2450

SourceMeter® SMU Instrument

The Model 2450 is Keithley's next-generation SourceMeter source measure unit (SMU) Instrument that truly brings Ohm's law (current, voltage, and resistance) testing right to your fingertips. Its innovative graphical user interface (GUI) and advanced, capacitive touchscreen technology allow intuitive usage and minimize the learning curve to enable engineers and scientists to learn faster, work smarter, and invent easier. The 2450 is the SMU for everyone: a versatile instrument, particularly well-suited for characterizing modern scaled semiconductors, nano-scale devices and materials, organic semiconductors, printed electronics, and other small-geometry and low-power devices. All this combined with Keithley SMU precision and accuracy allow users to Touch, Test, Invent™ with the new favorite go-to instrument in the lab for years to come.

- **Capabilities of analyzers, curve tracers, and I-V systems at a fraction of their cost.**

- **Five-inch, high resolution capacitive touchscreen GUI**

- **0.012% basic measure accuracy with 6½-digit resolution**

- **Enhanced sensitivity with new 20mV and 10nA source/ measure ranges**

- **Source and sink (4-quadrant) operation**

- **Four "Quickset" modes for fast setup and measurements**

- **Built-in, context-sensitive front panel help**

- **Front panel input banana jacks; rear panel input triaxial connections**

- **2450 SCPI and TSP® scripting programming modes**

- **Model 2400 SCPI-compatible programming mode**

- **Front panel USB memory port for data/programming/ configuration I/O**

Learn Faster, Work Smarter, Invent Easier

Unlike conventional instruments with dedicated pushbutton technology and small, obscure, limited-character displays, the 2450 features a five-inch, full-color, high resolution touchscreen that facilitates ease of use, learning, and optimizes overall speed and productivity. A simple icon-based menu structure reduces configuration steps by as much as 50 percent and eliminates the cumbersome multi-layer menu structures typically used on soft-key instruments. Built-in, context-sensitive help enables intuitive operation and minimizes the need to review a separate manual. These capabilities combined with its application versatility make the 2450 the SMU instrument inherently easy to use for basic and advanced measurement applications, regardless of your experience level with SMU instruments.


2450 main home screen.
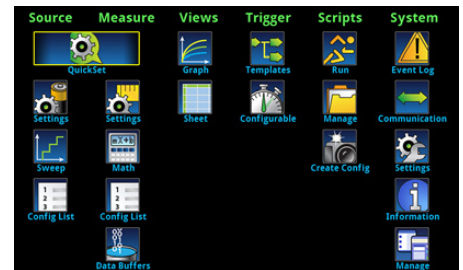
View of 2450 menu.

Fourth-Generation, All-in-One SMU Instrument

The 2450 is the fourth-generation member of Keithley's award-winning SourceMeter family of SMU instruments and leverages the proven capabilities of the Model 2400 SourceMeter SMU Instrument. It offers a highly flexible, four-quadrant voltage and current source/load coupled with precision voltage and current meters. This all-in-one instrument can be used as a:

- Precision power supply with V and I readback
- True current source
- Digital multimeter (DCV, DCI, ohms, and power with 6½-digit resolution).
- Precision electronic load
- Trigger controller
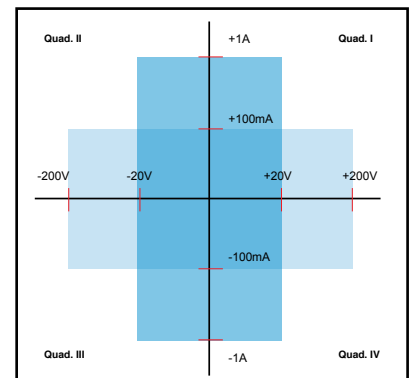
2450 power envelope.

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SourceMeter® SMU Instrument

Ordering Information

2450 — 200V, 1A, 20W SourceMeter Instrument

2450-NFP 200V, 1A, 20W SourceMeter Instrument, with No Front Panel

2450-RACK — 200V, 1A, 20W SourceMeter Instrument, without Handle

2450-NFP-RACK — 200V, 1A, 20W SourceMeter Instrument, with No Front Panel and No Handle

Accessories Supplied

8608 — High Performance Test Leads

USB-B-1 — USB Cable, Type A to Type B, 1m (3.3 ft)

CS-1616-3 Safety Interlock Mating Connector

CA-180-3A TSP-Link/Ethernet Cable

Documentation CD

2450 QuickStart Guide

Test Script Builder Software (supplied on CD)

KickStart Startup Software (supplied on CD)

LabVIEW and IVI Drivers available at www.keithley.com

Model 2400	Model 2450
V-Ranges: 200mV – 200V	V-Ranges: 20mV – 200V
I-Ranges: $1\mu A$ – 1A	I-Ranges: 10nA – 1A
0.012% Basic Accuracy	0.012% Basic Accuracy
Wideband Noise: $4mV_{rms}$ Typ.	Wideband Noise: $2mV_{rms}$ Typ.
Sweep Types: Linear, Log, Custom, Source-Memory	Sweep Types: Linear, Log, Dual Linear, Dual Log, Custom, Source-Memory (SCPI 2400 Mode)
5000 Point Reading Buffer	>250,000 Point Reading Buffer
>2000 Readings/Sec.	>3000 Readings/Sec.
SCPI Programming	SCPI (2400 + 2450) + TSP Programming
GPIB	GPIB, USB, Ethernet (LXI)
Front/Rear Banana Jacks	Front: Banana Jacks, Rear: Triax

Comparison of Model 2400 vs Model 2450.

Ease of Use Beyond the Touchscreen

In addition to its five-inch, color touchscreen, the 2450 front panel has many features that supplement its speed, user-friendliness, and learnability, including a USB 2.0 memory I/O port, a HELP key, a rotary navigation/control knob, a front/rear input selector button, and banana jacks for basic bench applications. The USB 2.0 memory port supports easy data storing, saving instrument configurations, loading test scripts, and system upgrades. Plus, all front panel buttons are backlit to enhance visibility in low-light environments.


Model 2450 front panel with high resolution, capacitive touchscreen.

Four "Quickset" modes simplify user setup. With one touch, the instrument can be quickly configured for various operating modes without the need to configure the instrument indirectly for this operation.

Comprehensive Built-in Connectivity

Rear panel access to rear-input triax connectors, remote control interfaces (GPIB, USB 2.0, and LXI/Ethernet), D-sub 9-pin digital I/O port (for internal/external trigger signals and handler control), instrument interlock control, and TSP-Link® jacks enables easy configuration of multiple instrument test solutions and eliminates the need to invest in additional adapter accessories.
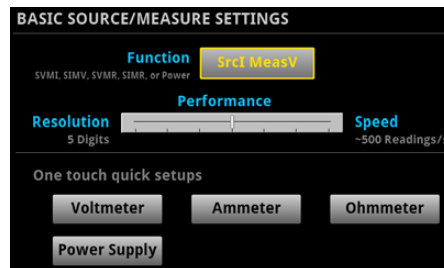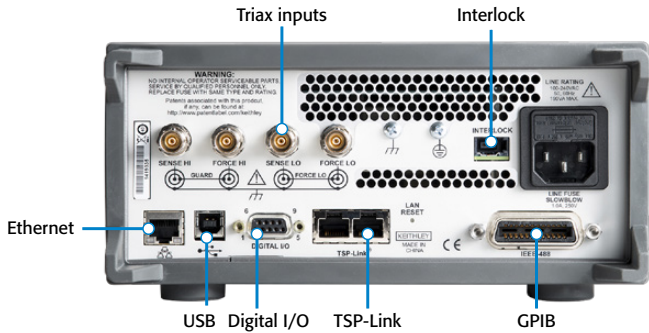

Quickset modes enable fast setup and time to measurements.

SourceMeter® SMU Instrument

Triax inputs   Interlock

Ethernet

USB   Digital I/O   TSP-Link   GPIB

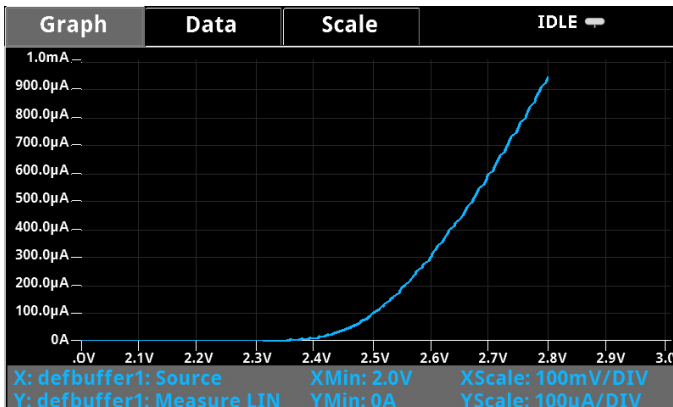**Rear panel connections are optimized for signal integrity.**

Convert Raw Data to Information

The 2450 provides a full plotting and sheet view to display sweeps, measurement data, and charting right on the screen. It also supports exporting to a spreadsheet for further analysis, dramatically improving productivity for research, bench-top testing, device qualification, and debugging.


| Graph | Data | Scale | IDLE |

X: defbuffer1: Source   XMin: 2.0V   XScale: 100mV/DIV
Y: defbuffer1: Measure LIN   YMin: 0A   YScale: 100μA/DIV

DATA SHEET

Buffer   defbuffer1   ↑ ↓   Jump   Refresh

	Time	Source	Measure
1	05/08 09:50	0	-2.51326e-07
2	09:50:03.6	0.1	6.38803e-05
3	09:50:05.3	0.2	0.000127991
4	09:50:05.8	0.3	0.00019225
5	09:50:06.4	0.4	0.000256259
6	09:50:06.9	0.5	0.000320488
7	09:50:07.5	0.6	0.000384533
8	09:50:08.0	0.7	0.000448547
9	09:50:08.6	0.8	0.000512793
10	09:50:09.1	0.9	0.000576823
11	09:50:09.7	1	0.000641066

Full data display, charting, and export to a spreadsheet lets you convert raw data to useful information.

TYPICAL APPLICATIONS

Ideal for current/voltage characterization and functional test of a wide range of today's modern electronics and devices, including:

- **Nanomaterials and Devices**
  - **Graphene**
  - **Carbon nanotubes**
  - **Nanowires**
  - **Low power nanostructures**

- **Semiconductor Structures**
  - **Wafers**
  - **Thin films**

- **Organic Materials and Devices**
  - **E-inks**
  - **Printable electronics**

- **Energy Efficiency and Lighting**
  - **LEDs/AMOLEDs**
  - **Photovoltaics/Solar Cells**
  - **Batteries**

- **Discrete and Passive Components**
  - **Two-leaded: Resistors, diodes, zener diodes, LEDs, disk drive heads, sensors**
  - **Three-leaded: Small signal bipolar junction transistors (BJTs), field effect transistors (FETs), and more**

- **Material Characterization**
  - **Resistivity**
  - **Hall Effect**
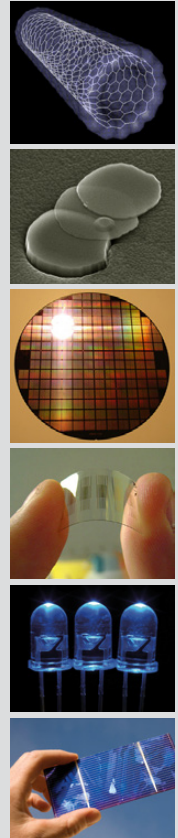
TriggerFlow™ Building Blocks for Instrument Control and Execution

The 2450 incorporates Keithley's new TriggerFlow triggering system that allows user control of instrument execution. Similar to developing a flow chart, TriggerFlow diagrams are created using four fundamental building blocks:

- Wait – Waits for an event to occur before the flow continues

- Branch – Branches when a condition has been satisfied

- Action – Initiates an action in the instrument, for example, measure, source, delay, set digital I/O, etc.

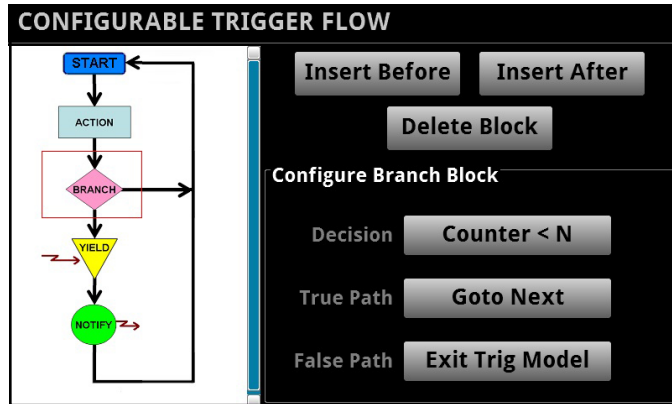- Notify – Notifies other equipment that an event has occurred

SMU INSTRUMENTS

SourceMeter® SMU Instrument

CONFIGURABLE TRIGGER FLOW

TriggerFlow building blocks let users create very simple to very complex triggering models.

A TriggerFlow model using a combination of these building blocks can be created from the front panel or by sending remote commands. With the TriggerFlow system, users can build triggering models from very simple to complex with up to 255 block levels. The 2450 also includes basic triggering functions, including immediate, timer, and manual triggering.

Unmatched System Integration and Programming Flexibility

When the 2450 is integrated as part of a multi-channel I-V test system, the Test Script Processor (TSP®) embedded scripting capability allows test scripts to be run by the instrument, enabling the user to create powerful measurement applications with significantly reduced development times. TSP technology also offers channel expansion without a mainframe. Keithley's TSP-Link® channel expansion bus, which uses a 100 Base T Ethernet cable, connects multiple 2450 instruments and other TSP instruments such as Keithley's Series 2600B SourceMeter SMU instruments and Series 3700A Switch/Multimeter systems in a master-slave configuration that behaves as one integrated system. The TSP-Link expansion bus supports up to 32 units per GPIB or IP address, making it easy to scale a system to fit an application's particular requirements.

The 2450 also includes a SCPI programming mode that optimizes the instrument's new features, as well as a SCPI 2400 mode that provides backwards compatibility with the existing Model 2400 SourceMeter instrument. Not only does this preserve your 2400 investment, but it also eliminates re-work normally associated with upgrading to a new instrument with new capabilities.

Parallel Test Capability

With the TSP technology in the 2450, multiple devices can be tested in parallel to meet the needs of device research, advanced semiconductor lab applications, and even high throughput production test. This parallel testing capability enables each instrument in the system to run its own complete test sequence, creating a fully multi-threaded test environment. The number of tests that can be run in parallel on a 2450 can be as high as the number of instruments in the system.

Free Instrument Control Start-up Software and Web Interface

KickStart, Keithley's new instrument control non-programming start-up software, lets users start taking measurements in minutes. In most cases, users merely need to make quick measurements, graph the data, and store the data to disk to perform analysis in software environments such as Excel.

KickStart offers the following functionality:

- Instrument configuration control to perform I-V characterization
- Native X-Y graphing, panning, and zooming
- Spreadsheet/tabular viewing of data
- Saving and exporting data for further analysis
- Saving of test setups
- Screenshot capturing of graph
- Annotation of tests
- Command line dialog for sending and receiving data
- HTML help
- GPIB, USB 2.0, Ethernet compliant
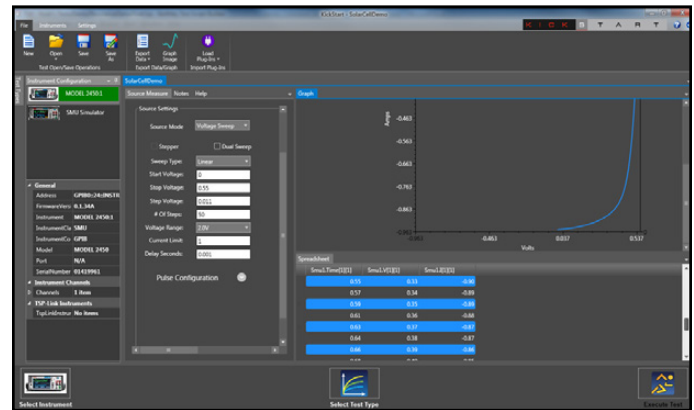
With KickStart start-up software, users are ready to take measurements in minutes.

Simplified Programming with Ready-to-Use Instrument Drivers

For users who want to create their own customized application software, native National Instruments LabVIEW® drivers, IVI-C, and IVI-COM drivers are available at **www.keithley.com**.

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ACCESSORIES AVAILABLE

TEST LEADS AND PROBES

1754	2-wire Universal 10-Piece Test Lead Kit
5804	Kelvin (4-Wire) Universal 10-Piece Test Lead Kit
5805	Kelvin (4-Wire) Spring-Loaded Probes
5806	Kelvin Clip Lead Set
5808	Low Cost Single-pin Kelvin Probe Set
5809	Low Cost Kelvin Clip Lead Set
8605	High Performance Modular Test Leads
8606	High Performance Modular Probe Kit
8608	High Performance Clip Lead Set

CABLES, CONNECTORS, ADAPTERS

237-ALG-2	3-slot Male Triax Connector to 3 Alligator Clips
237-BAN-3A	Triax to Banana Plug
2450-TRX-BAN	Triax to Banana Adapter. Converts the 4 Triax adapters on the rear panel to 5 banana jacks
7078-TRX-*	3-slot, Low Noise Triax Cable
7078-TRX-GND	3-slot Male Triax To BNC Adapter (guard removed)
8607	2-wire, 1000V Banana Cables, 1m (3.3 ft)
CA-18-1	Shielded Dual Banana Cable, 1.2m (4 ft)
CAP-31	Protective Shield/Cap for 3-lug Triax Connectors
CS-1546	Triax 3-lug Special Shorting Plug. Shorts center pin to outer shield
CS-1616-3	Safety Interlock Mating Connector

COMMUNICATION INTERFACES & CABLES

KPCI-488LPA	IEEE-488 Interface for PCI Bus
KUSB-488B	IEEE-488 USB-to-GPIB Interface Adapter
7007-1	Shielded GPIB Cable, 1m (3.3 ft)
7007-2	Shielded GPIB Cable, 1m (6.6 ft)
CA-180-3A	CAT5 Crossover Cable for TSP-Link/Ethernet
USB-B-1	USB Cable, Type A to Type B, 1m (3.3 ft)

TRIGGERING AND CONTROL

2450-TLINK	DB-9 to Trigger Link Connector Adapter.
8501-1	Trigger Link Cable, DIN-to-DIN, 1m (3.3 ft)
8501-2	Trigger Link Cable, DIN-to-DIN, 2m (6.6 ft)

RACK MOUNT KITS

4299-8	Single Fixed Rack Mount Kit
4299-9	Dual Fixed Rack Mount Kit
4299-10	Dual Fixed Rack Mount Kit. Mount one 2450 and one Series 26xxB
4299-11	Dual Fixed Rack Mount Kit. Mount one 2450 and one Series 2400, Series 2000, etc.
2450-BenchKit	Ears and Handle for 2450-NFP-RACK and 2450-RACK models

TEST FIXTURES

8101-PIV	DC Test Fixture

SERVICES AVAILABLE

2450-3Y-EW	1 Year Factory Warranty extended to 3 years from date of shipment
2450-5Y-EW	1 Year Factory Warranty extended to 5 years from date of shipment
C/2450-3Y-17025	KeithleyCare® 3 Year ISO 17025 Calibration Plan
C/2450-3Y-DATA	KeithleyCare 3 Year Calibration w/Data Plan
C/2450-3Y-STD	KeithleyCare 3 Year Std. Calibration Plan
C/2450-5Y-17025	KeithleyCare 5 Year ISO 17025 Calibration Plan
C/2450-5Y-DATA	KeithleyCare 5 Year Calibration w/Data Plan
C/2450-5Y-STD	KeithleyCare 5 Year Std. Calibration Plan

Voltage Specifications[1,2]

		Source			Measure[3]		
		Accuracy (23° ± 5°C) 1 Year	Noise (RMS)			Accuracy (23° ± 5°C) 1 Year	
Range	Resolution	±(% setting + volts)	(<10Hz)	Resolution	Input Resistance	±(% rdg. + volts)	
20.00000 mV	500 nV	0.100% + 200 μV	1 μV	10 nV	>10 GΩ	0.100% + 150 μV	
200.0000 mV	5 μV	0.015% + 200 μV	1 μV	100 nV	>10 GΩ	0.012% + 200 μV	
2.000000 V	50 μV	0.020% + 300 μV	10 μV	1 μV	>10 GΩ	0.012% + 300 μV	
20.00000 V	500 μV	0.015% + 2.4 mV	100 μV	10 μV	>10 GΩ	0.015% + 1 mV	
200.0000 V	5 mV	0.015% + 24 mV	1 mV	100 μV	>10 GΩ	0.015% + 10 mV	

Current Specifications[1,2]

		Source			Measure[3]		
		Accuracy (23° ±5°C)[4] 1 Year	Noise (RMS)			Accuracy (23° ±5°C) 1 Year	
Range	Resolution	±(% setting + amps)	(<10Hz)	Resolution	Voltage Burden	±(% rdg. + amps)	
10.00000 nA[5]	500 fA	0.100% + 100 pA	500 fA	10 fA	<100 μV	0.100% + 50 pA	
100.0000 nA[5]	5 pA	0.060% + 150 pA	500 fA	100 fA	<100 μV	0.060% + 100 pA	
1.000000 μA	50 pA	0.025% + 400 pA	5 pA	1 pA	<100 μV	0.025% + 300 pA	
10.00000 μA	500 pA	0.025% + 1.5 nA	40 pA	10 pA	<100 μV	0.025% + 700 pA	
100.0000 μA	5 nA	0.020% + 15 nA	400 pA	100 pA	<100 μV	0.020% + 6 nA	
1.000000 mA	50 nA	0.020% + 150 nA	5 nA	1 nA	<100 μV	0.020% + 60 nA	
10.00000 mA	500 nA	0.020% + 1.5 μA	40 nA	10 nA	<100 μV	0.020% + 600 nA	
100.0000 mA	5 μA	0.025% + 15 μA	100 nA	100 nA	<100 μV	0.025% + 6 μA	
1.000000 A	50 μA	0.067% + 900 μA	3 μA	1 μA	<100 μV	0.030% + 500 μA	

TEMPERATURE COEFFICIENT (0°–18°C and 28°–50°C): ±(0.15 × accuracy specification)/°C.

