

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

Low-Noise Multimeter Specifications

DC CHARACTERISTICS

CONDITIONS: MED (1 PLC)¹ or SLOW (5 PLC)

FUNCTION	RANGE	RESOLUTION	TEST CURRENT ±5% OR BURDEN VOLTAGE	INPUT RESISTANCE OR CLAMP VOLTAGE	ACCURACY: ±(ppm of reading + ppm of range) ppm = parts per million) (e.g., 10ppm = 0.001%)				
					24 Hour ² 23°C ±1°	90 Day 23°C ±5°	1 Year 23°C ±5°	2 Years 23°C ±5°	TEMPERATURE COEFFICIENT 0°–18°C & 28°–50°C
Voltage	100.00000 mV ³	10 nV		> 10 GΩ	10+9	25+9	37+9	50+10	2 + 6
	1.0000000 V	100 nV		> 10 GΩ	7+2	18+2	25+2	32+2	2 + 1
	10.000000 V	1 μV		> 10 GΩ	7+4	18+4	24+4	32+4	2 + 1
	100.00000 V	10 μV		10 MΩ ±1%	10+4	25+5	35+5	52+5	5 + 1
	1000.0000 V ⁴	100 μV		10 MΩ ±1%	17+6	31+6	41+6	55+6	5 + 1
Resistance ⁵	10.000000 Ω ⁶	1 μΩ	10 mA		15 + 9	40+9	60+9	100+10	8 + 6
	100.00000 Ω ⁶	10 μΩ	1 mA		15 + 9	36+9	52+9	90+10	8 + 6
	1.0000000 kΩ ⁶	100 μΩ	1 mA		15 + 2	33+2	50+2	80+2	8 + 1
	10.000000 kΩ ⁶	1 mΩ	100 μA		15 + 2	32+2	50+2	80+2	8 + 1
	100.00000 kΩ	10 mΩ	10 μA		15 + 4	40+4	70+4	120+4	8 + 1
	1.0000000 MΩ ⁷	100 mΩ	10 μA		20 + 3	50+4	70+4	125+4	8 + 1
	10.000000 MΩ ^{7,8}	1 Ω	640 nA // 10 MΩ		150 + 4	200+4	400+4	500+4	70 + 1
	100.00000 MΩ ^{7,8}	10 Ω	640 nA // 10 MΩ		800 + 4	1500+4	1500+4	1800+4	385 + 1
Dry Circuit Resistance ⁶	10.00000 Ω	10 μΩ	1 mA	20 mV	25 + 90	50 + 90	70 + 90	120 + 90	8 + 60
	100.0000 Ω	100 μΩ	100 μA	20 mV	25 + 90	50 + 90	70 + 90	120 + 90	8 + 60

¹ For the following ranges, add 4 ppm to the range accuracy specification: 100 mV, 10 Ω, 100 Ω, 10 mA, 100 mA, and 1 A. Dry Circuit function add 40 ppm.

² Relative to calibration accuracy.

³ When properly zeroed using REL function.

⁴ For signal levels >500 V, add 0.02 ppm/V uncertainty for the portion exceeding 500 V.

⁵ Specifications are for 4-wire ohms. For 2-wire ohms, add 1 Ω to "ppm of range" uncertainty. 10 Ω range is for 4-wire only.

⁶ Offset compensation on.

⁷ For rear inputs, add the following to Temperature Coefficient "ppm of reading" uncertainty: 1 MΩ 25ppm, 10 MΩ 250ppm, 100 MΩ 2500 ppm. Operating environment specified for 0 °C to 50 °C 50 % RH at 35 °C.

⁸ Must have 10 % matching of lead resistance in Input HI and LO.

Specifications are subject to change without notice.

