KEITHLEY
A Tektronix Company

Model 2001

Multimeter Specifications

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

The following pages contain the complete specifications for the Model 2001. Every effort has been made to make these specifications complete by characterizing its performance under the variety of conditions often encountered in production, engineering, and research.

The 2001 provides 5-minute, 1-hour, 24-hour, 90-day, 1-year, and 2-year specifications, with full specifications for the 90-day, 1-year, and 2-year specifications. This allows the user to utilize 90-day, 1-year, or 2-year recommended calibration intervals, depending upon the level of accuracy desired. As a general rule, the 2-year performance of the Model 2001 exceeds a 5½-digit DMM's 90-day, 180-day, or 1-year specifications. 6½- or 7½-digit performance is assured using 90-day or 1-year specifications.

ABSOLUTE ACCURACY

Based on factory calibration, all 90-day, 1-year, and 2-year specifications are absolute accuracy, traceable to the International System of Units (SI) through a National Metrology Institute (NMI).

TYPICAL ACCURACIES

Accuracy can be specified as typical or warranted. All specifications shown are warranted unless specifically noted. Almost 99% of the 2001's specifications are warranted specifications. In some cases, it is not possible to obtain sources to maintain traceability on the performance of every unit in production on some measurements (for example, high-voltage, high frequency signal sources with sufficient accuracy do not exist). Since these values cannot be verified in production, the values are listed as typical.

2001 SPECIFIED CALIBRATION INTERVALS

MEASUREMENT FUNCTION	24 HOUR[1]	90 DAY[2]	1 YEAR[2]	2 YEAR[2]
DC Volts	•	•	•	•
DC Volts Peak Spikes		•[3]	•	•
AC Volts RMS		•[3]	•	•
AC Volts Peak		•[3]	•	•
AC Volts Average		•[3]	•	•
AC Volts Crest Factor		•[3]	•	•
Ohms	•	•	•	•
DC Current	•	•	•	•
DC In-Circuit Current		•	•	•
AC Current		•[3]	•	•
Frequency		•	•	•
Temperature (Thermocouple)		•	•	•
Temperature (RTD)		•	•	•

[1] For T_{CAL} 1 °C.
[2] For T_{CAL} ±5 °C.
[3] For ±2 °C of last AC self cal.

DC VOLTS

DCV INPUT CHARACTERISTICS AND ACCURACY

RANGE	FULL SCALE	RESO-LUTION	INPUT RESISTANCE	ACCURACY[4] ±(ppm of reading + ppm of range)					TEMPERATURE COEFFICIENT ±(ppm of reading + ppm of range)/°C
				5 Minutes[5]	24 Hours[6]	90 Days[7]	1 Year[7]	2 Years[7]	Outside T_{CAL} ±5 °C
200mV[8]	±210.0mV	10nV	>10GΩ	3 + 3	10 + 6	25 + 6	37 + 6	50 + 6	3.3 +1.5
2V	±2.10V	100nV	>10GΩ	2 + 1.5	7 + 2	18 + 2	25 + 2	32 + 2	2.6 +0.15
20V	±21.0V	1µV	>10GΩ	2 + 1.5	7 + 4	18 + 4	24 + 4	32 + 4	2.6 +0.7
200V	±210.0V	10µV	10MΩ±1%	2 + 1.5	13 + 3	27 + 3	38 + 3	52 + 3	4.3 +1
1000V	±1100.0V	100µV	10MΩ±1%	10 + 1.5	17 + 6	31 + 6	41 + 6	55 + 6	4.1 +1

DC VOLTAGE UNCERTAINTY = ± [(ppm of reading) × (measured value) + (ppm of range) × (range used)] / 1,000,000.

% ACCURACY = (ppm or accuracy) /10,000.

1PPM OF RANGE = 2 counts for ranges up to 200V, 1 count on 1000V range at 6½ digits.

SPEED AND ACCURACY[9]

ACCURACY 90 Days ±(ppm of reading+ppm of range+ppm of range RMS noise[10])				
RANGE	1PLC DFILT On, 10 Readings	1PLC DFILT Off	0.1PLC DFILT Off	0.01PLC[11] DFILT Off
200mV[8]	25+6+0	25+6+0.6	25+30+10	100+200+15
2V	18+2+0	18+2+0.2	18+25+1	130+200+3
20V	18+4+0	18+4+0.3	18+20+0.5	130+200+3
200V	27+3+0	27+5+0.3	27+20+0.8	130+200+3
1000V	31+6+0	31+6+0.1	31+21+0.5	90+200+2
PLC = power line cycle; DFILT = digital filter				

NOISE REJECTION (DB)

SPEED (Number of Power Line Cycles)	AC and DC CMRR[12]		AC NMRR		
	Line Sync On[13]	Internal Trigger[14]	Line Sync On[13] 25-Reading DFILT On	Line Sync On[13] DFILT Off	Internal Trigger[14] DFILT Off
NPLC = 10	140	120	90	80	60
NPLC ≥ 1	140	120	90	80	60
NPLC < 1	60	50	30	20	0
Effective noise is reduced by a factor of 10 for every 20 dB of noise rejection (140 dB reduces effective noise by 10,000,000:1). CMRR is rejection of undesirable AC or DC signal between LO and earth. NMRR is rejection of undesirable AC signal between HI and LO.					

[4] Specifications are for 1 power line cycle, Auto Zero on, 10-reading digital filter, except as noted.
[5] DCV Transfer Stability typical applications are standard cell comparisons and relative accuracy measurements. Specs apply for 10 power line cycles, 20-reading digital filter, autozero on with type synchronous, fixed range following 2-hour warm-up at full scale to 10% of full scale, at T_{REF} ±1 °C (T_{REF} is the initial ambient temperature). Specifications on the 1000 V range are for measurements within 5% of the initial measurement value and following measurement settling.
[6] For T_{CAL} ±1 °C, following 55-minute warm-up. T_{CAL} is ambient temperature at calibration, which is 23 °C from factory.
[7] For T_{CAL} ±5 °C, following 55-minute warm-up.
[8] When properly zeroed using REL function.
[9] For T_{CAL} ±5 °C, 90-day accuracy. 1-year or 2-year accuracy can be found by applying the same speed accuracy ppm changes to the 1-year or 2-year base accuracy.
[10] Typical values when properly zeroed using the REL function with a 4-wire Kelvin short, DC Amps tested open circuit, 1000 readings.
[11] In burst mode, display off. Burst mode requires Auto Zero refresh (by changing resolution or measurement function) once every 24 hours.
[12] Applies for 1 kΩ imbalance in the LO lead. For 400 Hz operation, subtract 10 dB.
[13] For noise synchronous to the line frequency.
[14] For line frequency ±0.1%.

DCV READING RATES[10,15]

200MV, 2V, 200V RANGES

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY		READINGS/SECOND TO IEEE-488		READINGS/SECOND WITH TIME STAMP TO IEEE-488	
				Auto Zero Off	Auto Zero On	Auto Zero Off	Auto Zero On	Auto Zero Off	Auto Zero On
10	167ms (200ms)	28	7½	6 (5.1)	2 (1.7)	6	2 (1.6)	6 (4.1)	2 (1.6)
2	33.4ms (40ms)	26	7½	30 (25)	9 (7.6)	28 (23)	9 (7.3)	27 (22)	8 (7.2)
1	16.7ms (20ms)	25	6½	58 (48)	44 (34)	54 (45)	41 (32)	49 (41)	37 (30)
0.2	3.34ms (4ms)	22	6½	214 (186)	127 (112)	183 (162)	104 (101)	140 (126)	88 (85)
0.1	1.67ms (2ms)	21	5½	272 (272)	150 (148)	228 (225)	129 (123)	156 (153)	100 (96)
0.02	334µs (400µs)	19	5½	284 (287)	156 (155)	230 (230)	136 (134)	158 (156)	104 (103)
0.01	167µs (167µs)	16	4½	417 (417)	157 (157)	317 (317)	137 (134)	198 (198)	105 (103)
0.01[11]	167µs (167µs)	16	4½	2000 (2000)	—	2000 (2000)	—	—	—

20V, 1000V RANGES

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY		READINGS/SECOND TO IEEE-488		READINGS/SECOND WITH TIME STAMP TO IEEE-488	
10	167ms (200ms)	28	7½	6 (5.1)	2 (1.7)	6	2 (1.6)	6	2 (1.6)
2	33.4ms (40ms)	26	7½	30 (25)	9 (8.2)	28 (23)	9 (7.8)	27 (22)	9 (7.7)
1	16.7ms (20ms)	25	6½	57 (48)	42 (38)	54 (45)	43 (35)	48 (41)	39 (32)
0.2	3.34ms (4ms)	22	6½	201 (186)	102 (113)	173 (162)	102 (99)	129 (127)	84 (83)
0.1	1.67ms (2ms)	21	5½	201 (201)	126 (116)	175 (173)	105 (105)	129 (128)	86 (86)
0.02	334µs (400µs)	19	5½	227 (227)	129 (129)	178 (178)	114 (114)	138 (138)	90 (90)
0.01	167µs (167µs)	16	4½	422 (422)	130 (130)	333 (333)	117 (117)	199 (199)	95 (95)
0.01[11]	167µs (167µs)	16	4½	2000 (2000)	—	2000 (2000)	—	—	—

SETTLING CHARACTERISTICS: <500µs to 10ppm of step size. Reading settling times are affected by source impedance and cable dielectric absorption characteristics. Add 10ppm of range for first reading after range change.

