse voltage is more than 1500 volts, the peak and base of pulse should be same polarities.
Pulse measurement delay:
2 µs to (Period – pulse measurement time – 2 m) s, 2 µs resolution

Supplemental Characteristics

Current compliance setting accuracy (for opposite polarity):

For HPSMU and MPSMU:
For 1 pA to 10 nA ranges:
V/I setting accuracy ±12% of range
For 100 nA to 1 A ranges:
V/I setting accuracy ±2.5% of range

For HCSMU and MCSMU:
For 10 µA to 1 A ranges:
V/I setting accuracy ±2.5% of range
For 20 A range (HCSMU):
V/I setting accuracy ±0.6% of range

For HVSMU:
For 1 nA to 10 nA ranges:
V/I setting accuracy ±12% of range
For 100 nA to 10 mA ranges:
V/I setting accuracy ±2.5% of range

SMU pulse setting accuracy (fixed measurement range):

For HPSMU and MPSMU:
Width: ±0.5% ± 50 µs
Period: ±0.5% ± 100 µs
For HCSMU and MCSMU:
Width: ±0.1% ± 2 µs
Period: ±0.1% ± 100 µs
For HVSMU:
Width: ±0.1% ± 2 µs
Period: ±0.5% ± 100 µs

Minimum pulse measurement time:

16 µs (HPSMU and MPSMU)
2 µs (HCSMU and MCSMU)
6 µs (HVSMU)

Voltage source output resistance:

(Force line, non-Kelvin connection)
0.2 Ω (HPSMU)
0.3Ω (MPSMU)
3 Ω (HVSMU, at 10 mA range)

Voltage measurement input resistance:

≥ 10^{13} Ω (HPSMU, MPSMU)
≥ 10^{9} Ω (HCSMU, MCSMU, ≤ 1 A),
80 kΩ (HCSMU, 20 A)
≥ 10^{12} Ω (HVSMU)

Current source output resistance:

≥ 10^{13} Ω (HPSMU, MPSMU)
≥ 10^{9} Ω (HCSMU, MCSMU, ≤ 1 A),
80 kΩ (HCSMU, 20 A)
≥ 10^{12} Ω (HVSMU, at 10 nA range)

Maximum allowable cable resistance:

(Kelvin connection)
For HPSMU and MPSMU:
Sense: 10 Ω
Force: 10 Ω (≤ 100 mA),
1.5 Ω (>100 mA)
For HCSMU:
Sense: 10 Ω
Force: 0.6 Ω
(with Low Force)
For MCSMU:
Sense: 10 Ω
Force : 1 Ω
(with Low Force)

Maximum allowable inductance:

For HCSMU and MCSMU:
Force 3 µH
(with Low Force (shield))

Maximum load capacitance:

For HPSMU and MPSMU:
1 pA to 10 nA ranges: 1000 pF
100 nA to 10 mA ranges: 10 nF
100 mA and 1 A ranges: 100 µF
For HCSMU:
10 µA to 10 mA ranges: 12 nF
100 mA to 20 A ranges: 100 µF
For MCSMU:
10µA to 10 mA range : 12 nF
100 mA to 1 A range : 100 µF
For HVSMU:
1 nA to 1 µA ranges: 1000 pF
10 µA to 10 mA ranges: 10 nF

Maximum guard capacitance:

900 pF (HPSMU and MPSMU)
1500 pF (HVSMU)

Maximum shield capacitance:

5000 pF (HPSMU, MPSMU and HVSMU)

Noise characteristics:

For HPSMU, MPSMU and HVSMU (Filter ON for HPSMU and MPSMU.)
Voltage source:
0.01% of V range (rms.)
Current source:
0.1% of I range (rms.)
For HCSMU
Voltage/Current source:
100 mV (0 to peak) max
For MCSMU
Voltage / Current source:
200 mV (0 to peak) max

Overshoot:

(Filter ON for all SMUs)
For HPSMU and MPSMU
Voltage source: 0.03% of V range
Current source: 1% of I range
For HCSMU and MCSMU (filter ON)
Voltage/Current source:
10% of range
For HVSMU
Voltage source: 1V (resistive load)
Current source: 1% of I range

Range switching transient noise:

For HPSMU and MPSMU (filter ON):
Voltage ranging: 250 mV
Current ranging: 70 mV
For HCSMU and MCSMU:
10 µA to 1 A ranges:
Voltage ranging: 250 mV
Current ranging: 70 mV
20 A ranges:
Voltage ranging: 5 V max
For HVSMU:
Voltage ranging: 300 mV
Current ranging: 300 mV

Maximum guard offset voltage:

±1 mV (HPSMU)
±3 mV (MPSMU)
±5 mV (HVSMU)

Maximum slew rate:

0.2 V/µs (HPSMU and MPSMU)
1 V/µs (HCSMU and MCSMU)
0.4 V/µs (HVSMU)

Output settling time

For HVSMU:
Output settling time: 500 µs
To reach 0.01% of settling value.
Conditions:
100 V step, 8 mA compliance,
1000 pF load capacitance

MFCMU (multi frequency capacitance measurement unit) module specifications

Measurement functions

Measurement parameters:
Cp-G, Cp-D, Cp-Q, Cp-Rp, Cs-Rs, Cs-D, Cs-Q, Lp-G, Lp-D, Lp-Q, Lp-Rp, Ls-Rs, Ls-D, Ls-Q, R-X, G-B, Z-θ, Y-θ

Ranging:
Auto and fixed

Measurement terminal:
Four-terminal pair configuration, four BNC (female) connectors

Cable length:
1.5 m or 3 m, automatic identification of accessories

Test signal

Frequency:
Range: 1 kHz to 5 MHz
Resolution: 1 mHz (minimum)
Accuracy: ±0.008%

Output signal level:
Range: 10 mV_{rms} to 250 mV_{rms}
Resolution: 1 mV_{rms}
Accuracy:
±(10.0% + 1 mV_{rms}) at the measurement port of the MFCMU
±(15.0% + 1 mV_{rms}) at the measurement port of MFCMU cable (1.5 m or 3.0 m)

Output impedance: 50 Ω, typical

Signal level monitor:
Range: 10 mVrms to 250 mV_{rms}
Accuracy:
±(10.0% of reading + 1 mV_{rms}) at the measurement port of the MFCMU
±(15.0% + 1 mV_{rms}) at the measurement port of MFCMU cable (1.5 m or 3.0 m)

DC bias function

DC bias:
Range: 0 to ±25 V
Resolution: 1 mV
Accuracy: ±(0.5% + 5.0 mV)
at the measurement port or the MFCMU or the MFCMU cable (1.5 m/3 m)

Maximum DC bias current (Supplemental characteristics):

Impedance measurement range	Maximum DC bias current
50 Ω	10 mA
100 Ω	10 mA
300 Ω	10 mA
1 kΩ	1 mA
3 kΩ	1 mA
10 kΩ	100 µA
30 kΩ	100 µA
100 kΩ	10 µA
300 kΩ	10 µA

Output impedance: 50 Ω, typical

DC bias monitor:
Range: 0 to ±25 V
Accuracy (open load):
±(0.2% of reading + 10.0 mV)
at the measurement port or the MFCMU cable (1.5 m/3 m)

Sweep characteristics

Available sweep parameters:
Oscillator level, DC bias voltage, frequency

Sweep type: linear, log

Sweep mode: single, double

Sweep direction: up, down

Number of measurement points:
Maximum 1001 points

Measurement accuracy

The following parameters are used to express the impedance measurement accuracy at the measurement port of the MFCMU or the MFCMU cable (1.5 m or 3 m).

Z_X: Impedance measurement value (Ω)

D_X: Measurement value of D

$E = E_P' + (Z_S'/|Z_X| + Y_O'|Z_X|) \times 100$ (%)

$E_P' = E_{PL} + E_{POSC} + E_P$ (%)

$Y_O' = Y_{OL} + Y_{OSC} + Y_O$ (S)

$Z_S' = Z_{SL} + Z_{OSC} + Z_S$ (Ω)

|Z| accuracy
±E (%)

θ accuracy
±E/100 (rad)

C accuracy
at $D_X \leq 0.1$
±E (%)

at $D_X > 0.1$
$\pm E \times \sqrt{(1+D_x^2)}$(%)

D accuracy
at $D_X \leq 0.1$
±E/100

at $D_X > 0.1$
$\pm E \times (1 + D_X)/100$

G accuracy
at $D_X \leq 0.1$
$\pm E/ D_X$ (%)

at $D_X > 0.1$
$\pm E \times \sqrt{(1+D_x^2)}/Dx$(%)

Note: measurement accuracy is specified under the following conditions:
Temperature: 23 °C ±5 °C
Integration time: 1 PLC

Parameters E_{POSC} Z_{OSC}		
Oscillator level	**EP_{OSC} (%)**	**Z_{OSC} (mΩ)**
125 mV < V_{OSC} ≤ 250 mV	0.03 x (250/ V_{OSC} – 1)	5 x (250/V_{OSC} – 1)
64 mV < V_{OSC} ≤ 125 mV	0.03 x (125/ V_{OSC} – 1)	5 x (125/V_{OSC} – 1)
32 mV < V_{OSC} ≤ 64 mV	0.03 x (64/ V_{OSC} – 1)	5 x (64/V_{OSC} – 1)
V_{OSC} ≤ 32 mV	0.03 x (32/ V_{OSC} – 1)	5 x (64/V_{OSC} – 1)

V_{OSC} is oscillator level in mV.

Parameters E_{PL} Y_{OL} Z_{SL}			
Cable length	**E_{PL} (%)**	**Y_{OL} (nS)**	**Z_{SL} (mΩ)**
1.5 m	0.02 + 3 x f/100	750 x f/100	5.0
3 m	0.02 + 5 x f/100	1500 x f/100	5.0

f is frequency in MHz. If measurement cable is extended, open compensation, short compensation, and load compensation must be performed.

Parameters Y_{OSC} Y_0 E_P Z_S				
Frequency	**Y_{OSC} (nS)**	**Y_0 (nS)**	**E_P (%)**	**Z_S (mΩ)**
1 kHz ≤ f ≤ 200 kHz	1 x (125/ V_{OSC} – 0.5)	1.5	0.095	5.0
200 kHz < f ≤ 1 MHz	2 x (125/ V_{OSC} – 0.5)	3.0	0.095	5.0
1 MHz < f ≤ 2 MHz	2 x (125/ V_{OSC} – 0.5)	3.0	0.28	5.0
2 MHz < f	20 x (125/ V_{OSC} – 0.5)	30.0	0.28	5.0

f is frequency in Hz.
V_{OSC} is oscillator level in mV.

Example of calculated C/G measurement accuracy				
Frequency	**Measured capacitance**	**C accuracy [1]**	**Measured conductance**	**G accuracy [1]**
5 MHz	1 pF	± 0.61%	≤ 3 µS	± 192 nS
	10 pF	± 0.32%	≤ 31 µS	± 990 nS
	100 pF	± 0.29%	≤ 314 µS	± 9 µS
	1 nF	± 0.32%	≤ 3 mS	± 99 µS
1 MHz	1 pF	± 0.26%	≤ 628 nS	± 16 nS
	10 pF	± 0.11%	≤ 6 µS	± 71 nS
	100 pF	± 0.10%	≤ 63 µS	± 624 nS
	1 nF	± 0.10%	≤ 628 µS	± 7 µS
100 kHz	10 pF	± 0.18%	≤ 628 nS	± 11 nS
	100 pF	± 0.11%	≤ 6 µS	± 66 nS
	1 nF	± 0.10%	≤ 63 µS	± 619 nS
	10 nF	± 0.10%	≤ 628 µS	± 7 µS
10 kHz	100 pF	± 0.18%	≤ 628 nS	± 11 nS
	1 nF	± 0.11%	≤ 6 µS	± 66 nS
	10 nF	± 0.10%	≤ 63 µS	± 619 nS
	100 nF	± 0.10%	≤ 628 µS	± 7 µS
1 kHz	100 pF	± 0.92%	≤ 63 nS	± 6 nS
	1 nF	± 0.18%	≤ 628 nS	± 11 nS
	10 nF	± 0.11%	≤ 6 µS	± 66 nS
	100 nF	± 0.10%	≤ 63 µS	± 619 nS

1. The capacitance and conductance measurement accuracy is specified under the following conditions:
   D_X ≤ 0.1
   Integration time: 1 PLC
   Test signal level: 30 mV_{rms}
   At four-terminal pair port of MFCMU

Device Capacitance Selector (N1272A) specification

The N1272A simplifies 2 and 3 terminal device capacitance measurements by automatically creating the correct configuration of test resources (including adding any needed DC blocking capacitors and AC blocking resistors) for a specified capacitance measurement. To measure packaged device capacitance the N1273A Capacitance Test Fixture is also necessary. However, the N1272A can be used directly with a probe station to measure on-wafer device capacitances.

DC bias characteristics

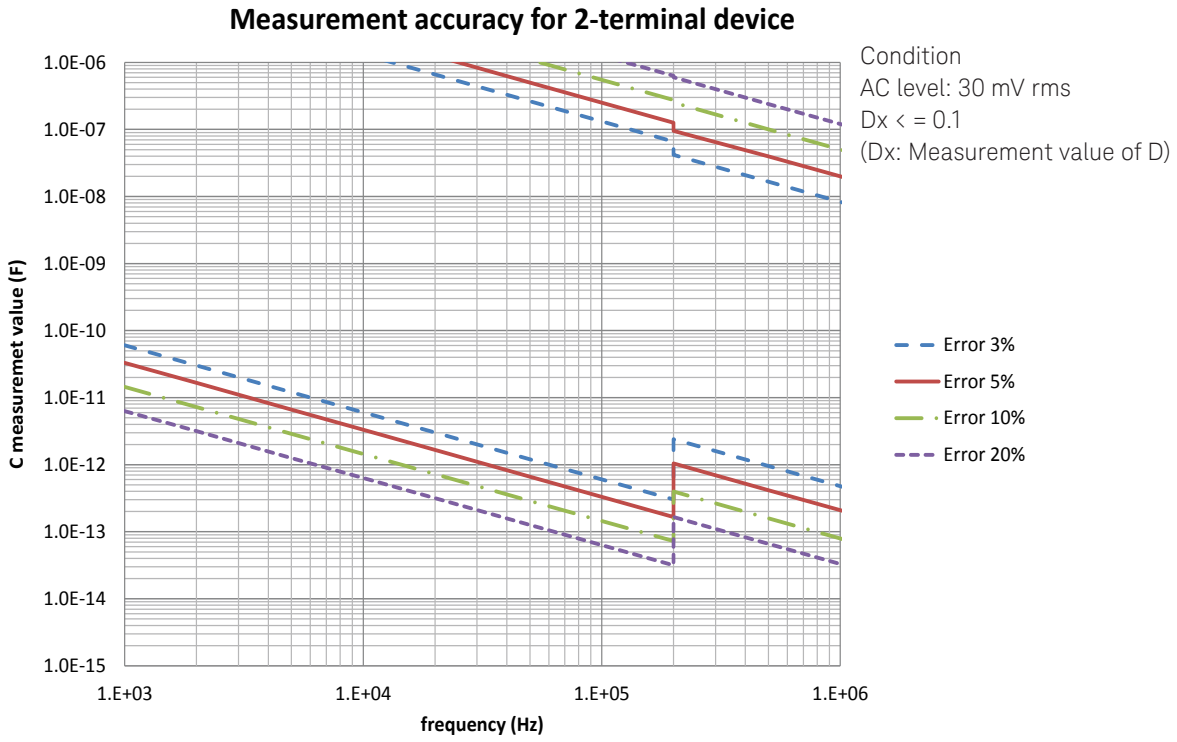
100 kΩ at SMU bias output resistance
Voltage drop compensation function is available.

