KEITHLEY
A Tektronix Company

Model 2182A

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Instrument specifications

Specification conditions

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

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

1. 23 °C ± 5 °C, < 80 percent relative humidity
2. After a 2½ hour warm-up period
3. A/D autozero enabled
4. Properly zeroed local operation using the relative offset (REL) function. If REL is not used, add 100 nV to the range accuracy.

Voltage specifications

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

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

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

Channel 1 Range	Resol-ution	Input resistance	Accuracy 24 Hour[1] T_{CAL} ±1°C	Accuracy 90 Day T_{CAL} ±5°C	Accuracy 1 Year T_{CAL} ±5°C	Accuracy 2 Year T_{CAL} ±5°C	Temperature coefficient 0 – 18°C & 28°– 50°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 = $\frac{\text{Channel 1 Reading + Channel 1 Accuracy}}{\text{Channel 2 Reading – Channel 2 Accuracy}} - \frac{\text{Channel 1 Reading}}{\text{Channel 2 Reading}}$

[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/°C 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 @ 25 s, 500 nV p-p @ 4.0 , 1.2 µV p-p @ 1 s, and 5 µV p-p @ 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 plus accuracy of I source range

DELTA measurement noise with 6220 or 6221: Typical $3nV_{RMS}/\sqrt{Hz}$ (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 ohms[9]:

$$V_{RMS} = \frac{C}{meas\_time * \sqrt{pulse\_avg\_count}}$$

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 performance[10]

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		**RANGE**						
Response Time	**NPLC, Filter**	**10 mV**	**100 mV**	**1 V**	**10 V**	**100 V**	**NMRR[11]**	**CMRR[12]**
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
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] meas_time(sec) = pulsewidth – source_delay in 33 μs increments
[10] Noise behavior using 2188 Low Thermal Short after 2.5 hour warm-up. ±1 °C. Analog Filter off. Observation time = 10X response time or 2 minutes, whichever is less.
[11] For L_{SYNC} On, line frequency ±0.1 %. If L_{SYNC} Off, use 60 dB.
[12] For 1 kΩ unbalance in LO lead. AC CMRR is 70 dB.

Voltage noise vs. source resistance

After 2.5 hour warm-up, ±1 °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 kΩ	15 nV	Off	100
10 kΩ	35 nV	Off	100
100 kΩ	100 nV	On	100
1 MΩ	350 nV	On	100

Temperature (thermocouples)

For Channel 1 or Channel 2, add 0.3 °C for external reference junction. Add 2 °C for internal reference junction.

Displayed in °C, °F, or K. Accuracy based on ITS-90, exclusive of thermocouple errors.

Accuracy is 90 day/1 year 23 °C ±5 °C relative to simulated reference junction.

Type	Range	Resolution	Accuracy
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[13,14] 60 Hz (50 Hz) operation

Function	Digits	Readings/s	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 binary data transfer out of the GPIB interface. Analog Filter On, 4 readings/s max.
[15] Sample count = 1024, Auto Zero Off.
[16] For Channel 2 Low Q mode Off, 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/s max.
[20] Display off, delay 1 ms

System speeds[13,21]

Range change time[14]: <40 ms (<50 ms)

Function change time[14]: <45 ms (<55 ms)

AUTORANGE time[14]: <60 ms (<70 ms)

ASCII reading to RS-232 (19.2K baud): 40/s (40/s)

Maximum internal trigger rate[19]: 120/s (120/s)

Maximum external trigger rate[19]: 120/s (120/s)

Measurement characteristics

A-D linearity: ±(0.8 ppm of reading + 0.5 ppm of range)

Front AUTOZERO off error

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

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

AUTOZERO off error

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

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

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

Input impedance

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

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

100 V: 10 MΩ ±1 %

DC input bias current[22]**:** <60 pA @ 23 °C, –10 V to 5 V <120 pA @ 23 °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 GΩ

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

Analog output

Maximum Output: ±1.2 V

Accuracy: ±(0.1 % of output + 1 mV)

Output resistance: 1 kΩ ±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

[21] Auto Zero Off, NPLC = 0.01.
[22] Analog Filter On, Digital Filter On.

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/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: 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% RH at 35 °C

Storage environment: –40 °C to 70 °C

EMC: Complies with European Union Directive 89/336/EEC (CE marking requirement), FCC part 15 class B, CISPR 11, IEC 801-2, IEC-801-3, IEC 801-4

Safety: Complies with European Union Directive 73/23/EEC (low voltage directive); meets EN61010-1 safety standard, Installation category I

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)

Supplied accessories

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

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

Available accessories

2107-30:	Low Thermal Input Cable with spade lugs, 9.1 m (30 ft)
2182-KIT:	Low Thermal Connector with strain relief
2187-4	Low Thermal Test Lead Kit
2188:	Low Thermal Calibration Shorting Plug
4288-1:	Single Fixed Rack Mount Kit
4288-2:	Dual Fixed Rack Mount Kit
7007-1:	Shielded GPIB Cable, 1 m (3.2 ft)
7007-2:	Shielded GPIB Cable, 2 m (6.5 ft)
7009-5:	Shielded RS-232 Cable 1.5 m (5 ft)
8501-1:	Trigger-Link Cable 1 m (3.2 ft)
8501-2:	Trigger-Link Cable 2 m (6.5 ft)
8503:	Trigger-Link Cable to 2 Male BNC Connectors