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Nanovoltmeter Instrument Specifications

SPECIFICATION CONDITIONS

This document contains specifications and supplemental information for the Model 2182A Nanovoltmeter. Specifications are the standards against which the 2182A is tested. Upon leaving the factory, the 2182A meets these specifications. Supplemental and typical values are nonwarranted, apply at 23 °C (73 °F), and are provided solely as useful information.

Measurement accuracies are specified at the 2182A terminals under these conditions:

1. 23 °C ±5 °C, < 80 percent relative humidity
2. After a 2.5 hour warm-up period
3. Analog-to-digital autozero enabled

VOLTAGE SPECIFICATIONS

Conditions: 1 programmable logic controller (PLC) with 10 reading digital filter or 5 PLCs with 2 reading digital filters

Accuracy: ± (ppm of reading + ppm of range)

where: ppm = parts per million, for example, 10 ppm = 0.001 %

Channel 1 range	Resolution	Input resistance	Accuracy				Temperature coefficient 0 – 18 °C & 28°– 50 °C
			24 Hour ¹ T _{CAL} ±1 °C	90 Day T _{CAL} ±5 °C	1 Year T _{CAL} ±5 °C	2 Year T _{CAL} ±5 °C	
10.000000 mV ^{2,3,4}	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 ⁵	18 + 2	25 + 2	32 + 3	(1 + 0.1) / °C
100.00000 V ⁴	10 μV	10 MΩ ± 1 %	10 + 3	25 + 3	35 + 4	52 + 5	(1 + 0.5) / °C
Channel 2^{6,7}							
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 ⁵	18 + 2	25 + 2	32 + 3	(1 + 0.5) / °C
Channel 1 / channel 2 ratio:							
For input signals ≥ 1 % of the range, ratio accuracy = $\frac{\text{channel 1 reading} + \text{channel 1 accuracy}}{\text{channel 2 reading} - \text{channel 2 accuracy}} - \frac{\text{channel 1 reading}}{\text{channel 2 reading}}$							

¹ Relative to calibration accuracy.

² With analog filter on, add 20 ppm of reading to the listed specification.

³ When properly zeroed using the relative offset (REL) function. If REL is not used, add 100 nV to the range accuracy.

⁴ Specifications include the use of the ACAL function. If ACAL is not used, add 9 ppm of reading per degree Celsius from T_{CAL} to the listed specification. T_{CAL} is the internal temperature stored during ACAL.

⁵ For 5 PLC with 2-reading digital filter. Use ± (4 ppm of reading + 2 ppm of range) for 1 PLC 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 the range selected for channel 2.

⁷ For low q mode on, add the following to DC noise and range accuracy at stated response time: 200 nV p-p at 25 s, 500 nV p-p at 4.0, 1.2 μV p-p at 1 s, and 5 μV p-p at 85 ms.



Delta (hardware-triggered coordination with 24XX series or 622X series current sources for low noise R measurement):

Accuracy = accuracy of selected channel 1 range + accuracy of I source range

Delta measurement noise with 6220 or 6221: Typical:

$$\frac{3 \text{ nV}_{\text{RMS}}}{\sqrt{\text{Hz}} \text{ (10 mV range)}^8}$$

1 Hz achieved with 1 PLC, delay = 1 ms, RPT filter = 23 (20 if 50 Hz)

Pulse mode (with 6221): Line synchronized voltage measurements within current pulses from 50 μs to 12 ms, pulse repetition rate up to 12 Hz

Pulse measurement noise: Typical RMS noise, R_{DUT} < 10 Ω:

$$V_{\text{RMS}} = \frac{C}{\text{meas_time} \times \sqrt{\text{pulse_avg_count}}}$$

Where:

meas_time (seconds) = pulse width – pulse_meas_delay in 33 μs increments

The constant C varies by range as follows:

- 10 mV range: 0.16 nV*s
- 100 mV range: 0.60 nV*s
- 1 V range: 2.2 nV*s
- 10 V range: 18 nV*s

DC NOISE PERFORMANCE⁹

DC noise is expressed in volts peak-to-peak.

Response time is the time required for the reading to be settled in noise levels from a stepped input, 60 Hz operation.