Bypass capacitance in the capacitance selector

	Capacitance	Withstand voltage
Drain to Source Terminal	1 µF	±3000V
Gate to Source Terminal	1 µF	±100V

Measurement accuracy for 2-terminal device (Supplemental characteristics)

The accuracy of the supplemental characteristics is defined at the output terminals of the TO socket adapter in the N1273A Capacitance Test Fixture when the N1272A is connected to B1505A with the 1.5 m CMU cable and the N1273A system cable.



Output terminals for 2-terminal device

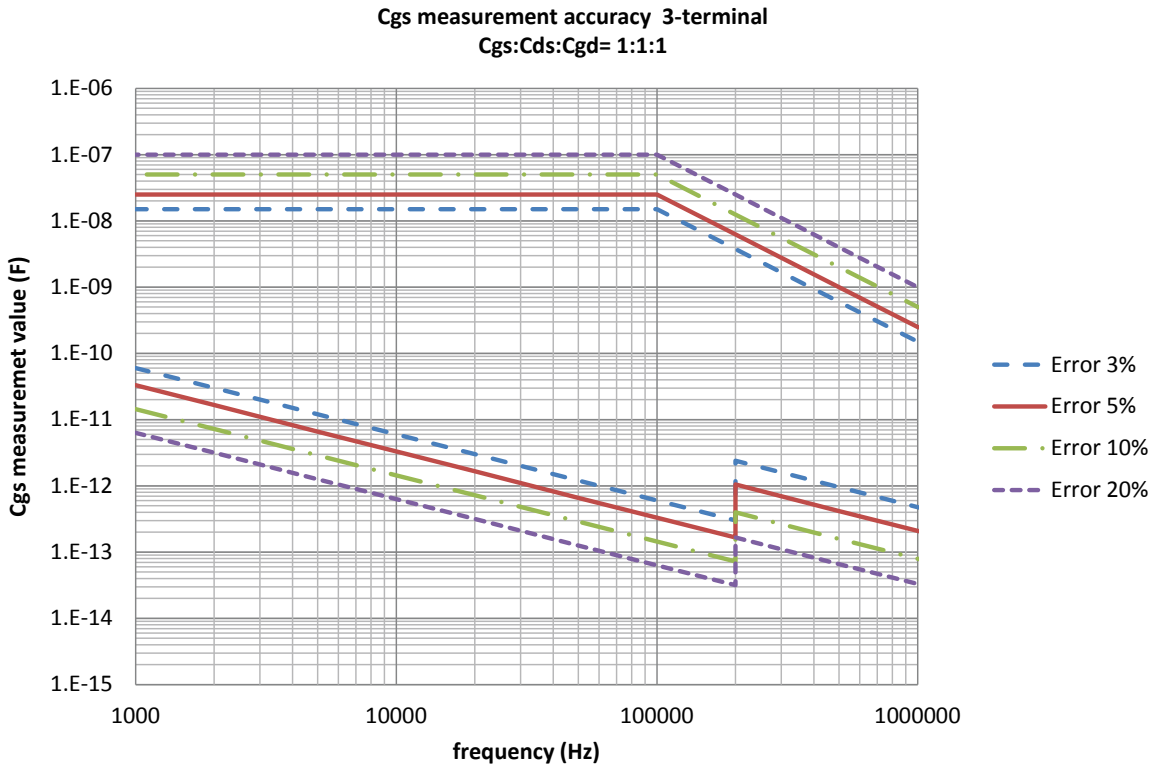
Collector/Drain	High	High	
Emitter/Source		Low	High
Base/Gate	Low		Low

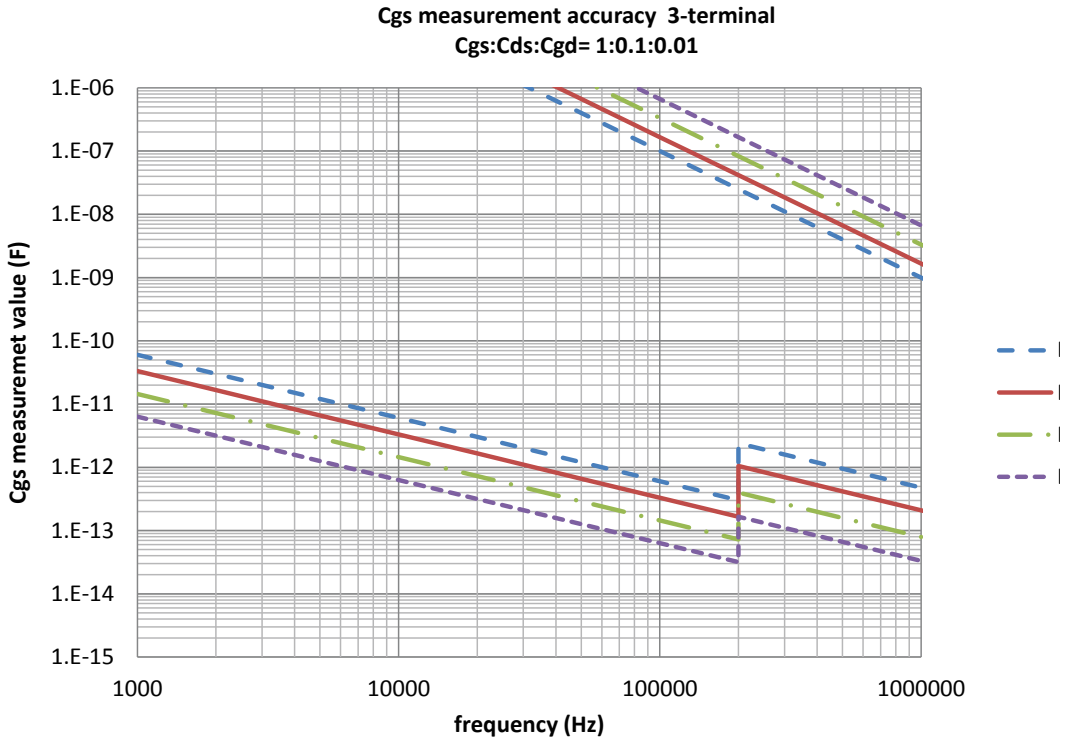
Measurement accuracy for 3-terminal device (Supplemental characteristics)

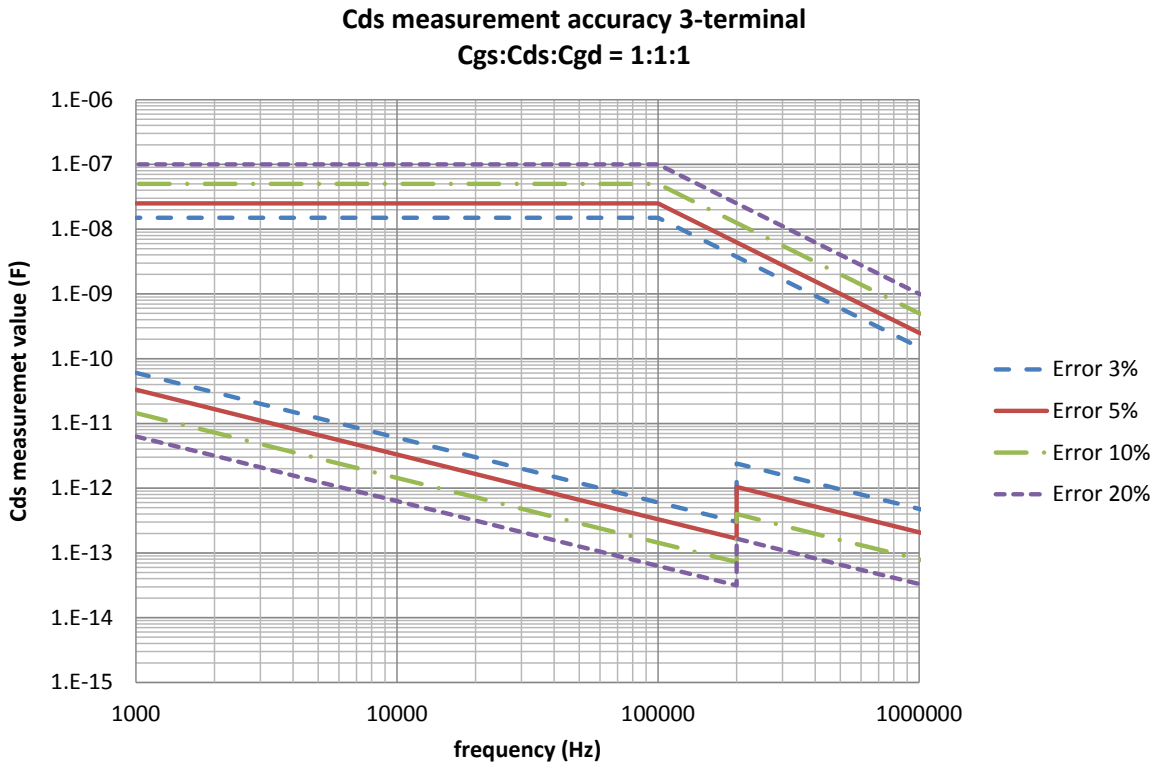
Accuracy of this supplemental characteristics is defined at the output terminals at the TO socket adapter in the N1273A Capacitance Test Fixture when N1272A is connected to B1505A with CMU 1.5 m cable and to the N1273A with system cable.

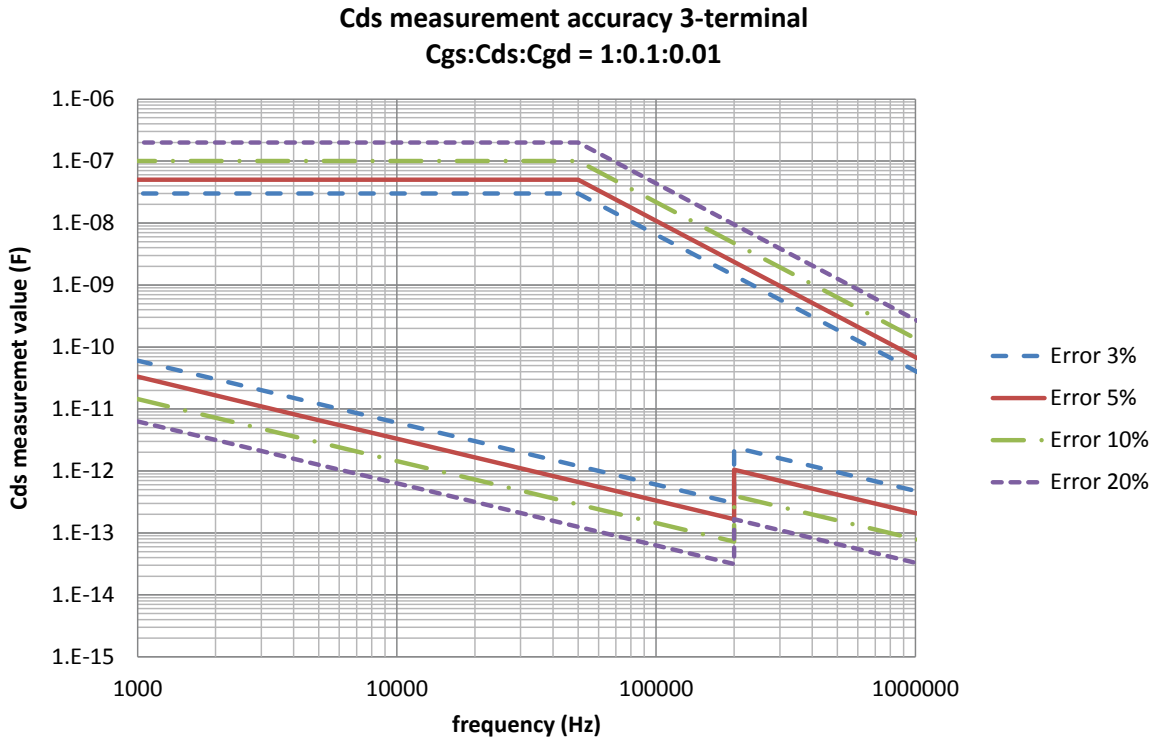
Condition

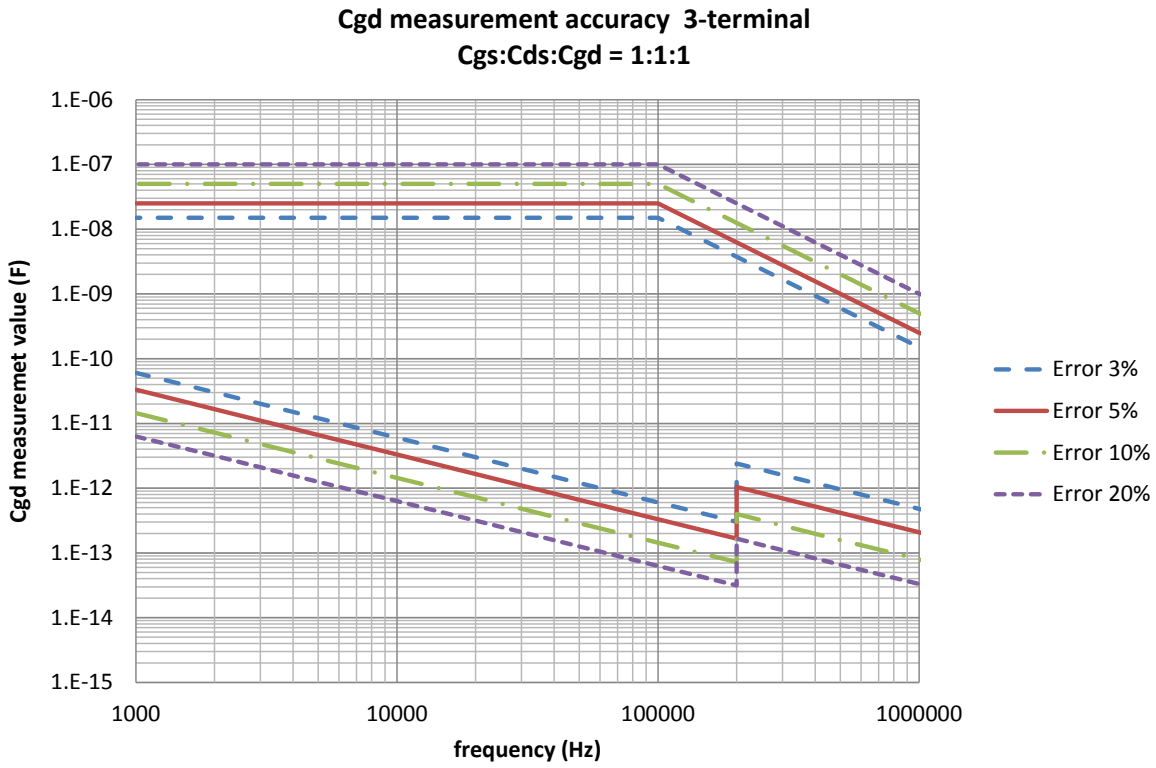
AC level: 30 mV rms, Dx < = 0.1 (Dx: Measurement value of D)






Cds measurement accuracy 3-terminal
Cgs:Cds:Cgd = 1:1:1
Cds measuremet value (F)
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
1.E-13
1.E-14
1.E-15
1000
10000
100000
1000000
frequency (Hz)
Error 3%
Error 5%
Error 10%
Error 20%


Cds measurement accuracy 3-terminal
Cgs:Cds:Cgd = 1:0.1:0.01
Cds measuremet value (F)
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
1.E-13
1.E-14
1.E-15
1000
10000
100000
1000000
frequency (Hz)
Error 3%
Error 5%
Error 10%
Error 20%