ZERO STABILITY: Typical variation in zero reading, 1 hour, T_{REF} ±1 °C, 6½-digit default resolution, 10-reading digital filter:

Range	1 Power Line Cycle Integration	10 Power Line Cycle Integration
2V to 1000V	±3 counts	±2 counts
200mV	±5 counts	±3 counts

ISOLATED POLARITY REVERSAL ERROR: This is the portion of the instrument error that is seen when high and low are reversed when driven by an isolated source. This is not an additional error — it is included in the overall instrument accuracy spec. **Reversal Error:** <2 counts at 10V input at 6½ digits, 10 power line cycles, 10-reading digital filter.

INPUT BIAS CURRENT: <100pA at 25 °C.

LINEARITY: <1ppm of range typical, <2ppm maximum.

AUTORANGING: Autoranges up at 105% of range, down at 10% of range.

[15] See Operating speed for additional detail. For DELAY=0, internal trigger, digital filter off, display off (or display in "hold" mode). Aperture is reciprocal of line frequency. These rates are for 60 Hz and (50 Hz).

DCV PEAK SPIKES MEASUREMENT

REPETITIVE SPIKES ACCURACY[16] 90 Days, ±2 °C from last AC self-cal ±(% of reading+% of range)

RANGE	0 to 1kHz[17]	1kHz to 10kHz	10kHz to 30kHz	30kHz to 50kHz	50kHz to 100kHz	100kHz to 300kHz	300kHz to 500kHz	500kHz to 750kHz	750kHz to 1MHz	TEMPERATURE COEFFICIENT ± (% of reading+ % of range)/° C Outside T_{CAL} ±2 °C
200mV	0.08+0.7	0.08+0.7	0.1 +0.7	0.15+0.7	0.25+0.7	1.0+0.7	2.5+0.7	5.5+ 0.7	9+0.7	0.002+0.03
2V	0.08+0.3	0.08+0.3	0.1 +0.3	0.15+0.3	0.25+0.3	1.0+0.3	2.5+0.3	5.5+0.3	9+0.3	0.002+0.03
20V	0.09+0.7	0.1 +0.7	0.12+0.7	0.17+0.7	0.25+0.7	1.0+0.7	2.5+0.7	5.5+0.7	9+0.7	0.004+0.03
200V[18]	0.09+0.3	0.1 +0.3	0.12+0.3	0.17+0.3	0.25+0.3	1.0+0.3[10]	2.5+0.3[10]	5.5+0.3[10]	9+0.3[10]	0.004+0.03
1000V[18]	0.1 +0.6	0.13+0.6	0.16+0.6	0.25+0.6[10]	0.5 +0.6[10]	—	—	—	—	0.01 +0.02
Max. % of Range	±125%	±125%	±125%	±125%	±125%	±125%	±125%	±100%	±75%	—

REPETITIVE SPIKES ACCURACY[16] 1 OR 2 YEARS, T_{CAL} ±5 °C ±(% OF READING+% OF RANGE)

RANGE	0 to 1kHz[4]	1kHz to 10kHz	10kHz to 30kHz	30kHz to 50kHz	50kHz to 100kHz	100kHz to 300kHz	300kHz to 500kHz	500kHz to 750kHz	750kHz to 1MHz	TEMPERATURE COEFFICIENT ± (% of reading+ % of range)/°C Outside T_{CAL} ±5 °C
200mV	0.08+0.7	0.09+0.7	0.1 +0.7	0.15+0.7	0.25+0.7	1.0+0.7	2.5+0.7	5.5+0.7	9+0.7	0.002+0.03
2V	0.08+0.3	0.09+0.3	0.1 +0.3	0.15+0.3	0.25+0.3	1.0+0.3	2.5+0.3	5.5+0.3	9+0.3	0.002+0.03
20V	0.1 +0.7	0.11+0.7	0.14+0.7	0.19+0.7	0.25+0.7	1.0+0.7	2.5+0.7	5.5+0.7	9+0.7	0.004+0.03
200V[18]	0.1 +0.3	0.11+0.3	0.14+0.3	0.19+0.3	0.25+0.3	1.0+0.3[10]	2.5+0.3[10]	5.5+0.3[10]	9+0.3[10]	0.004+0.03
1000V[18]	0.12+0.6	0.16+0.6	0.2 +0.6	0.25+0.6[10]	0.5 +0.6[10]	—	—	—	—	0.01 +0.02
Max. % of Range	±125%	±125%	±125%	±125%	±125%	±125%	±125%	±100%	±75%	—

DEFAULT MEASUREMENT RESOLUTION: 3½ digits.

MAXIMUM INPUT: ±1100 V peak value, $2x10^7$ V•Hz (for inputs above 20 V).

NON-REPETITIVE SPIKES: 10% of range per µs typical slew rate.

SPIKE WIDTH: Specifications apply for spikes ≥ 1 µs.

RANGE CONTROL: In Multiple Display mode, voltage range is the same as DCV range.

SPIKES MEASUREMENT WINDOW: Default is 100ms per reading (settable from 0.1 s to 9.9 s in Primary Display mode).

INPUT CHARACTERISTICS: Same as ACV input characteristics.

SPIKES DISPLAY: Access as multiple display on DC Volts. First option presents positive peak spikes and highest spike since reset. Second option presents negative spikes and lowest spike. Highest and lowest spike can be reset by pressing DCV function button. Third option displays the maximum and minimum levels of the input signal. Spikes displays are also available through CONFIG-ACV-ACTYPE as primary displays.

[16] Specifications apply for 10-reading digital filter. If no filter is used, add 0.25% of range typical uncertainty.
[17] Specifications assume AC+DC coupling for frequencies below 200Hz. Below 20Hz, add 0.1% of reading additional uncertainty.
[18] Add 0.001% of reading × (V_{IN}/100V)2 additional uncertainty for inputs above 100V.

AC VOLTS

AC MAGNITUDE: RMS or Average. Peak and Crest Factor measurements also available.

ACV INPUT CHARACTERISTICS

RMS RANGE	PEAK INPUT	FULL SCALE RMS	RESOLUTION	DEFAULT RESOLUTION	INPUT IMPEDANCE	TEMPERATURE COEFFICIENT[19] ±(% of reading + % of range) / °C Outside T_{CAL} ±5 °C
200 mV	1V	210.0mV	100nV	1µV	1MΩ ±2% with <140pF	0.004 + 0.001
2V	8V	2.10V	1µV	10µV	1MΩ ±2% with <140pF	0.004 + 0.001
20V	100V	21.0V	10µV	100µV	1MΩ ±2% with <140pF	0.006 + 0.001
200V	800V	210.0V	100µV	1mV	1MΩ ±2% with <140pF	0.006 + 0.001
750V	1100V	775.0V	1mV	10mV	1MΩ ±2% with <140pF	0.012 + 0.001

AC VOLTAGE UNCERTAINTY = ± [(% of reading) × (measured value) + (% of range) × (range used)] / 100.

PPM ACCURACY = (% of accuracy) × 10,000.

0.015% OF RANGE = 30 counts for ranges up to 200V and 113 counts on 750V range at 5½ digits.

