KEITHLEY

Model 2001

Multimeter Specifications

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The following pages contain the complete specifications for the 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 2001's 2-year performance 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

To minimize confusion, all 90-day, 1-year and 2-year 2001 specifications are absolute accuracy, traceable to NIST based on factory calibration. Higher accuracies are possible, based on your calibration sources. For example, calibrating with a 10V primary standard rather than a 20V calibrator will reduce calibration uncertainty, and can thereby improve total 2001 accuracy for measurements up to 50% of range. Refer to the 2001 calibration procedure for details.

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 (e.g., 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.

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DC VOLTS

DCV INPUT CHARACTERISTICS AND ACCURACY

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

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

% ACCURACY = (ppm 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]

RANGE	ACCURACY 90 Days ±(ppm of reading+ppm of range+ppm of range RMS noise[10])			
	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 20dB of noise rejection (140dB 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 TREF ±1°C (TREF is the initial ambient temperature). Specifications on the 1000V 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. Specifications include factory traceability to US NIST.
[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.
[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 1kΩ imbalance in the LO lead. For 400Hz operation, subtract 10dB.
[13] For noise synchronous to the line frequency.
[14] For line frequency ±0.1%.

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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:

ZERO STABILITY		
Range	1 Power Line Cycle Integration	10 Power Line Cycle Integration
2V – 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.

DCV PEAK SPIKES MEASUREMENT

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

RANGE	0–1kHz[17]	1kHz–10kHz	10kHz–30kHz	30kHz–50kHz	50kHz–100kHz	100kHz–300kHz	300kHz–500kHz	500kHz–750kHz	750kHz–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%	

[15] See Operating Speed section 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 60Hz and (50Hz).
[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.

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REPETITIVE SPIKES ACCURACY[16] 1 or 2 Years, TCAL ±5ºC ±(% of reading+% of range)

RANGE	0–1kHz[4]	1kHz–10kHz	10kHz–30kHz	30kHz–50kHz	50kHz–100kHz	100kHz–300kHz	300kHz–500kHz	500kHz–750kHz	750kHz–1MHz	TEMPERATURE COEFFICIENT ± (% of reading+% of range)/° C Outside TCAL ±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: ±1100V peak value, $2x10^7$V•Hz (for inputs above 20V).

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

SPIKE WIDTH: Specifications apply for spikes ≥1µs.

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 to 9.9s 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.

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 TCAL ±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) x (measured value) + (% of range) x (range used)] / 100.

PPM ACCURACY = (% accuracy) x 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-cal, 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]			

[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 sinewave input, AC + DC coupling, 1 power line cycle, digital filter off, following 55 minute warm-up.
[21] For 1% to 5% of range below 750V range, and for 1% to 7% of 750V range, add 0.01% to range uncertainty. For inputs from 200kHz to 2MHz, specifications apply above 10% of range.
[22] Add 0.001% of reading $x(V_{IN}/100V)^2$ additional uncertainty above 100V RMS.

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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]			

NORMAL MODE RMS[20] 90 Days, ±2°C from last AC self-cal 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	1–100Hz	0.1–30kHz	30–100kHz	100–200kHz	0.2–1MHz	1–2MHz
–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)			

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

	1–10Hz	10–20Hz	20–50Hz	50–100Hz	100–200Hz
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 200Hz, specifications apply for sine wave inputs only.

[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.

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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–1MHz. Add 0.025% of range for 50kHz–100kHz, 0.05% of range for 100kHz–200kHz, and 0.5% of range for 200kHz–1MHz.

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: 100ms plus RMS measurement time.
INPUT CHARACTERISTICS: Same as ACV input.
CREST FACTOR FREQUENCY RANGE: 20Hz – 1MHz.
CREST FACTOR DISPLAY: Access as multiple display on AC volts.

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

ACV PEAK VALUE MEASUREMENT[25]

REPETITIVE PEAK ACCURACY, ±(% of reading+% of range), 90 Days, 1 Year or 2 Years, TCAL ±5°C

RANGE	20Hz–1kHz[26]	1kHz–10kHz	10kHz–30kHz	30kHz–50kHz	50kHz–100kHz	100kHz–300kHz	300kHz–500kHz	500kHz–750kHz	750kHz–1MHz	TEMPERATURE COEFFICIENT ±(% of reading+% of range)/°C Outside TCAL ±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]	10–400%	10–400%	10–400%	10–350%	10–350%	10–250%	10–150%	10–100%	7.5–75%	

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: ±1100V peak.
SETTLING CHARACTERISTICS:

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

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

COMMON MODE REJECTION: For 1kΩ imbalance in either lead: >60dB for line frequency ±0.1%.
MAXIMUM VOLT•Hz PRODUCT: 2×10^7V•Hz (for inputs above 20V).
AUTORANGING: Autoranges up at 105% of range, down at 10% of range.

