

# MODEL 1801 NANO-VOLT PREAMP

## GENERAL NOTES:

- The Model 1801 Nanovolt Preamp consists of a power-supply card that plugs into the Model 2001 scanner slot, the remote nanovolt preamp, and a 3 meter cable to connect the two.
- The Model 1801 Nanovolt Preamp is specified only for use with the Model 2001 Multimeter. Specifications are based on the published Model 2001 performance and are referenced to the 1801 Nanovolt Preamp input. It is assumed the Model 2001 used with the nanovolt preamp is properly calibrated.
- 1801 Nanovolt Preamp specified calibration interval is 1 year.
- The Model 2001 checks for the presence of the nanovolt preamp on power up. If the nanovolt preamp is detected, the front panel menu tree is adjusted accordingly. A subset of the 2001 functions are active with ranges as follows:

## FUNCTION

DC Volts  
 DC Volts Peak Spikes  
 AC Volts Low Frequency rms  
 AC Volts Normal rms Average  
     Peak, Crest Factor  
 DC Current  
 DC In-Circuit Current  
 AC Current  
 2-Wire Ohms  
 4-Wire Ohms  
 Frequency  
 Temperature

## RANGES AVAILABLE

20 $\mu$ V, 200 $\mu$ V, 2mV.  
 Not Available.  
 500 $\mu$ V rms.  
 Not Available.  
 Not Available.  
 Not Available.  
 Not Available.  
 Not Available.  
 Not Available.  
 2m $\Omega$ , 20m $\Omega$ , 200m $\Omega$ , 2 $\Omega$ , 20 $\Omega$ , 200 $\Omega$ .  
 Available for Limited Frequency Range.  
 Only Differential Thermocouple Temperature is Specified. RTD Not Available.

## DC VOLTS

### DCV ACCURACY<sup>1</sup>

RANGE	FULL SCALE	7½ DIGIT RESOLUTION	DEFAULT RESOLUTION	ACCURACY <sup>2</sup>				TEMPERATURE COEFFICIENT ±(ppm of reading + ppm of range)/°C Outside Tcal ±5°C
				±(ppm of reading + ppm of range) 24 Hours <sup>3</sup>	90 Days <sup>4</sup>	1 Year <sup>4</sup>	2 Years <sup>4</sup>	
20 $\mu$ V	±21.000000	1 pV	10 pV	300 + 60	450 + 60	460 + 60	470 + 60	40 + 13
200 $\mu$ V	±210.000000	10 pV	100 pV	200 + 20	250 + 20	260 + 20	270 + 20	40 + 2
2 mV	±2.1000000	100 pV	1 nV	200 + 6	250 + 6	260 + 6	270 + 6	40 + 2

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

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

1PPM OF RANGE = 2 counts at 6½ digits.

### INPUT CHARACTERISTICS (HI to LO):

Input Bias Current: Adjustable at preamp to <20pA. Temperature drift less than 25pA/°C.

Zero Drift: Typical variation of zero reading with low thermal short (see Instruction Manual) is less than 10nV, 5nV/°C. (24 hours, TREF: 1°C, 1 PLC, 10-reading digital filter).

DC Input Resistance: >1G $\Omega$ .

Transient Input Resistance: >1k $\Omega$  1ms after step input. >10M $\Omega$  4s after step input.

Linearity: <4 ppm of range non-linearity, exclusive of zero offset and noise.

Isolated Polarity Reversal Error: <4 counts at 6½ digits, exclusive of zero offset and noise.

Maximum Input Levels: 1V or 100 mA peak.

Overload Recovery: 1s for <10mV overload, 1 minute for  $\geq$  10mV overload.

### COMMON MODE ISOLATION (input LO to 2001 chassis ground):

Isolation Impedance: 1G $\Omega$  in parallel with 1nF.

Maximum Common Mode Voltage: 41V peak.

Common Mode Current: <15nA p-p at 50 or 60Hz.

### NOISE REJECTION (dB):<sup>2</sup>

CMRR: <sup>1</sup> 175dB for DC, 50 or 60 Hz  $\pm$  0.1%, common mode signals up to 5V p-p AC, 41V p-p AC+DC.

NMRR (at 50 or 60 Hz  $\pm$  0.1%, NPLC  $\geq$  1, Line Sync OFF):

FILTER:	SLOW	MEDIUM	FAST
20 uV Range	90 dB	80 dB	60 dB
200 uV Range	90 dB	80 dB	60 dB
2 mV Range	90 dB	60 dB	60 dB

Effective noise is reduced by a factor of 10 for every 20dB of noise rejection (60dB reduces effective noise by 1,000:1).

CMRR is rejection of undesirable AC or DC signal between LO and earth.

With a 1 $\Omega$  imbalance in the LO lead.

NMRR is rejection of undesirable AC signal between HI and LO.