LOW FREQUENCY MODE RMS[20]

90 days, ±2 °C from last AC self-calibration, for 1% to 100% of range[21] ±(% of reading + % of range)

RANGE	1–10Hz[10]	10–50Hz	50–249Hz	251Hz–2kHz	2–10kHz	10–30kHz	30–50kHz	50–100kHz	100–200kHz	0.2–1MHz	1–2MHz
200mV	0.09+0.015	0.04+0.015	0.03+0.015	0.03+0.015	0.03+0.015	0.035+0.015	0.05+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
2V	0.09+0.015	0.04+0.015	0.03+0.015	0.03+0.015	0.03+0.015	0.035+0.015	0.05+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
20V	0.1 +0.015	0.05+0.015	0.04+0.015	0.04+0.015	0.06+0.015	0.08 +0.015	0.1 +0.015	0.3+0.015	0.75+0.025	4+0.2	7+0.2[10]
200V[22]	0.1 +0.015	0.05+0.015	0.04+0.015	0.04+0.015	0.06+0.015	0.08 +0.015	0.1 +0.015	0.3+0.015	0.75+0.025[10]	4+0.2[10]	—
750V[22]	0.13+0.015	0.09+0.015	0.08+0.015	0.08+0.015	0.09+0.015	0.12 +0.015	0.15+0.015[10]	0.5+0.015[10]	—	—	—

LOW FREQUENCY MODE RMS[20]

1 or 2 years, T_{CAL} ±5 °C for 1% to 100% of range[21] ±(% of reading + % of range)

RANGE	1–10Hz[10]	10–50Hz	50–249Hz	251Hz–2kHz	2–10kHz	10–30kHz	30–50kHz	50–100kHz	100–200kHz	0.2–1MHz	1–2MHz
200mV	0.11+0.015	0.06+0.015	0.05+0.015	0.05+0.015	0.05 +0.015	0.05+0.015	0.06+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
2V	0.11+0.015	0.06+0.015	0.05+0.015	0.05+0.015	0.05 +0.015	0.05+0.015	0.06+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
20V	0.12+0.015	0.07+0.015	0.06+0.015	0.06+0.015	0.085+0.015	0.12+0.015	0.13+0.015	0.3+0.015	0.75+0.025	4+0.2	7+0.2[10]
200V[22]	0.12+0.015	0.07+0.015	0.06+0.015	0.06+0.015	0.085+0.015	0.12+0.015	0.13+0.015	0.3+0.015	0.75+0.025[10]	4+0.2[10]	—
750V[22]	0.15+0.015	0.11+0.015	0.1+0.015	0.1+0.015	0.13+0.015	0.18+0.015	0.22+0.015[10]	0.5+0.015[10]	—	—	—

[19] Temperature coefficient applies to RMS or average readings. For frequencies above 100kHz, add 0.01% of reading/°C to temperature coefficient.
[20] Specifications apply for sine wave input, AC + DC coupling, 1 power line cycle, digital filter off, following 55 minute warm-up.
[21] For 1% to 5% of range below 750 V range, and for 1% to 7% of 750 V range, add 0.01% to range uncertainty. For inputs from 200 kHz to 2 MHz, specifications apply above 10% of range.
[22] Add 0.001% of reading × $(V_{IN}/100V)^2$ additional uncertainty above $100V_{RMS}$.

NORMAL MODE RMS[20]

90 days, ±2 °C from last AC self-calibration for 1% to 100% of range[21] ±(% of reading + % of range)

RANGE	20–50Hz	50–100Hz	0.1–2kHz	2–10kHz	10–30kHz	30–50kHz	50–100kHz	100–200kHz	0.2–1MHz	1–2MHz
200mV	0.25+0.015	0.07+0.015	0.03+0.015	0.03+0.015	0.035+0.015	0.05+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
2V	0.25+0.015	0.07+0.015	0.03+0.015	0.03+0.015	0.035+0.015	0.05+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
20V	0.25+0.015	0.07+0.015	0.04+0.015	0.06+0.015	0.08 +0.015	0.1 +0.015	0.3+0.015	0.75+0.025	4+0.2	7+0.2[10]
200V[22]	0.25+0.015	0.07+0.015	0.04+0.015	0.06+0.015	0.08 +0.015	0.1 +0.015	0.3+0.015	0.75+0.025[10]	4+0.2[10]	—
750V[22]	0.25+0.015	0.1 +0.015	0.08+0.015	0.09+0.015	0.12 +0.015	0.15+0.015[10]	0.5+0.015[10]	—	—	—

NORMAL MODE RMS[20]

1 or 2 years, T_{CAL} ±5 °C for 1% to 100% of range[21] ±(% of reading + % of range)

RANGE	20–50Hz	50–100Hz	0.1–2kHz	2–10kHz	10–30kHz	30–50kHz	50–100kHz	100–200kHz	0.2–1MHz	1–2MHz
200mV	0.25+0.015	0.08+0.015	0.05+0.015	0.05+0.015	0.05+0.015	0.06+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
2V	0.25+0.015	0.08+0.015	0.05+0.015	0.05+0.015	0.05+0.015	0.06+0.015	0.3+0.015	0.75+0.025	2+0.1	5+0.2
20V	0.25+0.015	0.08+0.015	0.06+0.015	0.085+0.015	0.12 +0.015	0.13 +0.015	0.3+0.015	0.75+0.025	4+0.2	7+0.2[10]
200V[22]	0.25+0.015	0.08+0.015	0.06+0.015	0.085+0.015	0.12 +0.015	0.13 +0.015	0.3+0.015	0.75+0.025[10]	4+0.2[10]	—
750V[22]	0.27+0.015	0.11 +0.015	0.1+0.015	0.13+0.015	0.18 +0.015	0.22+0.015[10]	0.5+0.015[10]	—	—	—

DB ACCURACY RMS

±dB, 90 days, 1 or 2 years, T_{CAL} ±5 °C, Reference=1V, Autoranging, Low Frequency Mode, AC+DC Coupling

INPUT	1 to 100Hz	0.1 to 30kHz	30 to 100kHz	100 to 200kHz	0.2 to 1MHz	1 to 2MHz
–54 to –40 dB (2mV to 10mV)	0.230	0.225	0.236	0.355	—	—
–40 to –34 dB (10mV to 20mV)	0.036	0.031	0.041	0.088	—	—
–34 to 6 dB (20mV to 2V)	0.023	0.018	0.028	0.066	0.265	0.630
6 to 26 dB (2V to 20V)	0.024	0.024	0.028	0.066	0.538	0.820[10]
26 to 46 dB (20V to 200V)	0.024	0.024	0.028	0.066[10]	0.538[10]	—
46 to 57.8 dB (200V to 775V)	0.018	0.021	0.049[10]	—	—	—

ACV READING RATES[10, 23]

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY		READINGS/SECOND TO IEEE-488		READINGS/SECOND WITH TIME STAMP TO IEEE-488	
				Auto Zero Off	Auto Zero On	Auto Zero Off	Auto Zero On	Auto Zero Off	Auto Zero On
10	167ms (200ms)	28	6½	6 (5.1)	2 (1.7)	2	2 (1.6)	2	2 (1.5)
2	33.4ms (40ms)	26	5½	30 (24)	9 (7.9)	28 (23)	9 (7.6)	27 (22)	9 (7.5)
1	16.7ms (20ms)	25	5½	57 (48)	38 (35)	53 (45)	36 (33)	48 (41)	34 (30)
0.1	1.67ms (2ms)	21	5½	136 (136)	70 (70)	122 (122)	64 (64)	98 (98)	56 (56)
0.01	167µs (167µs)	16	4½	140 (140)	71 (71)	127 (127)	66 (66)	99 (99)	58 (58)
0.01[11]	167µs (167µs)	16	4½	2000 (2000)	—	2000 (2000)	—	—	—

[23] For DELAY=0, digital filter off, display off (or display in “hold” mode). Internal Trigger, Normal mode. See Operating speed section for additional detail. Aperture is reciprocal of line frequency. These rates are for 60Hz and (50Hz). Applies for RMS and average mode. Low frequency mode rate is typically 0.2 readings per second.

AC COUPLING

For AC only coupling, add the following % of reading:

	1 to 10Hz	10 to 20Hz	20 to 50Hz	50 to 100Hz	100 to 200Hz
Normal Mode (RMS, average)	—	—	0.41	0.07	0.015
Low Frequency Mode (RMS)	0.1	0.01	0	0	0

For low frequency mode below 200 Hz, specifications apply for sine wave inputs only.

AC+DC COUPLING

For DC > 20% of AC RMS voltage, apply the following additional uncertainty, multiplied by the ratio (DC/AC RMS). Applies to RMS and average measurements.

RANGE	% of Reading	% of Range
200mV, 20V	0.05	0.1
2V, 200V, 750V	0.07	0.01

AVERAGE ACV MEASUREMENT

Normal mode RMS specifications apply from 10% to 100% of range, for 20Hz to 1MHz. Add 0.025% of range for 50 kHz to 100 kHz, 0.05% of range for 100 kHz to 200 kHz, and 0.5% of range for 200 kHz to 1 MHz.

ACV CREST FACTOR MEASUREMENT[24]

CREST FACTOR: = Peak AC / RMS AC.

CREST FACTOR RESOLUTION: 3 digits.

CREST FACTOR ACCURACY: Peak AC uncertainty + AC normal mode RMS uncertainty.

MEASUREMENT TIME: 100 ms plus RMS measurement time.

INPUT CHARACTERISTICS: Same as ACV input.

CREST FACTOR FREQUENCY RANGE: 20 Hz to 1 MHz.

CREST FACTOR DISPLAY: Access as multiple display on AC volts.

HIGH CREST FACTOR ADDITIONAL ERROR ±(% of reading)

Applies to RMS measurements.

CREST FACTOR:	1 to 2	2 to 3	3 to 4	4 to 5
ADDITIONAL ERROR:	0	0.1	0.2	0.4

[24] Subject to peak input voltage specification.