Cgd measurement accuracy 3-terminal
Cgs:Cds:Cgd = 1:1:1
Cgd measuremet value (F)
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
1.E-13
1.E-14
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frequency (Hz)
Error 3%
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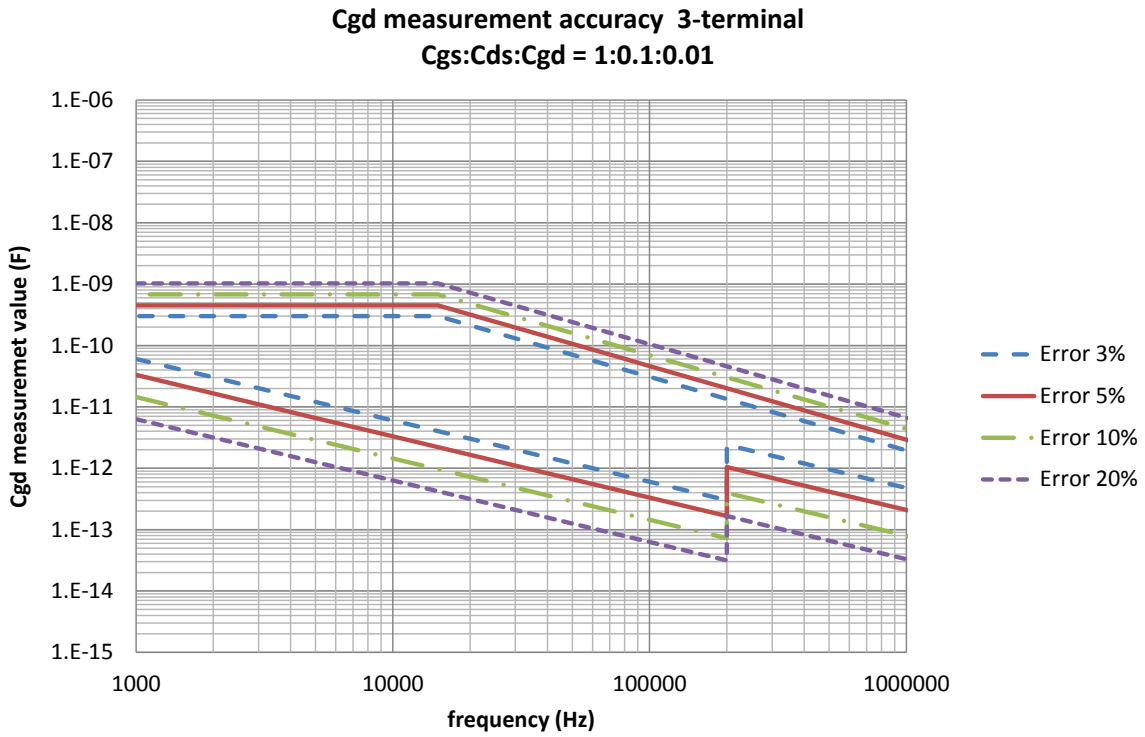
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1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
1.E-13
1.E-14
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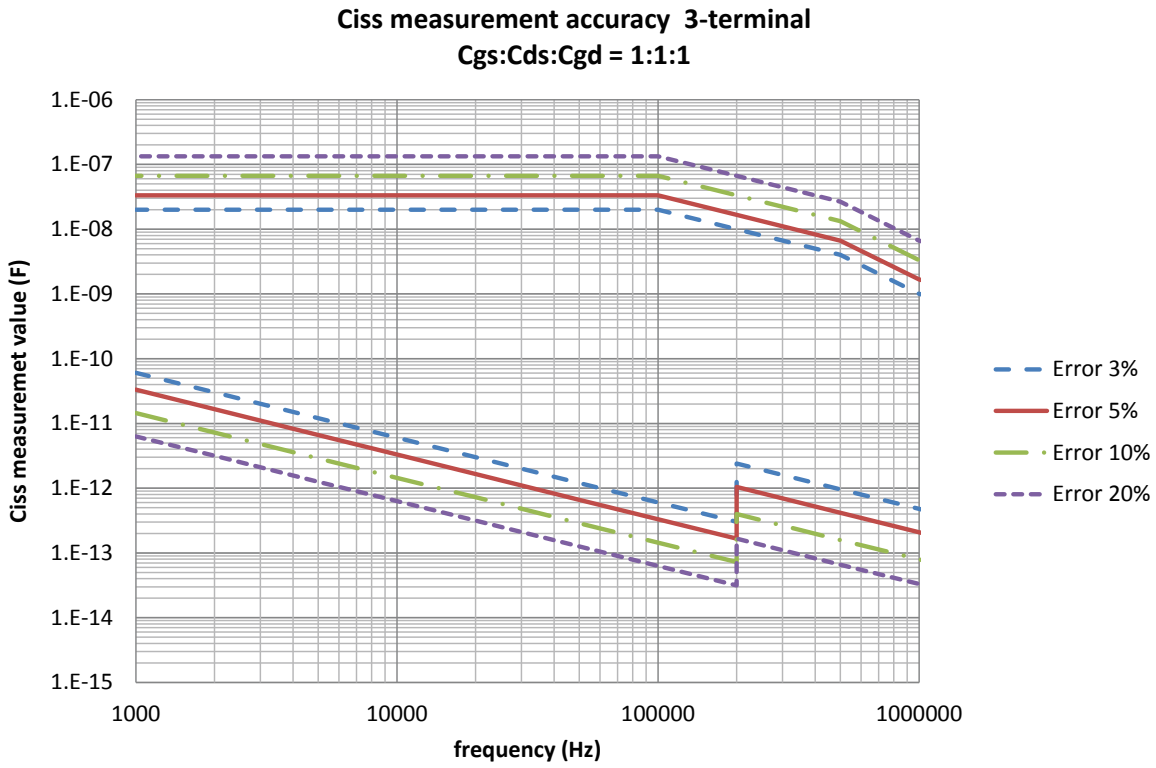
frequency (Hz)
Error 3%
Error 5%
Error 10%
Error 20%


Ciss measurement accuracy 3-terminal
Cgs:Cds:Cgd = 1:1:1
Ciss measuremet value (F)
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
1.E-13
1.E-14
1.E-15
1000
10000
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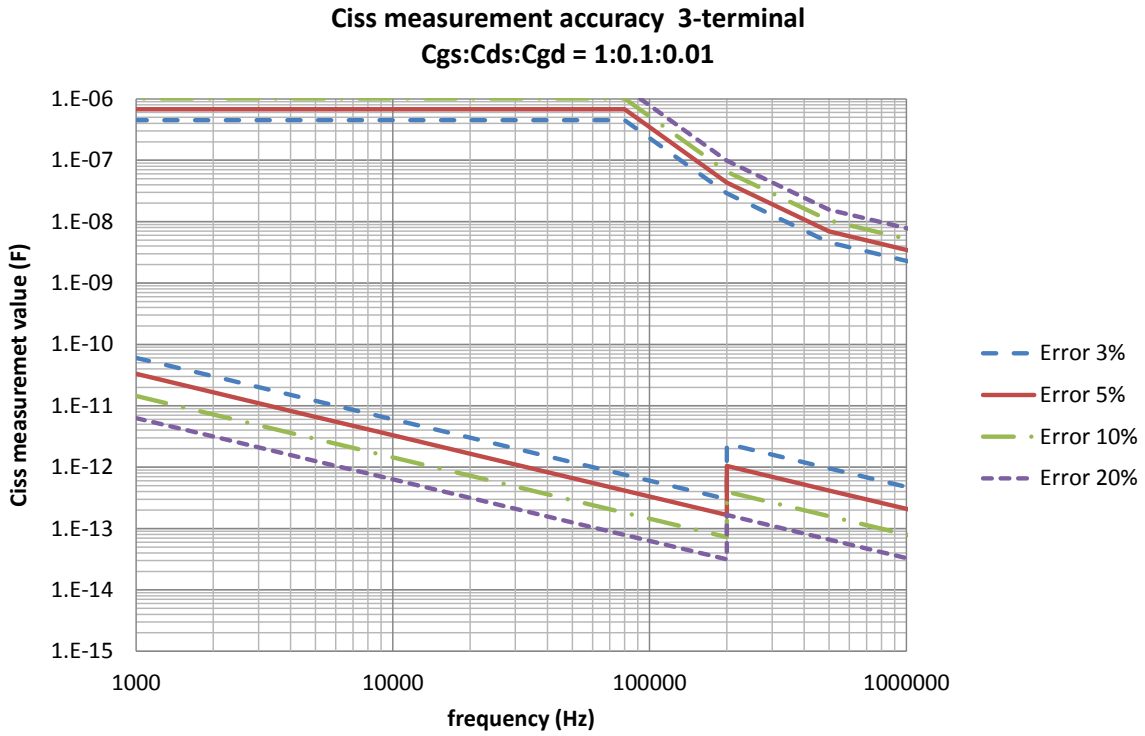
1000000
frequency (Hz)
Error 3%
Error 5%
Error 10%
Error 20%


Ciss measurement accuracy 3-terminal
Cgs:Cds:Cgd = 1:0.1:0.01
Ciss measuremet value (F)
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
1.E-13
1.E-14
1.E-15
1000
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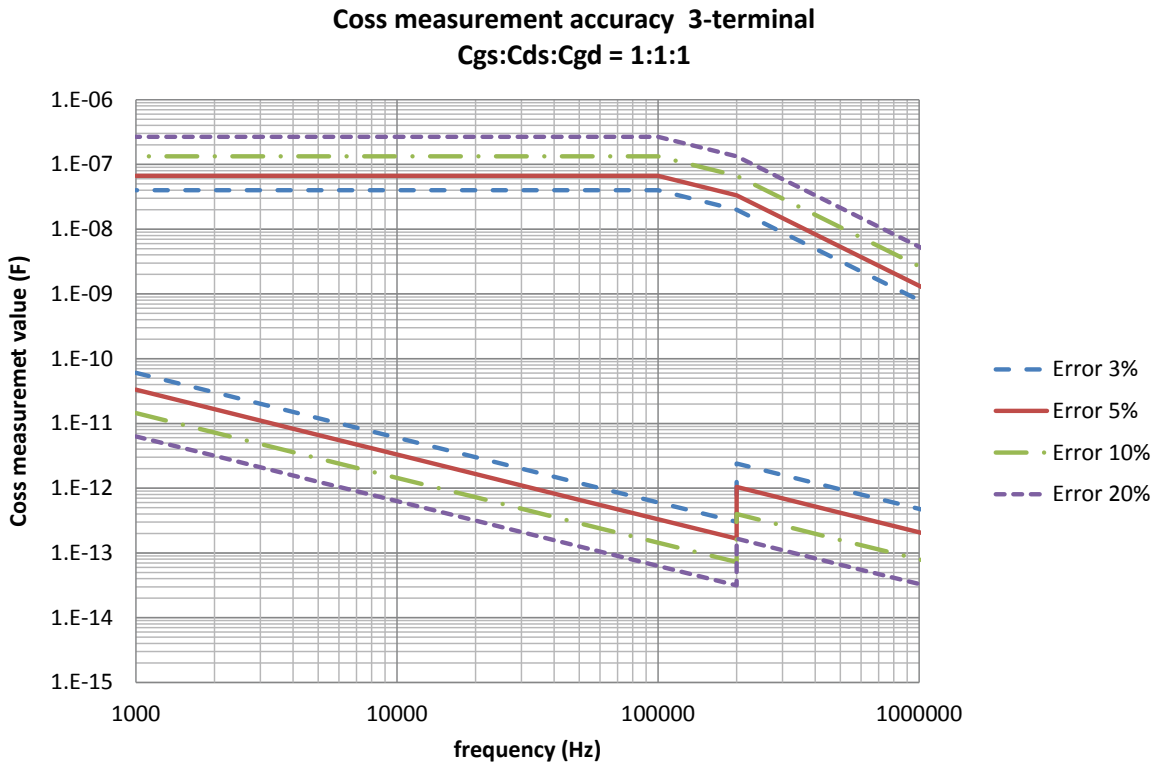
frequency (Hz)
Error 3%
Error 5%
Error 10%
Error 20%


Coss measurement accuracy 3-terminal
Cgs:Cds:Cgd = 1:1:1
Coss measuremet value (F)
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
1.E-13
1.E-14
1.E-15
1000
10000
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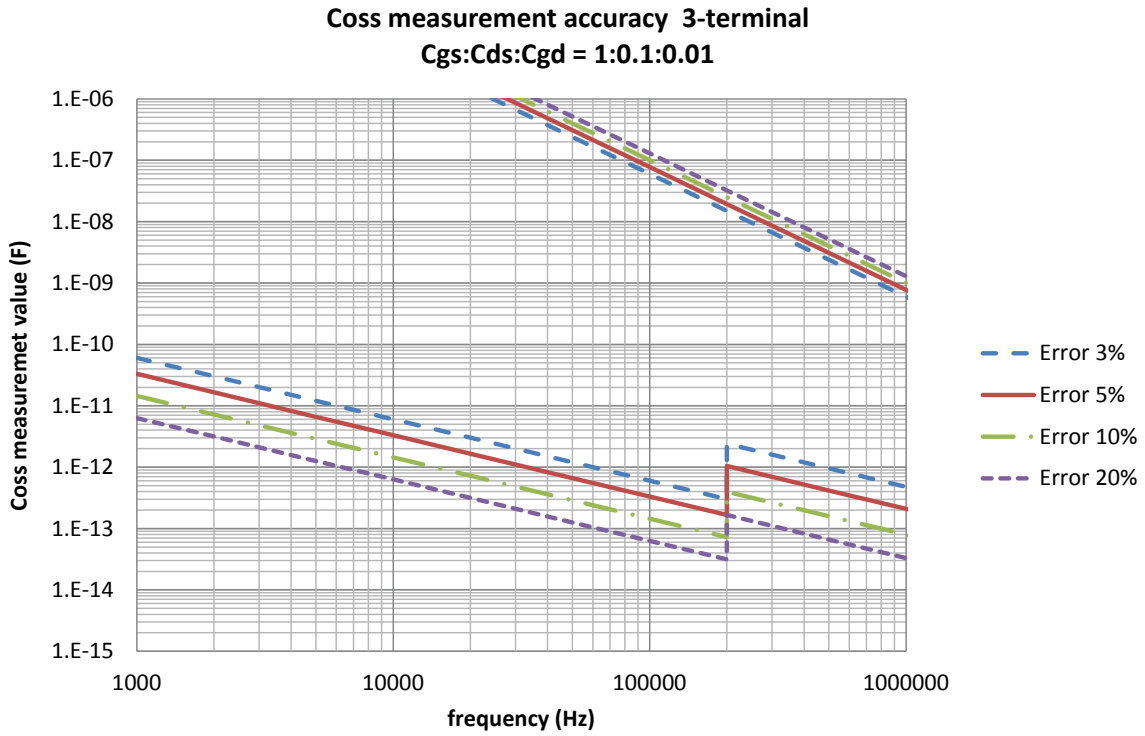
frequency (Hz)
Error 3%
Error 5%
Error 10%
Error 20%


Coss measurement accuracy 3-terminal
Cgs:Cds:Cgd = 1:0.1:0.01
Coss measuremet value (F)
1.E-06
1.E-07
1.E-08
1.E-09
1.E-10
1.E-11
1.E-12
1.E-13
1.E-14
1.E-15
1000
10000
100000
1000000
frequency (Hz)
Error 3%
Error 5%
Error 10%
Error 20%

DC path leakage (Supplemental characteristics)

HVSMU port input / Drain output
Offset: 100 pA
Leakage: Vo x 1E-13 (Vo: Output voltage)

HVSMU port input / Direct output
Offset: 100 pA
Leakage: Vo x 1E-13 (Vo: Output voltage)

MPSMU port input / Gate output
Offset: 50 pA
Leakage: Vo x 5E-13 (Vo: Output voltage)

Selector information

This information is provided for users not utilizing the N1273A capacitance test fixture but who wish to connect the selector outputs to other DUT interfaces such as a wafer prober.

