
PXle-4309 Specifications

2023-04-11



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PXIe-4309 Specifications

Terminology

Maximum and **minimum** specifications characterize the warranted performance of the instrument within the recommended calibration interval and under the stated operating conditions. These specifications are subject to production verification or guaranteed by design.

Typical specifications are specifications met by the majority of the instruments within the recommended calibration interval and under the stated operating conditions, based on measurements taken during production verification and/or engineering development. The performance of the instrument is not warranted.

Supplemental specifications describe the basic function and attributes of the instrument established by design and are not subject to production verification. They provide information that is relevant for the adequate use of the instrument that is not included in the previous definitions.

Measured specifications describe the measured performance of a representative model.

The following specifications are typical at 25 °C, unless otherwise noted.

- T_{extcal} is the device temperature at last external calibration.
- T_{selfcal} is the device temperature at last self-calibration.

Input Characteristics

Number of ADCs	8 simultaneously sampling ADCs
Number of channels	
Single channel per ADC	8 differential analog input channels

Multichannel per ADC ^[1]	32 differential analog input channels
ADC resolution	18 bits
Type of ADC	SAR
DNL	No missing codes
INL	Refer to Absolute Accuracy section
Measurement resolution ^[2]	18 bits - 28 bits
Maximum sample rate^[3]	
Auto zero none	
Single channel per ADC	2 MS/s
Multichannel per ADC, High Accuracy	10 kS/s (aggregate)
Multichannel per ADC, Maximum Throughput	400 kS/s (aggregate)
Auto zero once	
Single channel per ADC	2 MS/s
Multichannel per ADC, High Accuracy	10 kS/s (aggregate)
Multichannel per ADC, Maximum Throughput	400 kS/s (aggregate)
Auto zero every sample	
Single channel per ADC	10kS/s
Multichannel per ADC	10 kS/s (aggregate)



Notice In multichannel mode, sampling above 10ksps (aggregate) reduces accuracy, especially with source impedances ≥ 50 ohms. See Accuracy vs Number of Channels per ADC vs Sample Rate for more information.

Chopping	
Single channel per ADC	10 kS/s
Multichannel per ADC	10 kS/s (aggregate)
Input coupling	DC
Input range	± 0.1 V, ± 1.0 V, ± 10 V, ± 15 V
Input overrange	0.5% of range
Maximum working voltage (signal + common mode)	± 15.5 V of GND
Input impedance	
Device on, channel idle	
AI+ to AI-	>10 G Ω in parallel with 100 pF
AI- to GND	>100 G Ω in parallel with 10 pF
Device on, channel active	
AI+ to AI-	>10 G Ω in parallel with 200 pF
AI- to GND	>100 G Ω in parallel with 100 pF
Input bias current	
Device on, channel active	± 4.5 nA

Overvoltage protection	
Device on/off	±30 V min
Overvoltage protection input current	
Device on	±100 µA
Device off	±10 µA
FIFO buffer size	1,023 samples
Data transfers	Direct memory access (DMA), programmed I/O

Absolute Accuracy

Auto Zero None

Table 1. DC Voltage Specifications for Auto Zero None

Range	Absolute Accuracy [*] , ^{**} , ^{††}			Temperature Coefficient ^{††}
	24 Hour ^{†, ‡} T _{extcal} ± 1 °C T _{selfcal} ± 1 °C	2 Year T _{extcal} ± 5 °C T _{selfcal} ± 1 °C	2 Year T _{extcal} ± 10 °C T _{selfcal} ± 5 °C	0 °C - 55 °C
	± (ppm of reading + µV)			± (ppm of reading + µV) / °C
0.1 V	33 + 3.2	60 + 7.6	165 + 11.6	25 + 1
1.0 V	28 + 7.4	55 + 16.2	140 + 36.2	20 + 5
10 V	23 + 59.6	50 + 155	115 + 355	15 + 50
15 V	28 + 89.0	55 + 307	140 + 607	20 + 75

* Source Impedance ≤ 50 Ω.

† Relative to External Calibration Source.

Range	Absolute Accuracy [*] , ^{**} , ^{††}			Temperature Coefficient ^{††}
	24 Hour ^{†, ‡} T _{extcal} ± 1 °C T _{selfcal} ± 1 °C	2 Year T _{extcal} ± 5 °C T _{selfcal} ± 1 °C	2 Year T _{extcal} ± 10 °C T _{selfcal} ± 5 °C	0 °C - 55 °C
	± (ppm of reading + μV)			± (ppm of reading + μV) / °C

[‡] Assumes Offset Nulling.

