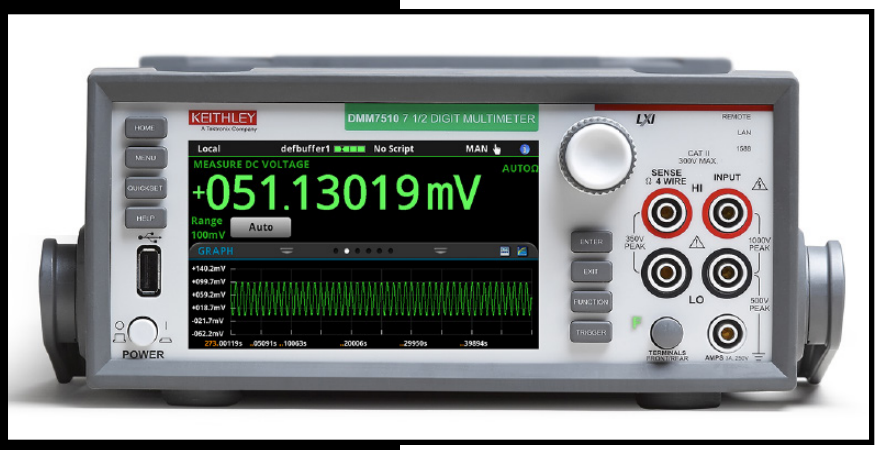
DMM7510

7½-Digit Graphical Sampling Multimeter

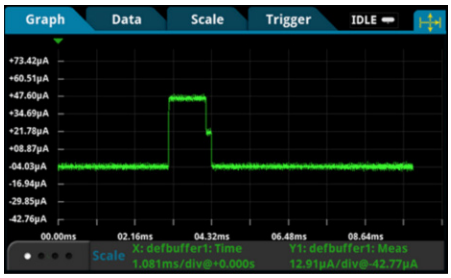


- **Precision multimeter with 3½- to 7½-digit resolution**
- **14 PPM basic one-year DCV accuracy**
- **100mV, 1Ω, and 10µA ranges offer the sensitivity needed for measuring low level signals**
- **Make accurate low resistance measurements with offset compensated ohms, four-wire, and dry circuit functions**
- **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**

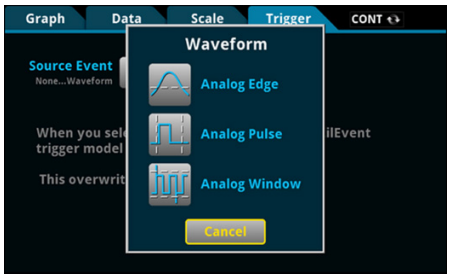
The Model DMM7510 combines all the advantages of a precision digital multimeter, a graphical touchscreen display, and a high speed, high resolution digitizer to create an industry first: a graphical sampling multimeter. The digitizer gives the Model DMM7510 unprecedented signal analysis flexibility; the five-inch capacitive touch-screen 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

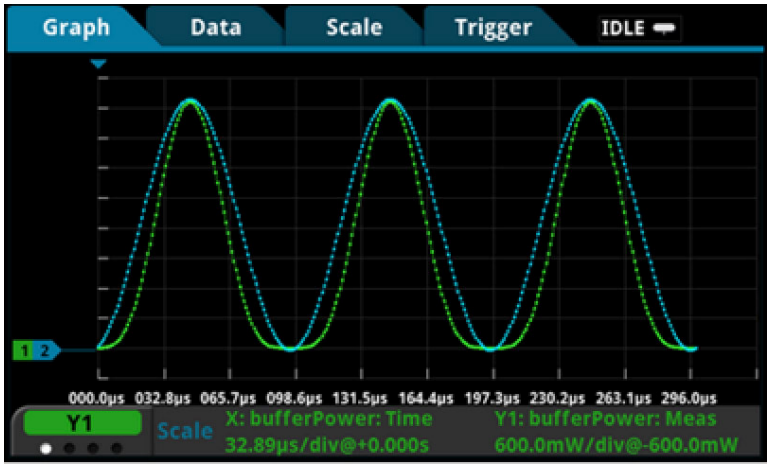
Capturing and displaying waveforms and transient events just got easier with the DMM7510's voltage or current digitizing function. The built-in 1MS/sec, 18-bit digitizer makes it possible to acquire waveforms without the need to use a separate instrument. The digitizing functions employ the same ranges 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.