[24] Subject to peak input voltage specification.
[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 200Hz.
[27] For overrange readings 200–300% of range, add 0.1% of reading. For 300–400% of range, add 0.2% of reading.

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OHMS

TWO-WIRE AND FOUR-WIRE OHMS (2W and 4W Ohms Functions)[28]

RANGE	FULL SCALE	RESOLUTION	DEFAULT RESOLUTION	CURRENT SOURCE[29]	OPEN CIRCUIT[10]	MAXIMUM LEAD RESISTANCE[30]	MAXIMUM OFFSET COMPENSATION[31]	TEMPERATURE COEFFICIENT ±(% of reading + % of range) / °C Outside TCAL ±5°C
20Ω	21.0Ω	1μΩ	10μΩ	9.2mA	5V	1.7Ω	±0.2V	8 + 1.5
200Ω	210.0Ω	10μΩ	100μΩ	0.98mA	5V	12Ω	±0.2V	4 + 1.5
2kΩ	2100.0kΩ	100μΩ	1mΩ	0.98mA	5V	100Ω	-0.2V to +2V	3.0 + 0.2
20kΩ	21.0kΩ	1mΩ	10mΩ	89μA	5V	1.5kΩ	-0.2V to +2V	4 + 0.2
200kΩ	210.0kΩ	10mΩ	100mΩ	7μA	5V	1.5kΩ		11 + 0.2
2MΩ[35]	2.10MΩ	100mΩ	1Ω	770nA	5V	1.5kΩ		25 + 0.2
20MΩ[35]	21.0MΩ	1Ω	10Ω	70nA	5V	1.5kΩ		250 + 0.2
200MΩ[35]	210.0MΩ	10Ω	100Ω	4.4nA	5V	1.5kΩ		4000 + 10
1GΩ[35]	1.050GΩ	100Ω	1kΩ	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) x (measured value) + (ppm of range) x (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.

2-WIRE ACCURACY[34] ±(ppm of range)

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

[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. Specifications include traceability to US NIST.
[35] For 2-wire mode.

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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 <200pF external circuit capacitance. For 200MΩ and 1GΩ 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 20Ω – 20kΩ ranges.

OHMS VOLTAGE DROP MEASUREMENT: Available as a multiple display.

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

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)

[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.
[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%–50% as fast as 20MΩ range. See Operating Speed section for additional detail.

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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)

DC AMPS

DCI INPUT CHARACTERISTICS AND ACCURACY[39]

RANGE	FULL SCALE	RESOLUTION	DEFAULT RESOLUTION	MAXIMUM BURDEN VOLTAGE[40]	ACCURACY[41] ±(ppm of reading + ppm of range)				TEMPERATURE COEFFICIENT ±(ppm of reading + ppm of range)/°C Outside TCAL ±5°C
					24 Hours[42]	90 Days[43]	1 Year[43]	2 Years[43]	
200µA	210.0µA	10pA	100pA	0.25V	63 + 25	300 + 25	500 + 25	1350 + 25	58 + 7
2mA	2.10mA	100pA	1nA	0.31V	64 + 20	300 + 20	400 + 20	750 + 20	58 + 5
20mA	21.0mA	1nA	10nA	0.4V	65 + 20	300 + 20	400 + 20	750 + 20	58 + 5
200mA	210.0mA	10nA	100nA	0.5V	96 + 20	300 + 20	500 + 20	750 + 20	58 + 5
2A	2.10A	100nA	1µA	1.5V	500 + 20	600 + 20	900 + 20	1350 + 20	58 + 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)			

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.

[39] Add 50 ppm of range for current above 0.5A for self heating.
[40] Actual maximum voltage burden = (maximum voltage burden) x ($I_{MEASURED}/I_{FULL\ SCALE}$).
[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. Specifications include traceability to US NIST.
[44] For DELAY=0, digital filter off, display off. Internal trigger. Aperture is reciprocal of line frequency. These rates are for 60Hz and (50Hz). See Operating Speed section for additional detail.
[45] 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.

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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.