^{**} Sample Rate ≤ 10 S/s.

^{††} Temperature Coefficient is an adder to the Absolute Accuracy values that does not apply unless operating outside of the stated self-calibration temperature intervals. Temperature Coefficient is included in the Absolute Accuracy values over the stated self-calibration temperature intervals.

Table 2. DC Voltage Performance Specifications for Auto Zero None

Range	Residual Offset [*] , [†]	Linearity [†]	Noise [*] , [†] , [‡]		
			10 S/s	10 kS/s	2 MS/s
	μV	ppm of range	μV _{pk-pk}	μV _{rms}	
0.1 V	5	5	2.2	0.6	6.9
1.0 V			2.4	0.8	11
10 V	50		9.6	5.8	84
15 V	75	10	14	8.7	125

^{*} Source Impedance ≤ 50 Ω.

[†] Residual Offset, Linearity and Noise are included in the Absolute Accuracy values in the DC voltage specifications table for Sample Rate ≤ 10 S/s.

[‡] Noise for Single Channel per ADC. For Multiple Channel per ADC, refer to the [Noise versus Sampling Rate](#) and Accuracy vs. Number of Channels per ADC vs Sample Rate section.

Auto Zero Once

Table 3. DC Voltage Specifications for Auto Zero Once

Range	Absolute Accuracy [*] , ^{**} , ^{††}			Temperature Coefficient ^{††}
	24 Hour ^{†, ‡} T _{extcal} ± 1 °C T _{selfcal} ± 1 °C	2 Year T _{extcal} ± 5 °C T _{selfcal} ± 1 °C	2 Year T _{extcal} ± 10 °C T _{selfcal} ± 5 °C	0 °C - 55 °C
	± (ppm of reading + μV)			± (ppm of reading + μV) / °C
0.1 V	33 + 2.3	60 + 6.7	165 + 7.1	25 + 0.1
1.0 V	28 + 2.5	55 + 11.3	140 + 11.7	20 + 0.1
10 V	23 + 9.7	50 + 104.9	115 + 105.3	15 + 0.1
15 V	28 + 14.1	55 + 232.1	140 + 232.5	20 + 0.1

^{*} Source Impedance ≤50 Ω.

[†] Relative to External Calibration Source.

[‡] Assumes Offset Nulling.

^{**} Sample Rate ≤10 S/s.

^{††} Temperature Coefficient is an adder to the Absolute Accuracy values that does not apply unless operating outside of the stated self-calibration temperature intervals. Temperature Coefficient is included in the Absolute Accuracy values over the stated self-calibration temperature intervals.

Table 4. DC Voltage Performance Specifications for Auto Zero Once

Range	Residual Offset [*] , [†]	Linearity [†]	Noise [*] , [†] , [‡]		
			10 S/s	10 kS/s	2 MS/s
	μV	ppm of range	μV _{pk-pk}	μV _{rms}	
0.1 V	5	5	2.2	0.6	6.9
1.0 V			2.4	0.8	11
10 V	50		9.6	5.8	84
15 V	75	10	14	8.7	125

^{*} Source Impedance ≤50 Ω .

Range	Residual Offset ^{*,†}	Linearity [†]	Noise ^{*,†,‡}		
			10 S/s	10 kS/s	2 MS/s
	μV	ppm of range	$\mu\text{V}_{\text{pk-pk}}$	μV_{rms}	

[†] Residual Offset, Linearity and Noise are included in the Absolute Accuracy values in the DC voltage specifications table for Sample Rate ≤ 10 S/s.

[‡] Noise for Single Channel per ADC. For Multiple Channel per ADC refer to the [Noise versus Sampling Rate](#) and the Accuracy vs Number of Channels per ADC vs Sample Rate section.

