

Keithley Instruments
28775 Aurora Road
Cleveland, Ohio 44139
1-800-935-5595
tek.com/keithley

Data Acquisition and Multimeter System Specifications

SPECIFICATION CONDITIONS

This document contains specifications and supplemental information for the DAQ6510. Specifications are the standards against which the DAQ6510 is tested. Upon leaving the factory, the DAQ6510 meets these specifications. Supplemental and typical values are nonwarranted, apply at 23 °C, and are provided solely as useful information. Measurement accuracies are specified for plug-in module user input terminals and DAQ6510 front input terminals and include conversion error for thermocouple, thermistor, and RTD measurements. Additional switching module errors are included in the Characteristics section under each function.

Measurement conditions include:

- After a 30-minute warmup period
- 1 PLC or 5 PLC measurement rate; for NPLC settings less than 1 PLC, add appropriate noise error from Measurement Noise table under each function
- Autozero enabled
- Calibration period: one year (recommended) or two years. Calibration period may vary depending on customer requirements
- 24-hour accuracy specification is relative to calibrator accuracy
- The communication accessory slot cover or an optional KTTI interface card is properly installed on the rear of the unit

Definitions:

- **T_{CAL}**: The temperature at which the instrument was calibrated (23 °C for factory calibration)
- **Temperature coefficient**: Additional uncertainty added for each °C outside T_{CAL} ±5 °C
- **Power Line Cycle (PLC)**: 16.67 ms at 60 Hz and 20 ms at 50 Hz or 400 Hz line frequency; frequency automatically sensed at power up

DC VOLTAGE

DC VOLTAGE ACCURACY \pm (% OF READING + % OF RANGE)

Range	Resolution	Input impedance	24 hours $T_{CAL} \pm 1^\circ C$	90 days $T_{CAL} \pm 5^\circ C$	1 year $T_{CAL} \pm 5^\circ C$	2 years $T_{CAL} \pm 5^\circ C$	Temperature coefficient
100 mV	100 nV	> 10 G Ω or 10 M $\Omega \pm 1\%$	0.0015 + 0.0030	0.0025 + 0.0035	0.0030 + 0.0035	0.0035 + 0.0035	0.0001 + 0.0005
1 V	1 μ V	> 10 G Ω or 10 M $\Omega \pm 1\%$	0.0015 + 0.0006	0.0020 + 0.0006	0.0025 + 0.0006	0.0030 + 0.0006	0.0001 + 0.0001
10 V	10 μ V	> 10 G Ω or 10 M $\Omega \pm 1\%$	0.0010 + 0.0004	0.0020 + 0.0005	0.0025 + 0.0005	0.0030 + 0.0005	0.0001 + 0.0001
100 V	100 μ V	10 M $\Omega \pm 1\%$	0.0015 + 0.0006	0.0035 + 0.0006	0.0040 + 0.0006	0.0050 + 0.0006	0.0006 + 0.0001
1000 V ¹	1 mV	10 M $\Omega \pm 1\%$	0.0020 + 0.0006	0.0035 + 0.0006	0.0040 + 0.0006	0.0050 + 0.0006	0.0006 + 0.0001

MEASUREMENT NOISE CHARACTERISTICS AND REJECTION RATIOS

Measurement rate in NPLCs	Digits	DCV RMS noise uncertainty (in % of range + fixed base) ²	NMRR ³	CMRR ³
5 ⁴	6.5	0	100 dB	140 dB
5		0	60 dB	140 dB
1 ⁴		0	90 dB	140 dB
1		0	60 dB	140 dB
0.1 ⁴		0.00015 + 1 μ V	40 dB	120 dB
0.1	5.5	0.00015 + 4 μ V	--	120 dB
0.01		0.00030 + 6 μ V	--	80 dB
0.0005	4.5	0.00500 + 40 μ V	--	80 dB

DC VOLTAGE CHARACTERISTICS

Overrange	20% on 100 mV, 1 V, 10 V, and 100 V ranges		1% on 1000 V range
ADC linearity (10 V range)	0.0001% of 10 V range		
Input impedance	100 mV to 10 V ranges: Selectable, > 10 G Ω or 10 M $\Omega \pm 1\%$ in parallel with < 400 pF 100 V to 1000 V ranges: 10 M $\Omega \pm 1\%$ in parallel with < 400 pF		
Input bias current	< 50 pA at 23 °C		
Common mode current	< 600 nA peak-peak at 50 Hz or 60 Hz		
Earth isolation	500 V _{PEAK} > 10 G Ω and < 300 pF any terminal to chassis		
Common mode voltage	500 V _{PEAK} LO terminal to chassis maximum		
Autozero off error	Add \pm (0.0002% of range + 3 μ V) within $\pm 1^\circ C$ and ≤ 10 minutes since last autozero Add \pm (0.0010% of range + 10 μ V) within $\pm 5^\circ C$ and ≤ 60 minutes since last autozero		
Input protection	Front-panel DAQ input: Input HI 1010 V, Sense HI (SHI) and Sense LO (SLO) 350 V referenced to LO Rear-panel DAQ input through the plug-in modules: 600 V _{PEAK} all ranges (note this level exceeds the maximum input signal for modules: see the table below for module levels)		
Plug-in module additional uncertainties and maximum input signal levels	Plug-in module	Add the following uncertainty	Maximum input signal level
	7000, 7002, 7008	1 μ V	300 V for 7700, 7702, and 7708
	7701, 7703, 7707	6 μ V	300 V for 7703 and 7707
			150 V for 7701
	150 V for 7701	3 μ V	300 V for 7706 and 7709
			60 V for 7710

¹ For each additional volt over ± 500 V, add 0.02 mV of uncertainty.

² Applies for 100 mV through 10 V ranges. Noise values apply to terminals using a low-thermal short for 50 Hz and 60 Hz operation only. Measurements through a card may introduce additional noise.

³ NMRR for line frequency is $\pm 0.1\%$. For DC common mode and 1 k Ω , unbalance on LO terminal, rejection of AC common mode signals is > 80 dB for a line frequency of $\pm 0.1\%$.

⁴ Line sync on.