Channel 1 response time	NPLC, filter	RANGE						
		10 mV	100 mV	1 V	10 V	100 V	NMRR ¹⁰	CMRR ¹¹
25.0 s	5, 75	6 nV ¹²	25 nV	75 nV	750 nV	75 μV	110 dB	140 dB
4.0 s	5, 10	15 nV	55 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
Channel 2^{6,7}								
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

⁸ Applies to measurements of room temperature resistances < 10 Ω, I_{source} range ≤ 20 μA.

⁹ Noise behavior using 2188 low thermal short after 2.5 hour warm-up. ± 1 °C. Analog filter off. Observation time = ten times the response time or two minutes, whichever is less.

¹⁰ For L_{SYNC} on, line frequency ± 0.1 %. If L_{SYNC} Off, use 60 dB.

¹¹ For 1 kΩ unbalance in LO lead. AC CMRR is 70 dB.

¹² Guaranteed by design.

Specifications are subject to change without notice

VOLTAGE NOISE VS. SOURCE RESISTANCE

After 2.5 hour warm-up, $\pm 1\text{ }^\circ\text{C}$, 5 PLC, 2 minute observation time, channel 1 10 mV range only.
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 k Ω	15 nV	Off	100
10 k Ω	35 nV	Off	100
100 k Ω	100 nV	On	100
1 M Ω	350 nV	On	100

TEMPERATURE (THERMOCOUPLES)

For channel 1 or channel 2, add 0.3 $^\circ\text{C}$ for external reference junction. Add 2 $^\circ\text{C}$ for internal reference junction.
Displayed in $^\circ\text{C}$, $^\circ\text{F}$, or $^\circ\text{K}$. Accuracy based on ITS-90, exclusive of thermocouple errors.
Accuracy is 90 days / 1 year 23 $^\circ\text{C} \pm 5\text{ }^\circ\text{C}$ relative to simulated reference junction.

Type	Range	Resolution	Accuracy
J	-200 to +760 $^\circ\text{C}$	0.001 $^\circ\text{C}$	$\pm 0.2\text{ }^\circ\text{C}$
K	-200 to +1372 $^\circ\text{C}$	0.001 $^\circ\text{C}$	$\pm 0.2\text{ }^\circ\text{C}$
N	-200 to +1300 $^\circ\text{C}$	0.001 $^\circ\text{C}$	$\pm 0.2\text{ }^\circ\text{C}$
T	-200 to +400 $^\circ\text{C}$	0.001 $^\circ\text{C}$	$\pm 0.2\text{ }^\circ\text{C}$
E	-200 to +1000 $^\circ\text{C}$	0.001 $^\circ\text{C}$	$\pm 0.2\text{ }^\circ\text{C}$
R	0 to +1768 $^\circ\text{C}$	0.1 $^\circ\text{C}$	$\pm 0.2\text{ }^\circ\text{C}$
S	0 to +1768 $^\circ\text{C}$	0.1 $^\circ\text{C}$	$\pm 0.2\text{ }^\circ\text{C}$
B	+350 to +1820 $^\circ\text{C}$	0.1 $^\circ\text{C}$	$\pm 0.2\text{ }^\circ\text{C}$

OPERATING CHARACTERISTICS^{13,14} 60 Hz (50 Hz) OPERATION

Function	Digits	Readings per second	PLCs
DCV channel 1, channel 2, thermocouple	7.5	3 (2)	5
	7.5 ^{15,16}	6 (4)	5
	6.5 ^{16,17}	18 (15)	1
	6.5 ^{16,17,18}	45 (36)	1
	5.5 ^{15,16}	80 (72)	0.1
	4.5 ^{15,16,19}	115 (105)	0.01
Channel 1/channel 2, (ratio), delta with 24XX, scan	7.5	1.5 (1.3)	5
	7.5 ^{15,16}	2.3 (2.1)	5
	6.5 ¹⁷	8.5 (7.5)	1
	6.5 ^{17,18}	20 (16)	1
	5.5 ¹⁵	30 (29)	0.1
	4.5 ¹⁵	41 (40)	0.01
Delta with 622X	6.5	47 (40) ²⁰	1

¹³ Speeds are for 60 Hz (50 Hz) operation using factory default operating conditions (*RST). Autorange off, display off, trigger delay = 0, analog output off.

¹⁴ Speeds include measurements and transfer into internal buffer. If analog filter is on, 4 readings per second, maximum.