Auto Zero Every Sample

Table 5. DC Voltage Specifications for Auto Zero Every Sample

Range	Absolute Accuracy ^{*, **, ††}			Temperature Coefficient ^{††}
	24 Hour ^{†, ‡} $T_{\text{extcal}} \pm 1^\circ\text{C}$ $T_{\text{selfcal}} \pm 1^\circ\text{C}$	2 Year $T_{\text{extcal}} \pm 5^\circ\text{C}$ $T_{\text{selfcal}} \pm 1^\circ\text{C}$	2 Year $T_{\text{extcal}} \pm 10^\circ\text{C}$ $T_{\text{selfcal}} \pm 5^\circ\text{C}$	$0^\circ\text{C} - 55^\circ\text{C}$
	\pm (ppm of reading + μV)			\pm (ppm of reading + μV) / $^\circ\text{C}$
0.1 V	33 + 0.3	60 + 4.7	165 + 5.1	25 + 0.1
1.0 V	28 + 0.5	55 + 9.3	140 + 9.7	20 + 0.1
10 V	23 + 2.7	50 + 55.4	115 + 55.8	15 + 0.1
15 V	28 + 4.0	55 + 156.1	140 + 156.5	20 + 0.1

* Source Impedance $\leq 50 \Omega$.

[†] Relative to External Calibration Source.

[‡] Assumes Offset Nulling.

** Sample Rate ≤ 10 S/s.

^{††} Temperature Coefficient is an adder to the Absolute Accuracy values that does not apply unless operating outside of the stated self-calibration temperature intervals. Temperature Coefficient is included in the Absolute Accuracy values over the stated self-calibration temperature intervals.

Table 6. DC Voltage Performance Specification for Auto Zero Every Sample

Range	Residual Offset ^{*, †}	Linearity [†]	Noise ^{*, †, ‡}	
			10 S/s	10 kS/s
	μV	ppm of range	$\mu\text{V}_{\text{pk-pk}}$	μV_{rms}
0.1 V	4	5	0.2	0.8
1.0 V			0.4	1.1
10 V			2.6	7.4
15 V		10	3.9	11

* Source Impedance $\leq 50 \Omega$.

† Residual Offset, Linearity and Noise are included in the Absolute Accuracy values in the DC voltage specifications table for Sample Rate ≤ 10 S/s.

‡ Noise for Single Channel per ADC. For Multiple Channel per ADC refer to the [Noise versus Sampling Rate](#) section and the Accuracy vs Number of Channels per ADC vs Sample Rate section.

Chopping

Table 7. DC Voltage Specifications for Chopping

Range	Absolute Accuracy ^{*, **, ††}			Temperature Coefficient ^{††}
	24 Hour ^{†, ‡} $T_{\text{extcal}} \pm 1^\circ\text{C}$ $T_{\text{selfcal}} \pm 1^\circ\text{C}$	2 Year $T_{\text{extcal}} \pm 5^\circ\text{C}$ $T_{\text{selfcal}} \pm 1^\circ\text{C}$	2 Year $T_{\text{extcal}} \pm 10^\circ\text{C}$ $T_{\text{selfcal}} \pm 5^\circ\text{C}$	$0^\circ\text{C} - 55^\circ\text{C}$
	\pm (ppm of reading + μV)			\pm (ppm of reading + μV) / $^\circ\text{C}$
0.1 V	33 + 0.1	60 + 2.6	165 + 2.6	25 + 0.01
1.0 V	28 + 0.2	55 + 7.1	140 + 7.2	20 + 0.01
10 V	23 + 1.3	50 + 52.7	115 + 52.7	15 + 0.01
15 V	28 + 2.0	55 + 153.0	140 + 153.1	20 + 0.01

* Source Impedance $\leq 50 \Omega$.

† Relative to External Calibration Source.

Range	Absolute Accuracy [*] , ^{**} , ^{††}			Temperature Coefficient ^{††}
		24 Hour ^{†, ‡} T _{extcal} ± 1 °C T _{selfcal} ± 1 °C	2 Year T _{extcal} ± 5 °C T _{selfcal} ± 1 °C	2 Year T _{extcal} ± 10 °C T _{selfcal} ± 5 °C
	± (ppm of reading + μV)			± (ppm of reading + μV) / °C

[‡] Assumes Offset Nulling.

^{**} Sample Rate ≤10 S/s.

^{††} Temperature Coefficient is an adder to the Absolute Accuracy values that does not apply unless operating outside of the stated self-calibration temperature intervals. Temperature Coefficient is included in the Absolute Accuracy values over the stated self-calibration temperature intervals.