1. Speed = 1 PLC.
2. All specifications are guaranteed with output ON.
3. Accuracies apply to 2- and 4-wire mode when properly zeroed.
4. For sink mode, 1μA to 100mA range accuracy is ±(0.15% + offset × 4). For 1A range, accuracy is ±(1.5% + offset × 8).
5. Rear panel triax connections only.

Resistance Measurement Accuracy (Local or Remote Sense)[2,3]

Range	Default Resolution[6]	Default Test Current	Normal Accuracy (23°C ±5°C) 1 Year, ±(% rdg. + ohms)	Enhanced Accuracy[7] (23°C ±5°C) 1 Year, ±(% rdg. + ohms)
<2.000000 Ω[8]	1 $\mu\Omega$	User defined	Source I$_{ACC}$ + Meas. V$_{ACC}$	Meas. I$_{ACC}$ + Meas. V$_{ACC}$
20.00000 Ω	10 $\mu\Omega$	100 mA	0.098% + 0.003 Ω	0.073% + 0.001 Ω
200.0000 Ω	100 $\mu\Omega$	10 mA	0.077% + 0.03 Ω	0.053% + 0.01 Ω
2.000000 kΩ	1 mΩ	1 mA	0.066% + 0.3 Ω	0.045% + 0.1 Ω
20.00000 kΩ	10 mΩ	100 μA	0.063% + 3 Ω	0.043% + 1 Ω
200.0000 kΩ	100 mΩ	10 μA	0.065% + 30 Ω	0.046% + 10 Ω
2.000000 MΩ	1 Ω	1 μA	0.110% + 300 Ω	0.049% + 100 Ω
20.00000 MΩ	10 Ω	1 μA	0.110% + 1 kΩ	0.052% + 500 Ω
200.0000 MΩ	100 Ω	100 nA	0.655% + 10 kΩ	0.349% + 5k Ω
>200.0000 MΩ[8]	—	User defined	Source I$_{ACC}$ + Meas. V$_{ACC}$	Meas. I$_{ACC}$ + Meas. V$_{ACC}$

TEMPERATURE COEFFICIENT (0°–18°C and 28°–50°C): ±(0.15 × accuracy specification)/°C.

SOURCE CURRENT, MEASURE RESISTANCE MODE:
Total uncertainty = Isource accuracy + Vmeasure accuracy (4-wire remote sense).

SOURCE VOLTAGE, MEASURE RESISTANCE MODE:
Total uncertainty = Vsource accuracy + Imeasure accuracy (4-wire remote sense).

GUARD OUTPUT IMPEDANCE: 0.5Ω (DC) in ohms mode.

6. 6.5 digit measure resolution
7. Source readback enabled. Offset compensation ON.
8. Source Current, Measure Resistance or Source Voltage, Measure Resistance only.

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OPERATING CHARACTERISTICS

MAX. OUTPUT POWER:	20W, four-quadrant source or sink operation.
SOURCE LIMITS:	**Vsource:** ±21V (≤ 1A range), ±210V (≤ 100mA range)
	Isource: ±1.05A (≤ 20V range), ±105mA (≤ 200V range)
OVERRANGE:	105% of range, source and measure.
REGULATION:	**Voltage: Line:** 0.01% of range. **Load:** 0.01% of range + 100μV.
	Current: Line: 0.01% of range. **Load:** 0.01% of range + 100pA.
SOURCE LIMITS:	**Voltage Source Current Limit:** Bipolar current limit set with single value. Min. 10% of range.
	Current Source Voltage Limit: Bipolar voltage limit set with single value. Min. 10% of range.
V-LIMIT / I-LIMIT ACCURACY:	Add 0.3% of setting and ±0.02% of reading to base specification.
OVERSHOOT:	**Voltage Source:** <0.1% typical (full scale step, resistive load, 20V range, 10mA I-Limit.
	Current Source: <0.1% typical (1mA step, R_{Load} = 10kΩ, 20V range)
RANGE CHANGE OVERSHOOT:	Overshoot into a fully resistive 100kΩ load, 10Hz to 20MHz BW, adjacent ranges: 250mV typical
OUTPUT SETTLING TIME:	Time required to reach 0.1% of final value, 20V range, 100mA I-Limit: <200μs typical.
MAXIMUM SLEW RATE:	0.2V/μs, 200V range, 100mA limit into a 2kΩ load (typical)
OVER VOLTAGE PROTECTION:	User selectable values, 5% tolerance. Factory default = none.
VOLTAGE SOURCE NOISE:	**10Hz–1MHz (RMS):** 2mV typical into a resistive load.
COMMON MODE VOLTAGE:	250V DC.
COMMON MODE ISOLATION:	>1GΩ, <1000pF.

NOISE REJECTION (TYPICAL):

NPLC	NMRR	CMRR
0.01	—	60 dB
0.1	—	60 dB
1	60 dB	100 dB*

* Except lowest two current ranges ~90dB.

LOAD IMPEDANCE:	20nF typical (standard). Stable into 50μF typical (High-C mode).
	High-C mode valid for ≥100μA ranges, ≥200mV ranges.
MAX. VOLTAGE DROP BETWEEN FORCE and SENSE TERMINALS: 5V.	
MAX. SENSE LEAD RESISTANCE:	1MΩ for rated accuracy.
SENSE INPUT IMPEDANCE:	>10GΩ.
GUARD OFFSET VOLTAGE:	<300μV, typical

System Measurement Speeds [9]

READING RATES (READINGS/SECOND) TYPICAL FOR 60Hz (50Hz):

SCRIPT (TSP) Programmed

	Measure				Source-Measure Sweep			
NPLC/Trigger Origin	To Mem.	To GPIB	To USB	To LAN	To Mem.	To GPIB	To USB	To LAN
0.01 / Internal	3130 (2800)	2830 (2570)	2825 (2600)	2790 (2530)	1710 (1620)	1620 (1540)	1630 (1540)	1620 (1540)
0.01 / External	2170 (2050)	2150 (2030)	2170 (2040)	2160 (1990)	1670 (1590)	1580 (1500)	1590 (1510)	1580 (1510)
0.1 / Internal	540 (460)	530 (450)	530 (450)	530 (450)	470 (410)	460 (400)	470 (400)	470 (400)
0.1 / External	500 (430)	490 (420)	500 (430)	500 (420)	470 (400)	460 (390)	460 (400)	460 (400)
1.00 / Internal	59 (49)	58 (49)	59 (49)	59 (49)	58 (48)	58 (48)	58 (48)	58 (48)
1.00 / External	58 (48)	57 (48)	58 (48)	58 (48)	57 (48)	57 (47)	57 (48)	57 (48)

SCPI Programmed [10]

	Measure				Source-Measure Sweep			
NPLC/Trigger Origin	To Mem.	To GPIB	To USB	To LAN	To Mem.	To GPIB	To USB	To LAN
0.01 / Internal	3130 (2800)	3060 (2760)	3000 (2790)	3010 (2710)	1710 (1630)	1610 (1600)	1440 (1380)	1690 (1590)
0.01 / External	2350 (2200)	2320 (2170)	2340 (2190)	2320 (2130)	1680 (1590)	1560 (1570)	1410 (1360)	1660 (1560)
0.1 / Internal	540 (460)	540 (450)	540 (460)	540 (450)	470 (410)	470 (410)	450 (390)	470 (410)
0.1 / External	510 (440)	510 (430)	510 (440)	510 (430)	470 (400)	470 (400)	450 (390)	470 (400)
1.00 / Internal	59 (49)	59 (49)	59 (49)	59 (49)	58 (48)	58 (48)	57 (48)	58 (48)
1.00 / External	58 (49)	58 (49)	58 (49)	58 (49)	58 (48)	58 (48)	57 (47)	58 (48)

9. Reading rates applicable for voltage or current measurements, autozero off, autorange off, filter off, binary reading format, and source readback off.
10. SCPI programming mode. Speeds do not apply to SCPI 2400 mode.

1.888.KEITHLEY (U.S. only)

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SMU INSTRUMENTS

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GENERAL CHARACTERISTICS (default mode unless specified)

FACTORY DEFAULT STANDARD POWER-UP: SCPI MODE.

SOURCE OUTPUT MODES: Fixed DC Level, Memory/Configuration List (mixed function), Stair (linear and log).

SOURCE MEMORY LIST: 100 points max. (SCPI 2400 Mode only).

MEMORY BUFFER: >250,000 readings. Includes selected measured value(s) and time stamp.

REAL-TIME CLOCK: Lithium battery backup (3 yr. + battery life).

REMOTE INTERFACES:
   GPIB: IEEE-488.1 compliant. Supports IEEE-488.2 common commands and status model topology.
   USB Device (rear panel, type B): 2.0 Full Speed USBTMC.
   USB Host (front panel, type A): USB 2.0, support for flash drives, FAT32.
   Ethernet: RJ-45 (10/100BT)

PROGRAMMABILITY: SCPI or TSP command sets.

TSP MODE: Embedded Test Script Processor (TSP) accessible from any host interface.

IP CONFIGURATION: Static or DHCP

EXPANSION INTERFACE: The TSP-Link expansion interface allows TSP enabled instruments to trigger and communicate with each other.

LXI COMPLIANCE: 1.4 LXI Core 2011.

DISPLAY: 5 inch capacitive touch, color TFT WVGA (800x480) with LED backlight.

INPUT SIGNAL CONNECTIONS: Front: Banana. **Rear:** Triaxial (3-Lug)

INTERLOCK: Active High Input

DIGITAL I/O INTERFACE:
   Lines: 6 Input/Output user defined for digital I/O or triggering
   Connector: 9-pin female D
   Input Signal Levels: 0.7 V (maximum logic low), 3.7 V (minimum logic high)
   Input Voltage Limits: -0.25 V (Abs. minimum), +5.25 V (Abs. maximum)
   Maximum Source Current: +2.0 mA @ >2.7 V (per pin)
   Maximum Sink Current: -50 mA @ 0.7 V (per pin, solid-state fuse protected)
   5 V Power Supply Pin: Limited to 500 mA @ >4V (solid-state fuse protected)
   Handler: User definable Start of Test, End of Test, 4 category bits

COOLING: Forced air, variable speed.

OVER TEMPERATURE PROTECTION: Internally sensed temperature overload puts unit in standby mode.

POWER SUPPLY: 100V to 240V RMS, 50–60Hz (automatically detected at power up).

VA RATING: 190 volt-amps max.

ALTITUDE: Maximum 2000 meters above sea level.

EMC: Conforms to European Union EMC Directive.

SAFETY: NRTL listed to UL61010-1 and UL61010-2-30. Conforms with European Union Low Voltage Directive.

VIBRATION: MIL-PRF-28800F Class 3 Random.

WARM-UP: 1 hour to rated accuracies.

DIMENSIONS: (With handle and bumpers): 106mm high × 255mm wide × 425mm deep (4.18 in × 10.05 in × 16.75 in). (Without handle and bumpers): 88mm high × 213mm wide × 403mm deep (3.46 in × 8.39 in × 15.87 in).

WEIGHT: With bumpers & handle: 4.04 kg (8.9 lbs.). Without bumpers & handle 3.58 kg (7.9 lbs.).

ENVIRONMENT: Operating: 0°–50°C, 70% R.H. up to 35°C. Derate 3% R.H./°C, 35°–50°C.
               Storage: –25°C to 65°C.

ACCESSORIES SUPPLIED: Test Leads, USB Cable, Ethernet/TSP Cable, Interlock Adapter, Power Cord, Quick Start Guide, CD User's Manual.

SourceMeter® SMU Instrument

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SMU INSTRUMENTS

Series 2280S

Precision Measurement, Low Noise, Programmable DC Power Supplies

The Series 2280S Precision Measurement, Low Noise, Programmable DC Power Supplies are much more than just sources of clean power; they are also precision measurement instruments. They can source stable, low noise voltages as well as monitor load currents over a wide dynamic range from amps to nanoamps. The Model 2280S-32-6 can output up to 32V at up to 6A; the Model 2280S-60-3 can output up to 60V at up to 3.2A.

Both supplies use linear regulation to ensure low output noise and superior load current measurement sensitivity. A high resolution color Thin Film Transistor (TFT) screen displays a wide range of information on measurements. Soft-key buttons and a navigation wheel combine with the TFT display to provide an easy-to-navigate user interface that speeds instrument setup and operation. In addition, built-in plotting functions allow monitoring such as drift. These supplies provide the flexibility required for both benchtop and automated test system applications. For example, they provide a list mode, triggers, and other speed optimization functions to minimize test time in automated testing applications.

DMM-Quality Low Current Measurements with High Resolution

Unlike conventional power supplies, Series 2280S supplies can also make measurements with up to $6\frac{1}{2}$ digits of resolution. Voltage output measurements can be resolved down to $100\mu V$. These supplies measure load currents from 100nA to amps and can resolve down to 10nA. Four load current measurement ranges (10A, 1A, 100mA, and 10mA) support measuring a device's full load current, standby mode current, and small sleep mode currents with DMM-quality accuracy. The high resolution allows characterizing small changes in load currents with confidence. It also makes it possible to make a broad range of measurements on a single range with excellent accuracy across both low and high current values.

Measure Rapidly Changing Loads

To monitor fast-changing and pulse-like load currents properly, Series 2280S supplies offer the speed necessary to capture load changes that occur at intervals as short as $140\mu s$. This capability allows designers and manufacturers of portable, battery-operated devices to monitor load currents easily in all of a device's operating modes so they can determine the device's total power consumption.

This high speed measurement capability allows measuring each state of a power-up load sequence and a power-down sequence. Measurements can be made as fast as 2500 readings per second, making it possible to characterize and test the current draw at each of the start-up states.

- **Monitor load currents from 100nA to 6A with high accuracy**
- **Measure voltage and current with 6½-digit resolution**
- **Capture dynamic load currents as short as 140µs**
- **Output up to 192W of low noise, linear regulated power**
- **Programmable rise and fall times eliminate voltage overshoot and undershoot transients**
- **Built-in graphing simplifies analyzing trends or displaying voltage or current waveforms**
- **High resolution TFT display and soft-key/icon-based user interface simplify power supply operation**
- **Programmable output sequences reduce test times**
- **Sink up to 0.45A to discharge voltage quickly**
- **Digital I/O for direct communication with other devices and instruments**
- **GPIB, USB, and LAN interfaces**
- **Built-in web page simplifies automated control/monitoring**
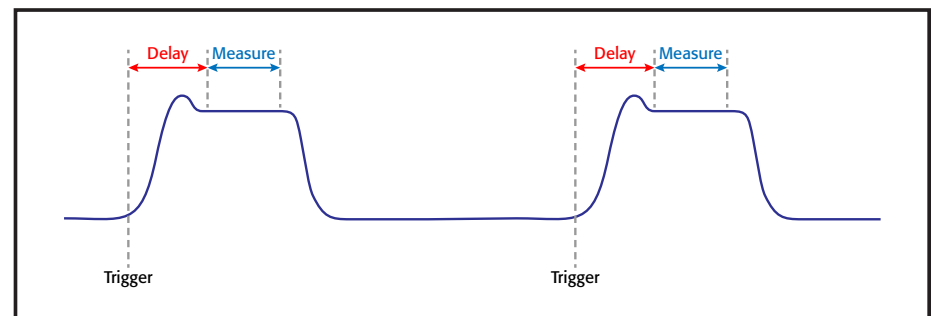- **Automate tests easily with KickStart start-up software**

Figure 1. Make time-critical measurements on fast-changing or pulse-like loads. An external trigger initiates the acquisition. Programmable delay and measure times enable measurements at a specific time on the load current pulse.

