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Multimeter Specifications

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 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

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 (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.

Specifications are subject to change without notice.

DC VOLTS

DCV INPUT CHARACTERISTICS AND ACCURACY

RANGE	FULL SCALE	RESOLUTION	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	>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) 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 200V, 1 count on 1000V range at 6½ digits.

SPEED AND ACCURACY⁹

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 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 T_{REF} ±1°C (T_{REF} 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%.

Specifications and characteristics are subject to change without notice.

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	
				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	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 – 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 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).

Specifications are subject to change without notice.

DCV PEAK SPIKES MEASUREMENT

REPETITIVE SPIKES ACCURACY¹⁶ 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%	

REPETITIVE SPIKES ACCURACY¹⁶ 1 OR 2 YEARS, T_{CAL} ±5°C ±(% 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 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: ±1100V peak value, 2x10⁷V•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.

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.

Specifications and characteristics are subject to change without notice.

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) 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 RMS²⁰

90 Days, ±2°C from last AC self-cal, for 1% to 100% of range²¹ ±(% 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 RMS²⁰

1 or 2 Years, T_{CAL} ±5°C for 1% to 100% of range²¹ ±(% 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 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}.

Specifications are subject to change without notice.

NORMAL MODE RMS²⁰

90 Days, ±2°C from last AC self-cal for 1% to 100% of range²¹ ±(% 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 RMS²⁰

1 or 2 Years, T_{CAL} ±5°C for 1% to 100% of range²¹ ±(% 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)			

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.

Specifications and characteristics are subject to change without notice.

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.

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 MEASUREMENT²⁴

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

²⁴ Subject to peak input voltage specification.

ACV PEAK VALUE MEASUREMENT²⁵

REPETITIVE PEAK ACCURACY, \pm (% of reading+% of range), 90 Days, 1 Year or 2 Years, T_{CAL} \pm 5°C

RANGE	20Hz–1kHz ²⁶	1kHz–10kHz	10kHz–30kHz	30kHz–50kHz	50kHz–100kHz	100kHz–300kHz	300kHz–500kHz	500kHz–750kHz	750kHz–1MHz	TEMPERATURE COEFFICIENT \pm (% of reading+% of range)/°C Outside T _{CAL} \pm 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 μ s typical slew rate for single spikes.

PEAK WIDTH: Specifications apply for all peaks \geq 1 μ s.

PEAK MEASUREMENT WINDOW: 100ms per reading.

MAXIMUM INPUT: \pm 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 1k Ω imbalance in either lead: >60dB for line frequency \pm 0.1%.

MAXIMUM VOLT·Hz PRODUCT: 2 x 10⁷V·Hz (for inputs above 20V).

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 200Hz.

²⁷ For overrange readings 200–300% of range, add 0.1% of reading. For 300–400% of range, add 0.2% of reading.

Specifications and characteristics are subject to change without notice.

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 ACCURACY³²

±(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.

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.

Specifications are subject to change without notice.

2-WIRE ACCURACY³⁴

±(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

SPEED AND ACCURACY³⁶

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.

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.

Specifications and characteristics are subject to change without notice.

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

Specifications are subject to change without notice.

DC AMPS

DCI INPUT CHARACTERISTICS AND ACCURACY³⁹

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	300 + 20	500 + 20	750 + 20	58 + 5
2A	2.10A	100nA	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)			

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.

Specifications and characteristics are subject to change without notice.

SPEED AND ACCURACY⁴⁵

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.

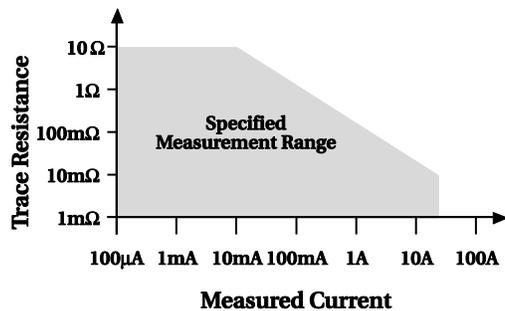
Trace Resistance: 1mΩ to 10Ω typical.

Voltage: ±200mV 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



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.

Specifications are subject to change without notice.

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) 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

⁴⁶ Actual maximum voltage burden = (maximum voltage burden) x (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.

Specifications and characteristics are subject to change without notice.

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.

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 × 10⁷V·Hz product (for inputs above 20V).

⁵¹ Valid for the lowest range. For each range increase, multiply these numbers by ten.

Specifications are subject to change without notice.

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): 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 RATES⁵⁵ (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 60Hz and (50Hz).

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.

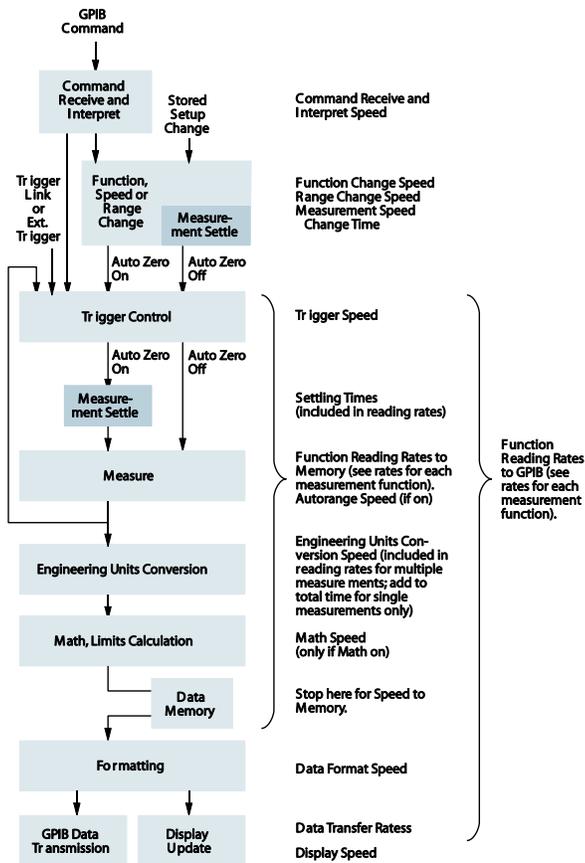
Specifications and characteristics are subject to change without notice.