FUNCTION	RANGE	RESOLUTION	TEST CURRENT ±5% OR BURDEN VOLTAGE	INPUT RESISTANCE OR CLAMP VOLTAGE	ACCURACY: ±(ppm of reading + ppm of range) ppm = parts per million) (e.g., 10ppm = 0.001%)				
					24 Hour ² 23°C ±1°	90 Day 23°C ±5°	1 Year 23°C ±5°	2 Years 23°C ±5°	TEMPERATURE COEFFICIENT 0°–18°C & 28°–50°C
Current	10.000000 mA	1 nA	< 0.15 V		60 + 30	300+80	500+80	740+80	50 + 5
	100.00000 mA	10 nA	< 0.18 V		100+300	300+800	500+800	740+800	50 + 5
	1.0000000 A	100 nA	< 0.35 V		200 + 30	500+80	800+80	1200+80	50 + 5
	3.000000 A	1 µA	< 1 V		1000+15	1200+40	1200+40	1800+40	50 + 5
Continuity 2W	1 kΩ	100 mΩ	1 mA		40 + 100	100+100	120 + 100	190 + 10	8 + 1
Diode Test	10.000000 V	1 µV	1 mA		20 + 6	30 + 7	40 + 7	55 + 7	8 + 1
	4.400000 V	1 µV	100 µA		20 + 6	30 + 7	40 + 7	55 + 7	8 + 1
	10.000000 V	1 µV	10 µA		20 + 6	30 + 7	40 + 7	55 + 7	8 + 1
DCV: DCV Ratio ⁹	100 mV to 1000 V				Ratio accuracy = accuracy of selected sense input range + accuracy of selected input range.				

DC OPERATING CHARACTERISTICS¹⁰

FUNCTION	DIGITS	READINGS/s	PLCs ¹¹
DCV (all ranges),	7½ ¹²	4 (3)	5
DCI (all ranges), and	6½ ^{12, 13}	30 (27)	1
Ohms (<10 M range)	6½ ^{12, 14}	50 (44)	1
	5½ ^{12, 14}	260 (220)	0.1
	5½ ¹⁴	490 (440)	0.1
	5½ ¹⁴	1000 (1000)	0.04
	4½ ¹⁴	2000 (1800)	0.01

⁹ Sense LO input must be referenced to Input LO. Sense HI input must not exceed 125% (referenced to Input LO) of range selected. Sense input has 100 mV, 1 V, and 10 V ranges.

¹⁰ Speeds are for 60 Hz (50 Hz) operation using factory default operating conditions (*RST). Autorange off, Display off, Trigger delay = 0.

¹¹ 1 PLC = 16.67 ms @ 60 Hz, 20 ms @ 50 Hz/400 Hz. The frequency is automatically determined at power up.

¹² Speeds include measurement and binary data transfer out the GPIB.

¹³ Ohms, 17 (15) readings/second.

¹⁴ Sample count = 1024, auto zero off.

DC NOISE PERFORMANCE

RATE	DIGITS	RMS NOISE 100 mV RANGE		RMS NOISE 10 V RANGE		NMRR ¹⁵	CMRR ¹⁶
		10 s	2 minute	10 s	2 minute		
5 PLC	7½	100 nV	110 nV	1.1 µV	1.2 µV	60 dB	140 dB
1 PLC	6½	120 nV	125 nV	1.3 µV	1.4 µV	60 dB	140 dB
0.1 PLC	5½	1.9 µV	1.9 µV	11 µV	11.5 µV	—	80 dB
0.01 PLC	4½	3.0 µV	2.9 µV	135 µV	139 µV	—	80 dB

DC SYSTEM SPEEDS^{10,17}

RANGE CHANGE¹²: 50/s (42/s).

FUNCTION CHANGE¹²: 45/s (38/s).

AUTORANGE TIME^{12,18}: <30 ms (<35 ms).

ASCII READINGS TO RS-232 (19.2K BAUD): 55/s (55/s).

MAXIMUM INTERNAL TRIGGER RATE: 2000/s (2000/s).

MAXIMUM EXTERNAL TRIGGER RATE: 480/s (480/s).

RATIO SPEED^{12,10}: 10/s (8/s).

DC GENERAL

LINEARITY OF 10VDC RANGE: ±(2 ppm of reading + 1 ppm of range).

DCV, Ω, TEMPERATURE, CONTINUITY, DIODE TEST INPUT PROTECTION: 1000 V, all ranges.

MAXIMUM 4WΩ LEAD RESISTANCE: 5 % of range per lead for 10 Ω, 100 Ω, and 1 kΩ ranges; 1kΩ per lead for all other ranges.

DC CURRENT INPUT PROTECTION: 3 A, 250 V fuse.

SHUNT RESISTOR: 0.1 Ω for 3 A and 1 A ranges. 1 Ω for 100 mA range. 10 Ω for 10 mA range.