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Series 2280S

Precision Measurement, Low Noise, Programmable DC Power Supplies

Ordering Information

2280S-32-6 Precision Measurement DC Power Supply, 32V, 6A

2280S-60-3 Precision Measurement DC Power Supply, 60V, 3.2A

Accessories Supplied

Quick Start Guide

KickStart Quick Start Guide

User Documentation CD

LAN Crossover Cable

Power Cord

Rear Panel Mating Connector with Cover

ACCESSORIES AVAILABLE

|	
2280-001	Rear Panel Mating Connector and Cover
CA-180-3A	LAN Crossover Cable
USB-B-1	USB Cable Type A to B, 1m (3.3 ft)
2450-TLINK	Trigger Link cable to connect 2280S digital I/O to Trigger Link I/O on other Keithley instruments
4299-8	Single Fixed Rack-Mount Kit
4299-9	Dual Fixed Rack-Mount Kit
4299-10	Dual Fixed Rack-Mount Kit for one 2U Graphical Display Instrument and one Series 26xx Instrument
4299-11	Dual Fixed Rack-Mount Kit for one 2U Graphical Display Instrument and one Series 24xx, Series 2000, or 2U Agilent Instrument
KPCI-488LPA	IEEE-488.2 Interface Board for the PCI Bus
KUSB-488B	IEEE-488.2 USB-GPIB Interface Adapter for USB Port with 2m (6.6 ft) cable
7007-05	Double Shielded Premium IEEE-488 Interface Cables, 0.5m (1.6 ft)
7007-1	Double Shielded Premium IEEE-488 Interface Cables, 1m (3.2 ft)
7007-2	Double Shielded Premium IEEE-488 Interface Cables, 2m (6.5 ft)
7007-3	Double Shielded Premium IEEE-488 Interface Cables, 3m (10 ft)
7007-4	Double Shielded Premium IEEE-488 Interface Cables, 4m (13 ft)
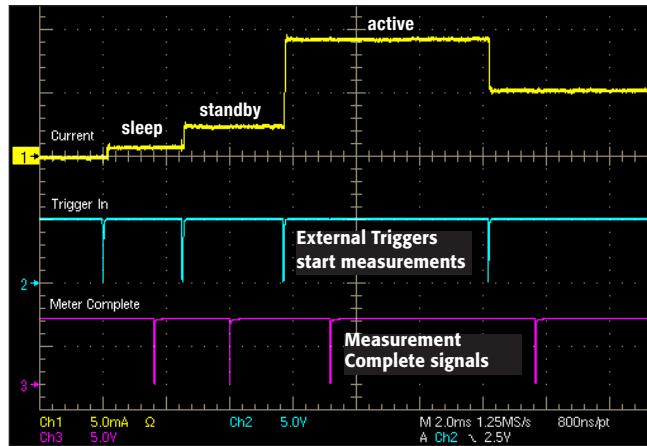
Figure 2. Measure the start-up load currents as a device powers up.

View and Control Every Parameter of the Supply for Maximum Performance

The bright, 4.3-inch TFT display shows voltage and current readings, the source settings and many additional settings in large, easy-to-read characters. The icon-based main menu provides all the functions users can control and program for fast access to source setup, measurement setup, display formats, trigger options, and system settings. Menus are short, and the menu options you need are easy to find and clearly described, so that you can set up test parameters quickly by using the navigation wheel, keypad, or soft-keys. Many set-up parameters, such as for voltage and current settings, can be entered directly from the home screen; less complex tests don't even require accessing the main menu to make adjustments. Whether your test's requirements are uncomplicated or complex, the Series 2280S supplies provide a simple way to set up all the required parameters.

Figure 3. Adjust voltage, current, the current range, the measurement mode, protection levels, and other functions from the home screen.
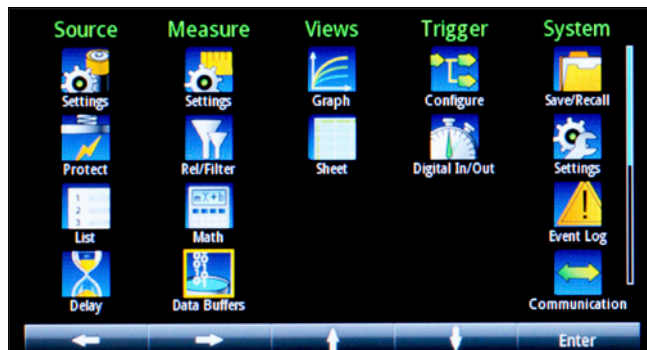

Figure 4. Access the full functionality of the Series 2280S supplies from the main menu.

Series 2280S

Precision Measurement, Low Noise, Programmable DC Power Supplies
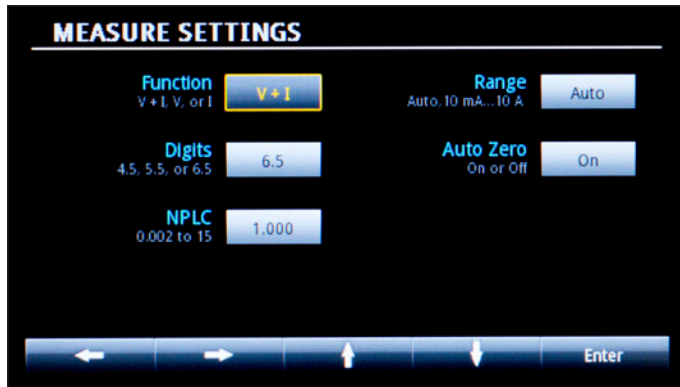

Figure 5. Configure the readback measurements exactly the way you need them using a Measure Sub-screen.

Controlled Rise and Fall Times Protect Devices Under Test

Are you working on a device or a system with a high in-rush current? Series 2280S supplies allow programming the voltage output's rise time to slow the voltage ramp and avoid voltage overshoot, which could potentially damage the DUT. The voltage fall time can also be controlled to prevent a fast ramp down of the output voltage. Voltage rise and fall times can be set as slow as 10V/s or as fast as 100V/s. Small voltage transitions can be programmed to rise and fall as fast as 1000V/s.
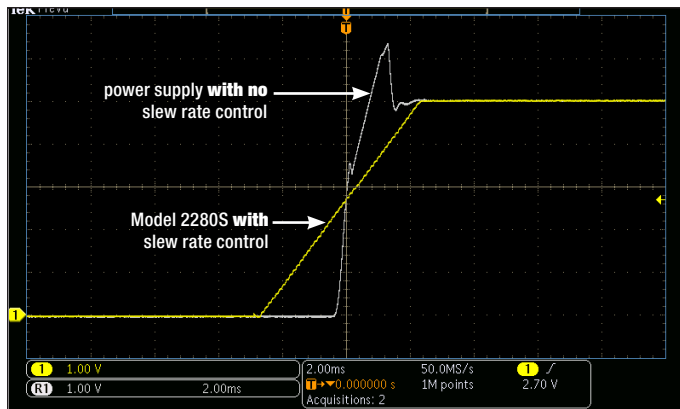
Figure 6. Programmable slew rates permit controlling voltage rise and fall rates, preventing undesirable transients during power up of capacitive loads.

Perform Semi-Automated Testing Right on Your Bench

Test your design over its operating voltage range automatically or study how it responds to DC output changes by using the Series 2280S supplies' built-in List Mode function. Create and save up to 10 lists of sequenced voltage levels with up to 99 distinct voltages in each list. The duration of each voltage level can be set as short as 1ms or as long as 60s. Create simple linear ramps or any custom configuration from either the front panel or an interface bus. A single trigger will automatically execute the list once or multiple times.
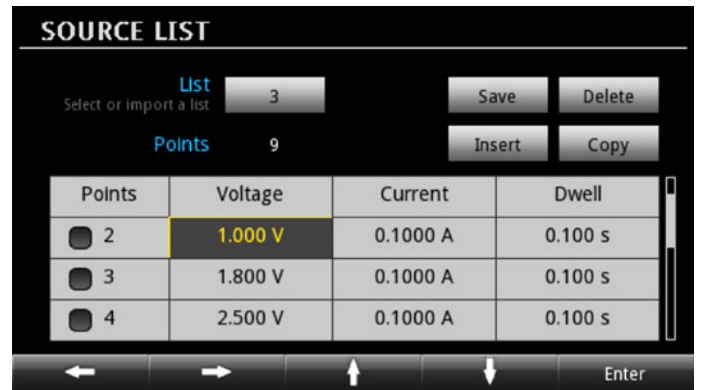
Figure 7A. Create an output sequence using the List setup screen.
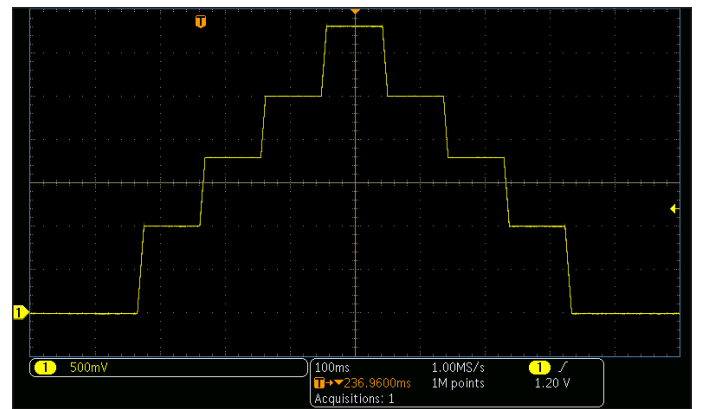
Figure 7B. Use the list mode to step the output voltage automatically through a series of levels. The voltages were created by the list shown in Fig. 7A.

Precision measurement, low noise, programmable DC power supplies

DC POWER SUPPLIES

Precision Measurement, Low Noise, Programmable DC Power Supplies

Trend Analysis and Load Current Characterization

Use the built-in graphing function to monitor the stability of the load current or capture and display a dynamic load current. Or, use it to view a start-up or turn-off load current. Series 2280S supplies can take measurements quickly and store up to 2,500 measurement points. In addition to displaying a voltage or current waveform or both, they can compute statistics on the stored data. Statistical calculation options include average, maximum, minimum, peak-peak, and standard deviation. All the information you need is accessible through a few display menus.
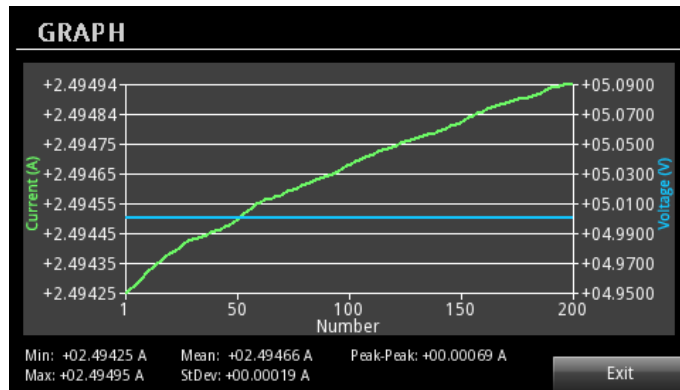

Figure 8. Monitor voltage, current, or both with the graphing function.

Automate a test quickly and easily with KickStart software

Set up an automated test for the Series 2280S supplies in four simple steps with the KickStart start-up software. KickStart is available for installation on your PC via a free download from www.keithley.com. Once the program is open, perform these steps: create a test file, select the 2280S power supply, select the power supply application, and enter the test parameters. Run the test, and get results without having to write a line of code. KickStart provides both graph and spreadsheet displays. Data is saved to the test file, and the data can be exported to data analysis programs. Or take a screen shot of the plot for reproduction in test reports. Up to 15,000 data points can be stored. KickStart may be all the software you ever need.
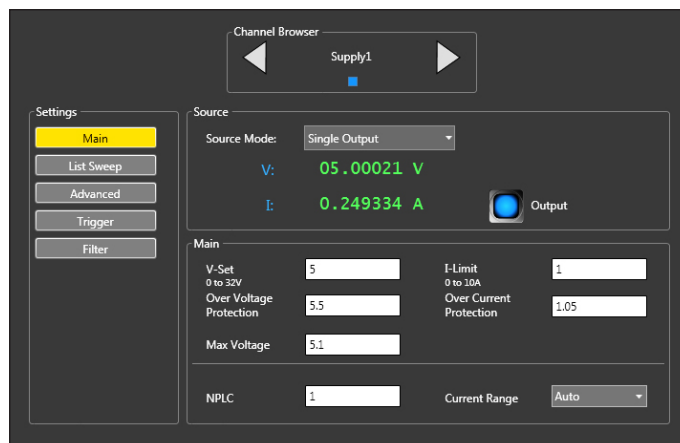
Figure 9. KickStart DC power main screen.
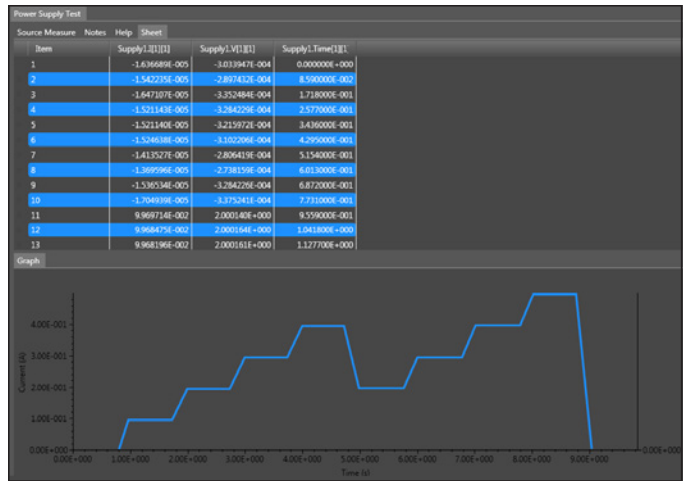
Figure 10. KickStart plot with measurement table.

Optimized Performance for Production Test

Series 2280S supplies are as powerful in a production test system as they are flexible on the R&D benchtop. In addition to their List Mode function, several other Series 2280S features help minimize test time in automated systems. For example, an external trigger input allows hardware synchronization and control by other instruments in the test system. To eliminate many system delays, Series 2280S supplies produce a "measurement complete output" to signal the test system when the supplies have completed their required actions. To reduce measurement time, the reading speed can be increased by reducing the acquisition time from power line cycle integration times, 16ms at 60 Hz (20 ms at 50 Hz), to $33\mu s$ ($40\mu s$). Furthermore, the Series 2280S supplies can sink up to 0.45A. Thus, these supplies can quickly discharge a voltage level and change to a different voltage.
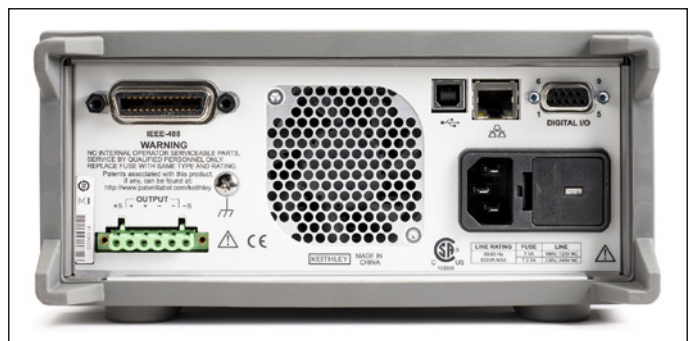
Figure 11. Series 2280S rear panel showing the rear output connector with remote sense inputs, digital I/O, and the three interfaces (GPIB, USB, and LAN).

A choice of front or rear panel terminals provides enhanced connection flexibility. For maximum voltage accuracy, 4-wire remote sensing ensures that the output voltage programmed is actually the level applied to the load. In addition, the sense lines are monitored in order to detect any breaks in them. These features ensure any production problems can be quickly identified and corrected. Four additional digital I/O pins can pro-

Series 2280S

Precision Measurement, Low Noise, Programmable DC Power Supplies

vide fault status outputs or control an external relay or status lamp. Series 2280S supplies can be controlled via their built-in GPIB, USB, or LAN interfaces. The USB interface is test and measurement system (TMC) compliant. The LXI Core compliant LAN interface supports controlling and monitoring a Series 2280S supply remotely, so test engineers can always access the power supply and view measurements, even if they're located on a different continent than their test systems.

To facilitate production test software development, native National Instruments LabVIEW™ drivers, IVI-C and IVI-COM drivers are available on the Keithley website, www.keithley.com.

Specifications

23°C ±5°C with 1-hour instrument warm-up.

DC OUTPUT RATINGS

	2280S-32-6	2280S-60-3
Voltage	0 to 32 V	0 to 60 V
Current	0 to 6 A	0 to 3.2 A
Maximum Power	192 W	192 W

VOLTAGE [1]

SOURCE SETTING

	2280S-32-6	2280S-60-3
Accuracy	± (0.02% + 3 mV)	± (0.02% + 6 mV)
Resolution	1 mV	1 mV

MEASUREMENT [2] (0.5V over-range)

	2280S-32-6	2280S-60-3
Accuracy	± (0.02% + 2 mV)	± (0.02% + 4 mV)
Resolution	0.1 mV	0.1 mV

ADDITIONAL OFFSET AT FASTER MEASUREMENT SETTINGS

	2280S-32-6	2280S-60-3
5½ (0.1 PLC)	0.21 mV	0.40 mV
4½ (0.01 PLC)	1.44 mV	2.7 mV
3½ (0.002 PLC)	7.60 mV	14.25 mV

REGULATION

	2280S-32-6	2280S-60-3
Load	±(0.01% + 2 mV)	±(0.01% + 2 mV)
Line	±(0.01% + 1 mV)	±(0.01% + 1 mV)

OUTPUT RIPPLE AND NOISE

	2280S-32-6	2280S-60-3
Bandwidth 20Hz–20MHz	$< 1mV_{RMS}$	$< 2mV_{RMS}$
	< 5mV p-p	< 7mV p-p

LOAD TRANSIENT RECOVERY TIME: Resistive load change 50% load to 100% load or 100% load to 50% load: <50μs to within 15mV of V-set.

SLEW RATE: Rising voltage and falling voltage: 10V/s to 100V/s. Up to 1000V/s under limited conditions [3]. 100V/s (default).

MAXIMUM SOURCE VOLTAGE DROP PER LEAD: To maintain specified voltage accuracy: 1V.

MAXIMUM SENSE HI AND SENSE LO LEAD RESISTANCE: To maintain specified voltage accuracy: 2Ω.