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.

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

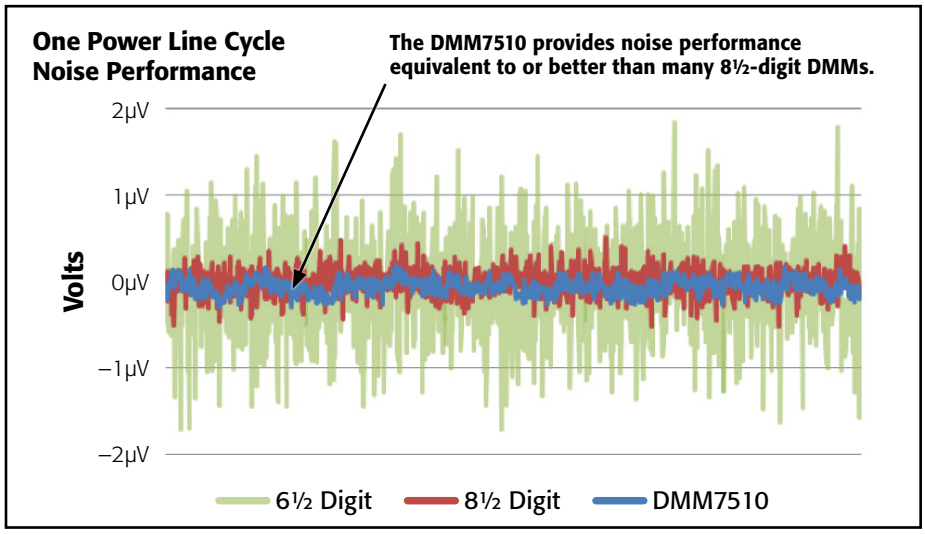
Test Script Builder Software (available at www.keithley.com)

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

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

Make Demanding Measurements with Confidence

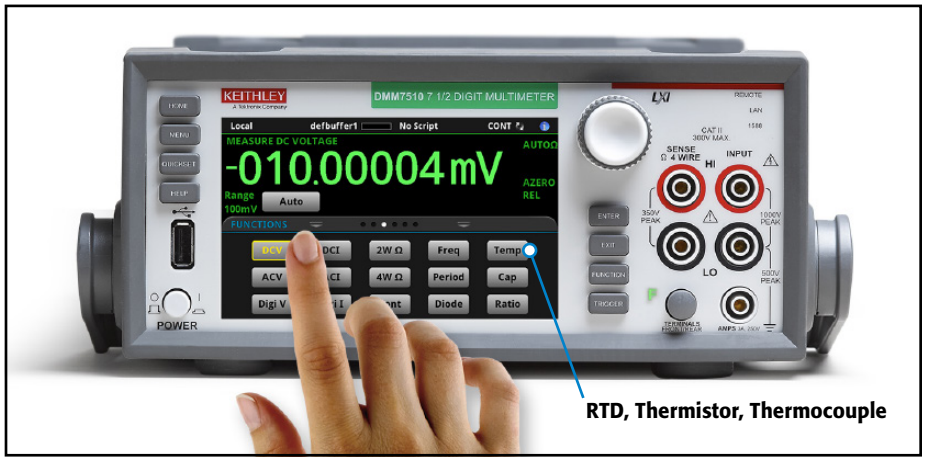
The Model DMM7510's design makes the most of Keithley's low level measurement expertise. Features like the low noise input stage and the 32-bit A-to-D converter allow this instrument to deliver DC accuracies typically only found in metrology-grade instrumentation—but at about half the price of those 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.



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.