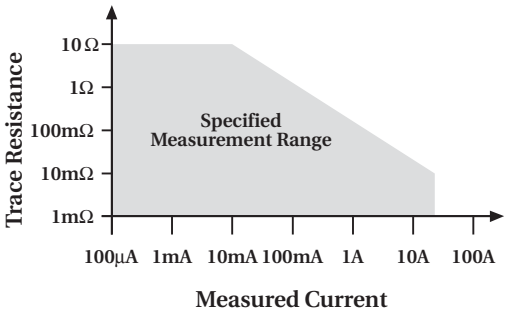
Trace Resistance: 1mΩ to 10Ω typical.

Voltage: ±200mV max. 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



AC AMPS

AC magnitude: RMS or Average.

ACI INPUT CHARACTERISTICS

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

[46] Actual maximum voltage burden = (maximum voltage burden) x ($I_{MEASURED}/I_{FULL\ SCALE}$).

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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) x (measured value) + (% of range) x (range used)] / 100.
PPM ACCURACY = (% accuracy) x 10,000.
0.015% OF RANGE = 30 counts at 5½ digits.

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

	20–50Hz	50–100Hz	100–200Hz
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

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]	0–600V	0.03
AC Current Input	1Hz– 1MHz	1µs – 1s	5 digits	150µA			1A pk	0–600mA	0.03

MEASUREMENT TECHNIQUE: Unique pulse count/time count at overflow.
TIME BASE: 7.68MHz ± 0.01%, 0°C to 55°C.

[47] Specifications apply for sinewave 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.
[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 2×10^7 V·Hz product (for inputs above 20V).
[51] Valid for the lowest range. For each range increase, multiply these numbers by ten.

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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.

TEMPERATURE (RTD)

RANGE	RESOLUTION	4-WIRE ACCURACY[52]			
		1 Hour[53]	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): 12Ω (to achieve rated accuracy).

SENSOR CURRENT: 1mA (pulsed).

COMMON MODE REJECTION: <0.005°C/V at DC, 50Hz, 60Hz and 400Hz, (100Ω 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[54] (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[55]
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

TC TEMPERATURE READING RATES[54]

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)

[52] Excluding probe errors. T_{CAL} ±5°C.
[53] For ambient temperature ±1°C, measured temperature ±10°C, 10-reading digital filter.
[54] Typical speeds for Auto Zero on. For DELAY=0, digital filter off, display off, internal trigger. Rates are for 60Hz and (50Hz).
[55] 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.

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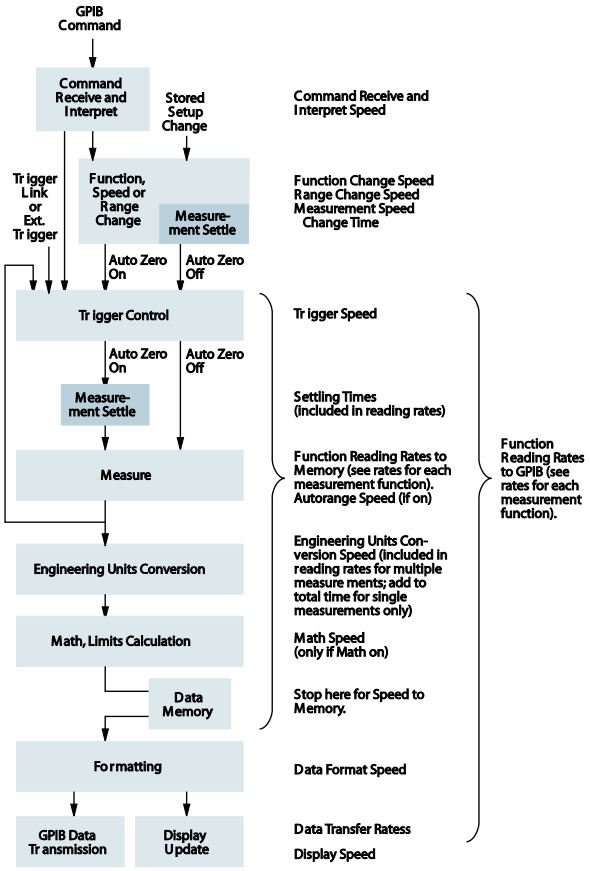
Operating Speed

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

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MEASUREMENT SPEED CHANGE TIMES[56, 57]

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

FUNCTION CHANGE SPEED[56]