ACV PEAK VALUE MEASUREMENT[25]

REPETITIVE PEAK ACCURACY, ±(% of reading+% of range), 90 days, 1 year or 2 years, T_{CAL} ±5 °C

RANGE	20Hz to 1kHz[26]	1kHz to10kHz	10kHz to 30kHz	30kHz to 50kHz	50kHz to 100kHz	100kHz to 300kHz	300kHz to 500kHz	500kHz to 750kHz	750kHz to 1MHz	TEMPERATURE COEFFICIENT ±(% of reading+% of range)/°C Outside T_{CAL} ±5 °C
200 mV	0.08+0.7	0.09+0.7	0.1 +0.7	0.15+0.7	0.25+0.7	1.0+0.7	2.5+0.7	5.5+0.7	9+0.7	0.002 + 0.03
2V	0.08+0.3	0.09+0.3	0.1 +0.3	0.15+0.3	0.25+0.3	1.0+0.3	2.5+0.3	5.5+0.3	9+0.3	0.002 + 0.03
20V	0.1 +0.7	0.11+0.7	0.14+0.7	0.19+0.7	0.25+0.7	1.0+0.7	2.5+0.7	5.5+0.7	9+0.7	0.004 + 0.03
200V[22]	0.1 +0.3	0.11+0.3	0.14+0.3	0.19+0.3	0.25+0.3	1.0+0.3[10]	2.5+0.3[10]	5.5+0.3[10]	9+0.3[10]	0.004 + 0.03
750V[22]	0.12+0.6	0.16+0.6	0.2 +0.6	0.25+0.6[10]	0.5 +0.6[10]	—	—	—	—	0.01 + 0.02
Valid % of Range[27]	10% to 400%	10% to 400%	10% to 400%	10% to 350%	10% to 350%	10% to250%	10% to 150%	10% to 100%	7.5% to 75%	—

DEFAULT MEASUREMENT RESOLUTION: 4 digits.

NON-REPETITIVE PEAK: 10% of range per µs typical slew rate for single spikes.

PEAK WIDTH: Specifications apply for all peaks ≥1 µs.

PEAK MEASUREMENT WINDOW: 100ms per reading.

MAXIMUM INPUT: ±1100 V_{peak}

SETTLING CHARACTERISTICS:

Normal Mode (RMS, avg.) <300 ms to 1% of step change
<450 ms to 0.1% of step change
<500 ms to 0.01% of step change

Low Frequency Mode (RMS) <5 s to 0.1% of final value

COMMON MODE REJECTION: For 1 kΩ imbalance in either lead: >60 dB for line frequency ±0.1%.

MAXIMUM VOLT•Hz PRODUCT: 2×10^7 V•Hz (for inputs above 20 V).

AUTORANGING: Autoranges up at 105% of range; down at 10% of range.

[25] Specifications apply for sine wave input with a 10-reading digital filter. If no filter is used, add 0.25% of range typical uncertainty.
[26] AC peak specifications assume AC + DC coupling for frequencies below 200 Hz.
[27] For overrange readings 200% to 300% of range, add 0.1% of reading. For 300% to 400% of range, add 0.2% of reading.

OHMS

TWO-WIRE AND FOUR-WIRE OHMS (2W and 4W ohms functions)[28]

RANGE	FULL SCALE	RESOLUTION	CURRENT SOURCE[29]	OPEN CIRCUIT[10]	MAXIMUM LEAD RESISTANCE[30]	MAXIMUM OFFSET COMPENSATION[31]	TEMPERATURE COEFFICIENT ±(% of reading + % of range) / °C Outside T_{CAL} ±5 °C
20Ω	21.0Ω	1μΩ	9.2mA	5V	1.7Ω	±0.2V	8 + 1.5
200Ω	210.0Ω	10μΩ	0.98mA	5V	12Ω	±0.2V	4 + 1.5
2kΩ	2.1kΩ	100μΩ	0.98mA	5V	100Ω	-0.2V to +2V	3.0 + 0.2
20kΩ	21.0kΩ	1mΩ	89μA	5V	1.5kΩ	-0.2V to +2V	4 + 0.2
200kΩ	210.0kΩ	10mΩ	7μA	5V	1.5kΩ	—	11 + 0.2
2MΩ[35]	2.10MΩ	100mΩ	770nA	5V	1.5kΩ	—	25 + 0.2
20MΩ[35]	21.0MΩ	1Ω	70nA	5V	1.5kΩ	—	250 + 0.2
200MΩ[35]	210.0MΩ	10Ω	4.4nA	5V	1.5kΩ	—	4000 + 10
1GΩ[35]	1.050GΩ	100Ω	4.4nA	5V	1.5kΩ	—	4000 + 10

RESISTANCE ACCURACY[32]

±(ppm of reading + ppm of range)

RANGE	24 Hours[33]	90 Days[34]	1 Year[34]	2 Years[34]
20Ω	29 + 7	52 + 7	72 + 7	110 + 7
200Ω	24 + 7	36 + 7	56 + 7	90 + 7
2kΩ	22 + 4	33 + 4	50 + 4	80 + 4.5
20kΩ	19 + 4	32 + 4	50 + 4	80 + 4.5
200kΩ	20 + 4.5	72 + 4.5	90 + 4.5	130 + 5
2MΩ[35]	50 + 4.5	110 + 4.5	160 + 4.5	230 + 5
20MΩ[35]	160 + 4.5	560 + 4.5	900 + 4.5	1100 + 5
200MΩ[35]	3000 + 100	10000 +100	20000 + 100	30000 + 100
1GΩ[35]	9000 + 100	20000 +100	40000 + 100	60000 + 100

RESISTANCE UNCERTAINTY: = ±[(ppm of reading) × (measured value) + (ppm of range) × (range used)] / 1,000,000.

% ACCURACY: = (ppm accuracy) / 10,000.

1PPM OF RANGE: = 2 counts for ranges up to 200MΩ and 1 count on 1GΩ range at 6½ digits.

[28] When measuring resistance of inductive loads, the inductance of that load must be 10mH or less.
[29] Current source is typically ±9% of absolute accuracy.
[30] Total of the measured value and lead resistance cannot exceed full scale.
[31] Maximum offset compensation plus source current times measured resistance must be less than source current times resistance selected.
[32] Specifications are for 1 power line cycle, 10 reading digital filter, Auto Zero on, 4-wire mode, offset compensation on (for 20Ω to 20kΩ ranges).
[33] For T_{CAL} ±1 °C, following 55-minute warm-up. T_{CAL} is ambient temperature at calibration (23 °C at the factory).
[34] For T_{CAL} ±5 °C, following 55-minute warm-up.
[35] For 2-wire mode.

2-WIRE ACCURACY[34]

±(ppm of range) when properly zeroed using the REL function with a 4-wire Kelvin short.

RANGE	20Ω	200Ω	2kΩ
ADDITIONAL UNCERTAINTY (inside T_{CAL} ±5 °C)	300ppm	30ppm	3ppm
TEMPERATURE COEFFICIENT (outside T_{CAL} ±5 °C)	70ppm/°C	7ppm/°C	0.7ppm/°C

SPEED AND ACCURACY[36]

RANGE	ACCURACY 90 Days ±(ppm of reading+ppm of range+ppm of range RMS noise[10])		
	1PLC DFILT Off	0.1PLC[37] DFILT Off	0.01PLC[11] DFILT Off
20Ω	52 + 7+0.6	52 + 30+10	110 + 200+35
200Ω	36 + 7+0.6	36 + 30+10	110 + 200+35
2kΩ	33 + 4+0.2	33 + 24+1	130 + 230+5
20kΩ	32 + 4+0.2	32 + 24+2	130 + 230+5
200kΩ	72 + 4.5+0.5	72 + 25+4	150 + 300+10
2MΩ[35]	110 + 4.5+2	110 + 25+15	150 + 300+150
20MΩ[35]	560 + 4.5+5	560 + 30+20	560 + 300+150
200MΩ[35]	10,000 + 100+40	10,000 + 120+80	10,000 + 700+250
1GΩ[35]	20,000 + 100 + 40	20,000 + 120+80	20,000 + 700+250
PLC = Power Line Cycles. DFILT = Digital Filter.			

SETTLING CHARACTERISTICS: For first reading following step change, add the total 90-day measurement error for the present range. Pre-programmed settling delay times are for <200 pF external circuit capacitance. For 200 MΩ and 1 GΩ ranges, add total 1 year errors for first reading following step change. Reading settling times are affected by source impedance and cable dielectric absorption characteristics.

OHMS MEASUREMENT METHOD: Constant current.

OFFSET COMPENSATION: Available on 20 Ω to 20 kΩ ranges.

OHMS VOLTAGE DROP MEASUREMENT: Available as a multiple display.

AUTORANGING: Autoranges up at 105% of range, down at 10% of range.