Specifications are subject to change without notice

RESISTANCE

RESISTANCE ACCURACY \pm (% OF READING + % OF RANGE)⁵

Range	Resolution	Test current ($\pm 5\%$)	Open circuit voltage ($\pm 5\%$)	24 hours $T_{CAL} \pm 1^\circ C$	90 days $T_{CAL} \pm 5^\circ C$	1 year $T_{CAL} \pm 5^\circ C$	2 years $T_{CAL} \pm 5^\circ C$	Temperature coefficient
1 Ω ⁶	1 $\mu\Omega$	10 mA	12.5 V	0.0080 + 0.0200	0.0080 + 0.0200	0.0085 + 0.0200	0.0100 + 0.0200	0.0006 + 0.0010
10 Ω ⁶	10 $\mu\Omega$	10 mA	12.5 V	0.0020 + 0.0020	0.0080 + 0.0020	0.0085 + 0.0020	0.0100 + 0.0020	0.0006 + 0.0001
100 Ω	100 $\mu\Omega$	1 mA	9.2 V	0.0020 + 0.0020	0.0075 + 0.0020	0.0085 + 0.0020	0.0100 + 0.0020	0.0006 + 0.0001
1 k Ω	1 m Ω	1 mA	9.2 V	0.0020 + 0.0006	0.0065 + 0.0006	0.0075 + 0.0006	0.0090 + 0.0006	0.0006 + 0.0001
10 k Ω	10 m Ω	100 μA	12.7 V	0.0020 + 0.0006	0.0065 + 0.0006	0.0075 + 0.0006	0.0090 + 0.0006	0.0006 + 0.0001
100 k Ω	100 m Ω	10 μA	12.5 V	0.0020 + 0.0006	0.0070 + 0.0010	0.0075 + 0.0010	0.0100 + 0.0010	0.0006 + 0.0001
1 M Ω	1 Ω	10 μA	12.5 V	0.0020 + 0.0006	0.0075 + 0.0006	0.0100 + 0.0006	0.0120 + 0.0006	0.0006 + 0.0001
10 M Ω ⁷	10 Ω	0.7 μA 10 M Ω	7.1 V	0.0150 + 0.0006	0.0200 + 0.0010	0.0400 + 0.0010	0.0450 + 0.0010	0.0105 + 0.0001
100 M Ω ⁷	100 Ω	0.7 μA 10 M Ω	7.1 V	0.0800 + 0.0030	0.2000 + 0.0030	0.2000 + 0.0030	0.2500 + 0.0030	0.0470 + 0.0001

RESISTANCE MEASUREMENT NOISE CHARACTERISTICS⁸

Measurement rate in NPLCs	Digits	2-wire RMS noise uncertainty (in % of range + fixed base)	4-wire RMS noise uncertainty, offset compensation OFF (in % of range + fixed base) ⁹	4-wire RMS noise uncertainty, offset compensation ON (in % of range + fixed base) ⁹
5	6.5	0	0	0
1		0	0	0
0.1 ¹⁰		0.00015 + 0.10 m Ω	0.00020 + 0.20 m Ω	0.00030 + 0.25 m Ω
0.1	5.5	0.00050 + 0.35 m Ω	0.00180 + 2.00 m Ω	0.00350 + 3.50 m Ω
0.01		0.00070 + 0.50 m Ω	0.00260 + 2.50 m Ω	0.00500 + 4.00 m Ω
0.0005	4.5	0.00650 + 3.50 m Ω	0.01000 + 7.00 m Ω	0.01500 + 10.00 m Ω

⁵ Specifications are for 2- and 4-wire resistance. For 2-wire, use relative offset, and add 100 m Ω of additional uncertainty. For 4-wire, turn offset compensation on for ≤ 10 k Ω and off for > 10 k Ω . The 1 Ω range is for 4-wire only.

⁶ Requires a 10-reading digital filter at 1 PLC or 2-reading digital filter at 5 PLC.

⁷ Specified for $< 10\%$ lead-resistance mismatch at HI and LO.

⁸ Applies for 1 Ω through 1 M Ω ranges. For 100 Ω range, multiple the listed values by five. Noise values apply to terminals using a low-thermal short for 50 Hz and 60 Hz operation only. Measurements through a switching module may introduce additional noise.

⁹ Open lead detection off.

¹⁰ Line sync on.

RESISTANCE CHARACTERISTICS

Overrange	20% on all ranges				
Autozero off error	Add $\pm(0.0005\%$ of range + 5 m Ω) within $\pm 1^\circ\text{C}$ and ≤ 10 minutes since last autozero Add $\pm(0.0020\%$ of range + 10 m Ω) within $\pm 5^\circ\text{C}$ and ≤ 60 minutes since last autozero				
Offset compensation	Selectable on 1 Ω , 10 Ω , 100 Ω , 1 k Ω , and 10 k Ω ranges, 4-wire mode only				
Maximum 4-wire lead-resistance	5 Ω per lead for 1 Ω range 10% of range per lead for 10 Ω , 100 Ω , 1 k Ω , and 10 k Ω ranges 1 k Ω per lead for 100 k Ω , 1 M Ω , 10 M Ω , and 100 M Ω ranges				
Open lead detector	Selectable on all ranges, 4-wire mode only; default is off				
Input protection	Front-panel DAQ input: Input HI 1010 V, Sense HI (SHI) and Sense LO (SLO) 350 V referenced to LO Rear-panel DAQ input through the plug-in modules: 600 V _{PEAK} all ranges (note this level exceeds the maximum input signal for modules: see maximum input signal levels for 7700 series plug-in modules listed in DC Voltage Characteristics or separately supplied module specifications)				
Switching module additional contact resistance	See Plug-in Switching Module Data Sheet				
Plug-in switching module additional uncertainties	Module		Add the following to % of reading accuracy		
			10 kΩ	100 kΩ	1 MΩ
			10 MΩ	100 MΩ	
	7701, 7703, 7707, 7709		0.001	0.01	0.1
	7706, 7708		0.0005	0.005	0.05
	7700, 7702		—	—	—
7710	% of reading error		0.0011	0.011	0.11
	Temperature coefficient (% reading / $^\circ\text{C}$)		0.00003	0.0003	0.003