CURRENT

CURRENT LIMIT SETTING

	2280S-32-6	2280S-60-3
Full-scale Amps	6 A	3.2 A
Accuracy	±(0.05% + 5 mA)	±(0.05% + 5 mA)
Resolution	0.1 mA	0.1 mA

MEASUREMENT [4] (120% over-range except 10A)

Range	Resolution	2280S-32-6	2280S-60-3
10 mA	10 nA	±(0.05% + 10 μA)	±(0.05% + 10 μA)
100 mA	100 nA	±(0.05% + 10 μA)	±(0.05% + 10 μA)
1 A	1 μA	±(0.05% + 250 μA)	±(0.05% + 250 μA)
10 A	10 μA	±(0.05% + 250 μA)	±(0.05% + 250 μA)

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Series 2280S specifications

DC POWER SUPPLIES

SERVICES AVAILABLE

2280S-32-6-EW	1 Additional Year of Factory Warranty (total of 4 years)
2280S-32-6-5Y-EW	2 additional years of factory warranty beyond the 3-Year factory warranty (total of 5 years)
C/2280S-32-6-3Y-STD	3 Calibrations Within 3 Years of Purchase
C/2280S-32-6-3Y-DATA	3 (ANSI-Z540-1 compliant) Calibrations Within 3 Years of Purchase
C/2280S-32-6-3Y-1702	3 (ISO 17025 Accredited) Calibrations within 3 Years of Purchase
C/2280S-32-6-5Y-STD	5 Calibrations Within 5 Years of Purchase
C/2280S-32-6-5Y-DATA	5 (ANSI-Z540-1 compliant) Calibrations Within 5 Years of Purchase
C/2280S-32-6-5Y-1702	5 (ISO 17025 Accredited) Calibrations within 5 Years of Purchase
2280S-60-3-EW	1 Additional Year of Factory Warranty (total of 4 years)
2280S-60-3-5Y-EW	2 additional years of factory warranty beyond the 3-Year factory warranty (total of 5 years)
C/2280S-60-3-3Y-STD	3 Calibrations Within 3 Years of Purchase
C/2280S-60-3-3Y-DATA	3 (ANSI-Z540-1 compliant) Calibrations Within 3 Years of Purchase
C/2280S-60-3-3Y-1702	3 (ISO 17025 Accredited) Calibrations within 3 Years of Purchase
C/2280S-60-3-5Y-STD	5 Calibrations Within 5 Years of Purchase
C/2280S-60-3-5Y-DATA	5 (ANSI-Z540-1 compliant) Calibrations Within 5 Years of Purchase
C/2280S-60-3-5Y-1702	5 (ISO 17025 Accredited) Calibrations within 5 Years of Purchase

ADDITIONAL OFFSET AT FASTER MEASUREMENT SETTINGS[10]

Measure Resolution and (NPLC)	Range	2280S-32-6	2280S-60-3
5½ (0.1 PLC)	10 mA	5.0 μA	5.0 μA
	100 mA	20 μA	20 μA
	1 A	80 μA	80 μA
	10 A	2.0 mA	2.0 mA
4½ (0.01 PLC)	10 mA	20 μA	20 μA
	100 mA	40 μA	40 μA
	1 A	500 μA	500 μA
	10 A	10 mA	10 mA
3½ (0.002 PLC)	10 mA	30 μA	30 μA
	100 mA	250 μA	250 μA
	1 A	25 mA	25 mA
	10 A	75 mA	75 mA

CURRENT PULSE MEASUREMENT [5]

	2280S-32-6	2280S-60-3
Minimum Pulse Width (10mA and 100mA range) [6]	2.1 ms	2.1 ms
Minimum Pulse Width (1A and 10A range) [6]	140 μs	140 μs
Minimum time to capture two consecutive pulses	0.5 ms	0.5 ms

REGULATION

	2280S-32-6	2280S-60-3
Load	±(0.01% + 0.25 mA)	±(0.01% + 0.25 mA)
Line	±(0.01% ± 0.25 mA)	±(0.01% ± 0.25 mA)

OUTPUT RIPPLE AND NOISE

	2280S-32-6	2280S-60-3
Bandwidth 20Hz–20MHz	< 3mA RMS	< 3mA RMS

MAXIMUM CONTINUOUS AVERAGE SINK CURRENT

	2280S-32-6	2280S-60-3
Non-programmable	0.45 A ±15%	0.45 A ±15%

SYSTEM MEASUREMENT SPEEDS

	Settings	Concurrent (V+I)		Current or Voltage (I or V)	
Readings/s	Measure Resolution and (NPLC)	Autozero On 60 Hz (50 Hz)	Autozero OFF 60 Hz (50 Hz)	Autozero On 60 Hz (50 Hz)	Autozero OFF 60 Hz (50 Hz)
'Read?' with BUS Transfer	6½ (5 PLC)	2.0 (1.5)	5.4 (4.5)	2.5 (2.3)	9.0 (8.5)
	6½ (1 PLC)	9.0 (8.0)	20 (18)	11.5 (9.5)	30.0 (28)
	5½ (0.1 PLC)	48 (38)	50 (48)	50.0 (48.0)	95.0 (85.0)
'*TRG and TRACe:DATa?' into Memory	4½ (0.01 PLC) [7]	440 (430)		1915 (1820)	
	3½ (0.002 PLC) [8]	510 (510)		2668 (2650)	

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Series 2280S
Precision Measurement, Low Noise, Programmable DC Power Supplies

PROTECTION

Overvoltage Protection (OVP)	2280S-32-6	2280S-60-3
Setting Accuracy	±(0.25% + 0.25 V)	±(0.25% + 0.5 V)
Resolution	125 mV	250 mV
Response Time	6 ms (typical)[9]	6 ms (typical)[9]

Overcurrent Protection (OCP)	2280S-32-6	2280S-60-3
Setting Accuracy	±(0.25% + 0.10 A)	±(0.25% + 0.10 A)
Resolution	25 mA	12.5 mA
Response Time	6 ms (typical)[9]	6 ms (typical)[9]

Overtemperature Protection (OTP)	2280S-32-6	2280S-60-3
Output turn-off Temperature	>93°C (typical)	>93°C (typical)
Response Time	6 ms (typical)[9]	6 ms (typical)[9]

OTHER TIMING DATA

CV TO CC TRANSITION TIME (V-Set = 5V, I-limit = 0.5A, Resistive Load change 25Ω to 2.5Ω): 2.4ms.

CC TO CV TRANSITION TIME (V-Set = 5V, I-limit = 0.5A, Resistive Load change 2.5Ω to 25Ω): 1.1ms.

FUNCTION CHANGE (from detection of bus command to function change completed): 10ms (typical).

OUTPUT OFF/ON (from detection of bus command to voltage beginning to decrease): 5ms (typical).

REVERSE LEADS ACTUATION: 6ms (typical)[9].

GENERAL

COMMON MODE CURRENT: < 6µA peak-peak.

CHASSIS ISOLATION: ±240V, any terminal to chassis. >1GΩ in parallel with <6.8nF.

TEMPERATURE COEFFICIENT: Add the following to all accuracy specifications when outside the range, 23°C ±5°C: (0.15 × specification)/°C for 0° to 18°C and 28° to 40°C.

MEASUREMENT DISPLAY MODES: Voltage and current, voltage only, current only.

MEASUREMENT ACQUISITION CONTROL: Continuous, Manual, External digital input, PC bus.

LIST MODE: **Maximum number of stored lists:** 9.
Number of points in a list: 2 – 99.
List Storage Location: Internal memory or USB memory stick.

MATH AND FILTER FUNCTIONS:
REL: Removes offset from current reading display, Range: -1×10^6 to $+1\times10^6$.
Mx+b: Reading = x, M = -1×10^6 to $+1\times10^6$, b = -1×10^6 to $+1\times10^6$.
Filter: Moving average, Count: 2–100, Window: 0.01% to 100%.

MEMORY BUFFER:
2500 locations; each location contains: Voltage measurement, current measurement, CV/CC Mode, and time stamp, NVRAM.

DISPLAY: 4.3 in. front panel color display, resolution: 480 pixels × 272 pixels.
Display Modes:
Real time voltage and current readings and settings.
Plots of stored data: voltage vs data point, current vs data point, voltage and current vs. data point, 100 point resolution.
Plots can also display statistics: mean, maximum, minimum, peak-peak, standard deviation.
Table of stored data: time/date, voltage, current.
Soft button and navigation wheel control.

COMMUNICATIONS:
GPIB: IEEE-488.2 compliant and status model topology.
LAN: RJ-45 connector, 10/100BT, Auto MDIX.
IP Configuration: Static or DHCP.
LXI Core 2011, version 1.4,
USB: USB2.0 device (rear panel, type B), USBTMC compliant.
USB2.0 host (front panel, type A), full speed, support USB Flash Drives.

INPUT CONNECTIONS:
Front: (2-wire). Adjustable supporting, safety shrouded banana, spade lug, or wire.
Rear: (4-wire sense). 6-pin removal screw terminal, safety shrouded cover, removable local sense jumpers.

REAL-TIME CLOCK: Capacitive charged, 20 days between next power on cycle at 23°C and ≤50%RH.

DIGITAL I/O: 9-pin female D-sub. 6 Input/Output pins.
Input Signal Levels:
0.7V (maximum logic low).
3.7V (minimum logic high).
Input Voltage Limits:
−0.25V (Absolute minimum).
+5.25V (Absolute maximum).
Maximum Source Current: +2.0mA@ >2.7V (per pin).
Maximum Sink Current: −50mA @ 0.7V (per pin, solid-state fuse protected).
5V power supply, limited to 0.5A @>4V (solid-state fuse protected).
Trig In minimum pulse ≥4µs, Logic Low pulse.
Meter Ready Pulse, 15–30µs, Logic Low Pulse.

EMC: Conforms to European Union EMC directive.

SAFETY:
U.S. NRTL Listing: UL61010-1 3rd ed 2012 and UL61010-2-030:2012.
Canadian Certification: CAN/CSA C22.2 No. 61010-1 3rd ed 2012.
European Union Compliance: Low Voltage Directive .

COOLING: Forced air, side intake and rear exhaust.

POWER SUPPLY: 100V/120V/220V/240V ±10%.

POWER LINE FREQUENCY: 50/60Hz ±3Hz, automatically sensed at power-on.

POWER CONSUMPTION: 630VA peak.

OPERATING ENVIRONMENT: 0° to 40°C, ≤80% RH up to 35°C, non-condensing.
Altitude: up to 2000 meters.

STORAGE ENVIRONMENT: −25° to 70°C.

LXI WEB BROWSER COMPATIBLE OPERATING SYSTEM AND SOFTWARE: Windows 2000, Win 7 and XP compatible, supports Web browsers with Java plug-in (requires Java plug-in 1.7 or higher). Web page served by Model 2280S.

RACK DIMENSIONS: (W×H×D), without boot: 213.8 × 88.4 × 383.3mm (8.42 × 3.48 × 15.1 in.).

BENCH DIMENSIONS: (W×H×D) with boot: 255.3 × 107.2 × 415.0mm (10.1 × 4.22 × 16.34 in.).

SHIPPING WEIGHT: 13.29kg (29.3 lbs.).

NET WEIGHT: 10.85kg (23.9 lbs.).

WARRANTY: 3 years.

Note: Specifications are subject to change without notice.

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DC POWER SUPPLIES

DMM7510

7½-Digit Graphical Sampling Multimeter

The Model DMM7510 combines all the advantages of a precision digital multimeter, a graphical touchscreen display, and a high speed, high resolution digitizer to create an industry first: a graphical sampling multimeter. The digitizer gives the Model DMM7510 unprecedented signal analysis flexibility; the five-inch capacitive touchscreen display makes it easy to observe, interact with, and explore measurements with "pinch and zoom" simplicity. This combination of high performance and high ease of use offers unparalleled insight into your test results.

Capture Waveforms with the Built-in 1MS/sec Digitizer

Capturing and displaying waveforms and transient events just got easier with the DMM7510's voltage or current digitizing function. The built-in 1MS/sec, 18-bit digitizer makes it possible to acquire waveforms without the need to use a separate instrument. The digitizing functions employ the same ranges that the DC voltage and current functions use to deliver exceptional dynamic measurement range. In addition, the voltage digitizing function uses the same DC voltage input impedance (10GΩ or 10MΩ) levels to reduce loading significantly on the DUT.

- **Precision multimeter with 3½- to 7½-digit resolution**

- **14 PPM basic one-year DCV accuracy**

- **100mV, 1Ω, and 10µA ranges offer the sensitivity needed for measuring low level signals**

- **Make accurate low resistance measurements with offset compensated ohms, four-wire, and dry circuit functions**

- **Capture and display waveforms or transients with 1MS/sec digitizer**

- **Large internal memory buffer; store over 11 million readings in standard mode or 27.5 million in compact mode**

- **Auto-calibration feature improves accuracy and stability by minimizing temperature and time drift**

- **Display more with five-inch, high resolution touchscreen interface**

- **Readings and screen images can be saved quickly via the front panel USB memory port**

- **Multiple connectivity options: GPIB, USB, and LXI-compliant LAN interfaces**

- **Two-year specifications allow for longer calibration cycles**

The high speed digitizing function allows capturing and displaying voltage and current waveforms.
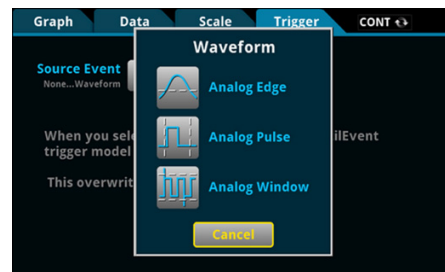
Advanced triggering options make it possible to capture a signal at precisely the right point.
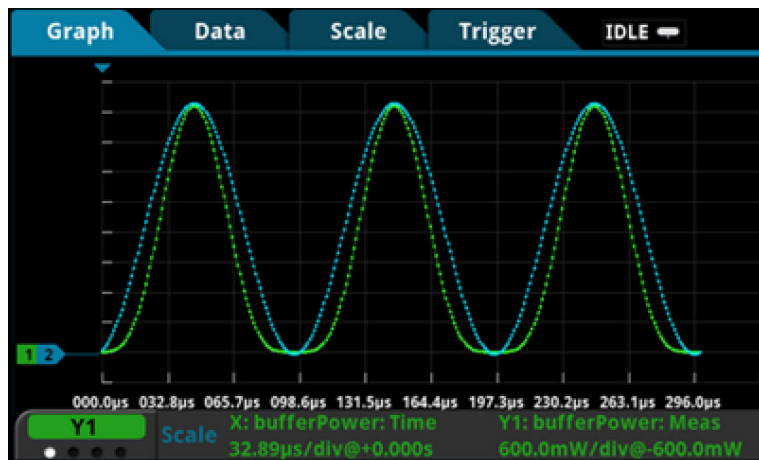
The built-in graphing utility supports displaying and comparing measurements or waveforms from up to four reading buffers at once.

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DMM7510

7½-Digit Graphical Sampling Multimeter

Ordering Information

DMM7510 7½-Digit Graphical Sampling Multimeter

DMM7510-NFP 7½-Digit Graphical Sampling Multimeter, with No Front Panel

DMM7510-RACK 7½-Digit Graphical Sampling Multimeter, with No Handle

DMM7510-NFP-RACK 7½-Digit Graphical Sampling Multimeter, with No Front Panel and No Handle

Accessories Supplied

1756 Test Leads

USB-B-1 USB Cable, Type A to Type B, 1m (3.3 ft)

CA-180-3A TSP-Link/Ethernet Cable Documentation CD

DMM7510 QuickStart Guide

Test Script Builder Software (available at www.keithley.com)

KickStart Startup Software (available at www.keithley.com)

LabVIEW and IVI Drivers (available at www.keithley.com)

Make Demanding Measurements with Confidence

The Model DMM7510's design makes the most of Keithley's low level measurement expertise. Features like the low noise input stage and the 32-bit A-to-D converter allow this instrument to deliver DC accuracies typically only found in metrology-grade instrumentation—but at about half the price of those solutions. The Model DMM7510's 100mV, 10Ω, and 10μA ranges deliver the sensitivity needed to measure low signals with confidence when characterizing today's demanding electronic designs. In addition to one- and two-year accuracy specifications, an auto-calibration function ensures greater accuracy between calibration cycles.

One Power Line Cycle Noise Performance

The DMM7510 provides noise performance equivalent to or better than many 8½-digit DMMs.

6½ Digit   8½ Digit   DMM7510
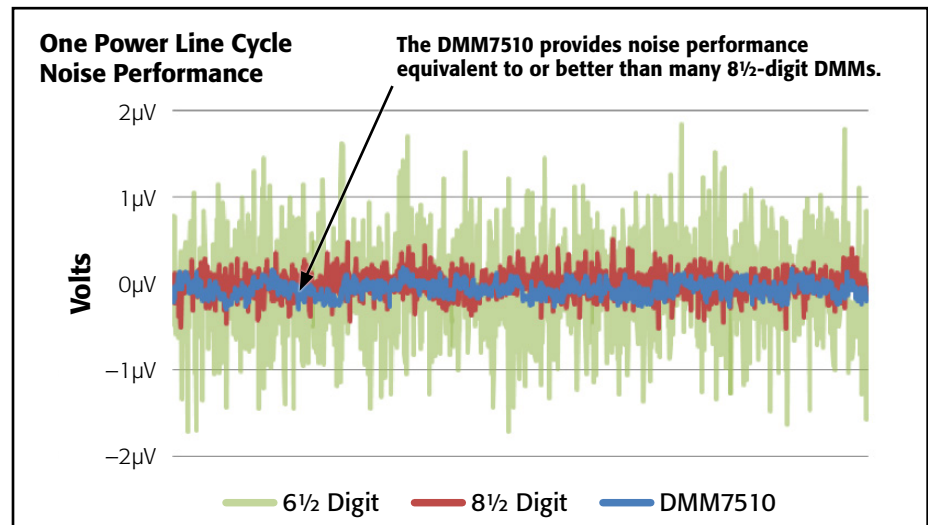
Comparison of the Model DMM7510's 1V DC noise performance with that of typical 6½- and 8½-digit multimeters. All data was taken at 1 NPLC with a low thermal short applied to the input.

15 Measurement Functions

The DMM7510 provides 15 basic measurement functions. In addition to the digitizing voltage and current functions, it includes capacitance, ACV and ACI, temperature (RTD, thermistor, and thermocouple), 2- and 4-wire resistance, dry circuit ohms, period, frequency, diode test, and DC voltage ratio. The instrument's flat menu structure allows for fast configuration and improves usability. Its intuitive design lets you learn how to operate the instrument and begin making device measurements faster and with greater confidence.
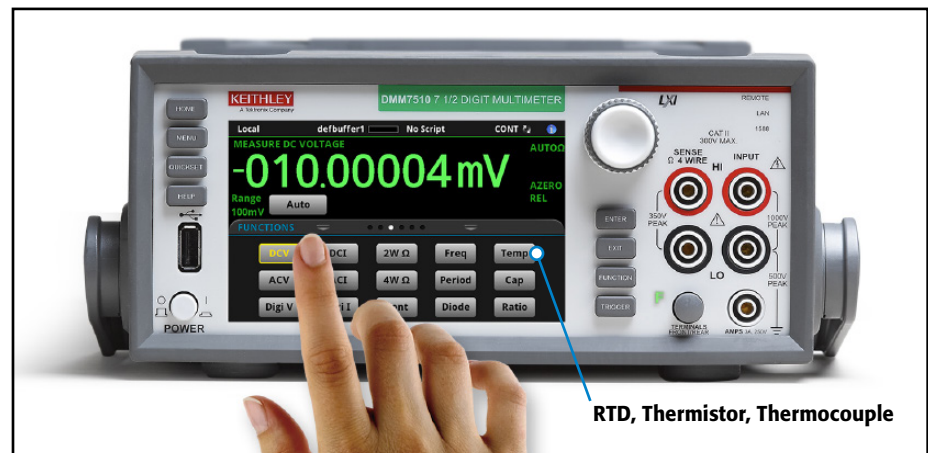
RTD, Thermistor, Thermocouple

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DMM7510   7½-Digit Graphical Sampling Multimeter

DMM7510 Measurement Capabilities

Logarithmic Scale

	1f	1p	1n	1µ	1m	1	1k	1M	1G

DC Voltage — 10nV to 1010V
AC Voltage — 100nV to 707VRMS
DC Current — 1pA to 10.1A
AC Current — 1nA to 10.1A
Resistance (2-wire) — 1µΩ to 1.2GΩ
Resistance (4-wire) — 100nΩ to 1.2GΩ
Dry Circuit Resistance — 1µΩ to 2.4kΩ
Capacitance — 0.1pF to 1.2mF
Period — 2µs to 330ms
Frequency — 3Hz to 500kHz

Digitize Voltage — 1µV to 1010V
Digitize Current — 0.1nA to 10.1A

Linear Scale

	−500°	0°	500°	1000°	1500°	2000°

Thermocouple — −200°C to 1820°C
Thermistor — −80°C to 150°C
3-Wire RTD — −200°C to 850°C
4-Wire RTD — −200°C to 850°C

Designed for Higher Testing Productivity

In addition to its advanced touchscreen, the Model DMM7510's front panel offers a variety of features that enhance its speed, user-friendliness, and learnability, including a USB 2.0 memory I/O port, a HELP key, a rotary navigation/control knob, and front/rear input selector button. All front-panel buttons are backlit to enhance visibility.