Functionality

Selector capability

The selector allows the user to make connections to perform various capacitance and DC measurements such as leakage, breakdown and threshold voltage measurement.

Output terminals:
HV Triaxial: 1 ea.
SHV terminals: 4 ea.
- Gate/Base
- Drain/Collector
- Source/Emitter
- AC/DC guard

Interlock terminal: 1ea
Digital I/O port: 1 ea. (D-sub 25 pin)
Indicators

Input terminals
- HV Triaxial: 1 ea. (HVSMU)
- Triaxial: 3 ea. (MPSMU Force/Sense, GNDU)
- BNC: 4 ea. (MCSMU Hcur, Lcur, Hpot, Lpot)
- Interlock terminal: 1ea,
- Direct IO

Output terminals for 3-terminal device

Parameter Name		Coss	Cds	Crss	Cgs	Ciss /Rg
Collector/Drain	Force	Open	Open	Open	Open	Open
	Sense	High	High	High	AC Guard	Low
Emitter/Source	Force	Open	Open	Open	Open	Open
	Sense	Low	Low	Low	AC Guard	Low
Base/Gate	High	Low	AC Guard	Low	High	High
	Low	Open	Open	Open	Open	Open

Definition of 3-terminal device capacitances

Symbol	Description
Cgs	Capacitace between Base/Gate terminal and Emitter/Source terminal
Cds	Capacitace between Collector/Drain terminal and Emitter/Source terminal
Cgd	Capacitace between Base/Gate terminal and Collector/Drain terminal
Crss	Capacitace between Base/Gate terminal and Collector/Drain terminal
Ciss	Capacitace between Base/Gate terminal and Emitter/Source terminal and capacitance between Base/Gate terminal and Collector/Drain terminal
Coss	Capacitace between Collector/Drain terminal and Emitter/Source terminal and capacitance between Base/Gate terminal and Collector/Drain terminal

UHC (Ultra High Current) Expander / Fixture (N1265A) Specifications

Specifications

Functions:

Fixture capability
Current expander capability
Expands the B1505A's current capability up to 1500 A. Current expansion is made using the Ultra High Current Unit (UHCU), which is comprised of an external module and either two MCSMUs, two HCSMUs or one MCSMU and one HCSMU.

Selector capability
This allows the user to switch the output between the UHCU and other modules connected to the selector input ports. The modules supported on the high-voltage input port are the HVSMU and HVMCU; the modules supported on the SMU input port are the HPSMU and MPSMU.

Channels:

Channel	Number	Input	Output
SMU	6 (When using non-Kelvin connections) 3 (When using Kelvin connections)	Triaxial[1]	Banana
UHV	1	UHV coaxial (High), SHV (Low)	UHV coaxial (High), SHV (Low)
Bias Tee	1	SHV x 2(High, Low)	SHV x 2 (High, Low)
Gate control	1	Triaxial x 2 (Force, Sense)	Banana x 2 (High, Low)
Selector	1[2]	HV Triaxial x 1 Triaxial x 2 (Force, Sense)	Banana x 6 (High Force/Sense, Low Force/Sense, Guard, Chassis)

1. *Either the HCSMU or the Dual HCSMU can be connected to the SMU 3 port.*
2. *The UHCU or any module connected to one of the other two selector input terminals can be connected to the output terminal.*

Maximum output for selector channel:

HVSMU Output : ±3000 V/4 mA, ±1500 V/8 mA
HVMCU Output : ±2200 V/1.1 A, ±1500 V/2.5 A
HPSMU Output: ±200 V/1 A
MPSMU Output: ±100 V/100 mA
UHCU Output: ±60 V/1500 A or 500 A
Refer to each module specification.

Gate control channel:

Non-Kelvin connection
Maximum Voltage : ±40 V
Maximum Current : ±1 A Pulse, 100m A DC.
Output Resistance: 0 Ω/10 Ω/100 Ω/1000 Ω (nominal value)

UHCU:

Output peak power	
Current range	**Peak power**
± 500 A	7.5 kW
± 1500 A	22.5 kW

Voltage range, resolution, and accuracy				
Voltage range	**Setting resolution**	**Measure resolution**	**Setting accuracy[1,2,3] ±(% + mV)**	**Measure accuracy[1,3] ±(% + mV)**
± 60 V	200 µV	100 µV	±(0.2 + 10)	±(0.2 + 10)

1. ±(% of reading value + fixed offset in mV)
2. Setting accuracy is defined at open load.
3. Accuracy is defined 1ms pulse width at 500A range and 500 µs pulse width at 1500A range.

Current range, resolution, and accuracy[1]				
Current range	**Setting resolution**	**Measure resolution**	**Setting accuracy[2,3] ±(% + A + A)**	**Measure accuracy[2,3] ±(% + A + A)**
± 500 A	1 mA	500 µA	±(0.6 + 0.3 + 0.01*Vo)	±(0.6 + 0.3 + 0.01*Vo)
± 1500 A	4 mA	2 mA	±(0.8 + 0.9 + 0.02*Vo)	±(0.8 + 0.9 + 0.02*Vo)

1. Maximum voltage compliance in current pulse mode is 63 V. Over 400 A at 500 A range and over 1200 A at 1500 A range are supplemental characteristics.
2. Accuracy is defined with 1ms pulse width at 500 A range and with 500 µs pulse width at 1500 A range.
3. ±(% of reading value + fixed offset in A + proportional offset in A), Vo is the Output Voltage.

UHCU Pulse width and resolution				
Current range	**Voltage pulse width**	**Current pulse width**	**Resolution**	**Pulse period[1]**
500 A	10 µsec – 1 msec	10 µsec – 1 msec	2 µsec	Duty ≤ 0.4%
1500 A	10 µsec – 500 µsec	10 µsec – 500 µsec	2 µsec	Duty ≤ 0.1%

1. At continuous maximum current output, the output current may be reduced due to insufficient charging time.

Other functionality

Fiilter

Filter can be used for UHC output in current mode at 500 A range.

Thermocouple input: 2ea

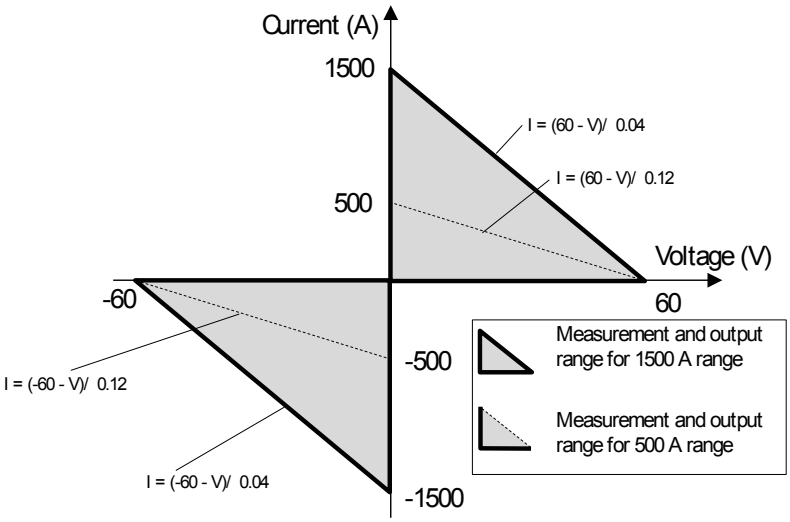
Two K-type thermocouple inputs

Temperature range: -50 °C to 300 °C.

Other Terminals/Indicators

Digital I/O input: 1ea.
Digital I/O output: 1 ea.
Power indicator: 1ea.
High voltage indicator: 1ea.
Selector indicator: 1ea.
Interlock terminal: 1ea.
Earth terminal: 1ea.
Wrist strap terminal: 1ea.

UHC measurement and output range



The UHCU output is only available in pulsed mode.

In the equations in the above diagram, 'I' stands for current, 'V' for Voltage.

The maximum current is defined when the output terminals are shorted.

Also, the maximum current is limited by the residual resistance of the test leads, by by contact resistance between the internal jumper cable and the DUT and by the DUT impedance.

Supplemental characteristics

UHCU Output resistance	
Output range	**Nominal value**
500 A	120 mΩ
1500 A	40 mΩ

Leakage

Selector channel

HVSMU is applied at High Sense terminal: less than 1n A

HPSMU/MPSMU is applied at High Force terminal: less than 10 nA

UHVU channel

Less than 1nA

SMU channel

Less than 1nA

Thermocouple reading accuracy	
Temperature range	**Accuracy**
0°C <= T < 100° C	+/-2°C
T>= 100° C	+/-5°C
T< 0° C	+/-5°C

HVSMU Current Expander (N1266A) Specifications

Specifications

Functions:

Current expander capability

Expands HVSMU current up to 2.5 A. Current expansion is made using the High Voltage Medium Current Unit (HVMCU), which is comprised of a module in the N1266A, HVSMU and two MCSMUs.

Selector capability

This allows the connections between the output terminal to be switched between the HVMCU and the HVSMU. The HVSMU output can be routed either directly or through a 100 kΩ resistor.

Output Terminals:

High (HV Triaxial)
Low (BNC)

Maximum output:

HVSMU : ±3000 V/4 mA, ±1500 V/8 mA
HVMCU : Refer to HVMCU specification

HVMCU

Output Peak Power	
Voltage range	**Peak power**
± 2200 V	600 W
± 1500 V	900 W

Voltage range, resolution, and accuracy				
Voltage range	**Setting resolution**	**Measure resolution**	**Setting accuracy[1, 2, 3] ±(% + V)**	**Measure accuracy[1, 2] ±(% + V)**
± 2200 V	3 mV	3 mV	±(5 + 20)	±(0.8 + 1.8)
± 1500 V	1.5 mV	3 mV	±(5 + 20)	±(0.8 + 1.8)

1. ±(% of reading value + fixed offset in V)
2. Accuracy is defined with 100 µs pulse at 1.1 A range and 2.5 A range, 1 ms pulse at 100 mA range.
3. Setting accuracy is defined at open load.

Current range, resolution, and accuracy[1, 2]		
Current range	**Measure resolution**	**Measure accuracy[1] ±(% + A + A)**
± 2.5 A	4 µA	±(0.9 + 4E-3 + Vo x 3E-7)
± 1.1 A	4 µA	±(0.9 + 4E-3 + Vo x 3E-7)
± 110 mA	200 nA	±(0.9 + 2E-4 + Vo x 3E-7)

1. Supplemental characteristics over 1.1 A.
2. Applicable condition: 20 averaging samples

HVMCU Pulse width and resolution		
Output range	**Pulse width**	**Resolution**
1500 V / 2.5 A	10 µsec – 100 µsec	2 µsec
2200 V / 1.1 A	10 µsec – 100 µsec	2 µsec
2200 V / 110 mA	10 µsec – 1 msec	2 µsec

Other Terminals / Indicators

Digital I/O Input: 1ea.
Digital I/O output: 1ea.
Power indicator: 1ea
Selector indicator: 1ea

Supplemental characteristics

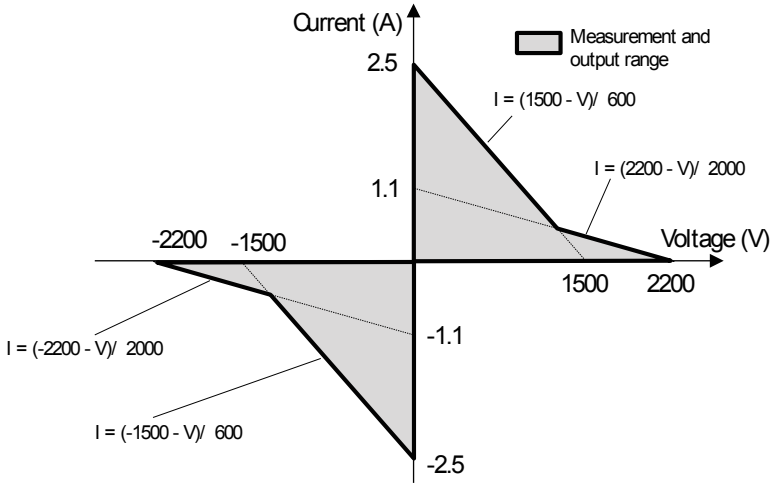
HVMCU Charged Capacitance: 0.22 µF

Output resistance	
Output range	**Nominal value**
1500 V / 2.5 A	600 Ω
2200 V / 1.1 A	2000 Ω
2200 V / 110 mA	20000 Ω

Leakage

Selector output
HVSMU: less than 80 pA

HVMCU Measurement and output range



The HVMC's output is only available in pulsed mode.

In the equations in the above diagram, 'I' stands for current, 'V' for Voltage.

The maximum current is defined when the output terminals are shorted.

Also, the maximum current is limited by the residual resistance of the test leads, by contact resistance between the internal jumper cable and the DUT and by the DUT impedance.

UHV (Ultra High Voltage) Expander (N1268A) Specifications

Specifications

Voltage range, resolution, and accuracy[1]				
Voltage range	Force resolution	Measure resolution	Setting accuracy[2, 3] ±(% + V)	Measure accuracy[2] ±(% + V)
± 10 kV	10 mV	10 mV	±(1.2 + 42)	±(1.2 + 42)

1. N1268A is controlled and makes measurement with two MCSMUs or a combination of a HCSMU and a MCSMU.
2. ±(% of reading value + fixed offset in V)
3. Setting accuracy is defined at open load.

Current range, resolution, and accuracy[1]		
Current range	Measure resolution	Measure accuracy[2] ±(% + A + A)
± 10 µA	10 pA	±(0.06 + 2E-9 + 1E-9)
± 100 µA	100 pA	±(0.06 + 2E-8 + 1E-9)
± 1 mA	1 nA	±(0.06 + 2E-7 + 1E-9)
± 10 mA	10 nA	±(0.06 + 2E-6 + 1E-9)
± 100 mA[3]	100 nA	±(0.06 + 20E-6 + 1E-9)

1. N1268A is controlled and makes measurement with two MCSMUs or a combination of a HCSMU and a MCSMU.
2. ±(% of reading value + fixed offset in A + fixed offset in A)
3. Pulsed mode only (Maximum pulse width is 1 ms). The maximum current is 20 mA.