[36] For T_{CAL} ±5 °C, 90-day accuracy. 1-year and 2-year accuracy can be found by applying the same speed accuracy ppm changes to the 1-year or 2-year base accuracy.

[37] Ohms measurements at rates lower than 1 power line cycle are subject to potential noise pickup. Care must be taken to provide adequate shielding.

2-WIRE RESISTANCE READING RATES[10, 38]

20Ω, 200Ω, 2kΩ, and 20kΩ ranges

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY		READINGS/SECOND TO IEEE-488		READINGS/SECOND WITH TIME STAMP TO IEEE-488	
				Auto Zero Off	Auto Zero On	Auto Zero Off	Auto Zero On	Auto Zero Off	Auto Zero On
10	167ms (200ms)	28	7½	6 (5.1)	2 (1.7)	5 (4)	2 (1.6)	5 (4)	2 (1.6)
2	33.4ms (40ms)	26	7½	30 (25)	8 (7.1)	28 (23)	8 (6.8)	27 (22)	8 (6.7)
1	16.7ms (20ms)	25	6½	58 (48)	40 (34)	53 (45)	37 (32)	49 (41)	35 (31)
0.2[37]	3.34ms (4ms)	22	6½	219 (189)	109 (97)	197 (162)	97 (87)	140 (129)	79 (74)
0.1[37]	1.67ms (2ms)	21	5½	300 (300)	126 (118)	248 (245)	112 (108)	164 (163)	89 (88)
0.02[37]	334µs (400µs)	19	5½	300 (300)	130 (130)	249 (249)	114 (114)	165 (165)	91 (91)
0.01[37]	167µs (167µs)	16	4½	421 (421)	135 (135)	306 (306)	114 (114)	189 (189)	92 (92)
0.01[11,37]	167µs (167µs)	16	4½	2000 (2000)	—	2000(2000)	—	—	—

2-WIRE RESISTANCE READING RATES[10, 38]

20MΩ range

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY		READINGS/SECOND WITH TIME STAMP TO IEEE-488	
				Auto Zero Off	Auto Zero On	Auto Zero Off	Auto Zero On
10	167ms (200ms)	28	7½	6 (5.1)	1 (0.8)	2 (1.8)	1 (0.8)
2	33.4ms (40ms)	26	7½	30 (25)	1 (0.8)	16 (14.5)	1 (0.8)
1	16.7ms (20ms)	25	6½	58 (48)	4 (3.8)	25 (22)	4 (3.5)
0.1[37]	1.67ms (2ms)	21	5½	300 (296)	5 (5)	43 (39)	5 (4.7)
0.02[37]	334µs (400µs)	19	5½	300 (300)	5 (5)	43 (43)	5 (5)
0.01[37]	167µs (167µs)	16	4½	412 (412)	5 (5)	43 (43)	5 (5)

4-WIRE RESISTANCE READING RATES[10, 38]

Any range

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS or READINGS WITH TIME STAMP/SECOND TO MEMORY or IEEE-488, AUTO ZERO ON	
				Offset Comp. Off	Offset Comp. On
10	167ms (200ms)	28	7½	2 (1.6)	0.6 (0.5)
2	33.4ms (40ms)	26	7½	7 (6.1)	2 (1.6)
1	16.7ms (20ms)	25	6½	12 (11.6)	3 (3.7)
0.1[37]	1.67ms (2ms)	21	5½	20 (20)	6 (6)
0.01[37]	167µs (167µs)	16	4½	21 (21)	7 (7)

[38] For DELAY=0, digital filter off, internal trigger, display off. Aperture is reciprocal of line frequency. These rates are for 60Hz and (50Hz). Speed for 200kΩ range is typically 10% slower than 20kΩ range; speed for 2MΩ range is typically 3 times faster than 20MΩ range; speed for 1GΩ range is typically 30% to 50% as fast as 20MΩ range. See Operating speed section for additional detail.

DC AMPS

DCI INPUT CHARACTERISTICS AND ACCURACY[39]

RANGE	FULL SCALE	RESOLUTION	MAXIMUM BURDEN VOLTAGE[40]	ACCURACY[41] ±(ppm of reading + ppm of range)				TEMPERATURE COEFFICIENT ±(ppm of reading + ppm of range)/°C Outside T_{CAL} ±5 °C
				24 Hours[42]	90 Days[43]	1 Year[43]	2 Years[43]	
200µA	210.0µA	10pA	0.25V	63 + 25	300 + 25	500 + 25	1350 + 25	58 + 7
2mA	2.10mA	100pA	0.31V	64 + 20	300 + 20	400 + 20	750 + 20	58 + 5
20mA	21.0mA	1nA	0.4V	65 + 20	300 + 20	400 + 20	750 + 20	58 + 5
200mA	210.0mA	10nA	0.5V	96 + 20	500 + 20	500 + 20	750 + 20	58 + 5
2A	2.10A	100nA	1.5V	500 + 20	800 + 20	900 + 20	1350 + 20	300 + 5

DC CURRENT UNCERTAINTY = ±[(ppm reading)x(measured value) + (ppm of range)x(range used)] / 1,000,000.

% ACCURACY = (ppm accuracy) / 10,000.

10PPM OF RANGE = 20 counts at 6½ digits.

DCI READING RATES[10, 44]

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY		READINGS/SECOND TO IEEE-488		READINGS/SECOND WITH TIME STAMP TO IEEE-488	
				Auto Zero Off	Auto Zero On	Auto Zero Off	Auto Zero On	Auto Zero Off	Auto Zero On
10	167ms (200ms)	28	7½	6 (5.1)	2 (1.7)	6 (4.8)	2 (1.6)	6 (4.8)	2 (1.6)
2	33.4ms (40ms)	26	7½	30 (24)	10 (8.2)	28 (23)	9 (7.8)	27 (22)	9 (7.7)
1	16.7ms (20ms)	25	6½	57 (48)	45 (38)	53 (45)	41 (35)	48 (41)	40 (32)
0.2	3.34ms (4ms)	22	6½	217 (195)	122 (111)	186 (168)	109 (98)	135 (125)	88 (85)
0.1	1.67ms (2ms)	21	5½	279 (279)	144 (144)	234 (229)	123 (123)	158 (156)	99 (98)
0.02	334µs (400µs)	19	5½	279 (279)	148 (148)	234 (234)	130 (130)	158 (158)	101 (101)
0.01	167µs (167µs)	16	4½	298 (298)	150 (150)	245 (245)	132 (132)	164 (164)	102 (102)
0.01[11]	167µs (167µs)	16	4½	2000 (2000)	—	2000 (2000)	—	—	—

[39] Add 50 ppm of range for current above 0.5 A for self-heating.
[40] Actual maximum voltage burden = (maximum voltage burden) × ($I_{MEASURED}/I_{FULL\ SCALE}$).
[41] Specifications are for 1 power line cycle, Auto Zero on, 10 reading digital filter.
[42] For T_{CAL} ±1 °C, following 55 minute warm-up.
[43] For T_{CAL} ±5 °C, following 55 minute warm-up.
[44] For DELAY=0, digital filter off, display off. Internal trigger. Aperture is reciprocal of line frequency. These rates are for 60 Hz and (50 Hz). See Operating speed section for additional detail.

SPEED AND ACCURACY[45]

RANGE	ACCURACY 90 Days ±(ppm of reading+ppm of range+ppm of range RMS noise[10])		
	1PLC DFILT Off	0.1PLC DFILT Off	0.01PLC[11] DFILT Off
200µA	300+25+0.3	300+50+8	300+200+80
2mA	300+20+0.3	300+45+8	300+200+80
20mA	300+20+0.3	300+45+8	300+200+80
200mA	300+20+0.3	300+45+8	300+200+80
2A	600+20+0.3	600+45+8	600+200+80

PLC = Power Line Cycle. DFILT = Digital Filter.

SETTLING CHARACTERISTICS: <500µs to 50ppm of step size. Reading settling times are affected by source impedance and cable dielectric absorption characteristics. Add 50ppm of range for first reading after range change.

MAXIMUM ALLOWABLE INPUT: 2.1A, 250V.

OVERLOAD PROTECTION: 2A fuse (250V), accessible from front (for front input) and rear (for rear input).

AUTORANGING: Autoranges up at 105% of range, down at 10% of range.

DC IN-CIRCUIT CURRENT

The DC in-circuit current measurement function allows a user to measure the current through a wire or a circuit board trace without breaking the circuit. When the In-Circuit Current Measurement function is selected, the 2001 will first perform a 4-wire resistance measurement, then a voltage measurement, and will display the calculated current.

TYPICAL RANGES:

Current: 100µA to 12A.