Five-inch touchscreen displays more information simultaneously

Rotary control knob offers an alternative to touchscreen navigation

Online HELP is just a button press away

Store test results and screen images quickly via the USB 2.0 Memory port

Lower swipe screen speeds access to often-used features

Front/rear input selector
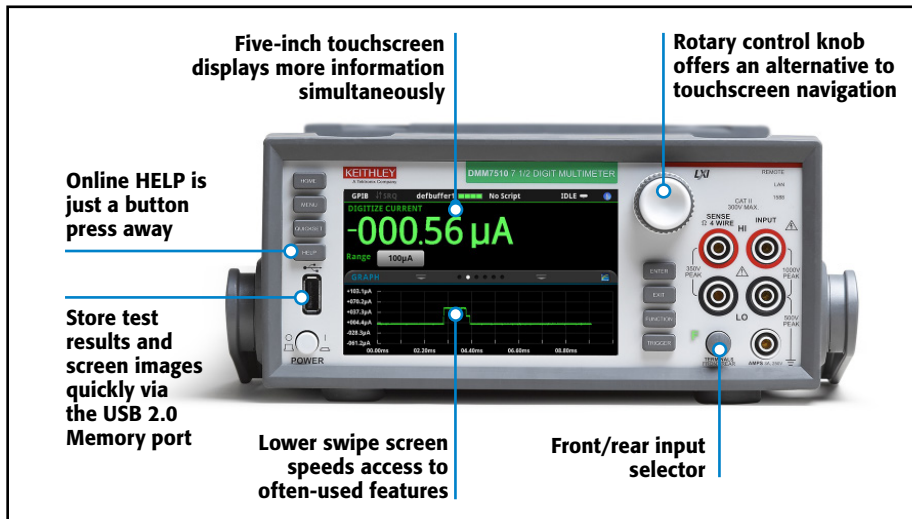
ACCESSORIES AVAILABLE

TEST LEADS AND PROBES

1752	Premium Safety Test Lead Kit
1754	2-Wire Universal 10-Piece Test Lead Kit
1756	General Purpose Test Lead Kit
5804	Kelvin (4-Wire) Universal 10-Piece Test Lead Kit
5805	Kelvin (4-Wire) Spring-Loaded Probes
5806	Kelvin Clip Lead Set
5808	Low Cost Single-pin Kelvin Probe Set
5809	Low Cost Kelvin Clip Lead Set
8606	High Performance Modular Probe Kit
8610	Low Thermal Shorting Plug

REPLACEMENT FUSES

DMM7510-FUSE-10A	11A Current Fuse For DMM7510
DMM7510-FUSE-3A	3.5A Current Fuse For DMM7510

CABLES, CONNECTORS, ADAPTERS

CA-18-1	Shielded Dual Banana Cable, 1.2m (4 ft.)

COMMUNICATION INTERFACES & CABLES

KPCI-488LPA	IEEE-488 Interface for PCI Bus
KUSB-488B	IEEE-488 USB-to-GPIB Interface Adapter
7007-1	Shielded GPIB Cable, 1m (3.2ft)
7007-2	Shielded GPIB Cable, 2m (6.5ft)
CA-180-3A	CAT5 Crossover Cable for TSP-Link / Ethernet
USB-B-1	USB Cable, Type A to Type B, 1m (3.3 ft)

TRIGGERING AND CONTROL

2450-TLINK	DB-9 to Trigger Link Connector Adapter
8501-1	Trigger Link Cable, DIN-to-DIN, 1m (3.2 ft.)
8501-2	Trigger Link Cable, DIN-to-DIN, 2m (6.5 ft.)
8503	DIN-to-BNC Trigger Cable

RACK MOUNT KITS

4299-8	Single Fixed Rack Mount Kit
4299-9	Dual Fixed Rack Mount Kit
4299-10	Dual Fixed Rack Mount Kit. Mount One DMM7510 and One Series 26xxB Instrument
4299-11	Dual Fixed Rack Mount Kit. Mount One DMM7510 and One Instrument from Series 2400, Series 2000, etc.
4299-12	Dual Fixed Rack Mount Kit. Mount One DMM7510 and One Keysight Instrument.
DMM7510-BenchKit	Ears and Handle for DMM7510-NFP-RACK and DMM7510-RACK Models

SERVICES AVAILABLE

EXTENDED WARRANTIES

DMM7510-EW	1 Year Factory Warranty Extended to 2 Years from Date of Shipment
DMM7510-3Y-EW	1 Year Factory Warranty Extended to 3 Years from Date of Shipment
DMM7510-5Y-EW	1 Year Factory Warranty Extended to 5 Years from Date of Shipment
DMM7510-NFP-EW	1 Year Factory Warranty Extended to 2 Years from Date of Shipment
DMM7510-NFP-3Y-EW	1 Year Factory Warranty Extended to 3 Years from Date of Shipment
DMM7510-NFP-5Y-EW	1 Year Factory Warranty Extended to 5 Years from Date of Shipment

CALIBRATION CONTRACTS

C/DMM7510-3Y-17025	KeithleyCare® 3 Year ISO-17025 Calibration Plan
C/DMM7510-3Y-DATA	KeithleyCare 3 Year Calibration w/ Data Plan
C/DMM7510-3Y-STD	KeithleyCare 3 Year Std Calibration Plan
C/DMM7510-5Y-17025	KeithleyCare 5 Year ISO-17025 Calibration Plan
C/DMM7510-5Y-DATA	KeithleyCare 5 Year Calibration w/ Data Plan
C/DMM7510-5Y-STD	KeithleyCare 5 Year Std Calibration Plan
C/DMM7510-NFP-3Y-17025	KeithleyCare 3 Year ISO-17025 Calibration Plan
C/DMM7510-NFP-3Y-DATA	KeithleyCare 3 Year Calibration w/ Data Plan
C/DMM7510-NFP-3Y-STD	KeithleyCare 3 Year Std Calibration Plan
C/DMM7510-NFP-5Y-17025	KeithleyCare 5 Year ISO-17025 Calibration Plan
C/DMM7510-NFP-5Y-DATA	KeithleyCare 5 Year Calibration w/ Data Plan
C/DMM7510-NFP-5Y-STD	KeithleyCare 5 Year Std Calibration Plan
C/NEW DATA	Calibration Data for New Units
C/NEW DATA ISO	ISO-17025 Calibration Data for New Units

Easily accessible current fuses

Measure Complete and External Trigger (Model 8503 BNC Accessory Available)

LAN/LXI interface

USB 2.0 interface

Six user-defined digital I/Os
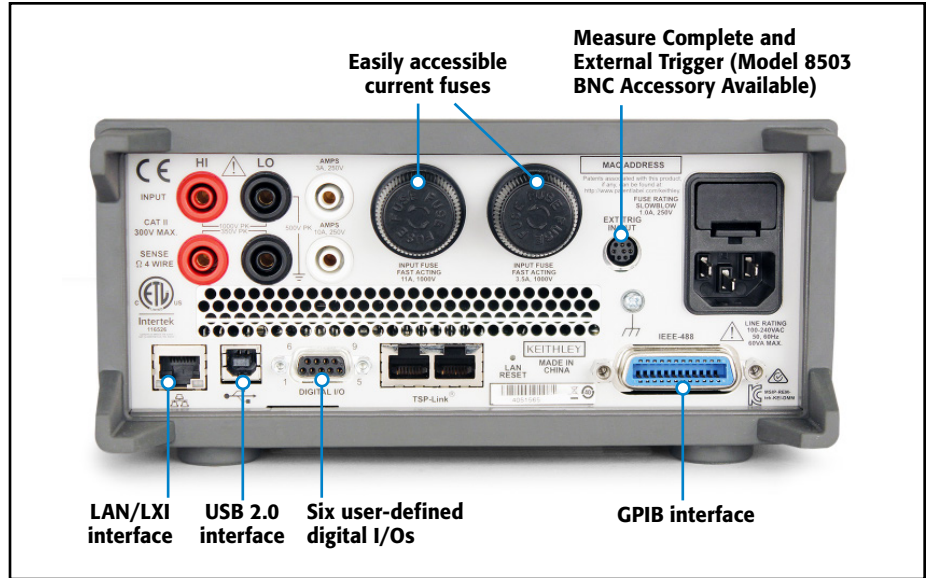
GPIB interface

The rear panel of the DMM7510 provides connections and controls that simplify configuring multi-instrument test solutions, including input connectors, remote control interfaces (GPIB, USB 2.0, and LXI/Ethernet), a D-sub 9-pin digital I/O port (for internal/external trigger signals and handler control), and TSP-Link® jacks for connecting to other TSP-enabled instruments.

Flexible System Integration and Programming

To offer users maximum programming flexibility and simplify configuring multi-instrument test systems, the DMM7510 includes Keithley's powerful Test Script Processor (TSP®) system and SCPI programming mode. The embedded scripting capability allows running powerful test scripts directly on the instrument, without the need for an external PC controller. These test scripts are complete test programs based on an easy-to-use yet highly efficient and compact scripting language, Lua (**www.lua.org**). Scripts are a collection of instrument control commands and/or program statements. Program statements control script execution and provide facilities such as variables, functions, branching, and loop control. This allows you to create powerful measurement applications with significantly reduced development times. Test scripts can contain any sequence of routines that are executable by conventional programming languages (including decision-making algorithms), so the instrument can manage every facet of the test without the need to communicate with a PC for decision-making. This eliminates delays due to GPIB, Ethernet or USB traffic congestion and greatly improves overall test times.

TSP technology also offers "mainframe-less channel expansion." The TSP-Link channel expansion bus and a 100 Base T Ethernet cable allow connecting multiple DMM7510s with other TSP-enabled instruments in a master-slave configuration so they operate as a single integrated system. These instruments include the Model 2450 and Model 2460 Interactive SourceMeter® SMU instruments, Series 2600B SourceMeter SMU instruments, and the Series 3700A Switch/Multimeter systems. TSP-Link supports up to 32 units per GPIB or IP address, so it's easy to scale a system to fit the requirements of an application.

A standard SCPI programming mode supports taking advantage of all of the DMM7510's new features when programming remotely. In addition, the instrument is code-compatible with the SCPI language, which many other DMMs use. This code compatibility avoids the need to rewrite code that is normally associated with upgrading to a new instrument with new capabilities.

DMM7510

7½-Digit Graphical Sampling Multimeter

Free Instrument Control Startup Software
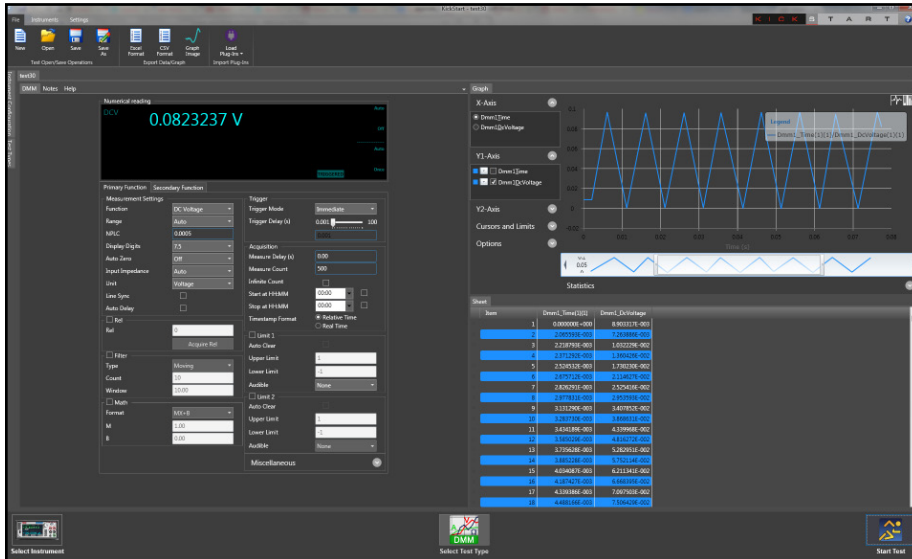
Keithley's KickStart instrument control startup software lets you begin taking measurements in minutes.

KickStart combines a wide range of functions to enhance testing productivity:

- Instrument-specific UI panel
- Manual instrument configuration
- Basic reading display and tabular viewing of data
- Datalogging
- Native X-Y data graphing
- Panning & zooming
- Basic statistics (native to instrument, mX+b)
- Saving/exporting data

- Connect using any remote interface (GPIB, USB, LAN)
- Save instrument setups
- Screenshot capture
- Command line dialog box

Ready-to-use Instrument Drivers Simplify Programming

Need to create your own customized application software? Native National Instruments LabVIEW®, IVI-C, and IVI-COM drivers are available for downloading at **www.keithley.com** to simplify the programming process.

DMM7510   *7½-Digit Graphical Sampling Multimeter*

Specification Conditions

This document contains specifications and supplemental information for the Model DMM7510 7½-Digit Graphical Sampling Multimeter instrument. Specifications are the standards against which the Model DMM7510 is tested. Upon leaving the factory, the Model DMM7510 meets these specifications. Supplemental and typical values are nonwarranted, apply at 23°C (73°F), and are provided solely as useful information. Measurement accuracies are specified at the Model DMM7510 terminals under these conditions:

- Temperature 23° ±5°C, 5% to 80% relative humidity, non-condensing.
- After a 90-minute warmup period.
- 1 PLC or 5 PLC; for NPLC settings less than 1 PLC, add appropriate ppm of range for peak noise uncertainty from the RMS noise table.
- Autozero enabled unless otherwise noted.
- Remote sense operation or properly zeroed local operation.
- Calibration period: One year or two years (calibration period may vary depending on customer requirements).
- T_{ACAL} = Ambient temperature of last automatic calibration.
- T_{CAL} = Ambient temperature of last external calibration; factory calibration performed at 23° ±1°C.

DC Voltage

ACCURACY (INPUT IMPEDANCE AUTO)

Range [1]	Resolution	Input Impedance [2]	Accuracy ±(ppm of reading + ppm of range)				
			24 Hour T_{CAL} ±1°C [2]	90 Day T_{CAL} ±5°C	1 Year T_{CAL} ±5°C	2 Year T_{CAL} ±5°C	Temperature Coefficient [3]
100.00000 mV [4]	10 nV	>10 GΩ or 10 MΩ ±1 %	6 + 9	12 + 9	18 + 9	29 + 9	0.1 + 2.5
1.0000000 V [4]	100 nV	>10 GΩ or 10 MΩ ±1 %	4 + 1	9 + 2	15 + 2	26 + 2	0.1 + 0.5
10.000000 V [4]	1 μV	>10 GΩ or 10 MΩ ±1 %	2 + 0.7	9 + 1.2	14 + 1.2	22 + 1.2	0.1 + 0.05
100.00000 V [4]	10 μV	10 MΩ ±1 %	8 + 3	(18 + 5) [5]	(22 + 5) [5]	(30 + 5) [5]	(0.15 + 0.05) [5]
				35 + 5	40 + 5	45 + 5	2.0 + 0.5
1000.0000 V [4, 6]	100 μV	10 MΩ ±1 %	8 + 3	(19 + 5) [5]	(23 + 5) [5]	(31 + 5) [5]	(0.15 + 0.05) [5]
				35 + 5	40 + 5	45 + 4	2.0 + 0.5

RMS NOISE (additional peak noise uncertainty) [7]

- Applies to ±ppm of range.
- Peak noise uncertainty is included in DC specifications for ≥1 PLC.
- Add peak noise uncertainty to measurements for <1 PLC.
- Input impedance set to Auto.

Examples:

- 10V at 0.006 PLC: 1.2 (from Accuracy table) + 11 (additional peak noise uncertainty) = 12.2 ppm of range.
- 10V at 1 PLC: 1.2 + 0 = 1.2 ppm of range.

NPLC	Digits	100 mV	1 V	10 V	100 V	1000 V
5	7½	0.5	0.08	0.06	0.3	0.06
1	7½	0.5	0.09	0.07	0.4	0.07
0.2 [8]	6½	2 (10)	0.2 (1.6)	0.1 (1.1)	1.1 (9.4)	0.1 (1)
0.2	6½	2 (12)	0.2 (1.6)	0.1 (1)	1.1 (8.9)	0.2 (1.1)
0.06	5½	3 (17)	0.4 (2.7)	0.3 (2.1)	3 (17)	0.3 (2.4)
0.006	4½	6 (42)	3 (18)	1 (11)	20 (100)	3 (18)
0.0005	3½	30 (220)	20 (150)	20 (130)	120 (690)	20 (150)

DC VOLTAGE SENSE ACCURACY

Range	Accuracy ±(ppm of reading + ppm of range)				
	24 Hour T_{CAL} ±1°C	90 Day T_{CAL} ±5°C	1 Year T_{CAL} ±5°C	2 Year T_{CAL} ±5°C	Temperature Coefficient [9]
100.00000 mV	6 + 14	12 + 14	18 + 14	29 + 14	0.1 + 2.5
1.0000000 V	4 + 1.5	9 + 3	15 + 3	26 + 3	0.1 + 0.5
10.00000 V	2 + 1.0	9 + 1.8	14 + 1.8	22 + 1.8	0.1 + 0.05

DC VOLTAGE RATIO

For input signals ≥1% of the range, ratio accuracy = ±[[V_{INPUT} ppm of reading + V_{INPUT} ppm of range * (V_{INPUT} range/V_{INPUT} input)] + [V_{SENSE} ppm of reading + V_{SENSE} ppm of range * (V_{SENSE} range/V_{SENSE} input)]].

---

1. 20% overrange on all ranges except 1% for 1000V range.
2. Relative to calibration accuracy.
3. Add per degree from T_{CAL} ±5°C.
4. When properly zeroed using the Rel function with external cables.
5. Specified within 30 days of autocalibration, T_{OPER} ±5°C from T_{ACAL}.
6. For signal levels greater than 500V, add 0.02 ppm/V to the ppm of the readings specification for measurements exceeding 500V.
7. Noise values are based on 1000 readings with autozero on and using low thermal 4-wire short. V_{RMS} noise is typical. Additional peak noise is guaranteed.
8. With line sync on.
9. Add per degree from T_{CAL} ±5°C.

DMM7510

7½-Digit Graphical Sampling Multimeter

DC VOLTAGE CHARACTERISTICS

ADC LINEARITY: 1.0 ppm of reading + 1.0 ppm of range.

INPUT IMPEDANCE:

100mV to 10V Ranges: Selectable >10GΩ ∥ <400pF (auto) or 10MΩ ±1% (10MΩ).

100V to 1000V Ranges: 10MΩ ±1%.

INPUT BIAS CURRENT: <50pA at 23°C under the following conditions: Autozero off or input impedance 10MΩ.

COMMON MODE CURRENT: <2.1μA peak-peak in 1MHz bandwidth.
<100nA peak-peak in 1kHz bandwidth.

COMMON MODE VOLTAGE: 500V$_{peak}$ LO terminal to chassis maximum.

DC VOLTAGE AUTOZERO OFF ERROR:

For ±1°C and ≤10 minutes, add ±(8ppm of reading + 15μV).

NORMAL MODE REJECTION

For DC voltage, line frequency ±0.1%.

	5 PLC	1 PLC	≤0.2 PLC	≤0.01 PLC
Line Sync On	110 dB	90 dB	45 dB	—
Line Sync Off	60 dB	60 dB	—	—

COMMON MODE REJECTION

For DC voltage and 1kΩ unbalanced in LO terminal; AC CMRR is 70dB.