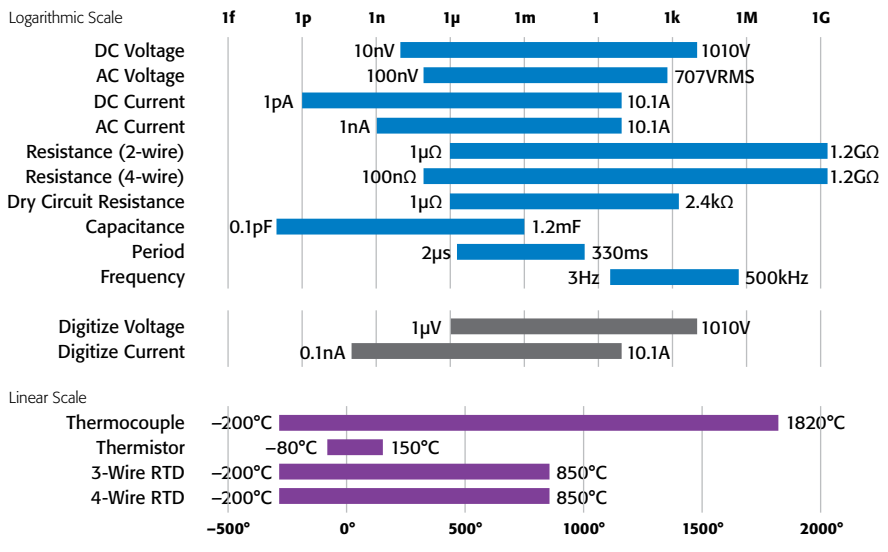
15 Measurement Functions

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.



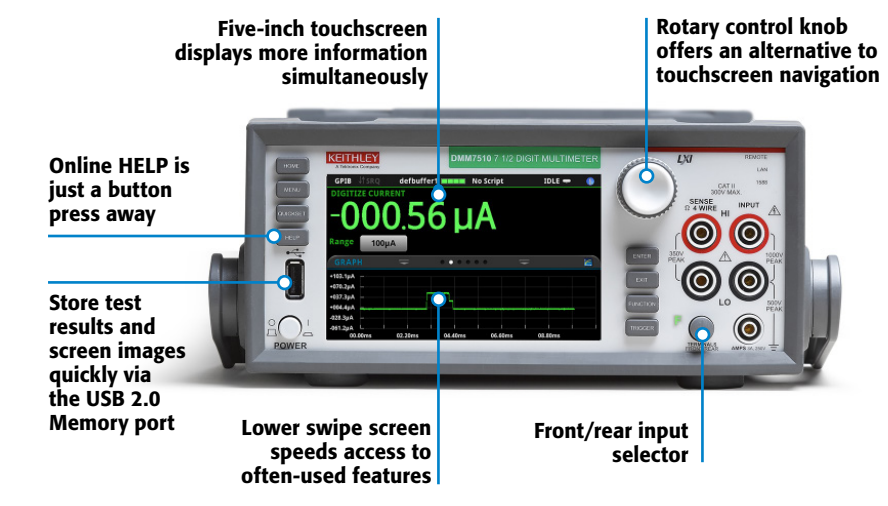
DMM7510 7½-Digit Graphical Sampling Multimeter

DMM7510 Measurement Capabilities



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.