Table 8. DC Voltage Performance Specifications for Chopping

Range	Residual Offset ^{*, †}	Linearity [†]	Noise ^{*, †, ‡}	
			10 S/s	10 kS/s
	μV	ppm of range	μV _{pk-pk}	μV _{rms}
0.1 V	2	5	0.1	0.5
1.0 V			0.2	0.8
10 V			1.3	6.2
15 V		10	2	9.2

^{*} Source Impedance ≤50 Ω.

[†] Residual Offset, Linearity and Noise are included in the Absolute Accuracy values in the DC voltage specifications table for Sample Rate ≤10 S/s.

[‡] Noise for Single Channel per ADC. For Multiple Channel per ADC refer to the [Noise versus Sampling Rate](#) section and the Accuracy vs Number of Channels per ADC vs Sample Rate section.

Offset Cancellation Long Term Stability Performance

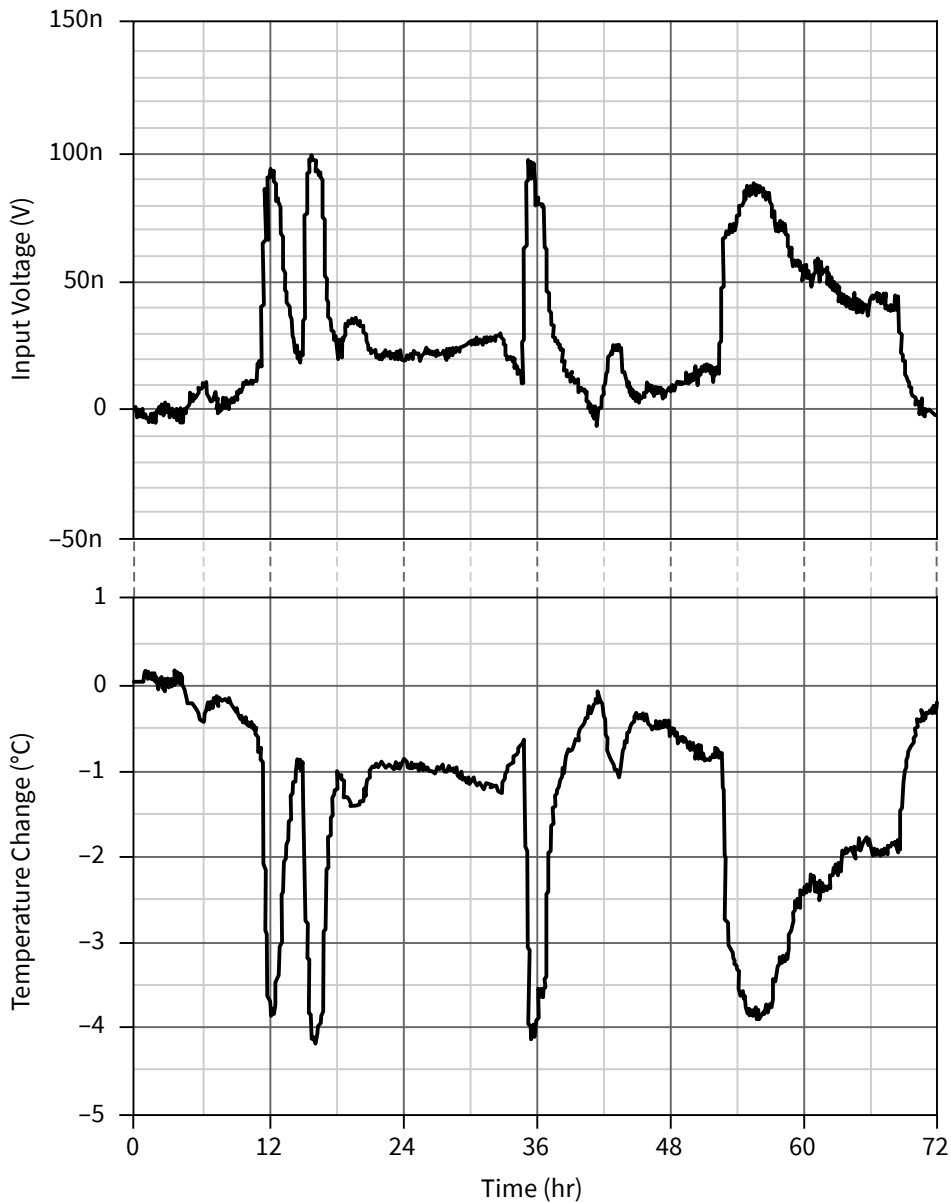
TB-4309 (ST), analog inputs shorted at the terminal block screw terminals