NPLC	5	1	0.2	≤ 0.2
Line Sync	On	On	On	Off
CMRR	140 dB	140 dB	120 dB	80 dB

Resistance

ENHANCED ACCURACY (within 30 days of autocalibration, T$_{OPER}$ ±5°C from T$_{ACAL}$) [10]

Range [11]	Resolution	Test Current [12] (±5%)	Accuracy ±(ppm of reading + ppm of range)				Temperature Coefficient [14]
			24 Hour T$_{CAL}$ ±1°C [13]	90 Day T$_{CAL}$ ±5°C	1 Year T$_{CAL}$ ±5°C	2 Year T$_{CAL}$ ±5°C	
1.0000000 Ω	0.1 μΩ	10 mA	15 + 50	30 + 50	30 + 50	30 + 50	0.15 + 0.1
10.000000 Ω	1 μΩ	10 mA	15 + 5	30 + 5	30 + 5	30 + 5	0.15 + 0.1
100.00000 Ω	10 μΩ	1 mA	12 + 4	27 + 4	27 + 4	27 + 4	0.15 + 0.1
1.0000000 kΩ	100 μΩ	1 mA	12 + 3	24 + 3	24 + 3	24 + 3	0.15 + 0.1
10.000000 kΩ [15]	1 mΩ	100 μA	13 + 3	30 + 3	30 + 3	30 + 3	0.15 + 0.1
100.00000 kΩ [15, 16]	10 mΩ	10 μA	13 + 3	30 + 3	30 + 3	30 + 3	0.15 + 0.1
1.0000000 MΩ [15, 17]	100 mΩ	10 μA	14 + 3	30 + 4	30 + 4	30 + 4	0.15 + 0.1
10.000000 MΩ [18]	1 Ω	0.69 μA ∥ 10 MΩ	150 + 6	200 + 10	200 + 10	200 + 10	70 + 1
100.00000 MΩ [18]	10 Ω	0.69 μA ∥ 10 MΩ	800 + 30	2000 + 30	2000 + 30	2000 + 30	385 + 1
1.0000000 GΩ [18]	100 Ω	0.69 μA ∥ 10 MΩ	9000 + 100	9000 + 100	9000 + 100	9000 + 100	3000 + 1

ACCURACY [19]

Range [20]	Resolution	Test Current [21] (±5%)	Accuracy ±(ppm of reading + ppm of range)				Temperature Coefficient [23]
			24 Hour T$_{CAL}$ ±1°C [22]	90 Day T$_{CAL}$ ±5°C	1 Year T$_{CAL}$ ±5°C	2 Year T$_{CAL}$ ±5°C	
1 Ω	0.1 μΩ	10 mA	15 + 50	40 + 50	50 + 50	70 + 50	2.5 + 5
10 Ω	1 μΩ	1 mA	15 + 5	40 + 5	50 + 5	70 + 5	2.5 + 0.5
100 Ω	10 μΩ	1 mA	12 + 4	35 + 4	47 + 4	65 + 4	5 + 0.25
1 kΩ	100 μΩ	1 mA	12 + 3	30 + 3	41 + 3	65 + 3	5 + 0.25
10 kΩ [24]	1 mΩ	100 μA	10 + 3	30 + 3	42 + 3	65 + 3	2.5 + 0.25
100 kΩ [24, 25]	10 mΩ	10 μA	13 + 3	38 + 3	50 + 3	65 + 3	5 + 1
1 MΩ [24, 26]	100 mΩ	10 μA	14 + 3	38 + 5	50 + 5	65 + 5	5 + 1
10 MΩ [27]	1 Ω	0.69 μA ∥ 10 MΩ	150 + 6	200 + 10	400 + 10	600 + 12	70 + 1
100 MΩ [27]	10 Ω	0.69 μA ∥ 10 MΩ	800 + 30	2000 + 30	2000 + 30	2600 + 30	385 + 1
1 GΩ [27]	100 Ω	0.69 μA ∥ 10 MΩ	9000 + 200	9000 + 200	13000 + 200	14000 + 200	3000 + 1

10. Specifications are for 4-wire resistance, offset compensation on for ≤10kΩ measurements, and offset compensation off for ≥10kΩ measurements. 1Ω range is 4-wire only. For 2-wire, with Rel, add 50mΩ to ppm of range uncertainty. Without Rel and with Model 1756 test leads, add 100mΩ to ppm of range uncertainty.

11. 20% overrange on all ranges.

12. Test current with offset compensation off, ±5%.

13. Relative to calibration accuracy.

14. Add per degree from T$_{CAL}$ ±5°C.

15. Specifications are for external cable and load capacitance <1nF.

16. For offset compensation on, add 10ppm uncertainty to ppm of reading.

17. For 4-wire 1MΩ, open lead detector on, add 10 ppm uncertainty to ppm of reading.

18. Specified for <10% lead resistance mismatch in HI and LO.

19. Specifications are for 4-wire resistance, offset compensation on for ≤10kΩ measurements, and offset compensation off for ≥10kΩ measurements. 1Ω range is 4-wire only. For 2-wire, with Rel, add 50mΩ to ppm of range uncertainty. Without Rel and with Model 1756 test leads, add 100mΩ to ppm of range uncertainty.

20. 20% overrange on all ranges.

21. Test current with offset compensation off.

22. Relative to calibration accuracy.

23. Add per degree from T$_{CAL}$ ±5°C.

24. Specifications are for external cable and load capacitance <1nF.

25. For offset compensation on, add 10ppm of uncertainty to ppm of reading.

26. For 4-wire, 1MΩ, open lead detection on, add 10ppm uncertainty to ppm of reading.

27. Specified for <10% lead resistance mismatch in HI and LO.

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RESISTANCE OPEN CIRCUIT DC VOLTAGE [28]

Range [20]	2-wire	Offset compensation off 4-wire	Offset compensation on 4-wire
1 Ω	–	9.2 V	9.5 V
10 Ω	9.2 V	9.2 V	9.5 V
100 Ω, 1 kΩ	14.0 V	14.2 V	14.3 V
10 kΩ	9.5 V	9.5 V	0.0 V
100 kΩ, 1 MΩ	12.7 V	14.3 V	0.0 V (100 kΩ range only)
10 MΩ to 1 GΩ	6.9 V	6.9 V	–

4-WIRE OHMS (≤10kΩ) Offset Compensation On

RMS NOISE (additional peak noise uncertainty) [29]

- Applies to ± ppm of range.
- Peak noise uncertainty is included in DC specifications for ≥1 PLC.
- Add peak noise uncertainty to measurements for <1 PLC.

EXAMPLES

- 1kΩ at 0.006 PLC: 3 (from Accuracy table) + 26 (additional peak noise uncertainty) = 29 ppm of range.
- 1kΩ at 1 PLC: 3 + 0 = 3 ppm of range.

NPLC	Digits	1 Ω	10 Ω	100 Ω	1 kΩ	10 kΩ
5	7½	2.8	0.3	0.3	0.07	0.3
1	7½	4.2	0.4	0.4	0.12	0.5
0.2 [30]	6½	30 (160)	3 (13)	3 (13)	0.4 (2.6)	1.2 (8.2)
0.2	6½	50 (250)	5 (22)	5 (22)	0.6 (3.2)	1.2 (8.3)
0.06	5½	110 (490)	11 (47)	11 (46)	1.1 (6.6)	2 (16)
0.006	4½	110 (710)	10 (70)	10 (70)	4 (26)	10 (60)
0.0005	3½	520 (3420)	50 (340)	50 (340)	40 (220)	50 (300)

2-WIRE OHMS

RMS NOISE (additional peak noise uncertainty) [29]

- Applies to ± ppm of range.
- Peak noise uncertainty is included in DC specifications for ≥1 PLC.
- Add peak noise uncertainty to measurements for <1 PLC.

EXAMPLES

- 10kΩ at 0.006 PLC: 3 (from Accuracy table) + 5 (50mΩ with Rel) + 43 (additional peak noise uncertainty) = 51 ppm of range.
- 10kΩ at 1 PLC: 3 + 5 + 0 = 8 ppm of range.

NPLC	Digits	10 Ω	100 Ω	1 kΩ	10 kΩ
5	7½	1.1	0.8	0.1	0.2
1	7½	0.6	0.6	0.09	0.4
0.2 [30]	6½	2 (17)	2 (10)	0.2 (1.5)	0.8 (6.3)
0.2	6½	2 (17)	2 (14)	0.3 (1.6)	0.8 (6.4)
0.06	5½	3 (22)	3 (19)	0.4 (3.7)	2 (12)
0.006	4½	6 (50)	6 (50)	3 (21)	6 (43)
0.0005	3½	30 (300)	30 (230)	20 (150)	30 (210)

RESISTANCE CHARACTERISTICS

MAXIMUM 4-WIRE OHMS LEAD RESISTANCE: 5Ω per lead for 1Ω range, 10% of range per lead for 10Ω to 1kΩ ranges; 1kΩ per lead for all other ranges.

OFFSET COMPENSATION: Selectable on 4-wire, 1Ω to 100kΩ ranges.

OPEN LEAD DETECTOR: Default is off.

AUTOZERO OFF ERROR:

For 2-wire ohms, ±1°C and ≤10 minutes, add ±(8ppm of reading) + 1.5mΩ for 10Ω, 15mΩ for 100Ω and 1kΩ ranges, 150mΩ for 10kΩ range, 1.5Ω for 100 kΩ range, and 15Ω for all other ranges.

For 4-wire ohms, ±1°C and ≤10 minutes, add ±(8ppm of reading).

INPUT CURRENT LIMIT:

For signals with a magnitude of +12V to +40V or −12V to −40V: ±13mA source or sink, typical.

For signals with a magnitude of greater than +40V or −40V: ±130μA source or sink, typical.

Dry Circuit Resistance

ENHANCED ACCURACY (within 30 days of autocalibration, T_OPER ±5°C from T_ACAL)

				Accuracy ±(ppm of reading + ppm of range)				
Range [31]	Resolution	Test Current [35] (±5%)	Open Circuit DUT Voltage [32]	24 Hour T_CAL ±1°C [33]	90 Day T_CAL ±5°C	1 Year T_CAL ±5°C	2 years T_CAL ±5°C	Temperature Coefficient [34]
1.000000 Ω	1 μΩ	10 mA	25 mV	25 + 80	50 + 80	50 + 80	50 + 80	1.5 + 0.1
10.00000 Ω	10 μΩ	1 mA	25 mV	25 + 80	50 + 80	50 + 80	50 + 80	1.5 + 0.1
100.0000 Ω	100 μΩ	100 μA	25 mV	25 + 80	90 + 80	90 + 80	90 + 80	1.5 + 0.1
1.000000 kΩ	1 mΩ	10 μA	25 mV	25 + 80	180 + 80	180 + 80	180 + 80	1.5 + 0.1
10.00000 kΩ	10 mΩ	5 μA	25 mV	25 + 80	320 + 80	320 + 80	320 + 80	1.5 + 0.1

ACCURACY

				Accuracy ±(ppm of reading + ppm of range)				
Range [31]	Resolution	Test Current [35] (±5%)	Open Circuit DUT Voltage [32]	24 Hour T_CAL ±1°C [33]	90 Day T_CAL ±°C	1 Year T_CAL ±5°C	2 Year T_CAL ±5°C	Temperature Coefficient [34]
1.000000 Ω	1 μΩ	10 mA	25 mV	25 + 80	50 + 80	70 + 80	90 + 80	2.5 + 1
10.00000 Ω	10 μΩ	1 mA	25 mV	25 + 80	50 + 80	70 + 80	90 + 80	5 + 1
100.0000 Ω	100 μΩ	100 μA	25 mV	25 + 80	90 + 80	140 + 80	200 + 80	2.5 + 1
1.000000 kΩ	1 mΩ	10 μA	25 mV	25 + 80	180 + 80	400 + 80	600 + 80	5 + 1
10.00000 kΩ	10 mΩ	5 μA	25 mV	25 + 80	320 + 80	800 + 80	1300 + 80	8 + 1

28. Open circuit voltage is typical, measured from input HI to LO, SHI and SLO open. For 1Ω to 1MΩ ranges using an external digital multimeter (DMM) set to 10MΩ input impedance; for 10MΩ to 1GΩ ranges, set external DMM to >10GΩ input impedance.

29. Noise values are based on 1000 readings with autozero on and using low thermal 4-wire short. RMS noise is typical. Additional peak noise is guaranteed.

30. With line sync on.

31. 20% overrange on all ranges, except 2.4kΩ for the 10kΩ range.

32. Maximum clamp voltages are DC, typical accuracy is ±20%. Add 20% for offset compensation on.

33. Relative to calibration accuracy.

34. Add per degree from T_CAL ±5°C.

35. Test current with offset compensation off.

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DMM7510

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RMS NOISE (additional peak noise uncertainty) [36]

- Applies to ± ppm of range.
- Peak noise uncertainty is included in DC specifications for ≥1 PLC.
- Add peak noise uncertainty to measurements when < 1 PLC.

EXAMPLES:

- 10Ω at 0.2 PLC: 80 (from Accuracy table) + 230 (additional peak noise uncertainty) = 310 ppm of range.
- 10Ω at 1 PLC: 80 + 0 = 80 ppm of range.

NPLC	Digits	1 Ω	10 Ω	100 Ω	1 kΩ	10 kΩ
5	7½	10	11	6	5	0.9
1	7½	9	9	7	7	0.8
0.2 [37]	6½	30 (130)	30 (120)	30 (120)	30 (120)	3 (16)
0.2	6½	60 (220)	60 (230)	50 (190)	50 (190)	9 (35)
0.06	5½	70 (350)	70 (350)	50 (290)	50 (280)	20 (90)
0.006	4½	130 (750)	120 (830)	110 (700)	100 (690)	20 (110)
0.0005	3½	520 (3550)	530 (3520)	530 (3380)	500 (3370)	100 (670)

DRY CIRCUIT RESISTANCE CHARACTERISTICS

MAXIMUM 4-WIRE OHMS LEAD RESISTANCE:
0.5Ω per lead for 1Ω range.
10% of range per lead for 10Ω to 100Ω ranges.
50Ω per lead for 1kΩ to 10kΩ ranges.

INPUT CURRENT LIMIT: For signals greater than ±20mV, current limited, ±13mA typical.

OFFSET COMPENSATION: Selectable on 1Ω to 10kΩ ranges.

AUTOZERO OFF ERROR: For ±1°C and ≤10 minutes, add ±8 ppm of reading.

DC Current

ENHANCED ACCURACY (within 30 days of autocalibration, T$_{OPER}$ ±5°C from T$_{ACAL}$)

Range [38]	Resolution	Maximum Burden Voltage	Accuracy ±(ppm of reading + ppm of range)				Temperature Coefficient [40]
			24 Hour T$_{CAL}$ ±1°C [39]	90 Day T$_{CAL}$ ±5°C	1 Year T$_{CAL}$ ±5°C	2 Year T$_{CAL}$ ±5°C	
10.000000 µA	1 pA	15 mV	30 + 30	75 + 30	75 + 30	75 + 30	0.15 + 0.1
100.00000 µA	10 pA	15 mV	20 + 5	60 + 9	60 + 9	60 + 9	0.15 + 0.1
1.0000000 mA	100 pA	15 mV	30 + 5	60 + 9	60 + 9	60 + 9	0.15 + 0.1
10.000000 mA	1 nA	20 mV	40 + 5	60 + 9	60 + 9	60 + 9	0.15 + 0.1
100.00000 mA	10 nA	200 mV	50 + 18	150 + 30	150 + 30	150 + 30	0.15 + 0.1
1.0000000 A	100 nA	400 mV	150 + 50	400 + 50	400 + 50	400 + 50	0.15 + 0.1
3.000000 A	1 µA	1300 mV	200 + 40	400 + 40	400 + 40	400 + 40	0.15 + 0.1
10.000000 A [41]	1 µA	650 mV	700 + 275	800 + 275	1500 + 275	2000 + 275	50 + 10

ACCURACY

Range [38]	Resolution	Maximum Burden Voltage	Accuracy ±(ppm of reading + ppm of range)				Temperature Coefficient [40]
			24 Hour T$_{CAL}$ ±1°C [39]	90 Day T$_{CAL}$ ±5°C	1 Year T$_{CAL}$ ±5°C	2 Year T$_{CAL}$ ±5°C	
10.000000 µA	1 pA	15 mV	30 + 30	100 + 30	125 + 40	175 + 50	10 + 8
100.00000 µA	10 pA	15 mV	20 + 5	75 + 12	100 + 15	150 + 20	10 + 3
1.0000000 mA	100 pA	15 mV	30 + 5	75 + 12	100 + 15	150 + 20	10 + 3
10.000000 mA	1 nA	20 mV	40 + 5	75 + 12	100 + 15	150 + 20	10 + 3
100.00000 mA	10 nA	200 mV	50 + 18	300 + 30	400 + 30	500 + 30	50 + 5
1.0000000 A	100 nA	400 mV	150 + 50	400 + 50	450 + 50	500 + 50	10 + 10
3.000000 A	1 µA	1300 mV	200 + 40	400 + 40	450 + 40	500 + 40	10 + 10
10.000000 A [41]	1 µA	650 mV	700 + 275	800 + 275	1500 + 275	2000 + 275	50 + 10

36. Noise values are based on 1000 readings with autozero on and using low thermal 4-wire short. RMS noise is typical. Additional peak noise is guaranteed.
37. With line sync on.
38. 20% overrange supported for all ranges except for 3A and 10A, which are 1% supported.
39. Relative to calibration accuracy.
40. Add per degree from T$_{CAL}$ ±5°C.
41. Rear input terminals only.

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RMS NOISE (additional peak noise uncertainty) [42]

- Applies to ± ppm of range.
- Peak noise uncertainty is included in DC specifications for ≥1 PLC.
- Add peak noise uncertainty to measurements when <1 PLC.

EXAMPLES:

- 1mA at 0.006 PLC: 9 (from Accuracy table) + 20 (additional peak noise uncertainty) = 29 ppm of range.
- 1mA at 1 PLC: 9 +0 = 9 ppm of range.

NPLC	Digits	10 µA	100 µA	1 mA	10 mA	100 mA	1A	3A	10A [43]
5	7½	0.15	0.14	0.09	0.1	0.3	0.3	0.2	0.8
1	7½	0.4	0.13	0.1	0.1	0.5	0.5	0.3	1.2
0.2	6½	0 (220)	0 (23)	0.2 (3.4)	0.2 (1.6)	2 (10)	2 (11)	0.7 (4.6)	4 (32)
0.2 [44]	6½	120 (260)	12 (26)	1.2 (3.8)	0.3 (1.8)	1.9 (9.8)	2 (10)	0.8 (5)	8 (37)
0.06	5½	130 (280)	12 (29)	1.3 (5.6)	0.4 (3.9)	2 (14)	2 (14)	1.2 (7.7)	10 (59)
0.006	4½	130 (350)	14 (42)	3 (20)	2 (20)	4 (30)	4 (31)	7 (51)	20 (110)
0.0005	3½	260 (2110)	30 (300)	20 (150)	20 (160)	30 (190)	30 (190)	70 (510)	60 (420)

DC CURRENT CHARACTERISTICS

Range	10 µA	100 µA	1 mA	10 mA	100 mA	1 A	3 A	10 A [43]
Effective Internal Shunt Value [45]	1 kΩ	100 Ω	10 Ω	1 Ω	0.1 Ω	0.1 Ω	0.1 Ω	0.005 Ω
Autozero Off Error: For ±1°C and ≤10 minutes add ±(8 ppm of reading + range error)	150 pA	1.5 nA	15 nA	150 nA	15 μA	150 μA	150 μA	3 mA
Overload Recovery: For each additional sustained amp beyond ±1.5A, add the following initial ppm of range error until thermally settled after overload recovery	15500	1800	150	150	6500	200	—	—

Temperature

4-WIRE RTD OR 3-WIRE RTD

TYPES: 100Ω platinum PT100, D100, F100, PT385, PT3916; or user-configurable 0Ω to 10kΩ.

Type	Range	Resolution	Accuracy ±°C 2 Year T_{CAL} ±5°C	Temperature Coefficient [46]
4-Wire RTD	−200 to 850 °C	0.01 °C	0.06 °C	0.003 °C/°C
3-Wire RTD [47]	−200 to 850 °C	0.01 °C	0.75 °C	0.003 °C/°C

THERMISTOR

TYPES: 2.252kΩ, 5kΩ, and 10kΩ.

