

# 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: $\pm(\text{ppm of reading} + \text{ppm of range})$ (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> $\pm 1^\circ\text{C}$	90 Day T <sub>CAL</sub> $\pm 5^\circ\text{C}$	1 Year T <sub>CAL</sub> $\pm 5^\circ\text{C}$	2 Year T <sub>CAL</sub> $\pm 5^\circ\text{C}$	
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±1%	10 + 3	25 + 3	35 + 4	52 + 5	(1 + 0.5)°C
<b>CHANNEL 2<sup>5,10</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:

For input signals  $\geq 1\%$  of the range, ratio accuracy =  $\pm$  [(Channel 1 ppm of reading + Channel 1 ppm of range • (Channel 1 range / Channel 1 input))  
+ (Channel 2 ppm of reading + Channel 2 ppm of range • (Channel 2 range / Channel 2 input))]

**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 I 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\*)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>5,10</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  $0^\circ$  to  $50^\circ C$ . Specified to 80% RH at  $35^\circ C$ .

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

**STORAGE ENVIRONMENT:**  $-40^\circ$  to  $70^\circ C$ .

**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:

1. Relative to calibration accuracy.
2. With Analog Filter on, add 20ppm of reading to listed specification.
3. When properly zeroed using REL function. If REL is not used, add 100nV to the range accuracy.
4. Specifications include the use of ACAL function. If ACAL is not used, add 9ppm of reading/ $^\circ C$  from  $T_{CAL}$  to the listed specification.  $T_{CAL}$  is the internal temperature stored during ACAL.
5. For 5PLC with 2-reading Digital Filter. Use  $\pm(4ppm$  of reading + 2ppm of range) for 1PLC with 10-reading Digital Filter.
6. 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.
7. 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.
8. For  $L_{SYNC}$  On, line frequency  $\pm 0.1\%$ . If  $L_{SYNC}$  Off, use 60dB.
9. For  $1k\Omega$  unbalance in LO lead. AC CMRR is 70dB.
10. 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.
11. After 2.5 hour warm-up,  $\pm 1^\circ C$ , 5PLC, 2 minute observation time, Channel 1 10mV range only.
12. For Channel 1 or Channel 2, add 0.3 $^\circ C$  for external reference junction. Add 2 $^\circ C$  for internal reference junction.
13. Speeds are for 60Hz (50Hz) operation using factory defaults operating conditions (\*RST). Autorange Off, Display Off, Trigger Delay = 0, Analog Output off.
14. Speeds include measurements and binary data transfer out the GPIB. Analog Filter On, 4 readings/s max.
15. Auto Zero Off, NPLC = 0.01.
16. 10mV range, 80 readings/s max.
17. Sample count = 1024, Auto Zero Off.
18. For  $L_{SYNC}$  On, reduce reading rate by 15%.
19. For Channel 2 Low Q mode Off, reduce reading rate by 30%.
20. Front Auto Zero Off, Auto Zero Off.
21. Applies to measurements of room temperature resistances  $< 10\Omega$ , Isource range  $\leq 20\mu A$
22. Display off, delay 1ms