DC CURRENT**DC CURRENT ACCURACY $\pm(\%$ OF READING + $\%$ OF RANGE)**

Range	Resolution	Burden voltage	24 hours $T_{\text{CAL}} \pm 1^\circ\text{C}$	90 days $T_{\text{CAL}} \pm 5^\circ\text{C}$	1 year $T_{\text{CAL}} \pm 5^\circ\text{C}$	2 years $T_{\text{CAL}} \pm 5^\circ\text{C}$	Temperature coefficient
10 μA ¹¹	10 pA	$< 0.13\text{ V}$	$0.007 + 0.002$	$0.035 + 0.005$	$0.045 + 0.005$	$0.055 + 0.005$	$0.0030 + 0.0006$
100 μA	100 pA	$< 0.14\text{ V}$	$0.010 + 0.002$	$0.035 + 0.005$	$0.045 + 0.005$	$0.055 + 0.005$	$0.0020 + 0.0005$
1 mA	1 nA	$< 0.17\text{ V}$	$0.007 + 0.006$	$0.035 + 0.005$	$0.045 + 0.005$	$0.055 + 0.005$	$0.0020 + 0.0005$
10 mA	10 nA	$< 0.17\text{ V}$	$0.006 + 0.003$	$0.018 + 0.005$	$0.020 + 0.005$	$0.025 + 0.005$	$0.0015 + 0.0005$
20 mA ¹²	10 nA	$< 0.05\text{ V}$	$0.010 + 0.150$	$0.015 + 0.025$	$0.020 + 0.025$	$0.025 + 0.025$	$0.0015 + 0.0025$
100 mA	100 nA	$< 0.20\text{ V}$	$0.010 + 0.003$	$0.015 + 0.005$	$0.020 + 0.005$	$0.025 + 0.005$	$0.0015 + 0.0005$
1 A	1 mA	$< 0.55\text{ V}$ ¹³	$0.020 + 0.004$	$0.030 + 0.005$	$0.040 + 0.005$	$0.050 + 0.005$	$0.0030 + 0.0005$
3 A	1 mA	$< 1.70\text{ V}$ ¹³	$0.030 + 0.004$	$0.040 + 0.004$	$0.050 + 0.004$	$0.060 + 0.004$	$0.0030 + 0.0005$

DC CURRENT CHARACTERISTICS

Overrange	20% on 10 μA , 100 μA , 1 mA, 10 mA, 100 mA, and 1 A ranges 1% on 3 A range
Front-panel input protection	Externally accessible 3 A, 250 V fast-acting fuse, 5 x 20 mm: Keithley replacement part number FU-99-1
Plug-in module input protection	Fuse provided in 7700 and 7702 plug-in modules; PCB-mounted 3 A, 250 V, fast-acting fuse
Autozero off error	Add $\pm 0.004\%$ of range within $\pm 1^\circ\text{C}$ and ≤ 10 minutes since last autozero Add $\pm 0.015\%$ of range within $\pm 5^\circ\text{C}$ and ≤ 60 minutes since last autozero
Nominal shunt resistance ¹⁴	10 μA : 10 k Ω ; 100 μA : 1 k Ω ; 1 mA: 100 Ω ; 10 mA: 10 Ω ; 100 mA: 1 Ω ; 1 A: 100 m Ω ; 3 A: 100 m Ω

¹¹ Specifications apply to front-panel inputs only.¹² 20 mA range for 27xx emulation mode only.¹³ Add 1.5 V when using with plug-in modules.¹⁴ Guaranteed by design.

DC CURRENT MEASUREMENT NOISE CHARACTERISTICS¹⁵

Measurement rate in NPLCs	Digits	DCI RMS noise uncertainty (in % of range + fixed base)
5	6.5	0
1		0
0.1 ¹⁶		0.0009 + 10.0 pA
0.1	5.5	0.0015 + 5.0 nA
0.01		0.0030 + 5.0 nA
0.0005	4.5	0.0200 + 5.0 nA

TEMPERATURE**THERMOCOUPLE ACCURACY \pm °C¹⁷**

Type	Resolution	Range	2-year accuracy, T _{CAL} ±5 °C; all uncertainties in °C						Temperature coefficient in °C / °C
			Simulated or external CJC			Internal CJC (on module)			
			Front terminals, 7700, 7702, 7708	7706, 7709, 7710	7701, 7703, 7707	7700, 7708	7706	7710	
J	0.001 °C	0 °C to 760 °C	0.20	0.20	0.20	1.00	1.00	1.30	0.03
		-200 °C to < 0 °C	0.20	0.20	0.40	1.50	1.90	3.00	0.03
K	0.001 °C	0 °C to 1372 °C	0.20	0.20	0.30	1.00	1.00	1.00	0.03
		-200 °C to < 0 °C	0.30	0.30	0.50	1.70	2.00	2.00	0.03
N	0.001 °C	0 °C to 1300 °C	0.20	0.20	0.30	1.00	1.00	1.40	0.03
		-200 °C to < 0 °C	0.50	0.60	0.80	1.80	2.30	3.60	0.03
T	0.001 °C	0 °C to 400 °C	0.20	0.20	0.20	1.00	1.00	1.50	0.03
		-200 °C to < 0 °C	0.30	0.30	0.50	1.60	2.00	3.50	0.03
E	0.001 °C	0 °C to 1000 °C	0.20	0.20	0.20	1.00	1.00	1.20	0.03
		-200 °C to < 0 °C	0.20	0.30	0.30	1.50	1.80	3.00	0.03
R	0.010 °C	600 °C to 1768 °C	0.40	0.50	0.70	1.00	1.00	1.20	0.03
		0 °C to < 600 °C	0.80	1.00	1.50	1.50	1.60	2.20	0.03
S	0.010 °C	600 °C to 1768 °C	0.40	0.50	0.70	1.00	1.00	1.20	0.03
		0 °C to < 600 °C	0.80	1.00	1.50	1.30	1.60	2.20	0.03
B	0.010 °C	1100 °C to 1820 °C	0.40	0.50	0.80	1.00	1.00	1.00	0.03
		350 °C to < 1100 °C	1.20	1.50	2.20	1.10	1.40	1.50	0.03