UHV Pulse width and resolution		
Output range	Pulse width	Resolution
100 mA	100 µs to 1 ms	2 µs
≤ 10 mA	100 µs to 2 s	2 µs

Pulse Period

Min: 10 ms
Max: 5 s

Output Terminals

High : UHV coaxial
Low : SHV

Other Terminals / Indicators

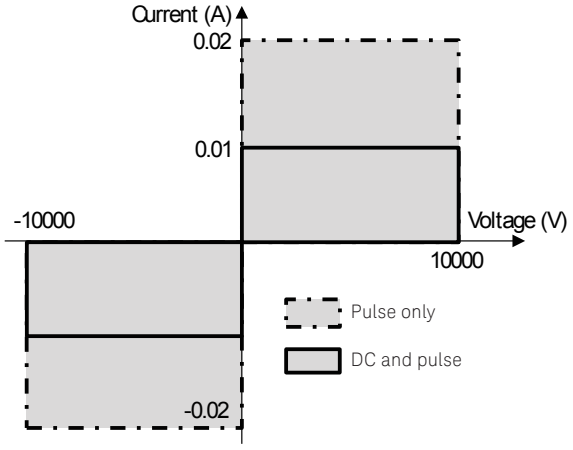
Digital I/O Input: 1ea.
Power indicator: 1ea
High Voltage indicator: 1ea
Interlock terminal Input: 1ea
Interlock terminal Output: 1ea
Earth terminal: 1ea

Supplemental characteristics

UHVU Output resistance	
Output range	Nominal value
High	10000 Ω
Low	1000 Ω

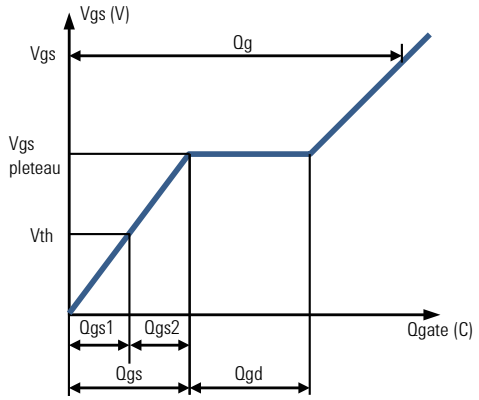
Other AC characteristics	
Slew rate	100 V/µs (with 1m cable)
Overshoot	±1% of setting voltage
Ripple	3 Vp-p
Maximum load capacitance	5 nF
Maximum load inductance	5 µH

UHV measurement and output range



Gate charge measurement specifications

The B1505A can perform gate charge characterization. Both packaged devices and on-wafer devices are supported. The following table shows the available solutions and their required accessories (which depend on device type and current level). Temperature dependent measurements using a Thermostream or the Thermal plate are not supported.



Qg: Gate charge
Qgs: Gate-source charge
Qgs1: Gate charge at threshold
Qgs2: Gate charge from threshold to onset of plateau
Qgd: Gate-drain charge

Hardware configuration and measurement/setting parameters

		Package solution			On-wafer solution		
Hardware configuration	High Voltage module	B1513B/C HVSMU					
	Max Voltage Range	3000V					
	High Current module	B1512A HCSMU	N1265A-500	N1265A-1500A	B1512A HC-SMU	N1265A-500A	N1265A-1500A
	Max Current Range	20A	500A	1500A	20A	500A	1500A
	Gate control module	B1514A MCSMU					
	Ireg control module	B1514A MCSMU					
	Fixture/Selector	N1259A	N1265A		N1258A	N1265A	
	Adapter/Selector	N1259AU-014	N1265AU-014		N1274A	N1275A	
Measurement parameter	Qg	1nC to 100uC					
	Min Resolution	10pC					
	Vds (Vce) @High Voltage	0V to +3000V					
	Voltage/Sampling Resolution	3mV / 6us					
	Vds(Vce) @ High Current	Not Support	-60V to 60V		Not Support	-60V to 60V	
	Voltage /Sampling Resolution		100uV / 2us			100uV / 2us	
	Id (Ic) maximum rated current	20A	350A (1,(3	500A (1,(2,(3	0 to 20A	350A (1	500A (1,(2
	Current/Sampling Resolution	2mA / 2us					
	Vgs (Vge)	-30V to +30V					
	Voltage/Sampling Resolution	40uV / 2us					
	Ig	10nA to 1A					
	Current/Sampling Resolution	10pA / 2us					

Hardware configuration and measurement/setting parameters (continued)

		Package solution			On-wafer solution		
Setting parameters	Vds (Vce) @High Voltage	0V to +3000V					
	Resolution	3mV					
	Vds(Vce) @ High Current	-40V to 40V	-60V to 60V		-40V to 40V	-60V to 60V	
	Resolution	40uV	100uV		40uV	100uV	
	Id max	20A	350A (1,(3	500A (1,(2,(3	20A	350A (1	500A(1,(2
	Gate Drive Vgs(Vge)	-30V to +30V					
	Resolution	40uV					
	Gate Control Current Ig	1uA to 1A					
	Resolution	0.1uA					
	Current Regulator Control Voltage	-30V to +30V					
	Resolution	40uV					
	On time	50 - 950us	50 - 450us		50 - 950us	50 - 450us	
	Resolution	2us					

Note) The maximum current will be reduced by the series resistance of the current source, residual resistance in the measurement path, and the DUT impedance. The gate charge measurement adapter also has a maximum current limit of 500 A.

Target devices:

MOSFETs and IGBTs in TO packages, in modules and on-wafer

N1267A High Voltage Source Monitor Unit / High Current Source Monitor Unit Fast Switch

Features

The N1267A supports fast switching between the HVSMU and HCSMU to enable the measurement of the Gallium Nitride current collapse effect.

The N1267A switch requires one MCSMU in the B1505A mainframe for control. The gate of the DUT (Device Under Test) can be driven by either an MCSMU or an HCSMU.

Note #1: The N1267A can only be used with the B1513B or B1503C HVSMU; it cannot be used with the B1513A HVSMU.
Note #2: The N1267A does not support the two HCSMU 40 A configuration.
Note #3: The N1267A does not support the N1265A test fixture/current expander.

Specifications

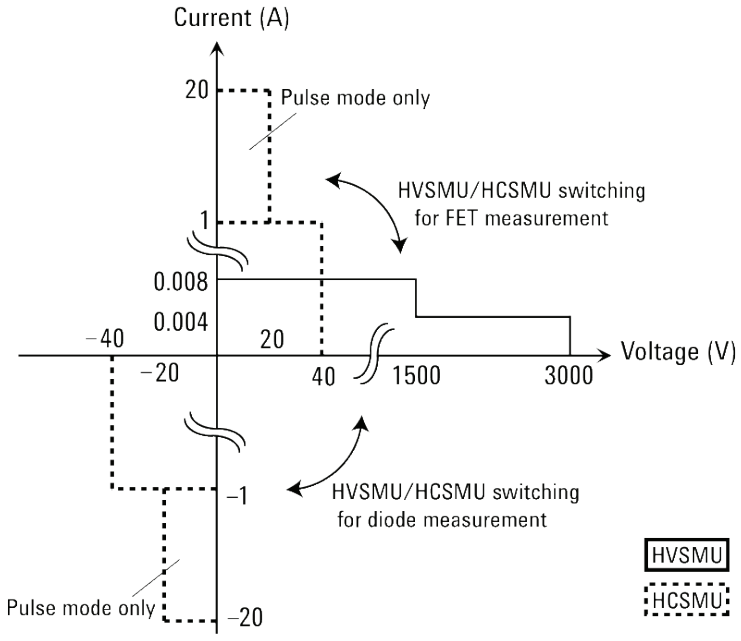
Input terminals:
HVSMU port, 1ea (HV triaxial)
HCSMU port, 1ea (Force: BNC, Sense: Triaxial)
MCSMU port, 1ea (Force/Sense: Triaxial)
GND port, 1ea (Triaxial)
Output terminals: High (HV triaxial), Low (BNC)
Maximum current: 20 A
Maximum voltage: 3000 V

Measurement mode

GaN Current collapse (Dynamic I-V) measure mode
1. I-V time domain measurement
2. I-V trace measurement

Static characteristics mode
1. Id-Vds, Vf-If measurement
2. Id(off)-Vds, Vr-Ir measurement

Source and Measure Range



GaN current collapse measure mode

To make the GaN current collapse measurement, the HVSMU first applies high voltage stress to the DUT when the DUT is in the OFF-state. Next the HVSMU performs voltage measurement and the HCSMU performs I-V measurement to monitor the ON-state characteristics of the DUT. When making the ON-state measurement, the HVSMU is measuring voltage and both the HVSMU and HCSMU are used to measure the total current.

HVSMU Source setting range for OFF-state	
Voltage	**Current**
+1 V - +3000 V [1]	4 mA (V > 1500 V), 8 mA (V ≤ 1500 V)

[1] Setting value must be the ON state voltage plus 1 V or more.

HCSMU source setting range for ON-state		
Voltage	**Current**	
0 V - ±40 V [2]	Maximum	Minimum
	20A pulse (V ≤ 20V) / 1A DC	20 mA [3]

[2] Voltage actually applied to the device under test (DUT) is the setting value minus the voltage drop of the switch.
[3] Sum of HCSMU output current and HVSMU output current flow into DUT.

Minimum voltage measurement resolution for OFF-state: 200 µV
Minimum current measurement resolution for ON-state: 100 nA
Minimum transition time (OFF to ON): 20 µs
Duration setting for OFF-state: 10 ms - 655.35
Sampling rate: 2 µs to 12 µs for current, 6 µs for voltage
Minimum ON state duration: 50 µs

Static characteristics mode

The following information applies to measurement of the DUT ON-state static characteristics. The N1267A ensures that the DUT is in the ON-state during these measurements. The HVSMU applies 0 V with 1 µA compliance and measures Vds or Vf. At the same time, the HCSMU is also performing an I-V measurement. The Id or If is determined by adding together the total current measured by both the HCSMU and the HVSMU.

HCSMU source setting for Id-Vds, Vf-If measurement		
Voltage	**Current**	
0 V - ±40 V	Maximum	Minimum
	20A pulse (V ≤ 20V) / 1A DC	20 mA [4]

Minimum voltage measurement resolution: 200 µV
Minimum current measurement resolution: 10 pA [4])

[4] Offset error for the Id-Vds, If-Vf measurement is typical 1 µA

The following information applies to measurement of the DUT OFF-state static characteristics. The N1267A ensures that the DUT is in the OFF-state during these measurements. The HCSMU applies 0 V. At the same time, the HVSMU performs I-V measurement and measures Vds or Vr. The Id(Off) or Ir is determined by adding together the total current measured by both the HCSMU and the HVSMU.

HVSMU source setting for Id(off)-Vds, Vr-Ir measurement		
Voltage	**Current**	
0 V - +3000V	Maximum	Minimum
	4 mA (V > 1500 V), 8 mA (V ≤ 1500 V)	10 µA [5]

Minimum voltage measurement resolution: 200 µV
Minimum current measurement resolution: 10 pA [5])

[5] Leak error for the Idss, Ir-Vr measurement is typical 2 nA.

Accessories

N1258A module selector

Specifications

Input terminals:
- HPSMU force port[1], 1 ea., (Triaxial)
- HPSMU sense port[1], 1 ea., (Triaxial)
- HCSMU force port, 1 ea. (BNC)
- HCSMU sense port, 1 ea. (Triaxial)
- HVSMU port[2], 1 ea. (HV triaxial)
- GNDU port, 1 ea. (Triaxial)
- Digital I/O port, 1 ea. (D-sub 25 pin)
- AC power line connector, 1 ea.
- 1. Either HPSMU or MPSMU can be connected to HPSMU port.
- 2. Either HVSMU or HVMCU can be connected to HVSMU port.

Output terminal:
- High force (HV triaxial)
- High sense (HV triaxial)
- Low force (BNC)
- Low sense (BNC)
- External relay control output (D-sub 15 pin)

Protection:
- HPSMU, GNDU, HCSMU Low Force

Power indicator:
- LED turns yellow when AC power is applied and turns green the module selector is ready to use.

Status indicator:
- Green LED lights to indicate the present connection path of module selector; Open, HCSMU, HPSMU, or HVSMU.

Maximum voltage/current:
- For HPSMU port:
  - ±200 V/1 A
- For HCSMU port:
  - ±40 V/2 A, ±20 V/30 A (Pulse width 1 ms, duty 1%)
- For HVSMU port:
  - ±3000 V/4 mA, ±1500 V/2.5 A, ±2200 V/1.1 A

Supplemental characteristics

Leakage current:
- For HPSMU:
  - 10 pA at 200 V
- For HCSMU:
  - 100 pA at 10 V (High Force to Low Force, High Sense to Low Sense)
- For HVSMU:
  - 10 pA at 1500 V (humidity range: 20% to 70% RH)
  - 20 pA at 3000 V (humidity range: 20% to 50% RH)

N1259A test fixture

Specifications

Input terminals:
- HPSMU port[1], 2 ea.
  - Force, sense (Triaxial)
- HCSMU port, 2 ea.
  - Force (BNC), sense (Triaxial)
- HVSMU port[2], 1 ea. (HV triaxial)
- GNDU port, 1 ea. (Triaxial)
- AUX port, 2 ea. (BNC)
- Interlock port, 1 ea.

1. Either HPSMU or MPSMU can be connected to HPSMU port.
2. Either HVSMU or HVMCU can be connected to HVSMU port.

Protection:
- HPSMU, GNDU, HCSMU Low Force terminal

High voltage indicator:
- LED turns red when a SMU output voltage is over 42 V.

Maximum voltage/current:
- For HPSMU port:
  - Force: ±200 V/1 A
  - Sense: ±200 V
- For HCSMU port:
  - High Force: ±40 V/2 A, ±20 V/40 A (Pulse width 1 ms, duty 1%)
  - Low Force: ±40 V/2 A, ±20 V/40 A (Pulse width 1 ms, duty 1%)
  - High Sense: ±40 V
  - Low Sense: ±40 V
- For HVSMU port:
  - Force: ±3000 V/4 mA, ±1500 V/2.5 A, ±2200 V/1.1 A

Note: The total power consumption of all modules cannot exceed 50 W when using test fixture under the condition that operating temperature is more than 35 °C.

Supplemental characteristics

Leakage current:
- For HPSMU (Force, Sense) port:
  - 10 pA at 200 V (Force, Sense)
- For HCSMU (High Force, High sense) port: 100 pA at 10 V
- For HVSMU (Force) port:
  - 10 pA at 1500 V (humidity range: 20% to 70% RH)
  - 20 pA at 3000 V (humidity range: 20% to 50% RH)

N1259A-010 inline package socket module (3 pin)

Specifications

Number of terminal:
- Sockets, 6 ea. (Ø4 mm jack (banana))

DUT interface:
- Inline package socket (3-pin)

Maximum voltage for terminals:
- 3000 Vdc

N1259A-011 universal socket module

Specifications

Number of terminal:
- Sockets, 8 ea. (Ø4 mm jack (banana))

Maximum voltage for terminals:
- 3000 Vdc

N1259A-013 Curve Tracer test adapter socket module

Specifications

Number of terminals:
Sockets, 6 ea.
(Ø4 mm jack (banana))
Test adapter interface:*
Sockets, 6 ea.
(Ø4 mm jack (banana))
Maximum voltage at terminals:
3000V Vdc
Maximum current for terminals:
For Collector/Drain Force and Emitter/Source Force
39 A (DC), 500 A (Pulse)
For others
1A (DC), 20 A (Pulse)

*A test adapter for Tektronix curve tracers (370B/371B) can be connected to this interface.

N1259A-014 Gate Charge Socket Adapter

Purpose

To make gate charge measurements with the N1259A.

Required Hardware

- N1259A test fixture, 1 ea.
- N1259A-300 Module selector, 1 ea.
- B1512A HCSMU, 1 ea.
- B1513B/C HVSMU, 1 ea.
- B1514A MCSMU, 2 ea.

Specifications

Number of terminals: Sockets, 8 ea.
(Ø4 mm jack (banana))
Maximum voltage at terminals:
For Gate DUT High:30 V
For Gate DUT Low: 10 V
For selector force High: 3000 V
For selector force Low: 10 V
For selector sense High: 3000 V
For selector sense Low: 10 V
For SMU control High: 30 V
For SMU control Low: 10 V
Maximum current for terminals:
For Gate DUT High:1 A
For Gate DUT Low: 1 A
For selector force: 500 A
For selector sense: 20 mA
For SMU control: 1 A

Furnished accessories

- Test lead (red), short, 2 ea.
- Test lead (black), short, 2 ea.
- Test lead (red), long, 4 ea.
- Test lead (black), long, 4 ea.