### PREAMP SETTLING CHARACTERISTICS (nominal, $\pm$ 20%):

FILTER:	10% to 90% Rise Time		
	SLOW	MEDIUM	FAST
20 uV Range	10 s	1 s	10 ms
200 uV Range	1 s	100 ms	2 ms
2 mV Range	100 ms	10 ms	500 $\mu$ s

ZERO SUPPRESSION: Adjustable  $\pm$  100 $\mu$ V at preamp. 2001 front panel suppression using REL.

INPUT NOISE (with low thermal short): Equivalent noise resistance of 20 $\Omega$ . There is no 1/f component, 1PLC integration.<sup>5</sup>

FILTER:	Input Noise		
	SLOW	MEDIUM	FAST
20 uV Range	0.6 nV p-p	2 nV p-p	30 nV p-p
200 uV Range	2 nV p-p	9 nV p-p	40 nV p-p
2 mV Range	6 nV p-p	20 nV p-p	90 nV p-p

MAXIMUM SOURCE RESISTANCE: 10k $\Omega$ .

**DC VOLTS NOTES:**

- Specifications are for 1 PLC, Auto Zero on, 10-reading digital filter, Preamp on SLOW filter.
- When properly zeroed (using zero adjustment initially then REL according to procedure in Instruction Manual) every 20 minutes or whenever the ambient temperature changes by more than 1°C.
- For TCAL ± 1°C, following 15-minute preamp warmup. TCAL is ambient temperature at calibration which is 23°C from factory.
- For TCAL ± 5°C, following 15-minute preamp warmup. Specifications include factory traceability to US NIST.
- For source resistance Rs above 1Ω multiply noise by  $\sqrt{\frac{20 + R_s}{20}}$

**DIFFERENTIAL TEMPERATURE:**

Temperature Sensor: Differential thermocouple of type J, K, T, E, R, S, B, or User-entered μV/°C value.  
 Measures differential thermocouple voltage using 2mV DC range. User enters temperature of the reference thermocouple pair. The °C/μV slope is determined from this value using internal thermocouple tables. Differential temperature reading is DCV reading × the °C/μV slope. Default resolution (0.1m°C). Maximum differential temperature reading 50°C.

**ANALOG OUTPUT:**

Connection: Screw terminals on power supply card.  
 Output: ± 2V full scale, maximum 1mA load.  
 Gain: 1000 on 2mV range, 10000 on 200μV range, 100000 on 20μV range.  
 Noise: Input Noise times gain plus modulation products.  
 Modulation Products: Up to 40mV p-p at 288 Hz.  
 Accuracy: ± (2% of output + 1mV) when properly zeroed at preamp.

Differential Thermocouple Type	Range
J	-200°C to + 760°C
K	-200°C to + 1372°C
T	-200°C to + 400°C
E	-200°C to + 1000°C
R	0°C to + 1768°C
S	0°C to + 1768°C
B	+350°C to + 1820°C

**AC VOLTS RMS**

AC Magnitude: Low Frequency rms.  
 Normal rms, Average, rms, Peak and Crest Factor measurement are not available using the 1801 Nanovolt Preamp.

RMS RANGE	PEAK INPUT	FULL SCALE RMS	7½ DIGIT RESOLUTION	DEFAULT RESOLUTION	ACCURACY <sup>3,4</sup>	SIGNAL FREQUENCY	TEMPERATURE COEFFICIENT <sup>5</sup> ±(% of reading + % of range) / °C Outside TCAL ±5°C
500 μV	2 mV	500.000	100 pV	1 nV	6 + 0.1	1 - 100 Hz	1 + 0.03

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

**SETTLING CHARACTERISTICS: <5s to 0.1% of final value.**

**ACV FREQUENCY**

**ACV NOTES:**

- Specifications apply for a sinewave input, crest factor = 1.4, AC+DC coupling, 1PLC, digital filter off. Accuracy specification applies for 90 days, 1 year or 2 years, TCAL±5°C for 5% to 100% of range. Low frequency rms only, AC+DC coupling. All ACV measurements are made with a preamp gain of 1000 and the fast filter.
- Low frequency mode requires autocal refresh (by changing mode or measurement function, using autocal command, or power up) once every 24 hours.

FREQUENCY RANGE	PERIOD RANGE	DEFAULT RESOLUTION	MINIMUM SIGNAL LEVEL	ACCURACY ±(% of reading)
1Hz-1kHz	1ms - 1s	5 digits	400μV peak	2%