RESISTANCE TEMPERATURE DETECTOR (RTD) ACCURACY \pm °CTypes: 100 Ω platinum PT100, D100, F100, PT385, and PT3916 or user-configurable 0 Ω to 10 k Ω

Measurement method	Resolution	Range	2-year accuracy $T_{CAL} \pm 5$ °C	Temperature coefficient in °C / °C
2-wire ¹⁸	0.01 °C	-200 °C to 850 °C	0.80	0.003
3-wire ¹⁹	0.01 °C	-200 °C to 600 °C	0.35	0.003
		> 600 °C to 850 °C	0.37	0.003
4-wire	0.01 °C	-200 °C to 600 °C	0.06	0.003
		> 600 °C to 850 °C	0.12	0.003

¹⁵ Applies for 10 μ A through 3 A ranges. Noise values apply to open terminals for 50 Hz and 60 Hz operation only. Measurements through a card may introduce additional noise.¹⁶ Line sync on.¹⁷ Accuracy excludes probe errors.¹⁸ Specifications do not include errors that may arise from the user's cable or terminal resistance.¹⁹ 3-wire RTD accuracy is for < 0.1 Ω lead-resistance mismatch for input HI and LO. Add 0.25 °C per 0.1 Ω of HI-LO resistance mismatch.

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THERMISTOR ACCURACY $\pm^{\circ}\text{C}$ Types: 2.2 k Ω , 5 k Ω , and 10 k Ω

Measurement method	Resolution	Range	2-years $T_{\text{CAL}} \pm 5^{\circ}\text{C}$	Temperature coefficient in $^{\circ}\text{C} / ^{\circ}\text{C}$
2-wire	0.01 $^{\circ}\text{C}$	-80 $^{\circ}\text{C}$ to 150 $^{\circ}\text{C}$	0.08	0.002

For readings > 70 $^{\circ}\text{C}$, add this additional uncertainty per Ω of lead, channel, and contact resistance

Thermistor type	Common model number	70 $^{\circ}\text{C}$ to 100 $^{\circ}\text{C}$	> 100 $^{\circ}\text{C}$ to 150 $^{\circ}\text{C}$
2.2 k Ω	44004	0.22 $^{\circ}\text{C}$ per Ω	1.11 $^{\circ}\text{C}$ per Ω
5 k Ω	44007	0.10 $^{\circ}\text{C}$ per Ω	0.46 $^{\circ}\text{C}$ per Ω
10 k Ω	44006	0.04 $^{\circ}\text{C}$ per Ω	0.19 $^{\circ}\text{C}$ per Ω

TEMPERATURE CHARACTERISTICS

Thermocouple conversion	ITS-90
Thermocouple reference junction	Internal (CJC on plug-in modules), external, or simulated (fixed)
Open thermocouple detection	Selectable per channel (open > 130 k Ω); default on
Earth isolation	500 V_{PEAK} > 10 G Ω and < 300 pF any terminal to chassis

AC VOLTAGE

AC VOLTAGE ACCURACY \pm (% OF READING + % OF RANGE)²⁰

Range	Resolution	Calibration cycle	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
100 mV	100 nV	24 hours	1.00 + 0.02	0.35 + 0.02	0.04 + 0.02	0.10 + 0.04	0.55 + 0.08	4.00 + 0.50
1 V	1 μ V	90 days	1.00 + 0.03	0.35 + 0.03	0.05 + 0.03	0.11 + 0.05	0.60 + 0.08	4.00 + 0.50
10 V	10 μ V	1 year	1.00 + 0.03	0.35 + 0.03	0.06 + 0.03	0.12 + 0.05	0.60 + 0.08	4.00 + 0.50
100 V	100 μ V	2 years	1.00 + 0.03	0.35 + 0.03	0.07 + 0.03	0.13 + 0.05	0.60 + 0.08	4.00 + 0.50
750 V	100 μ V							
Temperature coefficient			0.100 + 0.003	0.035 + 0.003	0.005 + 0.003	0.011 + 0.005	0.060 + 0.008	0.200 + 0.020

AC VOLTAGE CHARACTERISTICS

Overrange (voltages in V_{RMS})	20% on 100 mV, 1 V, 10 V, and 100 V ranges	0% for 750 V range
AC measurement method	AC-coupled digital sampling with anti-alias filter	
Crest factor (excludes sine wave)	Crest factors of up to 3:1 at full-scale input or 10:1 maximum, whichever is greater Autorange selects optimum range for crest factor up to 10:1 Accuracy specifications apply to all crest factors and are limited to a product of (crest factor) \times (fundamental frequency) \leq 3 kHz	
Volt*Hertz product	$\leq 8 \times 10^7 V \cdot Hz^{21}$	
Common-mode rejection ratio	≤ 70 dB, for 1 k Ω unbalance in LO lead	
Detector bandwidth	Setting of 3 Hz, 30 Hz, or 300 Hz sets maximum measurement aperture of 200 ms, 20 ms, or 2 ms, respectively; only signals with frequency greater than the detector bandwidth are measured	
Input impedance	1.1 M Ω \pm 2%, in parallel with < 100 pF	
Input protection	Front-panel input: 1100 V_{PEAK} or 400 VDC on all ranges Rear-panel input through the plug-in modules: 600 V_{PEAK} on all ranges (note this level exceeds the maximum input signal for modules; see maximum input signal levels for 7700 series plug-in modules listed below)	
Maximum DCV	400 V on any ACV range	
ACV frequency	Frequency reading is automatically returned in the reading buffer when in full buffer mode Frequency readings are specified in the frequency and period table	
Plug-in module maximum input signal levels	Module	Maximum input signal level
	7700, 7702, 7703, 7706, 7707, 7708, 7709	300 V_{RMS} / 425 V_{PEAK}
	7701	150 V_{RMS} / 212 V_{PEAK}
	7710	42 V_{RMS} / 60 V_{PEAK}

²⁰ Specifications are for sine wave inputs > 5% of range.

²¹ Guaranteed by design.