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

DMM7510 7½-Digit Graphical Sampling Multimeter

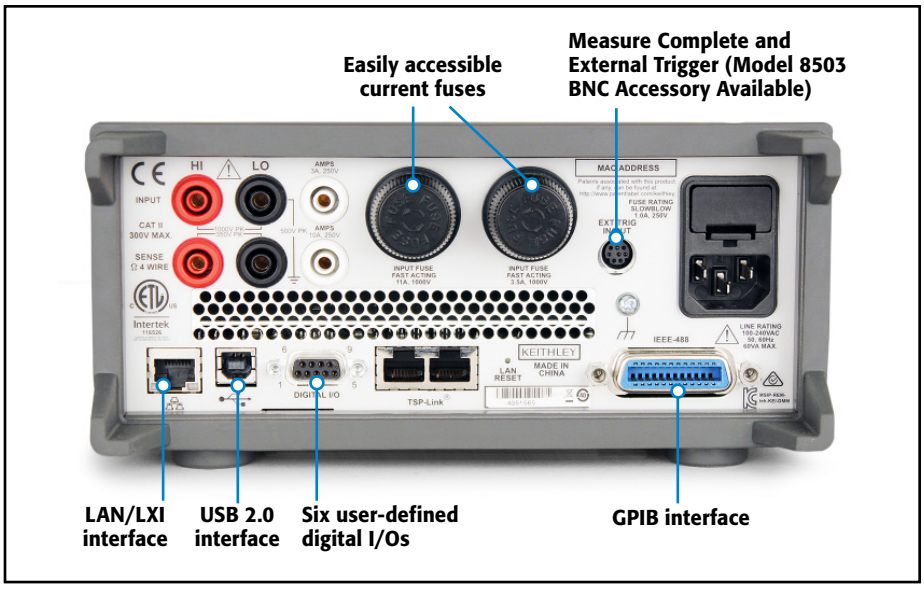
SERVICES AVAILABLE

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



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

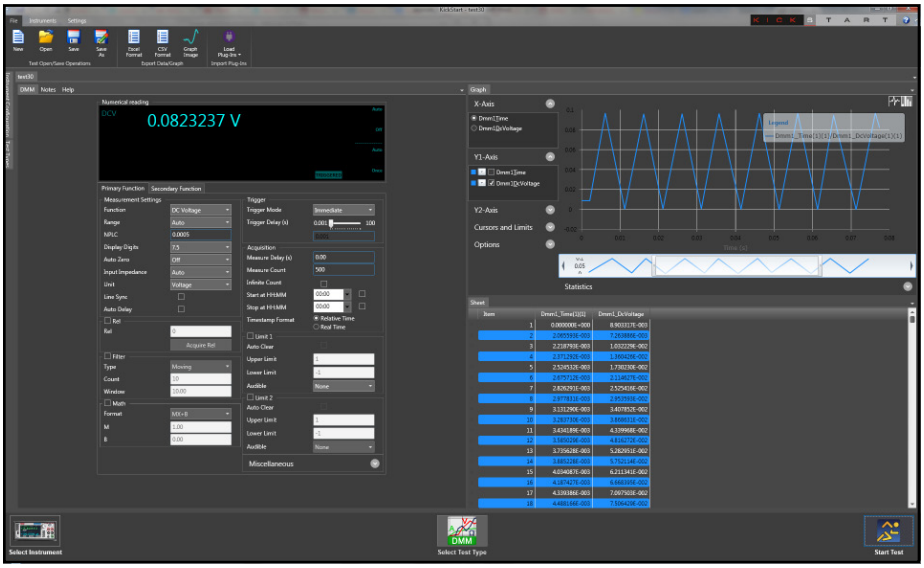
To offer users maximum programming flexibility and simplify configuring multi-instrument test systems, the DMM7510 includes Keithley's powerful Test Script Processor (TSP®) system and SCPI programming mode. The embedded scripting capability allows running powerful test scripts directly on the instrument, 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]

			Accuracy ±(ppm of reading + ppm of range)				
Range [11]	Resolution	Test Current [12] (±5%)	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	Temperature Coefficient [14]
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]

			Accuracy ±(ppm of reading + ppm of range)				
Range [20]	Resolution	Test Current [21] (±5%)	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	Temperature Coefficient [23]
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.

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})

Range [31]	Resolution	Test Current [35] (±5%)	Open Circuit DUT Voltage [32]	Accuracy ±(ppm of reading + ppm of range) 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

Range [31]	Resolution	Test Current [35] (±5%)	Open Circuit DUT Voltage [32]	Accuracy ±(ppm of reading + ppm of range) 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.

