

# 2182A Nanovoltmeter Specifications

## VOLTS SPECIFICATIONS (20% OVER RANGE)

CONDITIONS: 1PLC with 10 reading digital filter or 5PLC with 2 reading digital filter.

CHANNEL 1 RANGE	RESOLUTION	INPUT RESISTANCE	ACCURACY: $\pm$ (ppm of reading + ppm of range) (ppm = parts per million) (e.g., 10ppm = 0.001%)				TEMPERATURE COEFFICIENT 0°-18°C & 28°-50°C
			24 Hour <sup>1</sup> T <sub>CAL</sub> $\pm$ 1°C	90 Day T <sub>CAL</sub> $\pm$ 5°C	1 Year T <sub>CAL</sub> $\pm$ 5°C	2 Year T <sub>CAL</sub> $\pm$ 5°C	
10.000000 mV <sup>2,3,4</sup>	1 nV	>10 GΩ	20 + 4	40 + 4	50 + 4	60 + 4	(1 + 0.5)/°C
100.00000 mV	10 nV	>10 GΩ	10 + 3	25 + 3	30 + 4	40 + 5	(1 + 0.2)/°C
1.0000000 V	100 nV	>10 GΩ	7 + 2	18 + 2	25 + 2	32 + 3	(1 + 0.1)/°C
10.000000 V	1 μV	>10 GΩ	2 + 1 <sup>5</sup>	18 + 2	25 + 2	32 + 3	(1 + 0.1)/°C
100.00000 V <sup>4</sup>	10 μV	10 MΩ $\pm$ 1%	10 + 3	25 + 3	35 + 4	52 + 5	(1 + 0.5)/°C
<b>CHANNEL 2<sup>6,10</sup></b>							
100.00000 mV	10 nV	>10 GΩ	10 + 6	25 + 6	30 + 7	40 + 7	(1 + 1)/°C
1.0000000 V	100 nV	>10 GΩ	7 + 2	18 + 2	25 + 2	32 + 3	(1 + 0.5)/°C
10.000000 V	1 μV	>10 GΩ	2 + 1 <sup>5</sup>	18 + 2	25 + 2	32 + 3	(1 + 0.5)/°C

CHANNEL 1/CHANNEL 2 RATIO: Ratio accuracy =  $\frac{\pm \text{channel 2 reading (accuracy channel 1 range)} + \text{channel 1 reading (accuracy channel 2 range)}}{(\text{channel 2 reading})^2}$

**DELTA (hardware-triggered coordination with 24XX series or 622X series current sources for low noise R measurement):** accuracy = accuracy of selected Channel 1 range plus accuracy of 1 source range.

**DELTA measurement noise with 6220 or 6221 :** Typical 3nVRMS/√Hz (10mV range)<sup>21</sup>. 1 Hz achieved with 1PLC, delay = 1ms, RPT filter = 23 (20 if 50Hz)

**PULSE-MODE (with 6221):** line synchronized voltage measurements within current pulses from 50us to 12ms, pulse repetition rate up to 12 Hz

**Pulse measurement noise:** (typical RMS noise, R<sub>DUT</sub><10 ohms) (0.009ppm of range)<sup>22</sup>/meas\_time/√pulse\_avg\_count + 3nV/√(2 · meas\_time · pulse\_avg\_count) for 10mV range\*\*

\* 0.0028ppm for the 100mV range, 0.0016ppm for ranges 1V and above \*\*8nV/√Hz for ranges above 10mV meas\_time(sec) = pulsewidth – pulse\_meas\_delay in 33us incr.

## DC NOISE PERFORMANCE<sup>7</sup> (DC NOISE EXPRESSED IN VOLTS PEAK-TO-PEAK)

Response time = time required for reading to be settled within noise levels from a stepped input, 60Hz operation.