AC CURRENT

AC CURRENT ACCURACY \pm (% OF READING + % OF RANGE)²²

Range	Resolution	Burden voltage	Frequency	24 hours $T_{CAL} \pm 1\text{ }^{\circ}\text{C}$	90 days $T_{CAL} \pm 5\text{ }^{\circ}\text{C}$	1 year $T_{CAL} \pm 5\text{ }^{\circ}\text{C}$	2 years $T_{CAL} \pm 5\text{ }^{\circ}\text{C}$	Temperature coefficient
100 μA ²³	100 pA	< 0.14 V	3 Hz to 1 kHz	0.10 + 0.07	0.10 + 0.07	0.10 + 0.07	0.10 + 0.07	0.015 + 0.010
			1 kHz to 10 kHz ²⁴	0.15 + 0.07	0.15 + 0.07	0.15 + 0.07	0.15 + 0.07	0.030 + 0.010
1 mA	1 nA	< 0.17 V	3 Hz to 5 kHz	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.015 + 0.006
			5 kHz to 10 kHz ²⁴	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.030 + 0.006
10 mA	10 nA	< 0.17 V	3 Hz to 5 kHz	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.015 + 0.006
			5 kHz to 10 kHz ²⁴	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.030 + 0.006
100 mA	100 nA	< 0.20 V	3 Hz to 5 kHz	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.015 + 0.006
			5 kHz to 10 kHz ²⁴	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.030 + 0.006
1 A	1 μA	< 0.75 V ²⁵	3 Hz to 5 kHz ²⁶	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.10 + 0.04	0.015 + 0.006
			5 kHz to 10 kHz ²⁴	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.030 + 0.006
3 A	1 μA	< 1.70 V ²⁵	3 Hz to 5 kHz ²⁶	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.015 + 0.006
			5 kHz to 10 kHz ²⁴	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.15 + 0.06	0.030 + 0.006

AC CURRENT CHARACTERISTICS

Overrange	20% on 100 μA , 1 mA, 10 mA, 100 mA, and 1 A ranges 1% on 3 A range
AC measurement type	AC-coupled true RMS; measures the AC component of the input Digital sampling with anti-alias filter
Input protection	See DC CURRENT CHARACTERISTICS
Crest factor²⁷ (excludes sine wave)	10:1 maximum crest factor (1.75:1 at full-scale) Autorange selects the optimum range for crest factor up to 10:1 Accuracy specifications apply to all crest factors less than 5 and are limited to the product of (crest factor) \times (fundamental frequency) \leq 200 Hz
ACI frequency	Frequency readings are automatically returned in reading buffer when in full buffer mode Frequency values are typical
Nominal shunt resistance²⁸	100 μA : 1 k Ω ; 1 mA: 100 Ω ; 10 mA: 10 Ω ; 100 mA: 1 Ω ; 1 A: 100 m Ω ; 3 A: 100 m Ω

²² Specifications are for sine wave inputs > 5% of range and > 10 μA_{RMS} .

²³ The 100 μA range is only specified for front-panel inputs.

²⁴ Typical performance for the indicated frequency ranges.

²⁵ Add 1.5 V for the 1 A and 3 A ranges when used with a plug-in module.

²⁶ For signals of < 5 Hz, add 0.2% of reading uncertainty.

²⁷ 100 μA range is specified only for crest factors < 3.

²⁸ Guaranteed by design.

FREQUENCY AND PERIOD

FREQUENCY AND PERIOD ACCURACY \pm (% OF READING)²⁹

Range	Resolution	Frequency	Period	2-year accuracy $T_{CAL} \pm 5^\circ C$	Temperature coefficient
100 mV to 750 V (for signals > 5% of range and > 10 mV _{RMS})	0.0001% of reading	3 Hz to 10 Hz	333 ms to 100 ms	0.100	0.0002
		> 10 Hz to 100 Hz	< 100 ms to 10 ms	0.030	0.0002
		> 100 Hz to 1 kHz	< 10 ms to 1 ms	0.010	0.0002
		> 1 kHz to 300 kHz	< 1 ms to 3.3 μs	0.009	0.0002
		Square wave ³⁰		0.008	0.0002

FREQUENCY AND PERIOD CHARACTERISTICS

Measurement method	Reciprocal-counting technique; measurement is AC-coupled using AC measurement functions
Voltage ranges	100 mV _{RMS} full scale to 750 V _{RMS} ; auto or manual ranging
Aperture	User-definable from 2 ms to 273 ms (default 200 ms)

CONTINUITY

CONTINUITY ACCURACY 2-WIRE \pm (% OF READING + % OF RANGE)³¹

Range	Resolution	Test current	Open circuit voltage ($\pm 5\%$)	2-year accuracy $T_{CAL} \pm 5^\circ C$	Temperature coefficient
1 k Ω	100 m Ω	1 mA	9.2 V	0.010 + 0.010	0.0006 + 0.0001

CAPACITANCE

CAPACITANCE ACCURACY \pm (% OF READING + % OF RANGE)³²

Range	Resolution	Charge current ($\pm 5\%$) ³³	2-year accuracy $T_{CAL} \pm 5^\circ C$	Temperature coefficient
1 nF ³⁴	0.1 pF	1 μA	0.80 + 0.50	0.05 + 0.05
10 nF	1 pF	10 μA	0.40 + 0.10	0.01 + 0.01
100 nF	10 pF	100 μA	0.40 + 0.10	0.01 + 0.01
1 μF	0.1 nF	100 μA	0.40 + 0.10	0.01 + 0.01
10 μF	1 nF	1 mA	0.40 + 0.10	0.01 + 0.01
100 μF	10 nF	1 mA	0.40 + 0.10	0.01 + 0.01

CAPACITANCE CHARACTERISTICS

Overrange	20% on all ranges
Measurement method	Constant-current slope measurement
Maximum voltage and voltage clamp	For all devices: Clamped by hardware to < 3 V

²⁹ Specifications apply for sine wave input with detector bandwidth of 3 Hz. For a detector bandwidth of 30 Hz, add 100 mHz uncertainty. For a detector bandwidth of 300 Hz, add 1 Hz uncertainty.

³⁰ Used for square waves with amplitude > 10% of range and 10 Hz to 300 kHz.

³¹ Does not include user's lead-resistance or plug-in module contact resistance.

³² Accuracies specified for cable, channel, and other stray connector capacitance properly zeroed with the REL function.

³³ Discharge current limited to < 10 mA.