Continuous Acquisition, 0.1 V Range, Auto Zero Every Sample, 2 S/s

Offset Nulling: 2 samples prior to continuous acquisition

Waveform Filter: Average and Decimate by 720 (10 S/hr)

Figure 1. Auto Zero Every Sample Offset Cancellation Stability



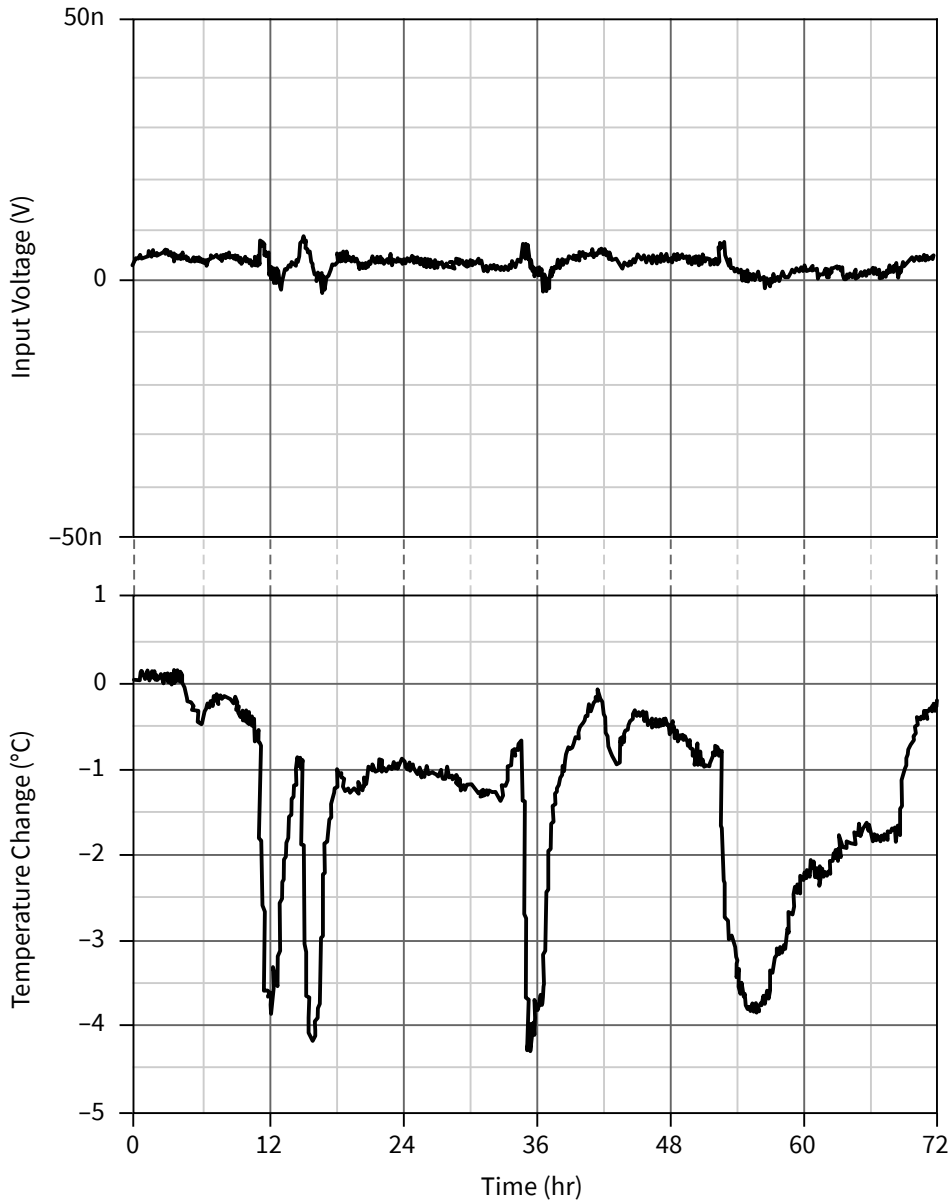
TB-4309 (ST), analog inputs shorted at the terminal block screw terminals