CHANNEL 1 RESPONSE TIME	NPLC, FILTER	RANGE					NMRR <sup>8</sup>	CMRR <sup>9</sup>
		10mV	100mV	1V	10V	100V		
25.0 s	5, 75	6 nV	20 nV	75 nV	750 nV	75 μV	110 dB	140 dB
4.0 s	5, 10	15 nV	50 nV	150 nV	1.5 μV	75 μV	100 dB	140 dB
1.0 s	1, 18	25 nV	175 nV	600 nV	2.5 μV	100 μV	95 dB	140 dB
667 ms	1, 10 or 5, 2	35 nV	250 nV	650 nV	3.3 μV	150 μV	90 dB	140 dB
60 ms	1, Off	70 nV	300 nV	700 nV	6.6 μV	300 μV	60 dB	140 dB
<b>CHANNEL 2<sup>6,10</sup></b>								
25.0 s	5, 75	-	150 nV	200 nV	750 nV	-	110 dB	140 dB
4.0 s	5, 10	-	150 nV	200 nV	1.5 μV	-	100 dB	140 dB
1.0 s	1, 10 or 5, 2	-	175 nV	400 nV	2.5 μV	-	90 dB	140 dB
85 ms	1, Off	-	425 nV	1 μV	9.5 μV	-	60 dB	140 dB

## VOLTAGE NOISE VS. SOURCE RESISTANCE<sup>11</sup> (DC NOISE EXPRESSED IN VOLTS PEAK-TO-PEAK)

SOURCE RESISTANCE	NOISE	ANALOG FILTER	DIGITAL FILTER
0 Ω	6 nV	Off	100
100 Ω	8 nV	Off	100
1 kΩ	15 nV	Off	100
10 kΩ	35 nV	Off	100
100 kΩ	100 nV	On	100
1 MΩ	350 nV	On	100

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## Temperature (Thermocouples)<sup>12</sup>

(DISPLAYED IN °C, °F, OR K. ACCURACY BASED ON ITS-90, EXCLUSIVE OF THERMOCOUPLE ERRORS.)

TYPE	RANGE	RESOLUTION	ACCURACY
			90 Day/1 Year 23° ±5°C Relative to Simulated Reference Junction
J	-200 to +760°C	0.001°C	±0.2°C
K	-200 to +1372°C	0.001°C	±0.2°C
N	-200 to +1300°C	0.001°C	±0.2°C
T	-200 to +400°C	0.001°C	±0.2°C
E	-200 to +1000°C	0.001°C	±0.2°C
R	0 to +1768°C	0.1°C	±0.2°C
S	0 to +1768°C	0.1°C	±0.2°C
B	+350 to +1820°C	0.1°C	±0.2°C

## OPERATING CHARACTERISTICS<sup>13,14</sup> 60HZ (50HZ) OPERATION

FUNCTION	DIGITS	READINGS/s	PLCs
DCV Channel 1,	7.5	3 (1.2)	5
Channel 2,	7.5 <sup>17,19</sup>	6 (1.7)	5
Thermocouple	6.5 <sup>18,19</sup>	18 (5.5)	1
	6.5 <sup>18,19,20</sup>	45 (7.2)	1
	5.5 <sup>17,19</sup>	80 (20.9)	0.1
	4.5 <sup>16,17,19</sup>	115 (28.0)	0.01
Channel 1/Channel 2,	7.5	1.5 (1.2)	5
(Ratio),	7.5 <sup>17,19</sup>	2.3 (1.7)	5
Delta with 24XX,	6.5 <sup>18</sup>	8.5 (5.5)	1
Scan	6.5 <sup>18,20</sup>	20 (7.2)	1
	5.5 <sup>17</sup>	30 (20.9)	0.1
	4.5 <sup>17</sup>	41 (28.0)	0.01
Delta with 622X	6.5	47 (40) <sup>22</sup>	1

## SYSTEM SPEEDS<sup>13,15</sup>

RANGE CHANGE TIME<sup>14</sup>: <40 ms (<50 ms).