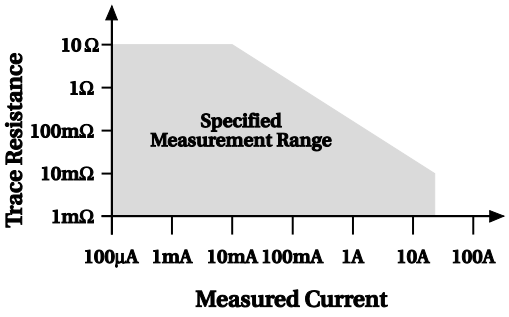
Trace Resistance: 1mΩ to 10Ω typical.

Voltage: ±200mV maximum across trace.

Speed: 4 measurements/second at 1 power line cycle.

Accuracy: ±(5% + 2 counts). For 1 power line cycle, Auto Zero on, 10 reading digital filter, T_{CAL}±5 °C, after being properly zeroed. 90 days, 1 year, or 2 years.

MEASUREMENT RANGE CHART



[45] For T_{CAL} ±5ºC, 90-day accuracy. 1-year and 2-year accuracy can be found by applying the same speed accuracy ppm changes to the 1-year or 2-year base accuracy.

AC AMPS

AC magnitude: RMS or Average.

ACI INPUT CHARACTERISTICS

RMS RANGE	PEAK INPUT	FULL SCALE RMS	RESOLUTION	MAXIMUM BURDEN VOLTAGE[46]	TEMPERATURE COEFFICIENT ±(% of reading + % of range)/°C Outside T_{CAL} ±5 °C
200µA	1mA	210.0mA	100pA	0.25V	0.01 + 0.001
2mA	10mA	2.10mA	1nA	0.31V	0.01 + 0.001
20mA	100mA	21.0mA	10nA	0.4V	0.01 + 0.001
200mA	1A	210.0A	100nA	0.5V	0.01 + 0.001
2A	2A	2.10A	1µA	1.5V	0.01 + 0.001

ACI ACCURACY[47, 48]

90 days, 1 year or 2 years, T_{CAL} ±5 °C, for 5% to 100% of range, ±(% of reading + % of range)

RANGE	20Hz–50Hz	50Hz–200Hz	200Hz–1kHz	1kHz–10kHz	10kHz–30kHz[10]	30kHz–50kHz[10]	50kHz–100kHz[10]
200µA	0.35 + 0.015	0.2 + 0.015	0.4 + 0.015	0.5 + 0.015	—	—	—
2mA	0.3 + 0.015	0.15 + 0.015	0.12 + 0.015	0.12 + 0.015	0.25 + 0.015	0.3 + 0.015	0.5 + 0.015
20mA	0.3 + 0.015	0.15 + 0.015	0.12 + 0.015	0.12 + 0.015	0.25 + 0.015	0.3 + 0.015	0.5 + 0.015
200mA	0.3 + 0.015	0.15 + 0.015	0.12 + 0.015	0.15 + 0.015	0.5 + 0.015	1 + 0.015	3 + 0.015
2A	0.35 + 0.015	0.2 + 0.015	0.3 + 0.015	0.45 + 0.015	1.5 + 0.015	4 + 0.015	—

AC CURRENT UNCERTAINTY = ±[(% of reading) × (measured value) + (% of range) × (range used)] / 100.

PPM ACCURACY = (% accuracy) × 10,000.

0.015% OF RANGE = 30 counts at 5½ digits.

AC COUPLING

For AC only coupling, add the following % of reading.

	20 to 50Hz	50 to 100Hz	100 to 200Hz
RMS, Average	0.55	0.09	0.015

AC+DC COUPLING

For DC>20% of AC RMS voltage, apply the following additional uncertainty, multiplied by the ratio (DC/AC RMS).

	% of Reading	% of Range
RMS, Average	0.05	0.1

[46] Actual maximum voltage burden = (maximum voltage burden) × ($I_{MEASURED}/I_{FULL\ SCALE}$).
[47] Specifications apply for sine wave input, AC+DC coupling, 1 power line cycle, digital filter off, following 55-minute warm-up.
[48] Add 0.005% of range uncertainty for current above 0.5A RMS for self-heating.

ACI READING RATES[10, 49]

NPLC	MEASUREMENT APERTURE	BITS	DEFAULT DIGITS	READINGS/SECOND TO MEMORY		READINGS/SECOND TO IEEE-488		READINGS/SECOND WITH TIME STAMP TO IEEE-488	
				Auto Zero Off	Auto Zero On	Auto Zero Off	Auto Zero On	Auto Zero Off	Auto Zero On
10	167ms (200ms)	28	6½	6 (5.1)	2 (1.7)	6 (4.9)	2 (1.6)	6 (4.8)	2 (1.6)
2	33.4ms (40ms)	26	5½	30 (25)	9 (7.9)	28 (23)	9 (7.6)	27 (22)	9 (7.5)
1	16.7ms (20ms)	25	5½	57 (48)	39 (35)	53 (45)	37 (33)	49 (41)	34 (30)
0.1	1.67ms (2ms)	21	5½	157 (136)	70 (70)	123 (123)	62 (62)	107 (107)	56 (53)
0.01	167µs (167µs)	16	4½	156 (136)	70 (70)	140 (140)	63 (63)	113 (113)	56 (56)
0.01[11]	167µs (167µs)	16	4½	2000 (2000)	—	2000 (2000)	—	—	—

SETTLING CHARACTERISTICS: <300ms to 1% of step change
<450ms to 0.1% of step change
<500ms to 0.01% of step change

AUTORANGING: Autoranges up at 105% of range, down at 10% of range.

AVERAGE ACI MEASUREMENT: RMS specifications apply for 10% to 100% of range.

HIGH CREST FACTOR ADDITIONAL ERROR

±(% of reading)

Applies to RMS measurements.

CREST FACTOR	1 – 2	2 – 3	3 – 4	4 – 5
ADDITIONAL ERROR	0	0.1	0.2	0.4

FREQUENCY COUNTER

FREQUENCY/PERIOD INPUT CHARACTERISTICS AND ACCURACY

90 days, 1 year, or 2 years

	Frequency Range[50]	Period Range	Resolution	Minimum Signal Level[51]			Maximum Input	Trigger Level	Accuracy ±(% of reading)
				1Hz–1MHz	1–5MHz	5–15MHz			
AC Voltage Input	1Hz–15MHz	67ns – 1s	5 digits	60mV	60mV	400mV	1100V pk[50]	0V–600V	0.03
AC Current Input	1Hz– 1MHz	1µs – 1s	5 digits	150µA	—	—	1A pk	0mA–600mA	0.03

MEASUREMENT TECHNIQUE: Unique pulse count/time count at overflow.

TIME BASE: 7.68MHz ± 0.01%, 0 °C to 55 °C.

READING TIME: 420ms maximum.

TRIGGER LEVEL ADJUSTMENT: Trigger level is adjustable in 0.5% of range steps to ±60% of range in real-time using the up and down range buttons.

FREQUENCY RANGING: Autoranging from Hz to MHz.

FREQUENCY COUPLING: AC only.

[49] For DELAY=0, digital filter off, display off, internal trigger. Aperture is reciprocal of line frequency. These rates are for 60Hz and (50Hz).
[50] Subject to 2×10^7V·Hz product (for inputs above 20V).
[51] Valid for the lowest range. For each range increase, multiply these numbers by ten. Signals in RMS.

TEMPERATURE (RTD)[52]

RANGE	RESOLUTION	4-WIRE ACCURACY[53]			
		1 Hour[54]	90 Days	1 Year	2 Years
–100° to +100°C	0.001°C	±0.005°C	±0.05°C	±0.08°C	±0.12°C
–200° to +630°C	0.001°C	±0.005°C	±0.12°C	±0.14°C	±0.18°C
–212° to +180°F	0.001°F	±0.009°F	±0.09°F	±0.15°F	±0.22°F
–360° to +1102°F	0.001°F	±0.009°F	±0.15°F	±0.18°F	±0.33°F

RTD TYPE: 100Ω platinum; DIN 43 760 or IPTS-68, alpha 0.00385, 0.00390, 0.003916, or 0.00392, 4-wire.

MAXIMUM LEAD RESISTANCE (each lead): 12 Ω (to achieve rated accuracy).

SENSOR CURRENT: 1 mA (pulsed).

COMMON MODE REJECTION: <0.005 °C/V at DC, 50 Hz, 60 Hz and 400 Hz, (100 Ω imbalance, LO driven).

TEMPERATURE COEFFICIENT: ±(0.0013% + 0.005 °C)/°C or ±(0.0013% + 0.01 °F)/°C outside T_{CAL} ±5 °C.