¹⁵ Sample count = 1024, auto zero off.

¹⁶ For channel 2 low q mode on, reduce reading rate by 30 %.

¹⁷ For L_{SYNC} on, reduce reading rate by 15 %.

¹⁸ Front auto zero off, auto zero off.

¹⁹ 10 mV range, 80 readings per second, maximum.

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SYSTEM SPEEDS^{13,21}

Range change time¹⁴	< 40 ms (< 50 ms)
Function change time¹⁴	< 45 ms (< 55 ms)
Autorange time¹⁴	< 60 ms (< 70 ms)
ASCII reading to RS-232 (19.2K baud)	40 per second (40 per second)
Maximum internal trigger rate¹⁹	120 per second (120 per second)
Maximum external trigger rate¹⁹	120 per second (120 per second)

MEASUREMENT CHARACTERISTICS

A-D linearity	$\pm (0.8 \text{ ppm of reading} + 0.5 \text{ ppm of range})$
Front autozero off error (Offset voltage error does not apply for delta mode)	10 mV – 10 V: Add $\pm (8 \text{ ppm of reading} + 500 \mu\text{V})$ for < 10 minutes and $\pm 1 \text{ }^\circ\text{C}$
Autozero off error (Offset voltage error does not apply for delta mode)	10 mV: Add $\pm (8 \text{ ppm of reading} + 100 \text{ nV})$ for < 10 minutes and $\pm 1 \text{ }^\circ\text{C}$
	100 mV – 100 V: Add $\pm (8 \text{ ppm of reading} + 10 \mu\text{V})$ for < 10 minutes and $\pm 1 \text{ }^\circ\text{C}$
Input impedance	10 mV – 10 V: > 10 G Ω , in parallel with < 1.5 nF (front filter on)
	10 mV – 10 V: > 10 G Ω , in parallel with < 0.5 nF (front filter off)
	100 V: 10 M $\Omega \pm 1 \%$
DC input bias current²²	< 60 pA @ 23 $^\circ\text{C}$, -10 V to 5 V < 120 pA @ 23 $^\circ\text{C}$, 5 V to 10 V
Common mode current	< 50 nA p-p at 50 Hz or 60 Hz
Input protection	150 V peak to any terminal, 70 V peak channel 1 LO to channel 2 LO
Channel isolation	> 10 G Ω
Earth isolation	350 V peak, > 10 G Ω and < 150 pF any terminal to earth. Add 35 pF/ft with Model 2107 Low Thermal Input Cable

²⁰ Display off, delay 1 ms.

²¹ Auto Zero Off, NPLC = 0.01.

²² Analog filter on, digital filter on.

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ANALOG OUTPUT

Maximum output	$\pm 1.2 \text{ V}$
Accuracy	$\pm (0.1 \% \text{ of output} + 1 \text{ mV})$
Output resistance	$1 \text{ k}\Omega \pm 5 \%$
Gain	Adjustable from 10^{-9} to 10^6 ; with gain set to 1, a full range input will produce a 1 V output
Output rel	Selects the value of input that represents 0 V at output; the reference value can be either a 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 (1 ms step size)
External trigger delay	2 ms + < 1 ms jitter with auto zero off, trigger delay = 0
Memory size	1024 readings

MATH FUNCTIONS

Rel, min/max/average/standard deviation/peak-to-peak (of stored reading), limit test, percentage, 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	100 V / 120 V / 220 V / 240 V
Line frequency	50 Hz, 60 Hz, and 400 Hz, automatically sensed at power-up
Power consumption	22 VA
Magnetic field density	10 mV range 4.0 s response noise tested to 500 gauss
Operating environment	Specified for 0 °C to 50 °C; specified to 80 % relative humidity at 35 °C
Storage environment	-40 °C to 70 °C
EMC	Complies with European Union EMC Directive
Safety	Complies with European Union Low Voltage Directive
Vibration	MIL-T-28800E Type III, Class 5
Warm-up	2.5 hours to rated accuracy
Dimensions	Rack mounting: 89 mm high x 213 mm wide x 370 mm deep (3.5 in. x 8.375 in. x 14.563 in.)
	Bench configuration (with handles and feet): 104 mm high x 238 mm wide x 370 mm deep (4.125 in. x 9.375 in. x 14.563 in.)
Shipping weight	5 kg (11 lb)