**4-WIRE OHMS**

RANGE	FULL SCALE	7½ DIGIT RESOLUTION	DEFAULT RESOLUTION	NOMINAL CURRENT SOURCE <sup>1</sup>	OPEN CIRCUIT VOLTAGE	MAXIMUM LEAD RESISTANCE <sup>2</sup>	MAXIMUM OFFSET COMPENSATION	MAX DUT POWER DISSIPATION
2 mΩ	±2.1000000	100 pΩ	1 nΩ	9.2 mA	5V	1.7 Ω	±20 μV	170 nW
20 mΩ	±21.0000000	1 nΩ	10 nΩ	9.2 mA	5V	1.7 Ω	±200 μV	1.7 μW
200 mΩ	±210.0000000	10 nΩ	100 nΩ	0.98 mA	5V	1.7 Ω	±200 μV	190 nW
2 Ω	±2.1000000	100 nΩ	1 μΩ	0.98 mA	5V	1.7 Ω	±2 mV	1.9 μW
20 Ω	±21.0000000	1 μΩ	10 μΩ	99 μA	5V	1.7 Ω	±2 mV	160 nW
200 Ω	±210.0000000	10 μΩ	100 μΩ	7 μA	5V	1.7 Ω	±2 mV	10 nW

**ACCURACY<sup>3,4,5</sup>**  
 ±(ppm of reading + ppm of range)

RANGE	24 Hours <sup>6</sup>	90 Days <sup>7</sup>	1 Year <sup>7</sup>	2 Years <sup>7</sup>
2 mΩ	350 + 100	550+ 100	560 + 100	570+ 100
20 mΩ	250 + 30	350+ 30	360 + 30	370+ 30
200 mΩ	250 + 30	350+ 30	360 + 30	370+ 30
2 Ω	250 + 10	350+ 10	360 + 10	370+ 10
20 Ω	250 + 10	350+ 10	360 + 10	370+ 10
200 Ω	270 + 10	350+ 10	360 + 10	370+ 10

**TEMPERATURE COEFFICIENT**  
 ± (ppm of reading + ppm of range)/°C  
 Outside TCAL ±5°C

50 + 3
50 + 3
50 + 3
50 + 3
50 + 3
50 + 3
60 + 3

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

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

1PPM OF RANGE = 2 counts at 6½ digits.

## SETTLING CHARACTERISTICS:

FILTER	10% to 90% Rise Time Nominal, ±20%			Offset Compensated Ohms Settling Time to Rated Accuracy		
	SLOW	MEDIUM	FAST	SLOW	MEDIUM	FAST
2 mΩ Range	1 s	100 ms	2 ms	5 s	1.5 s	200 ms
20mΩ - 200Ω Range	100 ms	10 ms	500 μs	800 ms	150 ms	130 ms

**OFFSET COMPENSATION:** Internal delay set for settling to rated accuracy.

**OHMS VOLTAGE DROP MEASUREMENT:** Available as a multiple display.

### OHMS NOTES:

- 1 Current source nominal ± 9%. Calibrated value available as a multiple display.
- 2 Maximum offset compensation plus source current × measured resistance must be less than source current × resistance range selected.
- 3 When properly zeroed (using zero adjustment initially then REL according to procedure in Instruction Manual) every 20 minutes or whenever the ambient temperature changes by more than 1°C.
- 4 Ohms specifications are derived from the 1801 DCV specifications and the Model 2001 ohms specifications. Specifications are guaranteed by verifying the 2001 ohms function and the 1801 DCV function separately.
- 5 Offset compensation on, SLOW filter, 10-reading digital filter, High accuracy mode, Auto zero on.
- 6 For TCAL ± 1°C, following 15-minute preamp warmup. TCAL is ambient temperature at calibration which is 23°C from factory.
- 7 For TCAL ± 5°C, following 15-minute preamp warmup. Specifications include factory traceability to US NIST.

### GENERAL SPECIFICATIONS AND STANDARDS COMPLIANCE

**INPUT CONNECTOR:** 3mm studs and nuts of pure copper.

**POWER:** Supplied through scanner slot of the Model 2001.

**PREAMP WARMUP:** 15-Minutes.

### ENVIRONMENT:

**Operating Temperature:** 0°C to 35°C.

**Storage Temperature:** -40°C to 70°C.

**Humidity:** <80% R.H., 0°C to 35°C.

**Magnetic Field Density:** <0.1 Tesla.

### NORMAL CALIBRATION:

**Type:** Software. No manual adjustments are required. Adjustments for voltage and current offset are provided for use during measurement setup.

**Sources:** Model 262 Voltage Divider and a DCV Calibrator with < 50ppm 1 year accuracy specifications.

### PHYSICAL:

**Remote Preamp Case Dimensions:** 35mm high × 70mm wide × 140mm long. 1.38in. high × 2.76in. wide × 5.5in. long. Add 6mm (0.25in.) to height to include terminals.

**Thermal Isolation Enclosure Dimensions:** 5 in. wide × 11 in. × 4 in. deep.

**Remote Preamp Weight:** 500g (1.1 lbs.).

**Shipping Weight:** 2212g (4lbs. 15oz).

**ACCESSORIES SUPPLIED:** The Model 1801 Nanovolt Preamp consists of a power-supply card that plugs into the Model 2001 scanner slot, the remote nanovolt preamp, and a 3 meter cable to connect the two. In addition, accessories supplied include 3 meters of SC-93 low thermal cable (shielded twisted pair, solid copper wires, unterminated), thermal isolation enclosure, and user's manual.

Specifications subject to change without notice.