			AUTO ZERO OFF		AUTO ZERO ON	
FROM Function	To Function	RANGE(s)	TIME	RATE (per second)	TIME	RATE (per second)
Any	DCV	200mV, 2V	8.1ms	120	36ms	27
		20V	8.1ms	120	8.6ms	110
		200V	24ms	40	52ms	19
		1000V	11ms	160	10.2ms	190
Any	ACV	Any	563ms	1.8	563ms	1.8
Any except ACI	DCI	200µA, 2mA, 20mA	4.5ms	220	5.1ms	190
		200mA, 2A	6.0ms	160	6.6ms	150
ACI		Any	21.1ms	45	22ms	45
Any	ACI	Any	521ms	1.9	521ms	1.9
Any	Ohms (2-wire)	20Ω, 200Ω, 2kΩ, 20kΩ	6.0ms	165	34ms	29
		200kΩ	26ms	38	61ms	16
		2MΩ	95ms	10.5	425ms	2.4
		20MΩ	265ms	4	690ms	1.4
		200MΩ, 1GΩ	366ms	3	5.5ms	180
Any	Ohms (4-wire)	20Ω, 200Ω, 2kΩ, 20kΩ	12ms	140	34.1ms	29
		200kΩ	26ms	38	60ms	16
Any except ACI and Ohms	Frequency[58]	Any	61ms	16	60ms	17
ACI, Ohms (4-wire)		Any	79ms	12	75ms	13
Ohms (2-wire)		Any	418ms	2	416ms	2
Any	RTD Temp. (2-wire)	Any	6.0ms	165	33ms	30
	RTD Temp. (4-wire)	Any	11.5ms	150	37ms	27
	TC Temp.	Any	8.0ms	125	35ms	28

[56] 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.
[57] Based on using 20V, 2KΩ, 200mA ranges.
[58] Based on 100kHz input frequency.

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RANGE CHANGE SPEED[56]

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

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[56]

CALCULATION	NOMINAL TIME	NOMINAL RATE (per second)	MAXIMUM TIME
mX + b	0.35ms	2850	0.44ms
Percent	0.60ms	1660	0.64ms
Limits[59]	0.35ms	2850	0.37ms
None	0.07ms		0.08ms

[59] Time to measure, evaluate limits, and set digital outputs are found by summing measurement time with limits calculation time.

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GPIB DATA FORMATTING TRANSMISSION TIME[60]

FORMAT	READINGS ONLY		READINGS WITH TIME STAMP	
	Time	Rdg./s	Time	Rdg./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

SINGLE FUNCTION SCAN SPEED[61] (Internal Scanner)

TYPE	DCV (20V)[62]		2-Wire Ohms (2kΩ)[62]		4-Wire Ohms (2kΩ)[62]		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[63] (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[56] (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.

[60] Auto Zero off, using 386SX/16 computer, average time for 1000 readings, byte order swapped, front panel disabled.
[61] Typical times for 0.01 power line cycle, autoranging off, Delay=0, 100 measurements into buffer.
[62] Auto Zero off.
[63] Ratio and delta functions output one value for each pair of measurements.

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MAXIMUM INPUT LEVELS

	RATED INPUT[64]	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
I 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.

GENERAL SPECIFICATIONS AND STANDARDS COMPLIANCE

POWER	**Voltage:** 90–134V and 180–250V, 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[65] 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 lbs.).
	Shipping Weight: <9.1kg (<20 lbs.).

[64] For voltages between other terminals, these ratings can be algebraically added.
[65] For MIL-T-28800E, applies to Type III, Class 5, Style E.

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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[65]. Designed to UL1244.

Reliability: MIL-T-28800E[65].

Maintainability: MIL-T-28800E[65].

MTTR: <90 minutes (includes disassembly and assembly, excludes recalibration). MTTR is Mean Time To Repair.

MTBF, Estimated: >75,000 hours (Bellcore method). MTBF is Mean Time Between Failure.

MTTC: <20 minutes for normal calibration. <6 minutes for AC self-calibration. MTTC is Mean Time To Calibrate.

Process: MIL-STD 45662A and BS5750.

ACCESSORIES SUPPLIED The unit is shipped with line cord, high performance modular test leads, user's manual, option slot cover, and full calibration data. A personal computer startup package is available free.

EXTENDED MEMORY/NON-VOLATILE 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	non-volatile
2001/MEM1	32k	6,909	1,381	non-volatile	5	non-volatile
2001/MEM2	128k	29,908	5,980	non-volatile	10	non-volatile

These are the minimum sizes to expect.