FUNCTION CHANGE TIME<sup>14</sup>: <45 ms (<55 ms).

AUTORANGE TIME<sup>14</sup>: <60 ms (<70 ms).

ASCII READING TO RS-232 (19.2K Baud): 40/s (40/s).

MAX. INTERNAL TRIGGER RATE<sup>16</sup>: 120/s (120/s).

MAX. EXTERNAL TRIGGER RATE<sup>16</sup>: 120/s (120/s).

## MEASUREMENT CHARACTERISTICS

A-D LINEARITY: 0.8ppm of reading + 0.5ppm of range.

FRONT AUTOZERO OFF ERROR: 10mV – 10V: Add ±(8ppm of reading + 500µV) for <10 minutes and ±1°C.

NOTE: Offset voltage error does not apply for Delta Mode.

### AUTOZERO OFF ERROR

10mV: Add ±(8ppm of reading + 100nV) for <10 minutes and ±1°C.

100mV-100V: Add ±(8ppm of reading + 10µV) for <10 minutes and ±1°C.

NOTE: Offset voltage error does not apply for Delta Mode.

### INPUT IMPEDANCE

10mV-10V: >10GΩ, in parallel with <1.5nF. (Front Filter ON)

10mV-10V: >10GΩ, in parallel with <0.5nF. (Front Filter OFF)

100V: 10MΩ±1%

DC INPUT BIAS CURRENT: <60pA @ 23°C, -10V to 5V.  
<120pA @ 23°C, 5 V to 10V.

COMMON MODE CURRENT: <50nA p-p at 50Hz or 60Hz.

INPUT PROTECTION: 150V peak to any terminal, 70V peak Channel 1 LO to Channel 2 LO.

CHANNEL ISOLATION: >10GΩ.

EARTH ISOLATION: 350V peak, >10GΩ and <150pF any terminal to earth. Add 35pF/ft with Model 2107 Low Thermal Input Cable.

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## ANALOG OUTPUT

**MAXIMUM OUTPUT:**  $\pm 1.2V$ .

**ACCURACY:**  $\pm(0.1\%$  of output + 1mV).

**OUTPUT RESISTANCE:**  $1k\Omega \pm 5\%$ .

**GAIN:** Adjustable from  $10^9$  to  $10^6$ . With gain set to 1, a full range input will produce a 1V output.

**OUTPUT REL:** Selects the value of input that represents 0V at output. The reference value can be either programmed value or the value of the previous input.

## TRIGGERING AND MEMORY

**WINDOW FILTER SENSITIVITY:** 0.01%, 0.1%, 1%, 10%, or full scale range (none).

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

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

**EXTERNAL TRIGGER DELAY:** 2ms + <1ms jitter with auto zero off, trigger delay = 0.

**MEMORY SIZE:** 1024 readings.

## MATH FUNCTIONS

Rel, Min/Max/Average/Std. Dev/Peak-to-Peak (of stored reading), Limit Test, %, and mX+b with user defined units displayed.

## REMOTE INTERFACE

Keithley 182 emulation.

GPIB (IEEE-488.2) and RS-232C.

SCPI (Standard Commands for Programmable Instruments).

## GENERAL SPECIFICATIONS

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

**LINE FREQUENCY:** 50Hz, 60Hz, and 400Hz, automatically sensed at power-up.

**POWER CONSUMPTION:** 22VA

**OPERATING ENVIRONMENT:** Specified for 0° to 50°C. Specified to 80% RH at 35°C.

**MAGNETIC FIELD DENSITY:** 10mV range 4.0s response noise tested to 500 gauss.

**STORAGE ENVIRONMENT:** -40° to 70°C.

**WARRANTY:** 3 years.

**SAFETY:** Complies with European Union Directive 73/23/EEC, EN61010-1.

**EMC:** Complies with European Union Directive 89/336/EEC, EN-61326-1.

**VIBRATION:** MIL-PRF-28800E Type III, Class 3.

**WARM-UP:** 2.5 hours to rated accuracy.

**DIMENSIONS:** Rack Mounting: 89mm high x 213mm wide x 370mm deep (3.5in x 8.375in x 14.563in). Bench Configuration (with handles and feet): 104mm high x 238mm wide x 370mm deep (4.125 in x 9.375 in x 14.563 in).