³⁴ Specifications apply to front-panel inputs only.

DIODE

DIODE VOLTAGE ACCURACY $\pm(\% \text{ OF READING} + \text{ADDITIONAL UNCERTAINTY})^{35}$

Voltage measure range	Resolution	Maximum voltage measurement	Test current ($\pm 5\%$)	2-year accuracy $T_{CAL} \pm 5^\circ C$	Temperature coefficient
10 V	10 μV	12 V	10 μA	$0.0045 + 60.0 \mu V$	$0.0008 + 10 \mu V$
		10 V	100 μA	$0.0045 + 80.0 \mu V$	$0.0008 + 10 \mu V$
		7 V	1 mA	$0.0045 + 170.0 \mu V$	$0.0010 + 10 \mu V$
		7 V	10 mA	$0.0045 + 1.1 mV$	$0.0010 + 10 \mu V$

DIGITIZE

DIGITIZE DC VOLTAGE ACCURACY $\pm(\% \text{ OF READING} + \% \text{ OF RANGE})^{36}$

Range	Resolution	Input impedance	2-year accuracy $T_{CAL} \pm 5^\circ C$	Temperature coefficient
100 mV	10 μV	$> 10 G\Omega$ or $10 M\Omega \pm 1\%$	$0.040 + 0.020$	$0.0025 + 0.0030$
1 V	100 μV	$> 10 G\Omega$ or $10 M\Omega \pm 1\%$	$0.030 + 0.010$	$0.0025 + 0.0010$
10 V	1 mV	$> 10 G\Omega$ or $10 M\Omega \pm 1\%$	$0.030 + 0.010$	$0.0025 + 0.0010$
100 V	10 mV	$10 M\Omega \pm 1\%$	$0.030 + 0.010$	$0.0025 + 0.0010$
1000 V	100 mV	$10 M\Omega \pm 1\%$	$0.030 + 0.010$	$0.0025 + 0.0010$

DIGITIZE DC CURRENT ACCURACY $\pm(\% \text{ OF READING} + \% \text{ OF RANGE})^{36}$

Range	Resolution	Burden voltage	2-year accuracy $T_{CAL} \pm 5^\circ C$	Temperature coefficient
100 μA	10 nA	$< 0.14 V$	$0.07 + 0.05$	$0.0030 + 0.0035$
1 mA	100 nA	$< 0.17 V$	$0.07 + 0.03$	$0.0030 + 0.0035$
10 mA	1 μA	$< 0.17 V$	$0.05 + 0.03$	$0.0030 + 0.0035$
100 mA	10 μA	$< 0.20 V$	$0.05 + 0.03$	$0.0020 + 0.0035$
1 A	100 μA	$< 0.55 V^{37}$	$0.07 + 0.03$	$0.0040 + 0.0035$
3 A	100 μA	$< 1.70 V^{37}$	$0.09 + 0.04$	$0.0040 + 0.0035$

TYPICAL DIGITIZE SIGNAL CHARACTERISTICS

Typical performance for these conditions: Sample rate 1 MS per s; sine wave input $V_{PEAK} = -1$ dB full-scale of range

Function: Range	Spur-free range SFDR (1 kHz / 10 kHz / 50 kHz)	THD + noise SNDR (1 kHz / 10 kHz / 50 kHz)	Bandwidth (-3 dB, 5%)	Effective number of bits (1 kHz / 10 kHz / 50 kHz)
DCV: 100 mV	75 / 70 / 50	65 / 60 / 50	210 kHz	9 / 9 / 7
DCV: 1 V	95 / 90 / 75	80 / 80 / 75	210 kHz	12 / 12 / 11
DCV: 10 V	95 / 80 / 70	90 / 80 / 70	440 kHz	13 / 12 / 10
DCV: 100 V	50 / 35 / 25	50 / 40 / 30	17 kHz	10 / 8 / 7
DCV: 1000 V	50 / 35 / 25	50 / 40 / 30	17 kHz	13 / 11 / 10
DCI: 100 μA	80 / 65 / 45	70 / 65 / 45	430 kHz	12 / 10 / 8
DCI: 1 mA	80 / 65 / 45	70 / 65 / 45	570 kHz	12 / 10 / 8
DCI: 10 mA	80 / 65 / 45	70 / 65 / 45	230 kHz	12 / 10 / 8
DCI: 100 mA	80 / 65 / 45	70 / 65 / 45	340 kHz	12 / 10 / 8
DCI: 1 A	70 / 50 / 40	65 / 50 / 40	25 kHz	11 / 8 / 7
DCI: 3 A	70 / 50 / 40	65 / 50 / 40	25 kHz	11 / 8 / 7

³⁵ Specifications apply to the front-panel inputs, only. Specifications do not include errors that may arise from user's cable or connection resistance.

³⁶ DC accuracy specified with 1000 samples per second, 100-reading digital filter.

³⁷ Add 1.5 V for 1 A and 3 A ranges when used with a plug-in module.

Specifications are subject to change without notice

DIGITIZING ADDITIONAL CHARACTERISTICS

Maximum resolution	16 bits
Measurement input coupling	DC coupled
Sampling rate	Programmable 1 kS through 1 MS per second
Minimum record time	1 μ s
Maximum record length (volatile)	7 million with standard buffer (includes channel and formatting information)

DC VOLTAGE RATIO CALCULATION³⁸

Method	Measurement
Channel ratio (through rear input plug-in module)	$\text{Channel ratio} = \frac{\text{channel A}}{\text{channel B}}$ $\text{Accuracy} = (\text{accuracy of channel A measure range} + \text{accuracy of channel B measure range}) \times \text{channel ratio}$
Channel average (through rear input plug-in module)	$\text{channel average} = \frac{\text{channel A} + \text{channel B}}{2}$ $\text{Accuracy} = \text{accuracy of channel A measure range} + \text{accuracy of paired channel B measure range}$
DCV Input ratio (HI-LO / SHI-SLO) ^{39 40}	$\text{ratio} = \frac{\text{HI signal}}{\text{SHI signal} - \text{SLO signal}}$ $\text{Accuracy} = \left(\frac{\text{HI range}}{\text{HI signal}} \times \text{DCV \% of range accuracy} + \frac{10 \text{ V}}{\text{SHI signal} - \text{SLO signal}} \times 0.0008\% \right) \times \text{ratio}$