Type	Range	Resolution	Accuracy ±°C 2 Year T_{CAL} ±5°C	Temperature Coefficient [46]
Thermistor	−80 to +150 °C	0.01 °C	0.08 °C	0.002 °C/°C

THERMOCOUPLE

TYPES: B, E, J, K, N, R, S, T

Type	Range	Resolution	Accuracy ±°C 2 Year, T_{CAL} ±5°C [48] Simulated Reference Junction	Temperature Coefficient [46]
B	350 to +1820 °C	0.1 °C	0.6 °C	0.03 °C/°C
E	−200 to +1000 °C	0.001 °C	0.2 °C	0.03 °C/°C
J	−200 to +760 °C	0.001 °C	0.2 °C	0.03 °C/°C
K	−200 to +1372 °C	0.001 °C	0.2 °C	0.03 °C/°C
N	−200 to +1300 °C	0.001 °C	0.2 °C	0.03 °C/°C
R	0 to +1768 °C	0.1 °C	0.6 °C	0.03 °C/°C
S	0 to +1768 °C	0.1 °C	0.6 °C	0.03 °C/°C
T	−100 to +400 °C	0.001 °C	0.2 °C	0.03 °C/°C

42. Noise values are based on 1000 readings with autozero on and AMPS terminal open. RMS noise is typical. Additional peak noise is guaranteed.

43. Rear input terminals only.

44. With line sync on.

45. Values are typical and guaranteed by design.

46. Add per degree from T_{CAL} ±5°C; specifications without autocalibration.

47. For 3-wire RTD, accuracy is for <0.1Ω lead resistance mismatch for input HI and LO. Add 0.25°C/0.1Ω of HI-LO lead resistance mismatch.

48. Exclusive of cold-junction errors.

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Continuity

Range [49]	Resolution	Test Current	Open Circuit Voltage	Accuracy ±(ppm of reading + ppm of range)	
				2 Year T_{CAL} ±5°C	Temperature Coefficient [50]
1.0000 kΩ	100 mΩ	1 mA	14.0 V	100 + 100	2.5 + 1

CONTINUITY CHARACTERISTICS

CONTINUITY HIGH LIMIT: User-selectable; default 10Ω.

Capacitance

Accuracies specified for additional cable and stray capacitance properly zeroed with the Rel function.

ACCURACY

Range [51]	Resolution	Charge Current [52, 53]	Maximum Circuit Voltage	Accuracy ±(% of reading + % of range)	
				2 years T_{CAL} ±5°C	Temperature Coefficient [50]
1.0000 nF	0.1 pF	1.1 μA	2.8 V	1 + 0.2	0.15 + 0.05
10.000 nF	1 pF	1.1 μA	2.8 V	1 + 0.1	0.15 + 0.01
100.00 nF	10 pF	10 μA	3 V	0.4 + 0.1	0.01 + 0.01
1.0000 μF	0.1 nF	100 μA	3 V	0.4 + 0.1	0.01 + 0.01
10.000 μF	1 nF	100 μA	3 V	0.4 + 0.1	0.01 + 0.01
100.00 μF	10 nF	1 mA	3 V	0.4 + 0.1	0.01 + 0.01
1000.0 μF	0.1 μF	10 mA	3 V	0.5 + 0.1	0.01 + 0.01

Diode

Voltage Measure Range [51]	Resolution	Bias Level (Selectable)	Accuracy ±(ppm of reading + ppm of range)			
			90 Day T_{CAL} ±5°C	1 Year T_{CAL} ±5°C	2 Year T_{CAL} ±5°C	Temperature Coefficient [50]
10.000000 V	1 μV	10 μA / 100 μA / 1 mA	20 + 5	30 + 5	45 + 5	2.5 + 1

Digitize Voltage

ACCURACY (Input Impedance AUTO)

Range [54, 55]	Resolution [56]	Input Impedance [57]	Accuracy ±(ppm of reading + ppm of range)			
			90 Day T_{CAL} ±5°C	1 Year T_{CAL} ±5°C	2 Year T_{CAL} ±5°C	Temperature Coefficient [58]
100.000 mV	1 μV	>10 GΩ or 10 MΩ ±1%	210 + 100	220 + 100	230 + 100	15 + 20
1.00000 V	10 μV	>10 GΩ or 10 MΩ ±1%	110 + 75	120 + 75	130 + 75	15 + 20
10.0000 V	0.1 mV	>10 GΩ or 10 MΩ ±1%	110 + 75	120 + 75	130 + 75	10 + 20
100.000 V [59]	1 mV	10 MΩ ±1%	110 + 75	120 + 75	130 + 75	15 + 20
1000.00 V [60]	10 mV	10 MΩ ±1%	110 + 75	120 + 75	130 + 75	10 + 20

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49. Specifications exclude lead resistance.
50. Add per degree from T_{CAL} ±5°C; specifications without autocalibration.
51. 20% overrange on all ranges.
52. Charging current values are typical, guaranteed by design.
53. Discharge current limited to <13mA.
54. For DC coupling, 20% overrange for 100mV to 100V. For AC coupling, 500% overrange 100mV to 100V. 1% for 1000V range DC and AC coupling.
55. Accuracy with sample rate 1k per second, aperture auto, and 100 reading buffer average.

56. Power up default is 4½ digits.
57. User-selectable.
58. Add per degree from T_{CAL} ±5%.
59. For 100V range, input impedance auto and without A_{CAL}, add 100ppm of range additional uncertainty and 15ppm/°C additional uncertainty for "of range" temperature coefficient for operation outside of T_{CAL} ±5°C.
60. For signal levels greater than 500V, add 0.02 ppm/V to the ppm of the readings specification for measurements exceeding 500V.

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SIGNAL CHARACTERISTICS [61, 62, 63]

TYPICAL AC AND DC COUPLED

| Range	Analog Bandwidth (–3dB)	Maximum Flatness Error 3 Hz to 20 kHz [64]	THD 20 kHz Signal (–1dB FS) [65]	DC-coupled Settling Time (0.5%)	AC-coupled Filter FAST Settling Time (0.5%)	AC-coupled Filter SLOW Settling Time (0.5%)	AC Coupling Low Frequency (–3dB) point [66]
100.000 mV	600 kHz	0.015 dB	0.04 %	5 μs	80 ms	2.3 s	1 Hz
1.00000 V	600 kHz	0.01 dB	0.03 %	6 μs	80 ms	2.5 s	1 Hz
10.0000 V	600 kHz	0.01 dB	0.01 %	4 μs	80 ms	2.5 s	1 Hz

TYPICAL DC COUPLED

| Range	Analog Bandwidth (–3dB)	Maximum Flatness Error 3 Hz to 1 kHz [64]	Total Harmonic Distortion (THD) 1 kHz Signal (–1dB FS) [65]	Settling Time (0.5%)
100.000 V	20 kHz [67]	0.1 dB	1.3 %	160 μs
1000.00 V	20 kHz	0.1 dB	1.8 %	80 μs

TYPICAL AC COUPLED

Range	Analog Bandwidth (–3dB)	Maximum Flatness Error 3 Hz to 20 kHz [64]	Filter FAST Settling Time (0.5%)	Filter SLOW Settling Time (0.5%)	Low Frequency Coupling Point [66] (–3dB)
100.000 V	600 kHz	0.1 dB	80 ms	2.3 s	1 Hz
1000.00 V	600 kHz	0.1 dB	80 ms	2.3 s	1 Hz

DC-COUPLED ADDITIONAL NOISE UNCERTAINTY, TYPICAL [68]

RMS Noise, Digitize Voltage
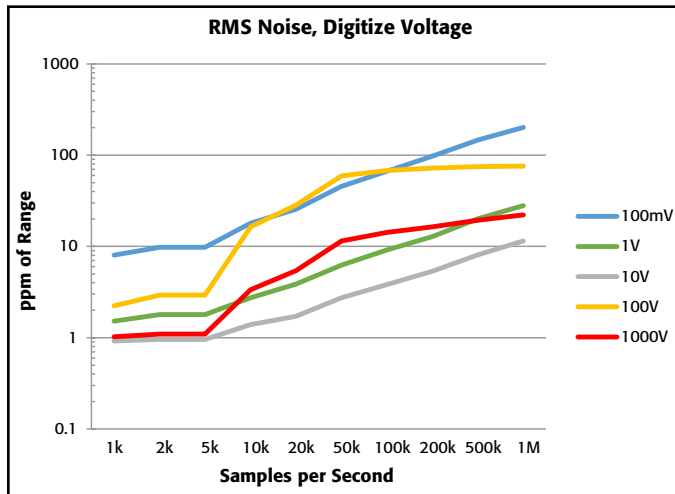
DC-COUPLED TOTAL HARMONIC DISTORTION (THD), TYPICAL [69]

Total Harmonic Distortion, Digitize Voltage
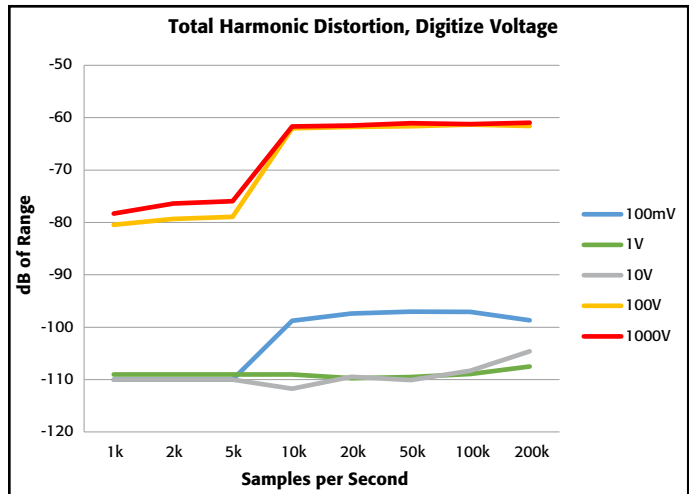
61. Accuracy with sample rate 1M per second and aperture 1μs.

62. Verified with sine wave input and DC content ≤3% of range.

63. For AC coupling, maximum crest factor of 5.

64. For DC coupled, 0dB reference frequency is 3Hz. For AC coupled, 0dB reference frequency is 1kHz. For AC coupled operation below 1kHz, add 0.1dB.

65. Exclusive of source input noise.

66. With AC coupling frequency = 3Hz and AC coupling filter = Slow.

67. For input impedance auto, bandwidth is 6kHz.

68. Specified with aperture auto and 4-wire short on input terminals. For 100V range, input impedance 10MΩ, multiply by 2.5. For all ranges and sample rate >1k, add an additional 3× RMS noise uncertainty to ppm of range.

69. Specified with aperture Auto, 100 Hz sine wave for sample rate ≤ 5 k, and 1 kHz sine wave for sample rate ≥ 10 k. Distortion is calculated using first five harmonics.

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DC-COUPLED EFFECTIVE NUMBER OF BITS (ENOB), TYPICAL [70]

Effective Number of Bits (ENOB), Digitize Voltage
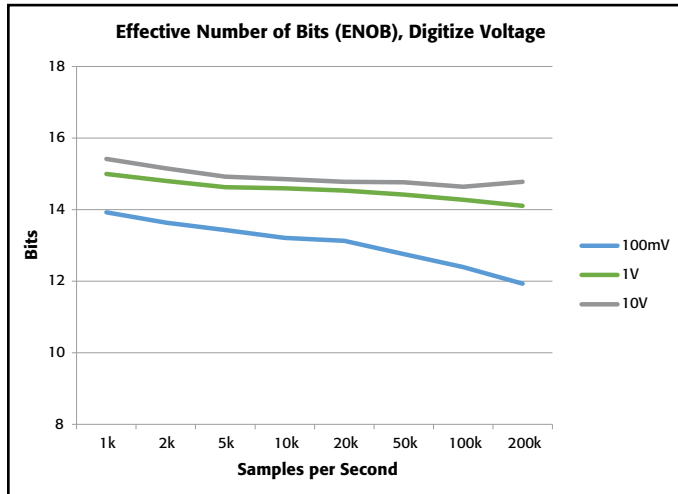
Digitize Current

DC ACCURACY [71]

Range [72]	Resolution [73]	Burden Voltage	Accuracy ± (ppm of reading + ppm of range)			Temperature Coefficient [74]
			90 Day T_{CAL} ±5°C	1 Year T_{CAL} ±5°C	2 Year T_{CAL} ±5°C	
10.0000 μA	0.1 nA	15 mV	150 + 75	160 + 75	170 + 75	30 + 15
100.000 μA	1 nA	15 mV	150 + 75	160 + 75	170 + 75	30 + 15
1.00000 mA	10 nA	15 mV	150 + 75	160 + 75	170 + 75	30 + 15
10.0000 mA	100 nA	20 mV	150 + 75	160 + 75	170 + 75	30 + 15
100.000 mA	1 μA	200 mV	340 + 100	450 + 100	560 + 100	50 + 20
1.00000 A	10 μA	400 mV	400 + 110	500 + 110	600 + 110	50 + 25
3.00000 A	100 μA	1300 mV	650 + 150	900 + 150	900 + 150	50 + 25
10.0000 A [75]	100 μA	650 mV	950 + 350	1500 + 350	2000 + 350	50 + 25

SIGNAL CHARACTERISTICS, TYPICAL [76]

Range [72]	Maximum Flatness Error 3 Hz to 20 kHz	Analog Bandwidth (−3dB)	Total Harmonic Distortion (THD) 20 kHz Signal (−1dB FS)	DC-coupled Settling Time (0.5%)
10.0000 μA	0.15 dB	100 kHz	0.02 %	8 μs
100.000 μA	0.15 dB	100 kHz	0.01 %	7 μs
1.00000 mA	0.1 dB	100 kHz	0.01 %	3 μs
10.0000 mA	0.1 dB	100 kHz	0.01 %	8 μs
100.000 mA	0.1 dB	100 kHz	0.02 %	5 μs
1.00000 A [77]	0.1 dB	100 kHz	0.02 %	6 μs
3.0000 A [77]	0.1 dB	100 kHz	0.02 %	6 μs
10.0000 A [75, 77, 78]	0.1 dB	100 kHz	0.02 %	6 μs

70. Specified with aperture Auto, 100Hz sine wave for sample rate ≤5k, and 1kHz sine wave for sample rate ≥10k. For the 100V and 1000V ranges, use the 1V and 10V range ENOB, respectively; guaranteed by design.

71. Accuracy with sample rate 1k per second, aperture auto, and 100 reading buffer average.

72. 20% overrange on all ranges except 3.3% for 3A and 10A ranges.

73. Power up default is 4½ digits.

74. Add per degree from T_{CAL} ±5°C.

75. Rear input terminals only.

76. Verified with sine wave input and DC content ≤ 3 % of range. 0 dB reference frequency is 3 Hz.

77. 10A range is available only on the rear input terminals.

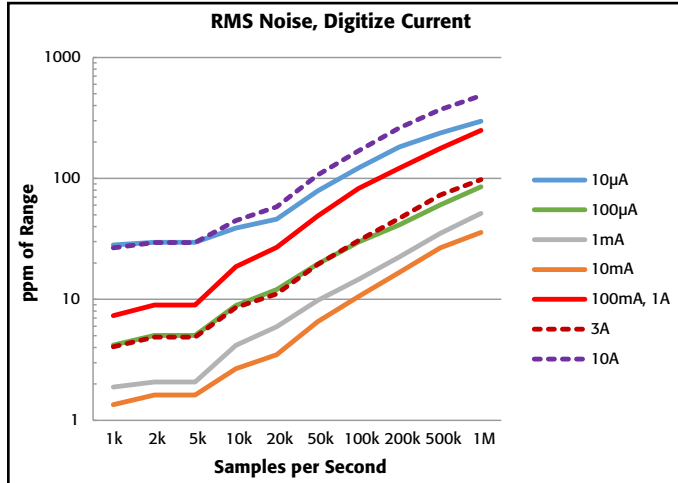78. 10A flatness verified to 10kHz; 100kHz guaranteed by design.
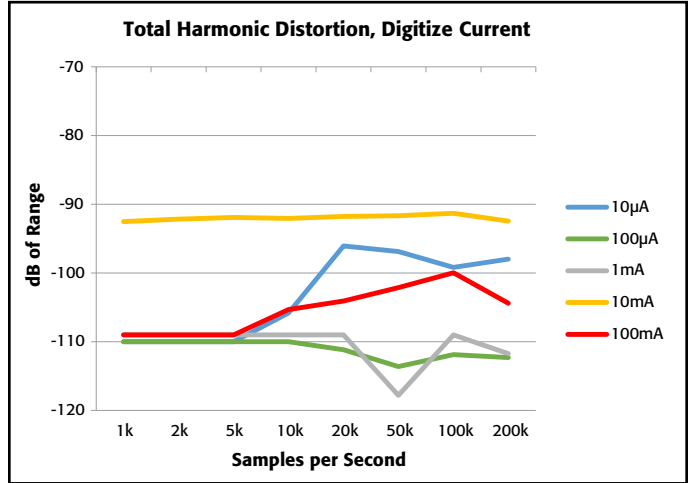
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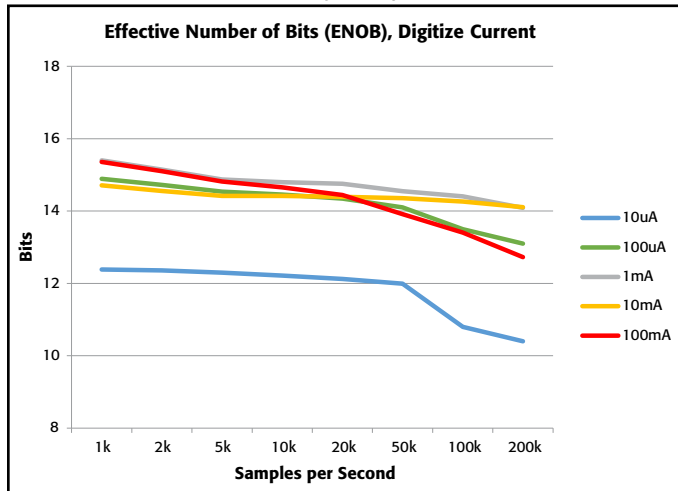
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ADDITIONAL NOISE UNCERTAINTY, TYPICAL [79]

RMS Noise, Digitize Current

TOTAL HARMONIC DISTORTION (THD), TYPICAL [80]

Total Harmonic Distortion, Digitize Current

EFFECTIVE NUMBER OF BITS (ENOB), TYPICAL [81]

Effective Number of Bits (ENOB), Digitize Current

Digitizer Characteristics

MAXIMUM RESOLUTION: 18 bits.

MEASUREMENT INPUT COUPLING: DC or AC (voltage only).

SAMPLING RATE [82]: Programmable 1k through 1 million.

VOLATILE SAMPLE MEMORY WITH TIMESTAMP: 27.5 million .

MINIMUM RECORD TIME: 1μs.

TIMESTAMP RESOLUTION: 1ns with standard or full buffer style. 1μs with compact buffer style.

TIMESTAMP ACCURACY:

With standard or full buffer style, 20ns between adjacent readings, with total buffer time <2s.

With compact buffer style, 2μs adjacent readings, with total buffer buffer time <2s.

MAXIMUM RECORD LENGTH: 8 million.

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79. Specified with aperture Auto and open input terminals. For all ranges and for ≥1k sample rate, add an additional 3× RMS noise uncertainty to ppm of range.