**SHIPPING WEIGHT:** 5kg (11 lbs).

## ACCESSORIES SUPPLIED

2107-4: Low Thermal Input Cable with spade lugs, 1.2m (4 ft).

User manual, service manual, contact cleaner, line cord, alligator clips.

## ACCESSORIES AVAILABLE

2107-30: Low Thermal Input Cable with spade lugs, 9.1m (30 ft)

2182-KIT: Low Thermal Connector with strain relief

2188: Low Thermal Calibration Shorting Plug

2187-4: Input Cable with safety banana plugs

4288-1: Single Fixed Rack Mount Kit

4288-2: Dual Fixed Rack Mount Kit

7007-1: Shielded GPIB Cable, 1m (3.2 ft)

7007-2: Shielded GPIB Cable, 2m (6.5 ft)

7009-5: Shielded RS-232 Cable 1.5m (5 ft)

8501-1: Trigger-Link Cable 1m (3.2 ft)

8501-2: Trigger-Link Cable 2m (6.5 ft)

8502: Trigger-Link Adapter to 6 female BNC connectors

8503: Trigger-Link Cable to 2 male BNC connectors

### Notes:

- Relative to calibration accuracy.
- With Analog Filter on, add 20ppm of reading to listed specification.
- When properly zeroed using REL function. If REL is not used, add 100nV to the range accuracy.
- Specifications include the use of ACAL function. If ACAL is not used, add 9ppm of reading/°C from  $T_{CAL}$  to the listed specification.  $T_{CAL}$  is the internal temperature stored during ACAL.
- For 5PLC with 2-reading Digital Filter. Use  $\pm(4\text{ppm of reading} + 2\text{ppm of range})$  for 1PLC with 10-reading Digital Filter.
- Channel 2 must be referenced to Channel 1. Channel 2 HI must not exceed 125% (referenced to Channel 1 LO) of Channel 2 range selected.
- Noise behavior using 2188 Low Thermal Short after 2.5 hour warm-up.  $\pm 1^\circ C$ . Analog Filter off. Observation time = 10X response time or 2 minutes, whichever is less.
- For  $L_{SYNC}$  On, line frequency  $\pm 0.1\%$ . If  $L_{SYNC}$  Off, use 60dB.
- For 1k $\Omega$  unbalance in LO lead. AC CMRR is 70dB.
- For Low Q mode On, add the following to DC noise and range accuracy at stated response time: 200nV p-p @ 25s, 500nV p-p @ 4.0s, 1.2 $\mu V$  p-p @ 1s, and 5 $\mu V$  p-p @ 85ms.
- After 2.5 hour warm-up,  $\pm 1^\circ C$ , 5PLC, 2 minute observation time, Channel 1 10mV range only.
- For Channel 1 or Channel 2, add 0.3°C for external reference junction. Add 2°C for internal reference junction.
- Speeds are for 60Hz (50Hz) operation using factory defaults operating conditions (\*RST). Autorange Off, Display Off, Trigger Delay = 0, Analog Output off.
- Speeds include measurements and binary data transfer out the GPIB. Analog Filter On, 4 readings/s max.
- Auto Zero Off, NPLC = 0.01.
- 10mV range, 80 readings/s max.
- Sample count = 1024, Auto Zero Off.
- For  $L_{SYNC}$  On, reduce reading rate by 15%.
- For Channel 2 Low Q mode Off, reduce reading rate by 30%.
- Front Auto Zero Off, Auto Zero Off.
- Applies to measurements of room temperature resistances <10 $\Omega$ , Isource range  $\leq 20\mu A$
- Display off, delay 1ms