RTD TEMPERATURE READING RATES[55] (2- OR 4-WIRE)

NPLC	READINGS or READINGS WITH TIME STAMP/SECOND TO MEMORY or IEEE-488	
	Autozero Off	Autozero On
10	1 (1)	1 (1)
2	5 (4.3)	4 (3.6)
1	7 (6.5)	6 (5.5)
0.1	12 (10.8)	9 (9)
0.01	12 (12)	10 (10)

TEMPERATURE (THERMOCOUPLE)

Thermocouple Type	Range	Default Resolution	Accuracy[56]
J	–200° to +760°C	0.1°C	±0.5°C
K	–200° to +1372°C	0.1°C	±0.5°C
T	–200° to +400°C	0.1°C	±0.5°C
E	–200° to +1000°C	0.1°C	±0.6°C
R	0° to +1768°C	1°C	±3°C
S	0° to +1768°C	1°C	±3°C
B	+350° to +1820°C	1°C	±5°C

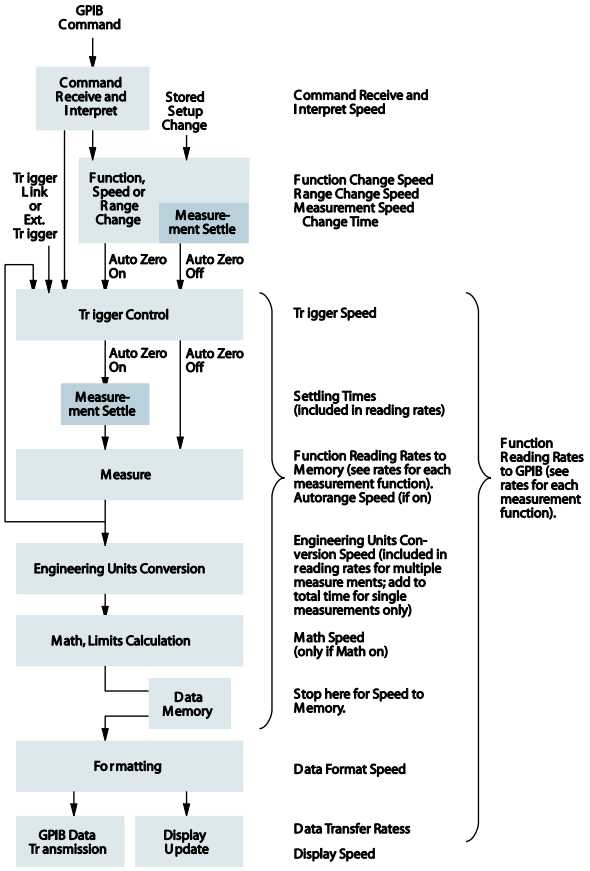
[52] Accuracy for all thermocouple types and the 100 Ω platinum, D100, and F100 RTD types based on ITS-90. Accuracy for the PT385 and PT3916 RTD types based on IPTS-68.
[53] Excluding probe errors. T_{CAL} ±5 °C.
[54] For ambient temperature ±1 °C, measured temperature ±10 °C, 10-reading digital filter.
[55] Typical speeds for Auto Zero on. For DELAY=0, digital filter off, display off, internal trigger. Rates are for 60 Hz and (50 Hz).
[56] Relative to external 0 °C reference junction; exclusive of thermocouple errors. Junction temperature may be external. Applies for 90 days, 1 year or 2 years, T_{CAL} ±5 °C.

TC TEMPERATURE READING RATES[55]

NPLC	READINGS/SECOND TO MEMORY AUTOZERO		READINGS/SECOND TO IEEE-488 AUTOZERO		READINGS/SECOND WITH TIME STAMP TO IEEE-488 AUTOZERO	
	Off	On	Off	On	Off	On
10	6 (5.1)	2 (1.7)	4 (3.4)	2 (1.4)	4 (3.4)	2 (1.4)
2	30 (25)	9 (7.6)	28 (23)	9 (7.3)	27 (22)	8 (7.2)
1	57 (48)	43 (37)	53 (45)	40 (32)	49 (41)	37 (30)
0.1	139 (139)	95 (95)	126 (123)	85 (84)	99 (99)	72 (72)
0.01	177 (177)	98 (98)	156 (156)	87 (87)	119 (119)	73 (73)

OPERATING SPEED

The following diagram illustrates the factors that determine a DMM's reading rate.



COMMAND RECEIVE AND INTERPRET SPEED

	FASTEST	TYPICAL	SLOWEST
Time per character	0.16ms	0.28ms	0.66ms
Characters per second	6250	3751	1515

TYPICAL COMMAND TIMES

COMMAND	RECEIVE AND INTERPRET TIME	RATE (PER SECOND)
SENSE1:VOLTAGE:AC: RESOLUTION MAXIMUM	9.4ms	106
VOLT:AC:RES:MAX	4.1ms	243
SENSE1:FUNC"VOLT:AC"	6.3ms	158
RESISTANCE:RANGE:UPPER 1E9	9.0ms	111
STATUS:QUEUE:CLEAR	5.1ms	196
STAT:QUE:CLE	3.1ms	322
*TRG	1.2ms	833

MEASUREMENT SPEED CHANGE TIMES[57, 58]

Typical delay before first reading after making a speed change.

FUNCTION	From	To	AUTO ZERO OFF Time	AUTO ZERO ON Time
DCV, DCI, ACI	Any	≤0.1 PLC	66ms	44ms
	Any	1 PLC	190ms	140ms
	Any	10 PLC	1540ms	1195ms
ACV	Any	≤0.1 PLC	120ms	100ms
	Any	1 PLC	250ms	197ms
	Any	10 PLC	1600ms	1250ms
Ohms (2-wire)	Any	≤0.1 PLC	69ms	57ms
	Any	1 PLC	195ms	170ms
	Any	10 PLC	1540ms	1370ms
Ohms (4-wire)	Any	≤0.1 PLC	110ms	46ms
	Any	1 PLC	240ms	165ms
	Any	10 PLC	1590ms	1370ms
TC Temperature	Any	≤0.1 PLC	80ms	55ms
	Any	1 PLC	195ms	170ms
	Any	10 PLC	1545ms	1370ms

[57] With display off, 1 power line cycle, autorange off, filter off, triggers halted. Display on may impact time by 3% worst case. To eliminate this impact, press ENTER (hold) to lock out display from front panel.
[58] Based on using 20V, 2kΩ, 200mA ranges.

FUNCTION CHANGE SPEED[57]

FROM Function	TO Function	RANGES	AUTO ZERO OFF		AUTO ZERO ON	
			TIME	RATE (per second)	TIME	RATE (per second)
Any	DCV	200mV, 2V 20V 200V 1000V	8.1ms 8.1ms 24ms 11ms	120 120 40 160	36ms 8.6ms 52ms 10.2ms	27 110 19 190
Any	ACV	Any	563ms	1.8	563ms	1.8
Any except ACI ACI	DCI	200µA, 2mA, 20mA 200mA, 2A Any	4.5ms 6.0ms 21.1ms	220 160 45	5.1ms 6.6ms 22ms	190 150 45
Any	ACI	Any	521ms	1.9	521ms	1.9
Any	Ohms (2-wire)	20Ω, 200Ω, 2kΩ, 20kΩ 200kΩ 2MΩ 20MΩ 200MΩ, 1GΩ	6.0ms 26ms 95ms 265ms 366ms	165 38 10.5 4 3	34ms 61ms 425ms 690ms 5.5ms	29 16 2.4 1.4 180
Any	Ohms (4-wire)	20Ω, 200Ω, 2kΩ, 20kΩ 200kΩ	12ms 26ms	140 38	34.1ms 60ms	29 16
Any except ACI and Ohms ACI, Ohms (4-wire) Ohms (2-wire)	Frequency[59]	Any Any Any	61ms 79ms 418ms	16 12 2	60ms 75ms 416ms	17 13 2
Any	RTD Temp. (2-wire) RTD Temp. (4-wire) TC Temp.	Any Any Any	6.0ms 11.5ms 8.0ms	165 150 125	33ms 37ms 35ms	30 27 28

RANGE CHANGE SPEED[57]

FUNCTION	From	To	AUTO ZERO OFF		AUTO ZERO ON	
			TIME	RATE (per second)	TIME	RATE (per second)
DCV	200mV, 2V 200V, 1000V 200mV, 2V, 20V 200V, 1000V 200mV, 2V, 20V 1000V Any	20V 20V 200mV, 2V, 20V 200mV, 2V 200V 200V 1000V	4.5ms 8.0ms 4.5ms 8.0ms 24ms 9ms 11ms	220 120 220 120 41 110 165	3.1ms 8.6ms 36ms 38ms 52ms 37ms 10.1ms	190 110 27 26 19 27 190
ACV	Any	Any	563ms	1.8	563ms	1.8
DCI	Any	200µA, 2mA, 20mA 200mA, 2A	4.5ms 6.0ms	220 160	5.2ms 6.6ms	190 150
ACI	Any	Any	525ms	1.9	525ms	1.9
Ohms (2-wire)	Any Any Any Any Any	20Ω, 200Ω, 2kΩ, 20kΩ 200kΩ 2MΩ 20MΩ 200MΩ, 1GΩ	6.0ms 26ms 95ms 265ms 366ms	160 38 10 3.7 2.7	34ms 66ms 420ms 690ms 5.5ms	29 15 2.3 1.4 180
Ohms (4-wire)	Any Any	20Ω, 200Ω, 2kΩ, 20kΩ 200kΩ	8ms 26ms	160 38	34ms 66ms	29 16

[59] Based on 100kHz input frequency.