CONTINUITY THRESHOLD: Adjustable 1 Ω to 1000 Ω.

OVERRANGE: 120 % of range except on 1000 V, 3 A, and Diode.

OFFSET COMPENSATION: Available for 10 kΩ and lower ranges only.

¹⁵ For line frequency ±0.1 %.

¹⁶ For 1kΩ unbalance in LO lead.

¹⁷ Auto zero off, NPLC = 0.01.

¹⁸ Add 120 ms for ohms.

TRUE RMS AC VOLTAGE AND CURRENT CHARACTERISTICS

ACCURACY¹⁹ 1: $\pm(\% \text{ of reading} + \% \text{ of range})$, 23 °C ± 5 °C

VOLTAGE RANGE	RESOLUTION	CALIBRATION CYCLE	3 Hz–10 Hz ²⁰	10 Hz–20 kHz	20 kHz–50 kHz	50 kHz–100 kHz–	100 kHz–300 kHz
100.0000 mV	0.1 μ V						
1.000000 V	1.0 μ V	90 Days	0.35 + 0.03	0.05 + 0.03	0.11 + 0.05	0.60 + 0.08	4 + 0.5
10.00000 V	10 μ V						
100.0000 V	100 μ V	1 Year	0.35 + 0.03	0.06 + 0.03	0.12 + 0.05	0.60 + 0.08	4 + 0.5
750.000 V	1 mV						
		TEMPERATURE COEFFICIENT/ $^{\circ}\text{C}^{21}$	0.035 + 0.003	0.005 + 0.003	0.006 + 0.005	0.01 + 0.006	0.03 + 0.01

CURRENT RANGE	RESOLUTION	CALIBRATION CYCLE	3 Hz–10 Hz	10 Hz–3 kHz	3 kHz–5 kHz
1.000000 A	1 μ A	90 Day/1 Year	0.30 + 0.04	0.10 + 0.04	0.14 + 0.04
3.00000 A ²²	10 μ A	90 Day/1 Year	0.35 + 0.06	0.15 + 0.06	0.18 + 0.06
		TEMPERATURE COEFFICIENT/ $^{\circ}\text{C}^{21}$	0.035 + 0.006	0.015 + 0.006	0.015 + 0.006

HIGH CREST FACTOR ADDITIONAL ERROR $\pm(\% \text{ of reading})^{23}$				
Crest Factor:	1–2	2–3	3–4	4–5
Additional Uncertainty:	0.05	0.15	0.30	0.40

AC OPERATING CHARACTERISTICS ²⁴				
FUNCTION	DIGITS	READINGS/s	RATE	BANDWIDTH
ACV (all ranges) and ACI (all ranges)	6½ ²⁵	0.5 (0.4)	SLOW	3 Hz–300 kHz
	6½ ²⁵	1.4 (1.5)	MED	30 Hz–300 kHz
	6½ ²⁶	4.0 (4.3)	MED	30 Hz–300 kHz
	6½ ²⁵	2.2 (2.3)	FAST	300 Hz–300 kHz
	6½ ²⁶	35 (30)	FAST	300 Hz–300 kHz

¹⁹ Specifications are for SLOW rate and sinewave inputs $>5\%$ of range.

²⁰ Typical uncertainties. Typical represents two sigma or 95 % of manufactured units measure $< 0.35\%$ of reading and three sigma or 99.7 % $< 1.06\%$ of reading.

²¹ Applies to 0 ° – 18 °C and 28 ° – 50 °C.

²² For signal levels >2.2 A, add additional 0.4 % to “of reading” uncertainty.

²³ Applies to non-sine waves >5 Hz and <500 Hz. (Guaranteed by design for Crest Factors >4.3 .)

²⁴ Speeds are for 60 Hz (50 Hz) operation using factory default operating conditions (*RST). Auto zero off, Auto range off, Display off, includes measurement and binary data transfer out the GPIB.

²⁵ 0.01 % of step settling error. Trigger delay = 400 ms.

²⁶ Trigger delay = 0.

Specifications and characteristics are subject to change without notice.

AC SYSTEM SPEEDS^{24,27}

FUNCTION/RANGE CHANGE²⁸: 4/s.

AUTORANGE TIME: <3 s.

ASCII READINGS TO RS-232 (19.2 K BAUD)²⁶: 50/s.