N1259A-020 high voltage bias-tee

Specifications

Input terminals:
DC bias input, 1 ea.
(Ø4 mm jack (banana))
MFCMU port, 1 ea.
Hcur, Hpot, Lcur, Lpot, (BNC)
Guard input, 1ea (Ø4 mm banana jack)
Output terminal:
MFCMU port
High (SHV)
Low (SHV)
External DC bias voltage: ±3000 V
Frequency:
10 kHz to 1 MHz (150 Ω at 10 kHz)
Series capacitance: 110 nF ±5%
Input resistance: 100 kΩ ±1%

N1259A-021 1 MΩ resistor box

Specifications

Input/output terminals:
Ø4 mm jack (banana), 1 ea.
Resistance: 1 MΩ ±5%
Maximum voltage: ±3000 V
Power rating: 9 W

Supplemental characteristics

Leakage current: 10 pA at 100 V

N1259A-022 100 kΩ resistor box

Specifications

Input/output terminals:
Ø4 mm jack (banana), 1 ea.
Resistance: 100 kΩ ±5%
Maximum voltage: ±3000 V
Power rating: 6.4 W

Supplemental characteristics

Leakage current: 10 pA at 100 V

N1259A-030 1 kΩ resistor box for gate

Specifications

Input/output terminals:
Ø4 mm jack (banana), 1 ea.
Resistance: 1 kΩ ±10%
Maximum voltage: ±200 V
Maximum power: 1 W

Supplemental characteristics

Leakage current: 10 pA at 100 V

N1259A-035 Universal resistor box

Specifications

Input/output terminals:
Ø4 mm banana jack, 1 ea.
Resistance: Installed by a user
Maximum voltage for terminals:
±3000 V

N1259A-300 module selector for test fixture

Specifications

Input terminals:
HPSMU port[1], 1 ea.
Force, sense (Triaxial)
HCSMU port, 1 ea.
Force (BNC), sense (Triaxial)
HVSMU port[2], 1 ea. (HV triaxial)
GNDU port, 1 ea. (Triaxial)
Digital I/O port, 1 ea. (D-sub 25 pin)
AC power line connector, 1 ea.

1. Either HPSMU or MPSMU can be connected to HPSMU port.
2. Either HVSMU or HVMCU can be connected to HVSMU port.

Output terminal:
High force and guard
High sense and guard
Low force
Low sense
(Ø4 mm jack (banana))
Protection:
HPSMU, GNDU, HCSMU Low Force
Power indicator:
LED turns yellow when AC power is applied and turns green the module selector is ready to use.
Status indicator:
Green LED lights to indicate the present connection path of module selector; Open, HCSMU, HPSMU, or HVSMU.
Maximum voltage/current:
For HPSMU port:
±200 V/1 A
For HCSMU port:
±40 V/2 A, ±20 V/30 A
(Pulse width 1 ms, duty 1%)
For HVSMU:
±3000 V/4 mA,
±1500 V/2.5 A, ±2200 V/1.1 A

Supplemental characteristics

Leakage current:
For HPSMU:
10 pA at 200 V
For HCSMU:
100 pA at 10 V (High Force to Low Force, High Sense to Low Sense)
For HVSMU:
10 pA at 1500 V (humidity range: 20% to 70% RH)
30 pA at 3000 V (humidity range: 20% to 50% RH)

N1260A high voltage bias-tee

Specifications

Input terminals:
HVSMU port, 1 ea. (HV triaxial)
MFCMU port, 1 ea.
(4 BNC, Hp, Hc, Lp, Hc)
Output terminal:
H-AC Guard (SHV connector)
L-AC Guard (SHV connector)
External DC bias voltage: ±3000 V
Frequency:
10 kHz to 1 MHz (150 Ω at 10 kHz)
Series capacitance: 110 nF ±5%
Input resistance: 100 kΩ ±1%

N1261A protection adapter

N1261A-001 protection adapter for HPSMU (triaxial output)

Specifications

Input terminals:
Force (Triaxial)
Sense (Triaxial)
Output terminals:
Force (Triaxial)
Sense (Triaxial)

1. Either the HPSMU or the MPSMU can be connected to HPSMU port.

Supplemental characteristics

Leakage current: 10 pA at 200 V

N1261A-002 protection adapter for GNDU (BNC output)

Specifications

Input terminals:
Force/Sense (Triaxial)
Output terminals:
Force (BNC)
Sense (BNC)

N1261A-003 protection adapter for HPSMU (HV triaxial output)

Specifications

Input terminals[1]:
Force (Triaxial)
Sense (Triaxial)
Output terminals:
Force (HV triaxial)
Sense (HV triaxial)

1. Either the HPSMU or the MPSMU can be connected to HPSMU port.

Supplemental characteristics

Leakage current: 10 pA at 200 V

N1261A-004 protection adapter for GNDU (SHV output)

Specifications

Input terminals:
Force/Sense (Triaxial)
Output terminals:
Force (SHV)
Sense (SHV)

N1262A Resistor Box

N1262A-001 1 MΩ resistor box

Specifications

Input terminals:
HVSMU port, 1 ea. (HV triaxial)
Output terminals:
SHV connector, 1 ea.
Resistance: 1 MΩ ±5%
Maximum voltage: ±3000 V
Maximum power: 9 W

Supplemental characteristics

Leakage current:
10 pA at 100 V

N1262A-002 100 kΩ resistor box

Specifications

Input terminals:
HVSMU port, 1 ea. (HV triaxial)
Output terminals:
SHV connector, 1 ea.
Resistance: 100 kΩ ±5%
Maximum voltage: ±3000 V
Maximum power: 6.4 W

Supplemental characteristics

Leakage current: 10 pA at 100 V

N1262A-010 1 kΩ resistor box for gate (triaxial output)

Specifications

Input terminals:
  Triaxial connector, 1 ea.
Output terminals:
  Triaxial connector, 1 ea.
Resistance: 1 kΩ ±10%
Maximum voltage: ±200 V
Maximum power: 1 W

Supplemental characteristics

Leakage current: 10 pA at 100 V

N1262A-011 1 kΩ resistor box for gate (SHV output)

Specifications

Input terminals:
  HV triaxial connector, 1 ea.
Output terminals:
  SHV connector, 1 ea.
Resistance: 1 kΩ ±10%
Maximum voltage: ±3000 V
Maximum power: 1 W

Supplemental characteristics

Leakage current: 10 pA at 100 V

N1262A-020 Universal resistor box, Triaxial

Specifications

Input terminals:
  Triaxial connector, 1 ea.
Output terminals:
  Triaxial connector, 1 ea.
Resistance: Installed by user
Maximum voltage for terminals: ±200 V

N1262A-021 Universal resistor box, HV Triaxial to SHV

Specifications

Input terminals:
  HVSMU port, 1 ea. (HV triaxial)
Output terminals:
  SHV connector, 1 ea.
Resistance: Installed by user
Maximum voltage for terminals:
±3000 V

N1262A-023 Universal resistor box for Ultra High Voltage

Specifications

Input terminals:
  UHV coaxial connector, 1 ea.
Output terminals:
  UHV coaxial connector, 1 ea.
Resistance: Installed by user
Maximum voltage for terminals:
±10 kV

N1262A-036 50 Ohm Termination Adapter

Specifications

Input terminal (BNC)
Output terminal (BNC)
Maximum power: 1 W

Accessories for N1265A

N1254A-524 Ultra High Current Prober System Cable

Specifications

Input terminals: 8 ea. (Ø4 mm jack (banana))
  Selector Output
    High Force
    High Sense
    Low Force
    Low Sense
    Guard
  Gate output
    High Force
    Low Force
  Chassis
Output terminals
    High Force (Ø4 mm jack (banana))
    Low Force (Ø4 mm jack (banana))
    High Sense (HV triaxial)
    Low Sense (BNC)
    Gate (BNC)
Maximum voltage / current
  For High Force
    ±3000 V/39 A (DC), 500 A (Pulse)
  For Low Force
    ±200 V/39 A (DC), 500 A (Pulse)
  For High Sense
    ±3000 V/1 A
  For Low Sense, Gate
    ±200 V/1 A

N1265A-010 Ultra High Current 3-pin Inline Package Socket Module

Specifications

Number of terminal:
  Sockets, 6 ea. (Ø4 mm jack (banana))
  DUT interface:
  Inline package socket (3-pin)
  Maximum voltage for terminals:
    3000 Vdc
Maximum current for terminals:
  For Force
    39 A (DC), 500 A (Pulse)
  For sense
    1A (DC), 20 A (Pulse)

N1265A-011 Universal Socket Module

Specifications

Number of terminal:
  Sockets, 6 ea. (Ø4 mm jack (banana))
Maximum voltage for terminals:
  3000 Vdc
Universal blank area :
  90 mm (W) x 81 mm (D)

N1265A-013 Curve Tracer Test Adapter Socket Module

Specifications

Number of terminals: Sockets, 6 ea. (Ø4 mm jack (banana))
Test adapter interface:*
  Sockets, 6 ea. (Ø4 mm jack (banana))
Maximum voltage at terminals:
  3000V Vdc
Maximum current for terminals:
  For Collector/Drain Force and Emitter/Source Force
    39 A (DC), 500 A (Pulse)
  For others
    1A (DC), 20 A (Pulse)

*A test adapter for Tektronix curve tracers (370B/371B) can be connected to this interface.

N1265A-014 Gate Charge Socket Adapter

Purpose
To make gate charge measurements with the N1265A.

Required Hardware
- N1265A UHC expander, 1 ea.
- B1513B/C HVSMU, 1 ea.
- B1514A MCSMU, 2 ea.

Specifications
Number of terminals: Sockets, 8 ea. (Ø4 mm jack (banana))
Maximum voltage at terminals:
For Gate DUT High:30 V
For Gate DUT Low: 10 V
For selector force High: 3000 V
For selector force Low: 10 V
For selector sense High: 3000 V
For selector sense Low: 10 V
For SMU control High: 30 V
For SMU control Low: 10 V
Maximum current for terminals:
For Gate DUT High:1 A
For Gate DUT Low: 1 A
For selector force: 500 A
For selector sense: 20 mA
For SMU control: 1 A

Furnished accessories
- Ultra high current banana test lead, 2 ea.
- Test lead (red), short, 2 ea.
- Test lead (black), short, 2 ea.
- Test lead (red), long, 2 ea.
- Test lead (black), long, 2 ea.

N1265A-035 Universal R-Box for N1265A

Specifications
Input: 4 ea. (Ø4 mm plug (banana))
High (Force, Sense)
Low (Force, Sense)
Output terminals: 2 ea. (Ø4 mm jack (banana))
High, Low
Resistance: Installed by a user
Maximum voltage for terminals: ±200 V

N1265A-040 10 kV Ultra High Voltage Gate Protection Adapter

Specifications
Input: 4 ea. (Ø4 mm plug (banana))
High (Force, Sense)
Low (Force, Sense)
Output terminals: 2 ea. (Ø4 mm jack (banana))
High, Low
Maximum voltage: ±200 V
Maximum surge voltage: ±10 kV

N1265A-041 Thermocouple, Type K, 2 ea

Feature
N1265A-041 can be connected to Thermocouple terminal inside the N1265A and enables B1505A to read out temperature at the top of the thermocouple.

Specifications
Connector: Type K plug
Length: 3000 mm

N1265A-045 Container for Protection Adapter and Bias Tee

Feature
N1265A-045 can accommodate protection adapters and bias tee which are used with N1265A to make the measurement environment clean and safe

Specifications
Dimension: 420 mm W x 193 mm H x 565 mm D
Weight: 15 kg
Maximum superimposed load: 50 kg

N1269A Ultra High Voltage Connection Adapter

Feature
To make the connection simple and to protect measurement resources from unexpected surge when connecting UHVU to wafer prober.

Specifications
Input terminals:
Gate MCSMU Force, 1ea (Triaxial)
Gate MCSMU Sense, 1ea (Triaxial)
Chuck MCSMU Force, 1ea (Triaxial)
Chuck MCSMU Sense, 1ea (Triaxial)
UHV Low, 1ea (HV triaxial)
Output terminals: 3ea (SHV)
Gate, Chuck, Source
Maximum voltage: ±200 V
Maximum surge voltage: ±10 kV

N1271A Thermal test enclosure

Operation Condition
Temperature: +5 °C to 30 °C
Humidity: 20% to 70% RH, Non-condensing
Accuracy specifications degrade by a factor of 3x versus measurements made without the thermal enclosure. (Supplemental characteristics)

Common furnished accessories:
200 mm high current cable, 2 ea.
300 mm high current cable, 2 ea.
200 mm normal cable, 6 ea.
300 mm normal cable, 4 ea.
Banana pin adapter, 14 ea.
Mini alligator clip, 10 ea.

Large clip, 4 ea.

N1271A-001 Thermal plate compatible enclosure for N1259A/N1265A

Purpose
Supports placement of the inTEST Thermal Plate within the test fixtures (N1259A/N1265A) to enable temperature dependency measurements up to 250 °C.

N1271A-002 Thermostream compatible enclosure for N1265A (3kV IV)

Purpose

To enable thermal testing by creating an interface between the N1265A and an inTEST Thermostream. The enclosure supports fully automated IV temperature measurements from -50 °C. to +220 °C.

Specifications

Accuracy specifications degrade by a factor of 3x versus measurements made without the thermal enclosure.
(Supplemental characteristics)

Number of channels
SMU: 6 (When using non-Kelvin connections), 3 (When using Kelvin connections)
Gate: 1
Selector output: 1

N1271A-005 Thermostream compatible enclosure for N1265A (3kV IV, CV & 10kV)

Purpose

To enable thermal testing by creating an interface between the N1265A and an inTEST Thermostream. The enclosure supports fully automated IV and CV measurements up to 3 kV, and IV measurements up to 10 kV at temperature ranging from -50 °C. to +220 °C.

Specifications

Accuracy specifications degrade by a factor of 3x versus measurements made without the thermal enclosure.
(Supplemental characteristics)

Number of channels
SMU: 4 (When using non-Kelvin connections), 2 (When using Kelvin connections)
Gate: 1
Gate with protection resistor for UHV: 1
Selector output: 1
UHV: 1
Capacitance: 1

N1273A Capacitance Test Fixture

Purpose

To enable packaged device capacitance testing in conjunction with the N1272A Device Capacitance Selector.
Specifications
Input terminals:
Collector/Drain (SHV) 3000V 20mA
Base/Gate (SHV) 100V 100mA
Emitter/Source (SHV) 100V 120mA
AC/DC Guard (SHV) 3000V 100mA
Interlock port, 1 ea.
Earth terminal

High voltage indicator:
LED turns red when a SMU output is over 42V.
Maximum voltage for SHV port: 3 kV

Furnished accessories
- System cable between selector and test fixture (SHV x 4, Interlock, Earth), 1 ea.
- 3-pin Inline Package Socket Module, 1 ea
- 200 mm normal cable, 4 ea.
- Banana pin adapter, 4 ea.
- Mini alligator clip, 4 ea.
- M5 8 mm Torx pan head screw, 2 ea.

N1273A-011 Universal Socket Module

Specifications

Number of terminals: Sockets, 6 ea. (Ø4 mm jack (banana))
Maximum voltage for terminals: 3 kV
Furnished accessories:
Test wire for thermal test (2 m)
Lag connectors x 14
Screws

N1273A-013 Curve Tracer Test Adapter Socket Module

Specifications

Number of terminals: Sockets, 6 ea. (Ø4 mm jack (banana))
(Sense terminals of this adapter are open. Only force terminals are connected to output terminals of N1273A.)
Maximum voltage for terminals: 3 kV 100mA
*A test adapter for Tektronix curve tracers (370B/371B) can be connected to this interface.