TC TEMPERATURE READING RATES⁵⁵

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

Specifications are subject to change without notice.

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.

Specifications and characteristics are subject to change without notice.

FUNCTION CHANGE SPEED⁵⁷

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	120	36ms	27
			8.1ms	120	8.6ms	110
			24ms	40	52ms	19
			11ms	160	10.2ms	190
Any	ACV	Any	563ms	1.8	563ms	1.8
Any except ACI	DCI	200µA, 2mA, 20mA 200mA, 2A Any	4.5ms	220	5.1ms	190
ACI			6.0ms	160	6.6ms	150
			21.1ms	45	22ms	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	165	34ms	29
			26ms	38	61ms	16
			95ms	10.5	425ms	2.4
			265ms	4	690ms	1.4
			366ms	3	5.5ms	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	16	60ms	17
			79ms	12	75ms	13
			418ms	2	416ms	2
Any	RTD Temp. (2-wire) RTD Temp. (4-wire) TC Temp.	Any Any Any	6.0ms	165	33ms	30
			11.5ms	150	37ms	27
			8.0ms	125	35ms	28

RANGE CHANGE SPEED⁵⁷

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 200V 1000V Any	20V	4.5ms	220	3.1ms	190
			8.0ms	120	8.6ms	110
		200mV, 2V, 20V	4.5ms	220	36ms	27
			8.0ms	120	38ms	26
		200V	24ms	41	52ms	19
			9ms	110	37ms	27
		200V	11ms	165	37ms	27
		1000V	11ms	165	10.1ms	190
Any	1000V	11ms	165	10.1ms	190	
ACV	Any	Any	563ms	1.8	563ms	1.8
DCI	Any	200µA, 2mA, 20mA 200mA, 2A	4.5ms	220	5.2ms	190
			6.0ms	160	6.6ms	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	160	34ms	29
			26ms	38	66ms	15
			95ms	10	420ms	2.3
			265ms	3.7	690ms	1.4
			366ms	2.7	5.5ms	180
Ohms (4-wire)	Any Any	20Ω, 200Ω, 2kΩ, 20kΩ 200kΩ	8ms	160	34ms	29
			26ms	38	66ms	16

⁵⁹ Based on 100kHz input frequency.

Specifications are subject to change without notice.

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 SPEED⁵⁷

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 TIME⁶¹

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

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.

Specifications and characteristics are subject to change without notice.

SINGLE FUNCTION SCAN SPEED⁶² (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 SPEED⁵⁷ (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.

Specifications are subject to change without notice.

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
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.

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

GENERAL SPECIFICATIONS AND STANDARDS COMPLIANCE

POWER	<p>Voltage: 90–134V and 180–250V, universal self-selecting.</p> <p>Frequency: 50Hz, 60Hz, or 400Hz, self-identifying.</p> <p>Consumption: <55VA.</p>
ENVIRONMENTAL	<p>Operating Temperature: 0°C to 50°C.</p> <p>Storage Temperature: –40°C to 70°C.</p> <p>Humidity: 80% R.H., 0°C to 35°C, per MIL-T-28800E⁶⁶ Para 4.5.5.1.2.</p>
NORMAL CALIBRATION	<p>Type: Software. No manual adjustments required.</p> <p>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.</p>
PHYSICAL	<p>Case Dimensions: 90mm high × 214mm wide × 369mm deep (3½ in. × 8½ in. × 14½ in.).</p> <p>Working Dimensions: From front of case to rear including power cord and IEEE-488 connector: 15.0 inches.</p> <p>Net Weight: <4.2kg (<9.2 lb).</p> <p>Shipping Weight: <9.1kg (<20 lb).</p>
STANDARDS	<p>EMI/RFI: Conforms to VDE 0871B (per Vfg 1046/1984), IEC 801-2. Meets FCC part 15 Class B, CISPR-22 (EN55022).</p> <p>Safety: Conforms to IEC348, CAN/CSA-C22.2. No. 231, MIL-T-28800E⁶⁶. Designed to UL1244.</p> <p>Reliability: MIL-T-28800E⁶⁶.</p> <p>Maintainability: MIL-T-28800E⁶⁶.</p> <p>MTTR: <90 minutes (includes disassembly and assembly, excludes recalibration). MTTR is Mean Time To Repair.</p> <p>MTBF, Estimated: >75,000 hours (Bellcore method). MTBF is Mean Time Between Failure.</p> <p>MTTC: <20 minutes for normal calibration. <6 minutes for AC self-calibration. MTTC is Mean Time To Calibrate.</p> <p>Process: MIL-STD 45662A and BS5750.</p>
ACCESSORIES SUPPLIED	<p>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.</p>

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.