MAX. INTERNAL TRIGGER RATE²⁶: 300/s.

MAX. EXTERNAL TRIGGER RATE²⁶: 300/s.

ADDITIONAL LOW FREQUENCY ERRORS

±(% of reading)

	SLOW	MED	FAST
20 Hz – 30 Hz	0	0.3	–
30 Hz – 50 Hz	0	0	–
50 Hz – 100 Hz	0	0	1.0
100 Hz – 200 Hz	0	0	0.18
200 Hz – 300 Hz	0	0	0.10
>300 Hz	0	0	0

AC GENERAL

INPUT IMPEDANCE: 1 M Ω $\pm$ 2 % paralleled by <100 pF.

ACV INPUT PROTECTION: 1000 V.

MAXIMUM DCV: 400 V on any ACV range.

ACI INPUT PROTECTION: 3 A, 250 V fuse.

BURDEN VOLTAGE: 1 A Range: <0.35 V_{rms}.
3 A Range: <1 V_{rms}.

SHUNT RESISTOR: 0.1 Ω on all ACI ranges.

AC CMRR: >70 dB with 1 k Ω in LO lead.

MAXIMUM CREST FACTOR: 5 at full scale.

VOLT HERTZ PRODUCT: $\leq 8 \times 10^7$ V·Hz.

OVERRANGE: 120 % of range except on 750 V and 3 A ranges.

²⁷ DETector: BANDwidth 300, NPLC = 0.01.

²⁸ Maximum useful limit with trigger delay = 175 ms.

FREQUENCY AND PERIOD CHARACTERISTICS^{29,30}

ACV RANGE	FREQUENCY RANGE	PERIOD RANGE	GATE TIME	RESOLUTION ±(ppm of reading)	ACCURACY 90 Day/1 Year ±(% of reading)
100 mV to 750 V	3 Hz to 500 kHz	333 ms to 2 µs	1 s	0.3	0.01

TEMPERATURE CHARACTERISTICS

THERMOCOUPLE^{31,32,33}

TYPE	RANGE	RESOLUTION	ACCURACY ³⁴ 90 DAY/1 YEAR (23°C ± 5°C) RELATIVE TO SIMULATED REFERENCE JUNCTION	USING 2001-TCSCAN ³⁵
J	–200 to + 760 °C	0.001 °C	±0.5 °C	±0.65 °C
K	–200 to +1372 °C	0.001 °C	±0.5 °C	±0.70 °C
N	–200 to +1300 °C	0.001 °C	±0.5 °C	±0.70 °C
T	–200 to + 400 °C	0.001 °C	±0.5 °C	±0.68 °C

4-WIRE RTD^{31,32,36,37}

RANGE	RESOLUTION	90 DAY/1 YEAR (23 °C ± 5 °C) ACCURACY ³⁸	2 YEAR (23 °C ± 5 °C) ACCURACY ³⁸
–100 °C to +100 °C	0.001 °C	±0.08 °C	±0.12 °C
–200 °C to +630 °C	0.001 °C	±0.14 °C	±0.18 °C

²⁹ Specifications are for square wave inputs only. Input signal must be >10 % of ACV range. If input is <20 mV on the 100 mV range, then the frequency must be >10 Hz. For sine wave inputs, frequency must be >100 Hz.

³⁰ 20 % overrange on all ranges except 750 V range.

³¹ Temperature can be displayed in °C, K, or °F.

³² Accuracy for all thermocouple types and the 100 Ω platinum, D100, and F100 RTD types based on ITS-90. Accuracy for the PT385 and PT3916 RTD types based on IPTS-68.

³³ Exclusive of thermocouple error.

³⁴ For temperatures ≤100 °C, add ±0.1 °C and >900 °C, add ±0.3 °C.

³⁵ Specifications apply to channels 2–6. Add 0.06 °C/channel from channel 6.

³⁶ 100 Ω platinum, D100, F100, PT385, PT3916, or user type.

³⁷ Maximum lead resistance (each lead) to achieve rated accuracy is 5 Ω.

³⁸ Exclusive of probe errors.

Specifications and characteristics are subject to change without notice.