N1274A On-Wafer Gate Charge measurement adapter/selector for 20 A/3 kV

Purpose

To enable gate charge measurements on-wafer using the HCSMU (20 A) and HVSMU (3 kV).
Note: The connection changes to switch between IV measurement and gate charge measurement are automatically performed via high voltage/high current switches in the N1258A module selector and relays in the N1274A.

Required Hardware

The following modules and accessories are required in addition to the N1274A.
N1258A Module selector
B1513B/B1513C HVSMU
B1514A MCSMU x 2
Current control MOSFET/IGBT

Specifications

Input terminals (Connector) [Maximum voltage/current]:
- Current control MCSMU Force (Triaxial) [±30 V/1 A]
- Current control MCSMU Sense (Triaxial) [±30 V/1 A]
- DUT Gate control MCSMU/HCSMU Force (Triaxial) [±30 V/1 A]
- DUT Gate control MCSMU/HC-

SMU Sense (Triaxial) [±30 V/1 A]
- High Force (HV triaxial) [±3 kV/20 A]
- High Sense (HV triaxial) [±3 kV/20 A]
- Low Force (BNC) [±40 V/20 A]
- Low Sense (BNC) [±40 V/1 A]
- Relay control port (D-sub 15 pin)

Output terminal (Connector) [Maximum voltage/current]:
- High Force (banana) [±30 V/1 A]
- High Sense (HV triaxial) [±30 V/1 A]
- Low Force (banana) [±30 V/1 A]
- Low Sense (banana) [±30 V/1 A]
- Gate (BNC) [±40 V/20 A]

DC leakage:
- 1 nA at 3000 V (for HVSMU)
- 1 nA at 100 V (for MPSMU)
- 1 nA at 200 V (for HPSMU)
- 1 nA at 40 V (for HCSMU)

Furnished cables
- HCSMU cable 30 cm, 2 ea.
- HVSMU cable 35 cm, 1 ea.
- HVTraiaxial plug coax cable 35 cm, 1 ea.
- Relay control cable 30 cm, 1 ea.

N1275A On-Wafer Gate Charge measurement adapter for N1265A

Purpose
To enable on-wafer gate charge measurements with the UHCU (500 A) and HVSMU (3 kV)

Note: Unlike the N1274A, switching between IV and Qg requires manual connection changes.

Required Hardware
The following modules and accessories are required in addition to the N1274A.
- N1265A Ultra High Current Expander
- N1254A-524 Prober System Cable
- B1513B/B1513C HVSMU
- B1514A MCSMU x 2
- Current control MOSFET/IGBT

Specifications
Input terminals (Connector) [Maximum voltage/current]:
- Current control MCSMU Force (Triaxial) [±30 V/1 A]
- Current control MCSMU Sense (Triaxial) [±30 V/1 A]
- High Force from N1254A Opt524 (banana) [±60 V/500 A]
- Low Sense from N1254A Opt524 (BNC) [±10 V/1 A]
- Output terminal (Connector) [Maximum voltage/current]:
- High Force to DUT (banana) [±60 V/500 A]
- Low Sense to DUT (banana) [±10 V/1 A]
- Gate (BNC) [±40 V/20 A]

Furnished cables
- Ultra high current banana to banana cable (30 cm), 1 ea.
- BNC cable (30 cm), 1 ea.

Keysight EasyEXPERT Software

Keysight EasyEXPERT, resident GUI-based software running on the B1505A's embedded Windows 7 platform, supports efficient and repeatable device characterization ranging from interactive manual measurements all the way up to test automation across a wafer in conjunction with an automatic wafer prober. With hundreds of ready-to-use measurements (application tests) furnished at no charge, EasyEXPERT makes it easy to perform complex device characterization immediately. The EasyEXPERT GUI can be accessed using the B1505A's 15-inch touch screen, as well as through an optional USB keyboard and mouse. EasyEXPERT also allows you the option of storing the test conditions and measurement data automatically after each measurement into unique workspaces. This ensures that valuable information is not lost and that measurements can be repeated at a later date. Finally, EasyEXPERT has built-in analysis capabilities and a graphical programming environment that facilitate the development of complex testing algorithms.

Key features:
- Ready-to-use application test library
- Multiple measurement modes (application test, classic test, tracer test, oscilloscope view and quick test)
- Multiple measurement functions (spot, sweep, time sampling, C-V, C-f, C-t, etc.)
- Data display, analysis and arithmetic functions
  Workspace and data management
- External instrument control
- Multiple programming methods (EasyEXPERT remote control and FLEX GPIB control)
- Multiple interface (USB, LAN, GPIB and digital I/O)

Device Type	Application Tests
Power MOSFET (Si, GaN)	Id-Vds, Rds-Id, Id-Vgs, Vth, Cgs, Cds, Cgd, Current collapse, Breakdown, QSCV, etc.
IGBT	Ic-Vce, Ic-Vge, Vth, Cge, Cce, Cgc, Breakdown, etc.
SiC	Id-Vds, Rds-Id, Id-Vgs, Vth, Cgs, Cds, Cgd, Breakdown, QSCV, etc.
Power BJT	Ic-Vce, Vce(sat), Ic-Vcbo, Ic-Vceo, Ie-Vbeo, etc.
Power Diode	If-Vf, Ir-Vr, Cj-Vr, etc.
Capacitor	C-V, C-f, C-t, leak-V, Breakdown, TDDB, etc.
And more	And more

Application library

EasyEXPERT comes with over 40 application tests conveniently organized by device type, application, and technology. You can easily edit and customize the furnished application tests to fit your specific needs. Application tests are provided for the following categories; they are subject to change without notice.

Measurement modes and functions

Operation mode:

Application test mode

The application test mode provides application oriented point-and-click test setup and execution. An application test can be selected from the library by device type and desired measurement, and then executed after modifying the default input parameters as needed.

Classic test mode

The classic test mode provides function oriented test setup and execution with the same look, feel, and terminology of the 4155/4156 user interface. In addition, it improves the 4155/4156 user interface by taking full advantage of EasyEXPERT's GUI features.

Tracer test mode

The tracer test mode offers intuitive and interactive sweep control using a rotary knob similar to a curve tracer. Just like an analog curve tracer, you can sweep in only one direction (useful for R&D device analysis) or in both directions (useful in failure analysis applications). Test set ups created in tracer test mode can be seamlessly and instantaneously transferred to classic test mode for further detailed measurement and analysis.
Each SMU can sweep using VAR1 (primary sweep), VAR2 (secondary sweep), or VAR1' (synchronous sweep).

Oscilloscope view

The oscilloscope view (available in tracer test mode) displays measured current or voltage data versus time. The pulsed measurement waveforms appear in a separate window for easy verification of the measurement timings. This function is useful for verifying waveform timings and debugging pulsed measurements. The following modules are supported in this view: HCSMU, MCSMU, HVSMU, UHCU, HVMCU, and UHVU. The oscilloscope view can display the pulsed waveform timings at any (user specified) sweep step of the sweep output.

Sampling interval:
2 µs (HCSMU/MCSMU/UHCU/HVMCU/UHVU)
6 µs (HVSMU)

Sampling points:
2000 Sa (HCSMU/MCSMU/UHCU/HVMCU/UHVU)
4000 Sa (HVSMU)

Marker function:
Read-out for each data channel
Resolution: 2µs

Data saving:
Numeric: Text/CSV/XMLSS
Image: EMF/BMP/JPG/PNG

Quick test mode

A GUI-based Quick Test mode enables you to perform test sequencing without programming. You can select, copy, rearrange and cut-and-paste any application tests with a few simple mouse clicks. Once you have selected and arranged your tests, simply click on the measurement button to begin running an automated test sequence.

Measurement modes:

The Keysight B1505A supports the following measurement modes:

- IV measurement
  - Spot
  - Staircase sweep
  - Pulsed spot
  - Pulsed sweep
  - Staircase sweep with pulsed bias
  - Sampling
  - Multi-channel sweep
  - Multi-channel pulsed sweep
  - List sweep
  - Linear search[1]
  - Binary search[1]
- C measurement
  - Spot C
  - CV (DC bias) sweep
  - Pulsed spot C
  - Pulsed sweep CV
  - C-t sampling
  - C-f sweep
  - CV (AC level) sweep
  - Quasi-Static CV (QSCV)

1. Supported only by FLEX commands.

Sweep measurement

Number of steps: 1 to 10001 (SMU), 1 to 1001 (CMU)
Sweep mode: Linear or logarithmic (log)
Sweep direction: Single or double sweep
Hold time:
0 to 655.35 s, 10 ms resolution

Recommended GPIB I/F

		Interface	B1505A
Keysight	82350B	PCI	✓[1]
	82357A	USB	✓[2]
	82357B	USB	✓[2]
National Instrument	GPIB-USB-HS	USB	✓[2]

1. An 82350B card is highly recommended because of stability and speed.
2. USB GPIB interfaces might cause serial poll error intermittently due to the intrinsic communication scheme differences. It is reported that using an even GPIB address sometimes significantly decreases the chance of the error. The NI GPIB-USB-HS is recommended for stability, and the Agilent 82357B is recommended for speed.

Delay time:
0 to 65.535 s, 100 µs resolution
0 to 655.35 s, 100 µs resolution
(CV (AC level) sweep, C-f sweep)
Step delay time:
0 to 1 s, 100 µs resolution
Step output trigger delay time:
0 to (delay time) s, 100 µs resolution
Step measurement trigger delay time:
0 to 65.535 s, 100 µs resolution

Sampling (time domain) measurement

Displays the time sampled voltage/current data (by SMU) versus time.
Sampling channels: Up to 10
Sampling mode: Linear, logarithmic (log)
Sampling points:
For linear sampling:
1 to 100,001/(number of channels)
For log sampling:
1 to 1+ (number of data for 11 decades)
Sampling interval range:
100 µs to 2ms, 10µs resolution
2 ms to 65.535 s, 1 ms resolution
For < 2ms, the interval is ≥ 100 µs +20 µs x (num. of channels – 1)
Hold time, initial wait time:
-90 ms to -100 µs, 100 µs resolution
0 to 655.35 s, 10 ms resolution
Measurement time resolution: 100 µs

Other measurement characteristics

Measurement control
Single, repeat, append, and stop
SMU setting capabilities
Limited auto ranging, voltage/current compliance, power compliance, automatic sweep abort functions, self-test, and self-calibration
Standby mode
SMUs in "Standby" remain programmed to their specified output value even as other units are reset for the next measurement.
Bias hold function
This function allows you to keep a source active between measurements. The source module will apply the specified bias between measurements when running classic tests inside an application test, in quick test mode, or during a repeated measurement. The function ceases as soon as these conditions end or when a measurement that does not use this function is started.
Current offset cancel
This function subtracts the offset current from the current measurement raw data, and returns the result as the measurement data. This function is used to compensate the error factor (offset current) caused by the measurement path such as the measurement cables, manipulators, or probe card.
Time stamp
The B1505A supports a time stamp function utilizing an internal quartz clock.
Resolution: 100 µs

Data display, analysis and arithmetic functions

Data Display

X-Y graph plot
X-axis and up to eight Y-axes, linear and log scale, real time graph plotting. X-Y graph plot can be printed or stored as image data to clip board or mass storage device. (File type: bmp, gif, png, emf)
Scale:
Auto scale and zoom
Marker:
Marker to min/max, interpolation, direct marker, and marker skip
Cursor:
Direct cursor
Line:
Two lines, normal mode, grad mode, tangent mode, and regression mode.
Overlay graph comparison:
Graphical plots can be overlaid.
List display
Measurement data and calculated user function data are listed in conjunction with sweep step number or time domain sampling step number. Up to 20 data sets can be displayed.

Data variable display
Up to 20 user-defined parameters can be displayed on the graphics screen.

Automatic analysis function

On a graphics plot, the markers and lines can be automatically located using the auto analysis setup. Parameters can be automatically determined using automatic analysis, user function, and read out functions.

Analysis functions
Up to 20 user-defined analysis functions can be defined using arithmetic expressions. Measured data, predefined variables, and read out functions can be used in the computation. The results can be displayed on the LCD.

Read out functions
The read out functions are built-in functions for reading various values related to the marker, cursor, or line.

Arithmetic functions

User functions
Up to 20 user-defined functions can be defined using arithmetic expressions.
Measured data and pre-defined variables can be used in the computation. The results can be displayed on the LCD.

Arithmetic operators
+, -, *, /, ^, abs (absolute value), at (arc tangent), avg (averaging), cond (conditional evaluation), delta, diff (differential), exp (exponent), integ (integration), lgt (logarithm, base 10), log (logarithm, base e), mavg (moving average), max, min, sqrt, trigonometric function, inverse trigonometric function, and so on.

1. In case of some supplemental characteristics, humidity range is defined as 20% to 50% RH

Physical constants

Keyboard constants are stored in memory as follows:
q: Electron charge, 1.602177E-19 C
k: Boltzmann's constant, 1.380658E-23
ε (e): Dielectric constant of vacuum, 8.854188E-12

Engineering units

The following unit symbols are also available on the keyboard:
a (10^{-18}), f (10^{-15}), p (10^{-12}), n (10^{-9}), u or μ (10^{-6}), m (10^{-3}), k (10^{3}), M (10^{6}), G (10^{9}), T (10^{12}) , P (10^{15})

Workspace and data management

Workspace

Workspaces are separate work environments residing on the B1505A's internal hard disk drive. Every workspace supports the following features:

- Setup and execute the measurement
- Save/Recall"My Favorite Setups"
- Save/Recall measurement data and settings
- Import/Export device definition, measurement settings, my favorite setup, measurement data, and application library
- Test result data management
- Private/public accessibility setting

Data auto record / auto export

EasyEXPERT has the ability to automatically store the measurement setup and data within a workspace. It can also export measurement data in real time, in a variety of formats. You can save data to any storage drive connected to the instrument's PC.

Import/export files

File type:

Keysight EasyEXPERT format, XML-SS format, CSV format

Workspace management

The EasyEXPERT has the ability to import/export a workspace for back-up and portability.

External instrument control

External instruments supported by application tests:

Keysight 4284A/E4980A, 81110A, 3458A

Prober control

Popular semi- or full-automatic wafer probers are supported by EasyEXPERT. You can define wafer, die, and module information for probing across an entire wafer. You can also combine wafer prober control with either Quick Test mode or an application test based test sequence to perform multiple testing on various devices across the wafer.

Program and interface capabilities

Data storage

Hard disk drive, DVD-R drive

Interfaces

GPIB, interlock, USB (USB 2.0, front 2, rear 2), LAN (1000BASE-T/100BASE-TX/10BASE-T), trigger in/out, digital I/O, VGA video output

Remote control capabilities

- FLEX commands (GPIB)
- EasyEXPERT remote control function (LAN)

Trigger I/O

This feature is only available using GPIB FLEX commands.
Trigger in/out synchronization pulses before and after setting and measuring DC voltage and current. Arbitrary trigger events can be masked or activated independently.

Furnished software

- Prober control execution files
- Desktop EasyEXPERT software
- 4155/56 setup file converter tool
- This tool can convert 4155 and 4156 measurement setup files (file extensions MES or DAT) into equivalent EasyEXPERT/Desktop EasyEXPERT classic test mode setup files.
- MDM file converter

This tool can convert data in the EasyEXPERT file formats (XTR/ZTR) to Keysight IC-CAP MDM file format.