SYSTEM SPECIFICATIONS**TYPICAL SINGLE-CHANNEL READING RATES, DC FUNCTIONS^{41, 42}**

60 Hz (50 Hz) operation

NPLCs	Functions: DCV (10 V) 2-wire Ω ($\leq 10 \text{ k}\Omega$), DCI (1 mA)		Functions: 4-wire Ω ($\leq 1 \text{ k}\Omega$) 4-wire and 3-wire RTD		Function: Thermistor or thermocouple	
	Measurements (readings per second) ⁴³					
	Buffer	Computer	Buffer	Computer	Buffer	Computer
5	12 (10)	11 (9)	5 (4)	5 (4)	12 (10)	11 (9)
1	59 (48)	58 (48)	28 (23)	28 (23)	59 (49)	57 (48)
0.1	584 (490)	440 (380)	180 (160)	170 (150)	580 (480)	440 (380)
0.01	4900 (4100)	4800 (4100)	400 (390)	400 (390)	4800 (4100)	4700 (4000)
0.0005	20600 (20600)	19800 (19800)	460 (460)	460 (460)	21000 (21000)	20300 (20300)

TYPICAL SINGLE-CHANNEL READING RATES, AC FUNCTIONS⁴¹

60 Hz (50 Hz) operation

Functions: ACV, ACI	Functions: Frequency, period	Measurements (readings per second)
Detector bandwidth	Aperture	Buffer or computer
3 Hz	200 ms	1
30 Hz	20 ms	10
300 Hz	2 ms	100

³⁸ See [DC VOLTAGE ACCURACY](#). SHI and SLO: 10 V range only. SHI and SLO (sense) terminals referenced to LO input. Maximum voltage referenced to LO 12 V.

³⁹ Sense terminals are limited to 10 V range during ratio measurement. Add 0.0015% + 0.0005% per °C temperature coefficient to DCV % of range accuracy when using the 100 V or 1000 V range on the input terminals.

⁴⁰ Specified for front inputs only.

⁴¹ Reading speeds for autozero off, fixed range, autodelay off, offset compensation off, and open lead detector off where applicable.

⁴² Buffer measurements: For < 0.1 PLC, multisample, and single buffer transfer binary readings only.

⁴³ Computer measurements: For 5 PLC, 1 PLC, and 0.1 PLC single reading and single transfer to computer (USB).

Specifications are subject to change without notice

SCANNING / MULTIPLE CHANNELS⁴⁴

Typical scanning measurement rates	Measurements into buffer or computer (channels per second)
Scanning DCV or 2-wire Ω	> 90 with 7700 plug-in module > 450 with 7703 plug-in module > 900 with 7710 plug-in module
Scanning thermocouple, thermistor, or 2-wire RTD	> 90 with 7700 plug-in module > 450 with 7703 plug-in module > 900 with 7710 plug-in module
Scanning 4-wire Ω and 3- or 4-wire RTD	> 80 with 7700 plug-in module > 300 with 7703 plug-in module > 400 with 7710 plug-in module
Scanning ACV ⁴⁵	> 60 with 7700 plug-in module > 170 with 7703 plug-in module > 220 with 7710 plug-in module
Scanning alternating DCV and 2-wire Ω	> 90 with 7700 plug-in module > 430 with 7703 plug-in module > 430 with 7710 plug-in module

DIGITAL I/O READ/WRITE, TOTALIZER READ SPEED

Read digital input	7707 plug-in module > 200
Write digital output	7706 plug-in module > 1400 7707 plug-in module > 500
Read totalizer	7706 plug-in module > 100

TYPICAL FUNCTION AND RANGE CHANGE SPEED

Function	Function change time ⁴⁶	Range change time ⁴⁷	Autorange time ⁴⁶
DCV, DCI, or 2-wire Ω ⁴⁸	< 4 ms	< 1.3 ms	< 3.2 ms
4-wire Ω ⁴⁹ or 3-wire RTD			< 5.5 ms
Thermistor			—
Frequency or period (2 ms aperture)	< 1800 ms	< 50 ms ⁵⁰	< 50 ms ⁵⁰
ACV (300 Hz bandwidth)			
ACI (300 Hz bandwidth)	< 100 ms	< 4 ms	< 5 ms
Capacitance	< 4 ms	< 3 ms	< 30 ms
Digitize	< 4 ms	< 5 ms	—
Diode	< 11 ms	—	—
Continuity	< 11 ms	—	—
Thermocouple	< 4 ms	—	—

BUS TRANSFER SPEED⁵¹

	Peak measurements into computer (per second)			
	USB	LAN	GPIO	RS232 (baud 115200)
Average for 1000 readings (binary)	441,000	268,000	201,000	10,000
Average for 1000 readings with relative timestamp (binary)	272,000	150,000	105,000	2,900
Average for 1000 readings with formatted elements ⁵²	46,000	29,000	17,000	290

⁴⁴ Set-up conditions for the factory default setting with the following exceptions: 3.5 digits (0.0005 PLC), autorange off, autozero off, autodelay off, and open lead detection off.

⁴⁵ Assume the signal is 10 kHz or above.

⁴⁶ 3.5 digits, autozero off, 0.0005 PLC, excludes measurement time.

⁴⁷ DCV = 10 V; 2-wire or 4-wire = 1 k Ω ; DCI = 1 mA; ACI = 1 mA; ACV = 1 V; Capacitance = 10 μ F.

⁴⁸ 2-wire function for 100 Ω range and up. For the 10 Ω range, add 2.7 ms.

⁴⁹ 4-wire function for 100 Ω range and up. For the 1 Ω and 10 Ω ranges, add 2.7 ms.

⁵⁰ When ranging to 10 V and above, add 1.8 s.

⁵¹ SCPI programmed using 4-byte binary format.

⁵² Format elements: Reading, relative timestamp, channel, and unit.