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) 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	Temperature Coefficient [40]
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) 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	Temperature Coefficient [40]
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	Accuracy ±°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	Accuracy ±°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	Accuracy ±°C: 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	Accuracy ±(ppm of reading + ppm of range) 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	Accuracy ±(% of reading + % of range) 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

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

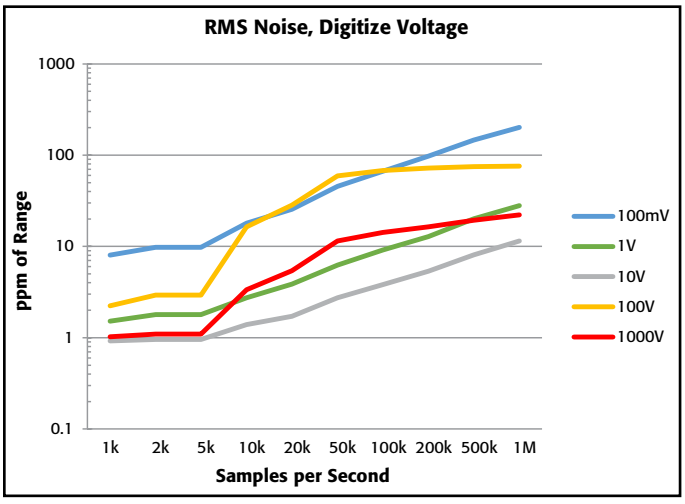
TYPICAL DC COUPLED

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

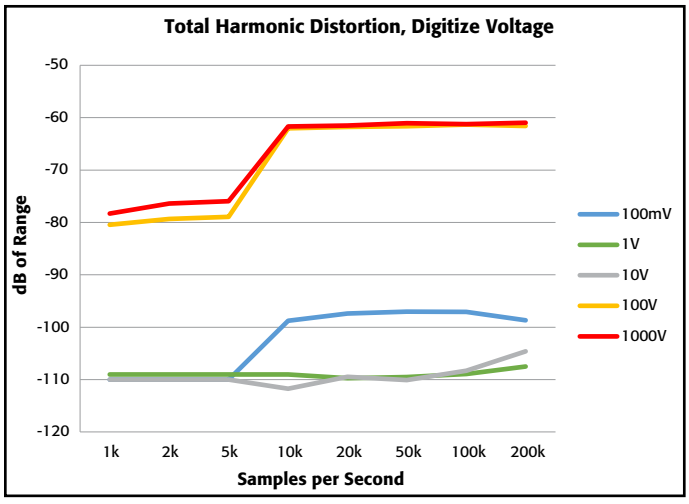
TYPICAL AC COUPLED

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]

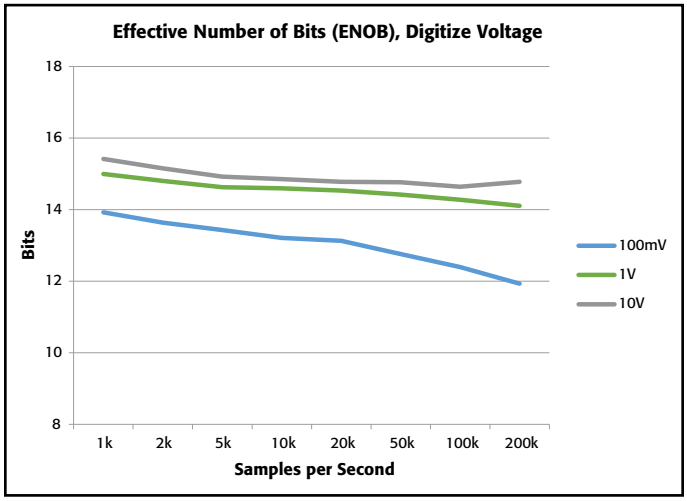


DC-COUPLED TOTAL HARMONIC DISTORTION (THD), TYPICAL [69]



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.

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



Digitize Current

DC ACCURACY [71]

Range [72]	Resolution [73]	Burden Voltage	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 [74]
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