TRIGGER SPEED (EXTERNAL TRIGGER OR TRIGGER-LINK)

	Autozero On	Autozero Off
Trigger Latency	1.2 ms typical	2µs
Trigger Jitter	—	±0.5µs

ENGINEERING UNIT CONVERSION SPEED

Included in reading times for multiple measurements; add to total time for single measurements only.

CONFIGURATION	TIME	RATE (per second)
DCV	2.4ms	416
DCV, Filter on	2.4ms	416
DCV, Relative on	2.5ms	400
DCV, Ratio on	3.7ms	270
ACV	5.3ms	188
ACV, Relative on	5.3ms	188
ACV, Filter on	6.8ms	147
ACV, dB	9.4ms	106
ACV, dBm	17.3ms	57

DISPLAY SPEED

Display updated 20 times per second. Display update can be suspended by holding the display (press ENTER) or setting Display Enable Off from GPIB.

MATH AND LIMITS CALCULATION SPEED[57]

CALCULATION	NOMINAL TIME	NOMINAL RATE (per second)	MAXIMUM TIME
mx + b	0.35ms	2850	0.44ms
Percent	0.60ms	1660	0.64ms
Limits[60]	0.35ms	2850	0.37ms
None	0.07ms	—	0.08ms

GPIB DATA FORMATTING TRANSMISSION TIME[61]

	READINGS ONLY		READINGS WITH TIME STAMP	
FORMAT	Time	Readings/s	Time	Reading/s
DREAL (Double precision real)	0.30ms	3330	2.0ms	500
SREAL (Single precision real)	0.37ms	2710	2.1ms	475
ASCII	3.9ms	255	8.2ms	120

[60] Time to measure, evaluate limits, and set digital outputs are found by summing measurement time with limits calculation time.
[61] Auto Zero off, using 386SX/16 computer, average time for 1000 readings, byte order swapped, front panel disabled.

SINGLE FUNCTION SCAN SPEED[62] (internal scanner)

TYPE	DCV (20V)[63]		2-Wire Ohms (2kΩ)[63]		4-Wire Ohms (2kΩ)[63]		ACV		FREQUENCY		TC TEMPERATURE		RTD TEMPERATURE (2-Wire)	
	Time per Chan.	Rate (Chan./ second)	Time per Chan.	Rate (Chan./ second)	Time per Chan.	Rate (Chan./ second)	Time per Chan.	Rate (Chan./ second)	Time per Chan.	Rate (Chan./ second)	Time per Chan.	Rate (Chan./ second)	Time per Chan.	Rate (Chan./ second)
Ratio or Delta[64] (2 channels)	4ms	250	4.4ms	230	18.5ms	54	—	—	—	—	—	—	—	—
Fast Scan (using solid state channels)	5.5ms	181	7ms	140	—	—	520ms	1.9	958ms	1	13.8ms	72	—	—
Normal Scan	10.3ms	97	12.1ms	80	21ms	47	532ms	1.8	974ms	1	18ms	55	95ms	10

MIXED FUNCTION SCAN SPEED[57] (internal scanner)

SCAN CONFIGURATION (Channels)	AVERAGE TIME/CHANNEL	AVERAGE RATE (Channel/s)
5 chan. DCV, 5 chan, 2wΩ	20ms	50
3 DCV, 3 2wΩ, 4 TC	22ms	45
5 2wRTD, 5 TC	60ms	17
5 2wΩ, 5 2wRTD	60ms	17
9 DCV, 1 ACV	73ms	13
2 DCV 1, ACV, 2 2wΩ, 1 4wΩ	122ms	8
5 DCV, 5 Freq.	490ms	2
3 DCV, 3 ACV, 2 4wΩ	220ms	5

DELAY AND TIMER

TIME STAMP
Resolution: 1µs.
Accuracy: ±0.01% ± 1µs.
Maximum: 2,100,000.000 000 seconds (24 days, 20 hours).

DELAY TIME
(Trigger edge to reading initiation)
Maximum: 999,999.999 seconds (11 days, 12 hours).
Resolution: 1ms.
Jitter: ±1ms.

TIMER
(Reading initiation to reading initiation)
Maximum: 999,999.999 seconds (11 days, 12 hours).
Resolution: 1ms.
Jitter: ±1ms.

NOTE: To find measurement speed, see each measurement section.

[62] Typical times for 0.01 power line cycle, autoranging off, Delay=0, 100 measurements into buffer.
[63] Auto Zero off.
[64] Ratio and delta functions output one value for each pair of measurements.

MAXIMUM INPUT LEVELS

	Rated Input[65]	Overload Recovery Time
HI to LO	±1100V pk	< 900ms
HI Sense to LO	± 350V pk 250V RMS	< 900ms
LO Sense to LO	± 350V pk 250V RMS	< 900ms
AMPS Input to LO	2A, ± 250V (fused)	—
HI to Earth	±1600V	< 900ms
LO to Earth	± 500V	—

IEEE-488 BUS IMPLEMENTATION

IMPLEMENTATION: IEEE-488.2, SCPI-1991.0.

MULTILINE COMMANDS: DCL, LLO, SDC, GET, GTL, UNT, UNL, SPE, SPD.

UNILINE COMMANDS: IFC, REN, EOI, SRQ, ATN.

INTERFACE COMMANDS: SH1, AH1, T5, TE0, L4, LE0, SR1, RL1, PP0, DC1, DT1, C0, E1.

DIGITAL I/O

CONNECTOR TYPE: 8 pin “D” subminiature.

INPUT: One pin, TTL compatible.

OUTPUTS: Four pins. Open collector, 30V maximum pull-up voltage, 100mA maximum sink current, 10Ω output impedance.

CONTROL: Direct control by output or set real-time with limits.

[65] For voltages between other terminals, these ratings can be algebraically added.

GENERAL SPECIFICATIONS AND STANDARDS COMPLIANCE

POWER	**Voltage:** 90V to 134V and 180V to 250V, universal self-selecting.
	Frequency: 50Hz, 60Hz, or 400Hz, self-identifying.
	Consumption: <55VA.
ENVIRONMENTAL	**Operating Temperature:** 0 °C to 50 °C.
	Storage Temperature: –40 °C to 70 °C.
	Humidity: 80% R.H., 0 °C to 35 °C, per MIL-T-28800E[66] Para 4.5.5.1.2.
NORMAL CALIBRATION	**Type:** Software. No manual adjustments required.
	Sources: 2 DC voltages (2V, 20V) and 2 resistances (19k and 1M). Different calibration source values are allowed. All other functions calibrated (adjusted) from these sources and a short circuit. No AC calibrator required for adjustment.
PHYSICAL	**Case Dimensions:** 90mm high × 214mm wide × 369mm deep (3½ in. × 8½ in. × 14½ in.).
	Working Dimensions: From front of case to rear including power cord and IEEE-488 connector: 15.0 inches.
	Net Weight: <4.2kg (<9.2 lb).
	Shipping Weight: <9.1kg (<20 lb).
STANDARDS	**EMI/RFI:** Conforms to VDE 0871B (per Vfg 1046/1984), IEC 801-2. Meets FCC part 15 Class B, CISPR-22 (EN55022).
	Safety: Conforms to IEC348, CAN/CSA-C22.2. No. 231, MIL-T-28800E[66]. Designed to UL1244.
	Reliability: MIL-T-28800E[66].
	Maintainability: MIL-T-28800E[66].
	Mean time to repair (MTTR): <90 minutes (includes disassembly and assembly, excludes recalibration).
	Mean time between failure (MTBF), estimated: >75,000 hours (Bellcore method).
	Mean time to calibrate (MTTC): <20 minutes for normal calibration. <6 minutes for AC self-calibration.
	Process: MIL-STD 45662A and BS5750.
ACCESSORIES SUPPLIED	The unit is shipped with line cord, high performance modular test leads, option slot cover, and full calibration data.

EXTENDED MEMORY/NONVOLATILE MEMORY OPTIONS

DATA STORAGE

Model	Size (Bytes)	4½-Digit	6½-Digit w/Time Stamp	Type	Setup Storage	
					Number	Type
2001	8k	2,027	404	volatile	1	nonvolatile
2001/MEM1	32k	6,909	1,381	nonvolatile	5	nonvolatile
2001/MEM2	128k	29,908	5,980	nonvolatile	10	nonvolatile

These are the minimum sizes to expect.

[66] For MIL-T-28800E, applies to Type III, Class 5, Style E.