80. Specified with aperture Auto, 100 Hz sine wave for sample rate ≤ 5 k, and 1 kHz sine wave for sample rate ≥ 10 k. Distortion is calculated using first five harmonics. For the 1 A, 3 A, and 10 A ranges, use the 100 mA range accuracy; guaranteed by design.

81. Specified with aperture Auto, 100Hz sine wave for sample rate ≤5k, and 1kHz sine wave for sample rate ≥10k. For the 1A, 3A, and 10A ranges, use the 100mA ENOB; guaranteed by design.

82. Sample rate is not continuously adjustable. For valid discrete settings, see the Model DMM7510 Reference Manual.

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DMM7510

7½-Digit Graphical Sampling Multimeter

True RMS AC Voltage and AC Current

Function	Range [83]	Resolution	1-Year Accuracy: ±(% of reading + % of range) T_{CAL} ±5°C					
			3 Hz to 5 Hz	5 Hz to 10 Hz	10 Hz to 20 kHz	20 kHz to 50 kHz	50 kHz to 100 kHz	100 kHz to 300 kHz
Voltage [84]	100.0000 mV	0.1 µV	1.0 + 0.03	0.30 + 0.03	0.06 + 0.03	0.14 + 0.05	0.6 + 0.08	4.0 + 0.5
	1.000000 V	1 µV	1.0 + 0.03	0.30 + 0.03	0.06 + 0.03	0.14 + 0.05	0.6 + 0.08	4.0 + 0.5
	10.00000 V	10 µV	1.0 + 0.03	0.30 + 0.03	0.06 + 0.03	0.14 + 0.05	0.6 + 0.08	4.0 + 0.5
	100.0000 V	100 µV	1.0 + 0.03	0.30 + 0.03	0.06 + 0.03	0.14 + 0.05	0.6 + 0.08	4.0 + 0.5
	700.000 V	1 mV	1.0 + 0.03	0.30 + 0.03	0.06 + 0.03	0.14 + 0.05	0.6 + 0.08	4.0 + 0.5
Temperature Coefficient/°C (all ranges)	–	–	0.01 + 0.003	0.03 + 0.003	0.005 + 0.003	0.006 + 0.005	0.01 + 0.006	0.03 + 0.01

Function	Range [83]	Resolution	1-Year Accuracy: ±(% of reading + % of range) T_{CAL} ± 5°C				
			3 Hz to 5 Hz	5 Hz to 10 Hz	10 Hz to 2 kHz	2 kHz to 5 kHz	5 kHz to 10 kHz
Current [84]	1.000000 mA	1 nA	1.0 + 0.04	0.30 + 0.04	0.08 + 0.03	0.09 + 0.03	0.09 + 0.03
	10.00000 mA	10 nA	1.0 + 0.04	0.30 + 0.04	0.08 + 0.03	0.09 + 0.03	0.09 + 0.03
	100.0000 mA	100 nA	1.0 + 0.04	0.30 + 0.04	0.08 + 0.03	0.09 + 0.03	0.09 + 0.03
	1.000000 A	1 µA	1.0 + 0.04	0.30 + 0.04	0.20 + 0.04	0.88 + 0.04	2.0 + 0.04
	3.000000 A	1 µA	1.0 + 0.05	0.30 + 0.05	0.20 + 0.05	0.88 + 0.05	2.0 + 0.05
	10.00000 A [85]	10 µA	1.0 + 0.05	0.40 + 0.05	0.40 + 0.05	0.88 + 0.05	2.0 + 0.05
Temperature Coefficient/°C (all ranges)	–	–	0.10 + 0.004	0.030 + 0.004	0.005 + 0.003	0.006 + 0.005	0.006 + 0.005

ADDITIONAL AC UNCERTAINTIES – LOW FREQUENCY UNCERTAINTY

Additional Uncertainty ±(% of reading), Lower Frequency Uncertainty	Detector Bandwidth (BW)		
	3 BW (3 Hz to 300 kHz)	30 BW (30 Hz to 300 kHz)	300 BW (300 Hz to 300 kHz)
20 Hz to 30 Hz	0	0.3	—
30 Hz to 50 Hz	0	0	—
50 Hz to 100 Hz	0	0	4.0
100 Hz to 200 Hz	0	0	0.72
200 Hz to 300 Hz	0	0	0.18
300 Hz to 500 Hz	0	0	0.07
> 500 Hz	0	0	0

ADDITIONAL AC VOLTAGE CREST FACTOR UNCERTAINTIES [86]

ADDITIONAL UNCERTAINTY: ±(% of reading).

Input Signal Frequency	Detector Bandwidth	Maximum Crest Factor: 5 at Range Full Scale			
		1 to 2	2 to 3	3 to 4	4 to 5
3 Hz to 5 Hz	3 Hz	1.00	4.00	4.80	5.00
5 Hz to 10 Hz	3 Hz	0.50	1.20	1.30	1.40
10 Hz to 30 Hz	3 Hz	0.20	0.30	0.60	0.90
5 Hz to 100 Hz	30 Hz	0.20	0.30	0.60	0.90
100 Hz to 300 Hz	30 Hz	0.05	0.15	0.30	0.40
100 Hz to 300 Hz	300 Hz	0.50	1.20	1.30	1.50
500 Hz to 10 kHz	300 Hz	0.05	0.15	0.30	1.20

83. 20% overrange on AC functions except 1% on 700V, 3.33% on 3A, and 1% on 10A. Default resolution is 6½ digits.

84. Specifications are for detector bandwidth of 3Hz and sine wave inputs >5% of range. Detector bandwidth of 3Hz and 30Hz are multisample A/D conversions. Detector bandwidth of 300Hz is a single A/D conversion, programmable from 0.0005 PLC to 15 PLC (60Hz), 12 PLC (50Hz). Default condition set to 1 PLC.

85. Rear terminals only.

86. Applies for non-sine wave inputs, DC content ≤3% of range, maximum crest factor ≤5.0. For bandwidth 30Hz, autozero off, 6½ digits at 1 PLC, 3½ digits at 0.0005 PLC.

AC VOLTAGE CHARACTERISTICS

MEASUREMENT METHOD: AC-coupled, true RMS.

INPUT IMPEDANCE: 1MΩ ± 2% ∥ <150pF.

VOLT*HERTZ PRODUCT: <2.1 × 10⁷V*Hz verified; input frequency verified for <300kHz.

AC CURRENT CHARACTERISTICS

MEASUREMENT METHOD: AC-coupled, true RMS.

Range	1 mA	10 mA	100 mA	1 A	3 A	10 A [87]
Burden Voltage (RMS)	<16 mV	<20 mV	<0.2 V	<0.4 V	<1.3 V	<0.65 V
Overload Recovery: For each additional sustained ampere beyond ±1.5A, add the following initial % of range error until thermally settled after overload recovery	0.006	0.006	0.12	0.05	—	—

Frequency and Period

MEASUREMENT ACCURACY [88]

Aperture	Measurement Resolution	Accuracy ±(ppm of reading + ppm of aperture time) Frequency: 3 Hz to 500 kHz Period: 333 ms to 2 µs	
		1 Year, T_{CAL} ±5°C	2 Year, T_{CAL} ±5°C
250 ms	0.1 ppm	80 + 0.333	160 + 0.333
100 ms	0.1 ppm	80 + 3.33	160 + 3.33
10 ms	0.1 ppm	80 + 33.3	160 + 33.3

THRESHOLD LEVEL ACCURACY [89]

Threshold Range	Threshold Resolution	Accuracy ±(% of reading) 2 Year, T_{CAL} ±5°C
100 mV to 700 V	0.05%	1.0%

FREQUENCY AND PERIOD CHARACTERISTICS

MEASUREMENT METHOD: Reciprocal counting technique.

APERTURE: 10ms to 273ms; default is 10ms.

TYPICAL READING RATES, 60Hz (50Hz) OPERATION [90, 91, 92, 93]

NPLC	Digits	Functions: DC Voltage (10 V), 2-wire Ohms (≤10kΩ), DC Current (1 mA)		Functions: 4-wire ohms (≤1 kΩ), 4-wire/3-wire RTD		Functions: Thermistor		Functions: Dry Circuit (≤1 kΩ)	
		Measurements Into Buffer	Measurements Into Computer	Measurements Into Buffer	Measurements Into Computer	Measurements Into Buffer	Measurements Into Computer	Measurements Into Buffer	Measurements Into Computer
1	7½	59.8 (49.8)	58 (48)	29 (24)	28 (24)	57 (48)	57 (48)	27 (23)	26 (22)
0.2	6½	295 (240)	250 (210)	128 (109)	119 (100)	230 (200)	230 (200)	100 (89)	96 (85)
0.06	5½	965 (810)	950 (800)	310 (280)	315 (280)	900 (750)	900 (750)	190 (180)	190 (180)
0.006	4½	7500 (6700)	7300 (6500)	750 (730)	740 (720)	6800 (6000)	6800 (6000)	295 (290)	295 (290)
0.0005	3½	26000 (26000)	24000 (24000)	860 (860)	860 (860)	18000 (18000)	18000 (18000)	310 (310)	310 (310)

Detector Bandwidth (Hz)	Digits	Functions: ACV, ACI	
		Measurements Into Buffer	Measurements Into Computer
3	6½	0.5 (0.5)	0.5 (0.5)
30	6½	3.3 (3.3)	3.3 (3.3)
300 [94]	6½	59.8 (49.8)	55 (46)
300 [94]	3½	26200 (26200)	24500 (24500)

DIGITIZE, TYPICAL

Sampling Rate	Digits	Resolution	Measurements Into Computer [93]
10 kS/s	5½	18	9700
20 kS/s	4½	16	19000
50 kS/s	4½	16	44400
100 kS/s	4½	15	80000
1 MS/s	3½	12	108000

87. Rear input terminals only.

88. Specified for square wave inputs. Input signal must be >10% of ACV range. If input is<20mV on the 100mV range, then the frequency must be >10Hz. For sine wave inputs, frequency must be >100Hz. For frequencies ≤100Hz, threshold level ≤50% of input signal and ≤7Hz, threshold level ≤3% of range.

89. Threshold range is voltage RMS and threshold level voltage peak. Specified with 1kHz square wave. 100V and 700V threshold ranges guaranteed by design.

90. Reading speeds for autozero off, fixed range, autodelay off. Offset compensation off and open lead detector off where applicable.

91. Buffer measurements: For <0.2 PLC, multisample, single buffer transfer binary reading only.

92. PC measurements: For 1 and 0.2 PLC single reading and single transfer to computer (USB).

93. Reading rates using factory default operating conditions and autorange off, autodelay off. Speeds include measurement and data transfer out of the USB. ≥1000 readings with binary transfer over USB.

94. For bandwidth 300Hz, autozero off, 6½ digits at 1 PLC, 3½ digits at 0.0005 PLC.

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System Performance, Typical

MODE: 3½-digit, autozero off, 0.0005 PLC, excludes measurement time.

Time includes function change from DC voltage or 2-wire ohms to listed function.

Function	Function Change (ms)	Range Change (ms)
DC Voltage or 2-wire ohms (<10 kΩ)	6	1.3
4-wire ohms (<10 kΩ)	7	1.3
DC Current	7	1.3
Frequency or Period [95]	7	1.3
AC Voltage or AC Current	7	1.3
Digitize Voltage or Current	7	1.3

RANGES FOR FUNCTION CHANGE TIMES

Function change times apply to the ranges listed in the table below.

Function	Range
DC Voltage	10 V
2-wire or 4-wire Ohms	1 kΩ
DC Current	1 mA
Dry-circuit Ohms	10 Ω
Thermocouple	Use DC Voltage rates
Thermistor	Use 2-wire Ohms rates
AC Current	1 mA
AC Voltage	1 V

Buffer Transfer Speed (Binary)	Measurements into Computer (per second)		
	USB	LAN	GPIB
Average for 1000 readings	280000	270000	190000
Average for 1000 readings with timestamp	170000	140000	100000

Triggering

TIME BASE ACCURACY: 25ppm.

TRIGGER SOURCE: Analog DCV, DCI, or any system trigger.

TRIGGER COUPLING: DC or AC (DCV function only).

INPUT TRIGGER LATENCY [96, 97, 98]**:** <225ns.

INPUT TRIGGER JITTER [96, 97]**:** <50ns.

SAMPLE PERIOD JITTER [96, 97]**:** <1ns.

DMM REAR-PANEL TRIGGERS

EXT TRIG IN AND OUT: 0V to 5V logic signal input and output, TTL compatible.

EXT TRIGGER LATENCY (IN and OUT): <400ns.

EXT TRIGGER LATENCY (IN or OUT): <200ns (guaranteed by design).

ANALOG TRIGGERING [99]

ANALOG LEVEL, EDGE, OR WINDOW TRIGGER TYPES [100]

Trigger Characteristics	Voltage Input	Current Input
Input	100 mV to 1000 V	10 μA to 10 A
Resolution	0.05%	0.05%
Basic Accuracy (T_{ACAL} ±5°C) [101, 102]	1%	1%

ANALOG TRIGGER LATENCIES

	Digital I/O	External
Positive Logic	800 ns + 40 ns jitter	930 ns + 40 ns jitter
Negative Logic	800 ns + 40 ns jitter	840 ns + 40 ns jitter

WINDOW FILTER AND MEMORY (BUFFER)

WINDOW FILTER SIZE: 0 to 10% of reading, where 0 averages all readings.

MEMORY: Up to 27.5 million timestamped readings with the compact buffer style, with additional memory available using an external USB flash drive.

MAXIMUM INTERNAL MEMORY (Buffer): 27.5 million readings with the compact buffer style (6½-digit without formatting), 11 million readings with the standard or full buffer style.

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95. For DC voltage or 2-wire ohms to frequency or period, 10ms aperture. For AC current or AC voltage, detector bandwidth is 300Hz.

96. Guaranteed by design; for digital I/O only.

97. Stimulus command required to meet specifications.

98. If using trigger model, add 200ns uncertainty.

99. For DC or AC coupled, the trigger level can be set up to 100% of measure range.

100. Rising or falling edge triggering supported. Window trigger requires setting two independent levels.

101. Trigger event occurs after the threshold crossing at a time determined by total trigger latencies.

102. Accuracy specifications require user A_{CAL} and are verified with level trigger amplitude set to 50% of range with a 100Hz sine wave at 100% full scale of range. High frequency rejection is off. NPLC 0.0005 (DC voltage/DC current) or aperture 1μs for digitize voltage or digitize current. Specified for fixed range, autozero off. For digitized DC voltage AC coupled, add 0.5 %. For DC current and digitized DC current 3A or 10A ranges, add an additional 2%.

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DMM7510   7½-Digit Graphical Sampling Multimeter

GENERAL INSTRUMENT SPECIFICATIONS

SPECIFICATION CONDITIONS: This document contains specifications and supplemental information for the Model DMM7510 Precision Sampling Digital Multimeter instrument. Specifications are the standards against which the Model DMM7510 is tested. Upon leaving the factory, the Model DMM7510 meets these specifications. Supplemental, typical, and characteristic values are non-warranted, apply at 23°C, and are provided solely as useful information. All specifications apply to front or rear terminal inputs, except 10 A specifications (rear terminals only).

INPUT PROTECTION: 1010 V DC (715 V_{RMS} V AC) all ranges and functions on HI and LO terminals; 350V all ranges and functions on sense HI, sense LO terminals; 250V rated current input terminal; fused 3A and 10A ranges; current input terminals protected to 1kV.

3A INPUT FUSE PROTECTION: 3.5A, 1kV fast blow type; Keithley part number DMM7510-FUSE-3A.

10A INPUT FUSE PROTECTION: 11A, 1kV fast blow type; Keithley part number DMM7510-FUSE-10A.

AC VOLTAGE INPUT: Maximum DCV: 1000V on any AC voltage range.

COMMON MODE ISOLATION: 500VDC or ACVpeak LO to chassis. All terminals >10GΩ, <350pF any terminal to chassis.

POWER LINE: Universal input, 100V to 240V.

LINE FREQUENCY: 50Hz or 60Hz, automatically sensed at power-up.

POWER CONSUMPTION: 60VA.

OPERATING ENVIRONMENT: Specified for 0° to 50°C, ≤80% relative humidity at 35°C, altitude up to 2000 meters.

STORAGE ENVIRONMENT: −30° to 70°C.

REAL TIME CLOCK: Lithium battery backup (3+ years battery life).

EMC: Conforms to European Union EMC Directive.

SAFETY: NRTL listed to UL61010-1, and CSA C22.2 No 61010-1; conforms with European Union Low Voltage Directive.

VIBRATION: MIL-PRF-28800F Class 3, Random.

WARM-UP: 90 minutes to rated accuracy.

INPUT SIGNAL CONNECTIONS: Front and rear safety banana jacks.

COOLING: Forced air, fixed speed.

DIMENSIONS:
- **Without handle and bumpers:** 88mm high × 213mm wide × 410mm deep (3.46 in. × 8.39 in. × 16.13 in.).
- **With handle and bumpers (bench configuration):** 106mm high × 255mm wide × 425mm deep (4.18 in. × 10.05 in. × 16.75 in.).

SHIPPING WEIGHT (with bumpers and handle): 4.08kg (9.0 lb.).

SHIPPING WEIGHT (without bumpers and handle): 3.63kg (8.0 lb.).

DIGITAL I/O:
- **Connector:** 9-pin female D.
- **5V Power Supply Pin:** Limited to 500 mA at > 4 V (solid-state fuse protected).
- **Lines:** Six input/output, user-defined, for digital I/O or triggering.
- **Input Signal Levels:** 0.7V (maximum logic low) 3.7V (minimum logic high).
- **Input Voltage Limits:** −0.25V (absolute minimum) +5.25V (absolute maximum).
- **Maximum Source Current:** +2.0mA at >2.7V (per pin).
- **Maximum Sink Current:** −50mA at 0.7V (per pin, solid-state fuse protected).
- **Handler:** User-defined start of test, end of test, four category bits

MATH FUNCTIONS: Rel, dB, Limit Test, Percentage, 1/x, and mX + b.

REMOTE INTERFACE:
- **LAN:** RJ-45 connector, 10/100BT; Virtual Front Panel.
- **IP Configuration:** Static or DHCP.
- **GPIB:** IEEE-488.1 compliant. Supports IEEE-488.2 common commands and status model topology.
- **USB Device (rear panel, type B):** 2.0 full speed, USBTMC compliant.
- **USB Host (front panel, type A):** USB 2.0, support for flash drives, FAT 32.

LXI COMPLIANCE: LXI version 1.4 Core 2011.

LANGUAGE: Embedded Test Script Processor (TSP) accessible from any host interface; responds to high-speed test scripts comprised of remote commands and statements (for example, branching, looping, math); able to execute high-speed test scripts stored in memory without host intervention; also SCPI (default command set).

ACCESSORIES SUPPLIED: Product Information CD-ROM, Model DMM7510 Quick Start Guide, Kickstart Software Quick Start Guide, power cord, 1 m USB cable (type A to type B), 3 m LAN cable, and Model 1756 Standard Test Lead Kit.

ACCESSORIES AVAILABLE: (Calibration / Data / ISO 17025), software IVI/VISA drivers for Microsoft® Visual Basic®, Visual C/C++®, National Instruments (NI™) LabVIEW™, Keithley Test Script Builder, Keithley KickStart, and NI LabWindows™/CVI.

DISPLAY: Five-inch capacitive touch, color thin-film-transistor (TFT) WVGA (800×480) with LED backlight.

PASSWORD PROTECTION: 30 characters.

EXPANSION INTERFACE: The TSP-Link® expansion interface allows TSP-enabled instruments to trigger and communicate with each other.

IP CONFIGURATION: Static or DHCP (manual or automatic).