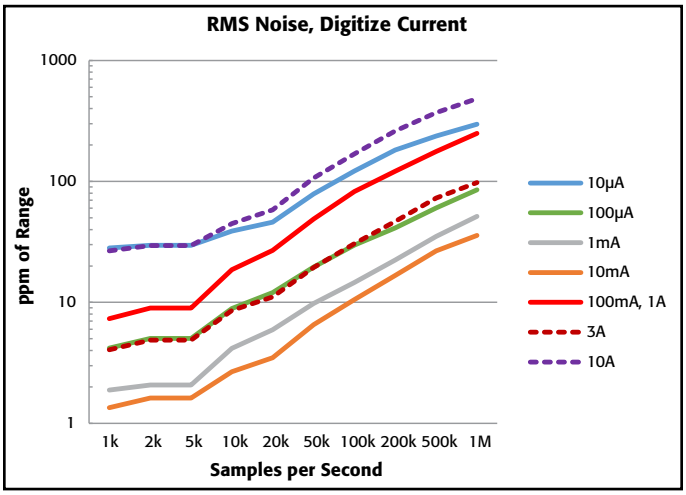
SIGNAL CHARACTERISTICS, TYPICAL [76]

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

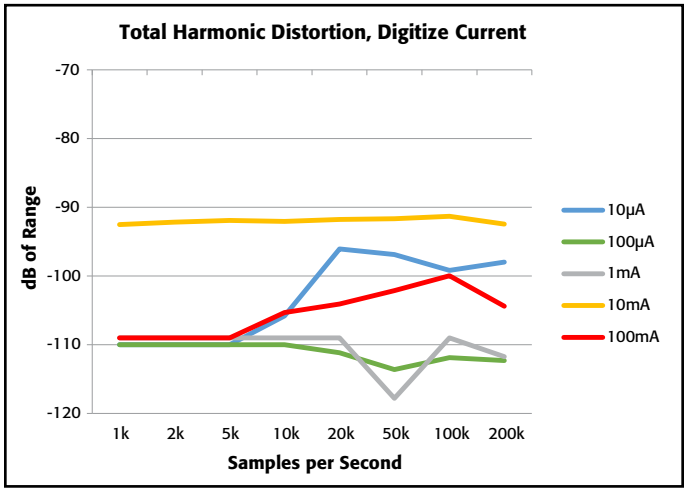
70. Specified with aperture Auto, 100Hz sine wave for sample rate ≤5k, and 1kHz sine wave for sample rate ≥10k. For the 100V and 1000V ranges, use the 1V and 10V range ENOB, respectively; guaranteed by design.
71. Accuracy with sample rate 1k per second, aperture auto, and 100 reading buffer average.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

DMM7510 7½-Digit Graphical Sampling Multimeter

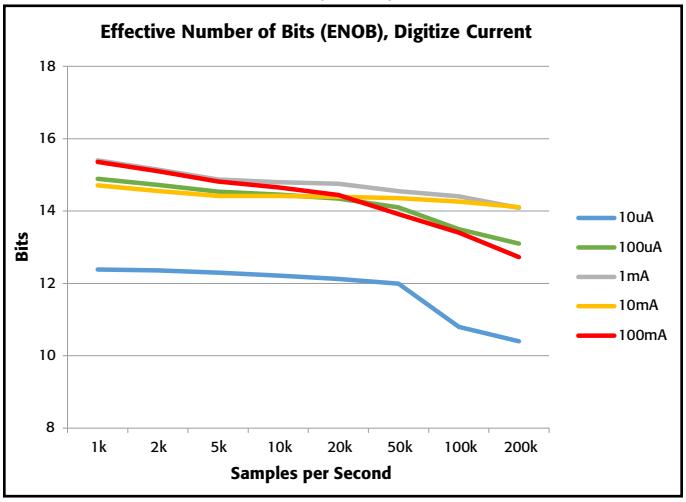
ADDITIONAL NOISE UNCERTAINTY, TYPICAL [79]



TOTAL HARMONIC DISTORTION (THD), TYPICAL [80]



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



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.

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.

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.

DMM7510 7½-Digit Graphical Sampling Multimeter

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) Measurements Into Buffer	Measurements Into Computer	Functions: 4-wire ohms (≤1 kΩ), 4-wire/3-wire RTD Measurements Into Buffer	Measurements Into Computer	Functions: Thermistor Measurements Into Buffer	Measurements Into Computer	Functions: Dry Circuit (≤1 kΩ) 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.

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

	Measurements into Computer (per second)		
Buffer Transfer Speed (Binary)	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.

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%.

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).

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DMM7510-NFP DMM7510 DMM7510-NFP-RACK

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