INTERNAL SCANNER SPEED

MAXIMUM INTERNAL SCANNER RATES: RANGE: CHANNELS/s³⁹

TRIGGER DELAY = 0

DCV ⁴⁰	ACV ^{40,41}	2 WIRE OHMS ⁴⁰	4 WIRE OHMS ⁴⁰	T/C TEMPERATURE ⁴⁰	RTD TEMPERATURE ⁴⁰
All: 105	All: 96	All: 102	<10 M Ω : 55	All: 70	All: 2

TRIGGER DELAY = AUTO

DCV ⁴⁰	ACV ^{40,41}	2 WIRE OHMS ⁴⁰	4 WIRE OHMS ⁴⁰	T/C TEMPERATURE ⁴⁰	RTD TEMPERATURE ⁴⁰
0.1 V: 100	All: 1.8	100 Ω : 82	100 Ω : 42	All: 70	All: 2
1 V: 100		1 k Ω : 85	1 k Ω : 42		
10 V: 100		10 k Ω : 42	10 k Ω : 25		
100 V: 70		100 k Ω : 28	100 k Ω : 21		
1000 V: 70		1 M Ω : 8	1 M Ω : 7		
		10 M Ω : 5	10 M Ω : 5		
		100 M Ω : 3	100 M Ω : 3		

TRIGGERING AND MEMORY

READING HOLD SENSITIVITY: 0.01 %, 0.1 %, 1 %, or 10 % of reading.

TRIGGER DELAY: 0 to 99 hours (1 ms step size).

EXTERNAL TRIGGER DELAY: <1 ms.

EXTERNAL TRIGGER JITTER: <500 μ s.

MEMORY: 1024 readings.

MATH FUNCTIONS

Rel, Min/Max/Average/StdDev (of stored reading), dB, dBm, Limit Test, %, and mX+b with user-defined units displayed.

dBm REFERENCE RESISTANCES: 1 to 9999 Ω in 1 Ω increments.

REMOTE INTERFACE

Keithley 199/196 Emulation

GPIB (IEEE-488.2) and RS-232C

SCPI (Standard Commands for Programmable Instruments)

³⁹ Speeds are for 60 Hz or 50 Hz operation using factory default operating conditions (*RST). Auto Zero off, Auto Range off, Display off, sample count = 1024.

⁴⁰ NPLC = 0.01.

⁴¹ DETector BANDwidth: 300.

GENERAL

POWER SUPPLY: 100 V / 120 V / 220 V / 240 V.

LINE FREQUENCY: 50 Hz to 60 Hz and 440 Hz, automatically sensed at power-up.

POWER CONSUMPTION: 22 VA.

COMMON MODE VOLTAGE AND ISOLATION: 500 V_{peak}, >10 G Ω and <150 pF.

OPERATING ENVIRONMENT: Specified for 0 °C to 50 °C. Specified to 80% R.H. at 35 °C. Altitude up to 2000 meters.

STORAGE ENVIRONMENT: -40 °C to 70 °C.

SAFETY: Conforms to European Union Directive 73/23/EEC EN61010-1, CAT II.

EMC: Complies with European Union Directive 89/336/EEC, EN61326-1.

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

WARMUP: 2 hours to rated accuracy.

DIMENSIONS:

Rack Mounting: 89 mm high $\times$ 213 mm wide $\times$ 370 mm deep (3½ in. $\times$ 8-3/8 in. $\times$ 14-9/16 in.).

Bench Configuration (with handle and feet): 104 mm high $\times$ 238 mm wide $\times$ 370 mm deep (4-1/8 in. $\times$ 9-3/8 in. $\times$ 14-9/16 in.).

SHIPPING WEIGHT: 5 kg (11 lb).

VOLT HERTZ PRODUCT: $\leq 8 \times 10^7$ V·Hz.

ACCESSORIES SUPPLIED: Model 1751 Safety Test Leads, User Manual, Service Manual.

ACCESSORIES AVAILABLE

2000-SCAN	10-Channel Scanner
2001-TCSCAN	9-Channel Thermocouple Scanner (includes 1-channel reference junction)
4288-1	Single Fixed Rack Mount Kit
4288-2	Dual Fixed Rack Mount Kit
5804	4-Terminal Test Lead Set
5805	Kelvin Probes
7007-1	Shielded GPIB Cable, 1m (3.2 ft)
7007-2	Shielded GPIB Cable, 2m (6.5 ft)
7009-5	Shielded RS-232 Cable 1.5m (5 ft)