Only the following Classic Mode measurements made using EasyEXPERT are supported:

- IV Sweep
- Multi-channel IV Sweep
- CV Sweep

Supported operating systems:

Microsoft Windows XP Professional (Service Pack 3 or later), Windows Vista Business (Service Pack 2 or later (32bit only)), and Windows 7 Professional (Service Pack 1 or later (32bit and 64bit))

Supported language: English (US))

Supported .NET Framework:
Microsoft .NET Framework 3.5 SP1

General specification

Temperature range

Operating: +5 °C to +40 °C
Storage: -20 °C to +60 °C

Humidity range[1]

Operating: 20% to 70% RH, non-condensing
Storage: 10% to 90% RH, non-condensing
Storage: 20% to 80% RH, non-condensing (N1268A)

Altitude

Operating: 0 m to 2,000 m (6,561 ft)
Storage: 0 m to 4,600 m (15,092 ft)
0 m to 2,000 m (6,561 ft) (N1268A)

Power requirement
ac Voltage: 90 V to 264 V
Line Frequency: 47 Hz to 63 Hz

Maximum volt-amps (VA)
B1505A: 900 VA
N1258A: 65VA
N1259A-300: 35VA
N1265A: 400 VA
N1266A: 60 VA
N1268A: 350 VA
N1272A: 70 VA

Acoustic Noise Emission
Lpa < 65 dB
Lwa: 66 dB (Operating mode)
Lwa: 73 dB (Worst case mode)

About measurement accuracy
RF electromagnetic field and SMU measurement accuracy: SMU voltage and current measurement accuracy can be affected by RF electromagnetic field strengths greater than 3 V/m in the frequency range of 80 MHz to 1 GHz. The extent of this effect depends upon how the instrument is positioned and shielded.

Induced RF field noise and SMU measurement accuracy:
SMU voltage and current measurement accuracy can be affected by induced RF field noise strengths greater than 3 Vrms in the frequency range of 150 kHz to 80 MHz. The extent of this effect depends upon how the instrument is positioned and shielded.

Regulatory compliance
EMC:
- IEC 61326-1 / EN 61326-1
- Canada: ICES/NMB-001
- AS/NZS CISPR 11

Safety:
- IEC61010-1 / EN 61010-1
- CAN/CSA-C22.2 No. 61010-1

Certification
CE, cCSAus, RCM

Dimensions
B1505A:
420 mm W x 330 mm H x 575 mm D
N1258A module selector:
330 mm W x 120 mm H x 410 mm D
N1259A test fixture:
420 mm W x 272 mm H x 410 mm D
N1260A High voltage bias-tee:
164 mm W x 53 mm H x 125 mm D
N1261A-001 HPSMU protection adapter (Triaxial output):
80 mm W x 40 mm H x 110 mm D
N1261A-002 GNDU protection adapter (BNC output):
80 mm W x 40 mm H x 110 mm D
N1261A-003 HPSMU protection adapter (HV triaxial output):
90 mm W x 40 mm H x 140 mm D
N1261A-004 GNDU protection adapter (SHV output):
80 mm W x 40 mm H x 125 mm D
N1262A resister box:
50 mm W x 40 mm H x 125 mm D
N1265A UHC expander / fixture:
420 mm W x 285mm H x 575 mm D
N1266A HVSMU current expander:
420 mm W x 75 mm H x 575 mm D
N1267A HVSMU / HCSMU fast switch:
202 mm W x 56 mm H x 175 mm D
N1268A UHV expander:
420 mm W x 222 mm H x 482 mm D
N1269A Ultra High Voltage Connection Adapter:
134 mm W x 56 mm H x 150 mm D
N1271A-001 Thermal plate compatible enclosure for N1259A/N1265A
500 mm W 190 mm H 365 mm D
N1271A-002 Thermostream compatible enclosure for N1265A (3kV IV)
330 mm W 340 mm H 430 mm D
N1271A-005 Thermostream compatible enclosure for N1265A (3kV IV, CV & 10kV)
330 mm W 340 mm H 430 mm D
N1272A
420 mm W x 75 mm H x 575 mm D
N1273A:
340 mm W x 200 mm H x 345 mm D
N1274A:
330 mm W x 90 mm H x 410 mm D
N1275A:
116 mm W x 78 mm H x 125 mm D

Weight
B1505A (empty): 20 kg
B1511B: 1.1 kg
B1510A: 2.0 kg
B1512A: 2.1 kg
B1513C: 2.0 kg
B1514A: 1.3 kg
B1520A: 1.3 kg
N1258A: 5.0 kg
N1259A: 12.0 kg
N1260A: 0.6 kg
N1261A: 0.3 kg
N1262A: 0.3 kg
N1265A: 30 kg
N1266A: 10 kg
N1267A: 0.8 kg
N1268A: 18 kg
N1269A: 0.4 kg
N1271A-001: 4.5 kg
N1271A-002: 10.5 kg
N1271A-005: 10.5 kg
N1272A: 9.4 kg
N1273A: 0.7 kg
N1274A: 3.2 kg
N1275A: 0.4 kg

Furnished accessories
Measurement cables and adapter
- Triaxial cable for HPSMU, MPSMU and MCSMU, 2 ea.
- HCSMU cable, 1 ea.
- HCSMU Kelvin adapter, 1 ea.
- HVSMU cable, 1 ea.

Interlock cable, 1 ea.
Ground unit cable, 1 ea.
Keyboard, 1 ea.
Mouse, 1 ea.
Stylus pen, 1 ea.
Power cable, 1 ea.
Manual CD-ROM, 1 ea.
Desktop EasyEXPERT CD-ROM, 1 ea.
License-to-use for EasyEXPERT and Desktop EasyEXPERT,
Software CD-ROM (including utility tools)
Disk set for Keysight 4155B/4155C/4156B/4156C firmware update, 1 set
SMU number label for the B1505A installed with SMU, 1 sheet
N1258A : Digital I/O cable, 1 ea.
N1259A-300 : Digital I/O cable, 1 ea.
N1265A : Digital I/O cable, 1 ea.
N1266A : Digital I/O cable, 1 ea.
N1268A : Digital I/O cable, 1 ea., Interlock cable, 1 ea.
N1272A : Digital I/O cable 1.5m, 1 ea HVSMU cable 1.5 m, 1 ea.

Order Information

Mainframe and modules	
B1505A	Power Device Analyzer/Curve Tracer mainframe
	Configure the following modules: High power SMU (HPSMU) Medium power SMU (MPSMU) High current SMU (HCSMU) Medium current SMU (MCSMU) High voltage SMU (HVSMU) Multi frequency CMU (MFCMU)
B1505A-015	1.5 m cable
B1505A-030	3.0 m cable
B1505A-050	50 Hz line frequency
B1505A-060	60 Hz line frequency
B1505A-A6J	ANSI Z540 compliant calibration
B1505A-UK6	Commercial calibration certificate with test data
B1505A-ABA	English documentation
B1505A-ABJ	Japanese documentation
B1500A-1CM	Rackmount kit
B1505A expanders/fixtures	
N1259A	Test fixture
N1259A-010	Inline package socket module (3 pin)
N1259A-011	Universal socket module
N1259A-012	Blank PTFE board
N1259A-013	Curve Tracer test adaptor socket module
N1259A-014	Gate Charge socket adapter
N1259A-020	High voltage bias-tee
N1259A-021	1 MΩ Resistor box
N1259A-022	100 kΩ Resistor box
N1259A-030	1 kΩ Resistor box for gate
N1259A-035	Universal R-Box
N1259A-300	Module selector
N1265A	UHC expander / fixture
N1265A-010	500 A Ultra High Current 3-pin Inline Package Socket Module
N1265A-011	Universal Socket Module
N1265A-013	Curve Tracer Test Adapter Socket Module
N1265A-014	Gate Charge socket adapter
N1265A-015	1500 A Current Option
N1265A-035	Universal R-Box for N1265A
N1265A-040	10 kV Ultra High Voltage Gate Protection Adapter
N1265A-041	Thermocouple, Type K, 2 ea
N1265A-045	Container for Protection Adapter and Bias Tee
N1266A	High Voltage Source Monitor Unit Current Expander
N1267A	High Voltage Source Monitor Unit / High Current Source Monitor Unit Fast Switch
N1268A	Ultra High Voltage Expander
N1271A	Thermal Test Enclosure
N1271A-001	Thermal plate compatible enclosure for N1259A/ N1265A
N1271A-002	Thermostream compatible enclosure for N1265A (3kV IV)
N1271A-005	Thermostream compatible enclosure for N1265A (3kV IV, CV & 10kV)
N1272A	Device Capacitance Selector
N1273A	Capacitance Test Fixture
N1273A-011	Universal Socket Module
N1273A-013	Curve Tracer Test Adapter Socket Module
N1274A	On-Wafer Gate Charge measurement adapter/selector for 20A/3kV
N1275A	On-Wafer Gate Charge measurement adapter for N1265A
B1505A accessories	
16444A-001	Keyboard
16444A-002	Mouse
16444A-003	Stylus pen
N1253A-100	Digital I/O cable
N1253A-200	Digital I/O BNC box
N1254A-100	Ground unit Kelvin adapter
N1254A-101	Triaxial(m)-BNC(f)
N1254A-102	Triaxial(m)-BNC(m)
N1254A-103	Triaxial(m)-BNC(f)
N1254A-104	Triaxial(f)-BNC(m)
N1254A-105	Triaxial(f)-BNC(m)
N1254A-106	Triaxial(m)-BNC(f)
N1254A-107	Triaxial(m)-BNC(f)
N1254A-500	HV Jack Connector (Solder Type)
N1254A-501	HV Jack /Jack Adapter
N1254A-502	HV plug Connector(Solder Type)
N1254A-503	BNC Coax Cable Assy 1.5m(Open End)
N1254A-504	HVTriax Jack Coax Cable Assy 1.5m(Open End)
N1254A-505	HVTriax Plug Triax Cable Assy 1.5m (Open End)
N1254A-506	HVTriax Plug Coax Cable Assy 1.5m(Open End)
N1254A-507	HVTriax Plug Coax Cable Assy 1.5m
N1254A-508	Test Lead cable Black
N1254A-509	Test Lead cable Red
N1254A-510	Dolphin clip 2 ea. (red and black)
N1254A-511	Cable lag adapter 2 ea. (red and black)
N1254A-512	SHV Cable Assy 250mm
N1254A-513	SHV to Banana
N1254A-514	BNC-Plug Plug
N1254A-515	BNC-Jack-Plug-Jack
N1254A-516	BNC-Jack-Jack-Jack
N1254A-517	Adapter, Trixial Jack to Triaxial Plug
N1254A-518	SHV Cable 1.5 m
N1254A-520	10 kV Ultra High Voltage Open End Cable, 1 m.
N1254A-521	10 kV Ultra High Voltage Jack to Jack Adapter
N1254A-522	1500 A Ultra High Current Banana to Banana Cable, 2 ea.
N1254A-523	1500 A Ultra High Current Banana to Open End Cable, 1 m, 2 ea

Order Information (continued)

B1505A accessories (continued)	
N1254A-524	Ultra High Current Prober System Cable
N1254A-525	SHV Cable Assy 1.5m - SHV Plug To Open-end
N1254A-526	Ultra High Current Cable, 2m, No Connectors At Either End
N1254A-527	PTFE Standoff, Jack, 4 ea.
N1254A-528	PTFE Standoff With Banana Plug, 4 ea.
N1254A-556	Test Leads and Connection Kit for Capacitance Test, 30 cm, 4 ea.
N1254A-557	Test Leads And Connection Kit For Thermal Test with N1271A
N1254A-558	SHV Cable 3m
N1258A	Module selector
N1260A	High voltage bias-tee
N1261A	Protection adapter
N1262A	Resistor box
N1262A-020	Universal R-Box, Triaxial
N1262A-021	Universal R-Box, HV Triaxial to SHV
N1262A-023	Universal R-Box for Ultra High Voltage
N1262A-036	50 Ohm Termination Adapter
SMU cables/accessories	
16493S-001	HCSMU cable (1.5 m)
16493S-002	HCSMU cable (3 m)
16493S-010	HCSMU Kelvin adapter
16493S-011	HCSMU non-Kelvin adapter
16493S-020	Dual HCSMU Kelvin combination adapter
16493S-021	Dual HCSMU combination adapter
16493T-001	High voltage triaxial cable (1.5 m)
16493T-002	High voltage triaxial cable (3 m)
16493U-001	High current BNC cable (1.5 m)
16493U-002	High current BNC cable (3 m)
16494A-001	Triaxial cable (1.5 m)
16494A-002	Triaxial cable (3 m)
16493K-001	Kelvin triaxial cable (1.5 m)
16493K-002	Kelvin triaxial cable (3 m)
16493V-001	10 kV Ultra High Voltage Cable, 1.5 m
16493V-002	10 kV Ultra High Voltage Cable, 3 m
N1269A	Ultra High Voltage Connection Adapter
CMU accessories	
N1300A-001	CMU cable (1.5 m)
N1300A-002	CMU cable (3 m)
Other accessories	
16493G-001	Digital I/O cable (1.5 m)
16493G-002	Digital I/O cable (3 m)
16493J-001	Interlock cable (1.5 m)
16493J-002	Interlock cable (3 m)
16493L-001	GNDU cable (1.5 m)
16493L-002	GNDU cable (3 m)

Retrofit and upgrade kits	
B1505AU	Upgrade kit for B1505A
B1505AU-001	Conversion kit from B1500A to B1505A
B1505AU-010	High power source monitor unit (B1510A)
B1505AU-11B	Medium power source monitor unit (B1511B)
B1505AU-012	High current source monitor unit (B1512A)
B1505AU-13C	High voltage source monitor unit (B1513C)
B1505AU-014	Medium current source monitor unit (B1514A)
B1505AU-020	Multi frequency capacitance measurement unit (B1520A)
B1505AU-SWS	EasyEXPERT Extension support and subscription
N1259AU	Upgrade kit for N1259A
N1265AU	Upgrade kit for N1265A
Package solution	
B1505AP	Pre-configured Power Device Analyzer/Curve Tracer (B1505A w/ modules/fixture)
B1505AP-H20	3 kV / 20 A / Fixture Pack
B1505AP-H21	3 kV / 20 A / C-V / Fixture Pack
B1505AP-H50	3 kV / 500 A / Fixture Pack
B1505AP-H51	3 kV / 500 A / C-V / Fixture Pack
B1505AP-H70	3 kV / 1500 A / Fixture Pack
B1505AP-H71	3 kV / 1500 A / C-V / Fixture Pack
B1505AP-U50	10 kV / 500 A / Fixture Pack
B1505AP-U70	10 kV / 1500 A / Fixture Pack

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A personalized view into the information most relevant to you.

Three-Year Warranty

www.keysight.com/find/ThreeYearWarranty
Keysight's commitment to superior product quality and lower total cost of ownership. The only test and measurement company with three-year warranty standard on all instruments, worldwide.

Keysight Assurance Plans

www.keysight.com/find/AssurancePlans
Up to five years of protection and no budgetary surprises to ensure your instruments are operating to specification so you can rely on accurate measurements.

www.keysight.com/quality
Keysight Technologies, Inc.
DEKRA Certified ISO 9001:2008
Quality Management System

Keysight Channel Partners

www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

www.keysight.com/find/b1505a

Keysight B1500A Semiconductor Device Analyzer
www.keysight.com/find/B1500A

Keysight B2900A Series Precision Source/ Measure Unit
www.keysight.com/find/B2900A

Keysight B1506A Power Device Analyzer for Circuit Design
www.keysight.com/find/B1506A

Keysight B1507A Power Device Capacitance Analyzer
www.keysight.com/find/B1507A

KEYSIGHT TECHNOLOGIES

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at:
www.keysight.com/find/contactus

Americas

Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	0124 229 2010
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100

Europe & Middle East

Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	800 000154
Sweden	0200 882255
Switzerland	0800 805353 Opt. 1 (DE) Opt. 2 (FR) Opt. 3 (IT)
United Kingdom	0800 0260637

For other unlisted countries:
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(BP-02-06-15)

Published in USA, February 27, 2015
5990-3853EN
www.keysight.com