Specifications are subject to change without notice

TYPICAL DIGITIZE VOLTAGE OR CURRENT⁵³

Sampling rate	Measurements over USB to computer
10 kS per s	Up to 10,000 readings per s
50 kS per s	Up to 50,000 readings per s
100 kS per s	Up to 100,000 readings per s
1 MS per s up to 7 s maximum duration	At least 90,000 readings per s

TRIGGERING

Trigger sources	Front-panel trigger key, timer, command interface, LAN/LXI, trigger in (BNC rear panel), digital I/O (optional accessory card), and TSP-Link® (optional accessory card)
External trigger delay	< 1 μ s when triggering from accessory card or rear BNC input
External trigger jitter	< 1 μ s when triggering from accessory card or rear BNC input
External trigger in and trigger out	0 V to 5 V logic signal input and output, TTL-compatible, programmable edge pulse Minimum pulse width: 1 μ s
External trigger out, maximum rate	Up to 90 kHz, measurement dependent
External trigger in, maximum rate	Up to 150 kHz, measurement dependent

SCANNING

Scan count	1 to continuous
Scan interval	0 s to 27.7 hours
Channel delay	0 s to 60 s
Measure interval	0 s to 27.7 hours

INTERNAL MEMORY

Maximum reading memory (volatile)	Up to 7 million readings with a standard buffer (includes channel and formatting information)
Internal (nonvolatile) memory for saved scripts and scan configurations	6 MB, enables hundreds of scan configurations or TSP scripts to be saved in nonvolatile memory

⁵³ SCPI programmed using 4-byte binary format.

GENERAL SPECIFICATIONS

LINE POWER	
Power supply	100 V, 120 V, 220 V, and 240 V ($\pm 10\%$)
Power line frequency	50 Hz to 60 Hz and 400 Hz, automatically sensed at power-up
Maximum power consumption	65 VA
Typical power consumption	30 VA
Mains input fuse	250 V, 1.25 A slow-blow fuse: Keithley replacement part number FU-106-1.25
ENVIRONMENT AND REGULATORY	
Operating environment	Specified for 0 °C to 50 °C, $\leq 80\%$ relative humidity at 35 °C, altitude up to 2000 meters
Storage environment	-40 °C to 70 °C
Vibration	MIL-PRF-28800F Class 3, random
Warm-up	30 minutes to rated accuracy
Safety	NRTL listed to UL61010-1 and CSA C22.2 No 61010-1; conforms to European Union Low Voltage Directive
EMC	Conforms to European Union EMC Directive
MECHANICAL	
Display	12.7 cm (5 in.) capacitive touch, color TFT WVGA (800 × 480) with LED backlight
Rack dimensions (W × H × D)	213.8 mm (8.42 in.) × 88.4 mm (3.48 in.) × 356.6 mm (14.04 in.)
Bench dimensions (W × H × D)	224.0 mm (8.82 in.) × 107.2 mm (4.22 in.) × 387.4 mm (15.25 in.)
Shipping weight	4.54 kg (10.0 lb) instrument only
Input signal connections	Front plug-in modules
Plug-in module slot	Two slots on the rear panel; see PLUG-IN MODULE ACCESSORIES
Communication slot	One slot on the rear panel; see OPTIONAL INTERFACES AND PROGRAMMABLE DIGITAL I/O
Cooling	Forced air, fixed speed
REMOTE INTERFACE: STANDARD	
LAN/LXI compliance	RJ-45 connector, 10/100BT; IP configuration; static or DHCP (manual or automatic) Web interface; virtual front panel; LXI compliance: LXI version 1.5 core 2016
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, FAT32; Capability: Import and export instrument configuration files, reading buffers, screen captures, and scripts
LANGUAGE	
SCPI (default)	Default command set: Standard Commands for Programmable Instruments, SCPI-1999
TSP	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, and math); able to execute test scripts stored in memory without host intervention
Emulation modes	Keithley Model 2700 and Model 2701
MATH FUNCTIONS	
REL, minimum, maximum, average, standard deviation, peak-peak, dB, limit test, percent, 1/x, and mX+b with user-defined units displayed	
MISCELLANEOUS	
Real-time clock	Lithium battery backup, CR2032 coin-type, factory replaceable (3+ years of battery life); set and read year, month, day, hour, minute, and seconds (note that seconds are not adjustable)
Timestamp resolution	15 ns with standard or full buffer style
Password protection	30 characters
Alarms	Up to six: see OPTIONAL INTERFACES AND PROGRAMMABLE DIGITAL I/O
Power failure recovery mode	User selectable, resumes scanning once power is restored

PLUG-IN MODULE ACCESSORIES	
Module model	Description
7700	20-channel differential multiplexer module
7701	32-channel differential multiplexer module
7702	40-channel differential multiplexer module
7703	32-channel, high-speed, differential multiplexer module
7705	40-channel single-pole control module
7706	All-in-one I/O module
7707	32-channel digital I/O module
7708	40-channel differential multiplexer module
7709	2-pole, 6 × 8 matrix module
7710	20-channel solid-state differential multiplexer with automatic CJC
7711	2 GHz, 50 Ω RF module
7712	3.5 GHz, 50 Ω RF module
OPTIONAL INTERFACES AND PROGRAMMABLE DIGITAL I/O	
KTTI-RS232	RS232, 9-pin d-sub female connector; standard baud rates from 300 bps to 115,200 bps are supported
KTTI-GPIB	GPIB IEEE-488.1 compliant; supports IEEE-488.2 common commands and status model topology
KTTI-TSP	RJ-45 (quantity 2); TSP-Link [®] expansion interface allows TSP-enabled instruments to trigger and communicate with each other
Digital I/O	<p>For KTTI-RS232, KTTI-GPIB, and KTTI-TSP</p> <p>Connector: 9 pin d-sub female</p> <p>5 V power supply pin: Limited to 500 mA > 4 V (solid-state fuse protected)</p> <p>Lines: Six input / output, user-defined for control, alarms (limits), or triggering</p> <p>Input signal levels: 0.7 V (maximum logic low), 3.7 V (minimum logic high)</p> <p>Input voltage limits: -0.25 V (absolute minimum), 5.25 V (absolute maximum)</p> <p>Maximum source current: 2.0 mA at > 2.7 V (per pin)</p> <p>Maximum sink current: -50 mA at 0.7 V (per pin, solid state fused)</p>