Continuous Acquisition, 0.1 V Range, Chopping, 2 S/s

Offset Nulling: 2 samples prior to continuous acquisition

Waveform Filter: Average and Decimate by 720 (10 S/hr)

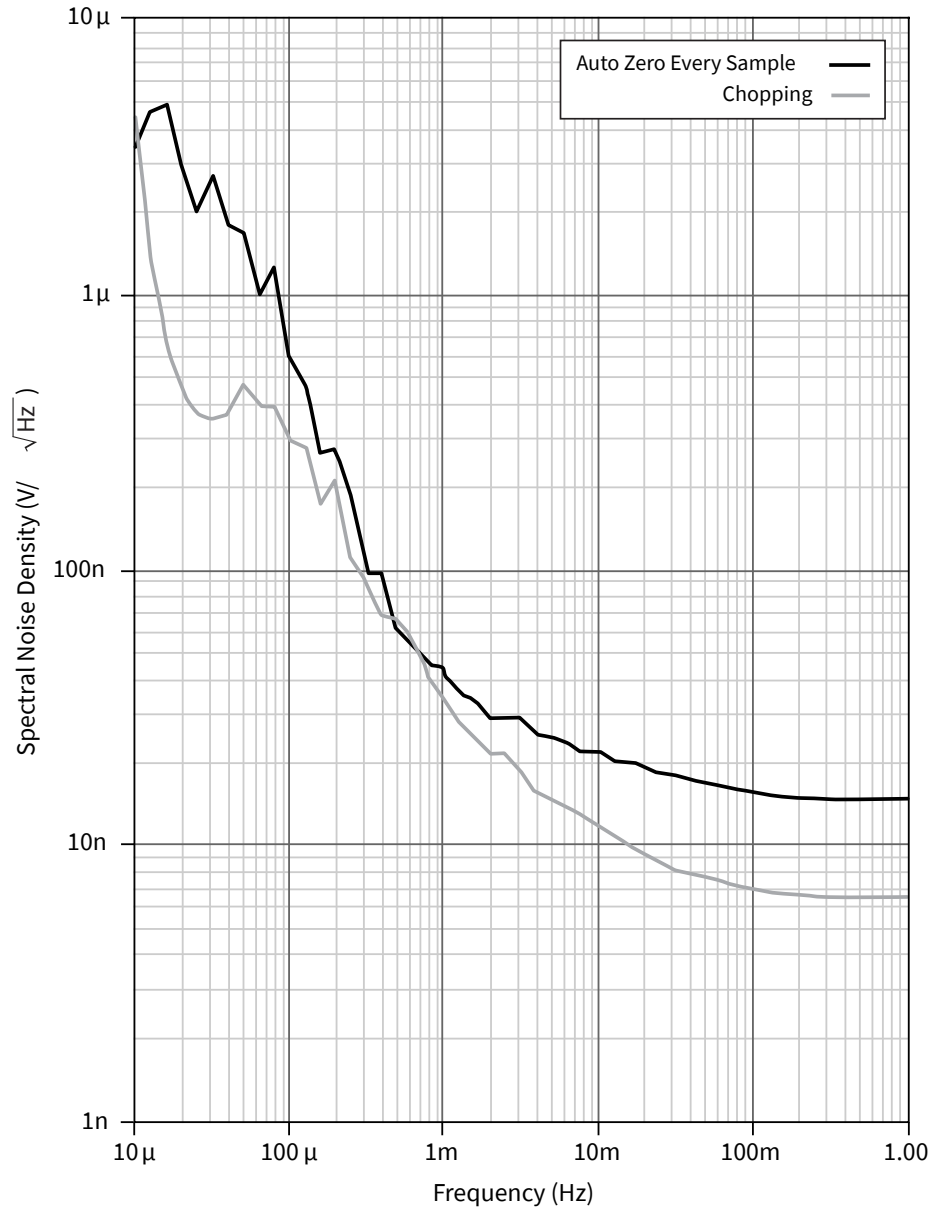
Figure 2. Chopping Offset Cancellation Stability



Offset Cancellation Spectral Noise Density Performance

TB-4309 (ST), analog inputs shorted at the terminal block screw terminals
 Continuous Acquisition, 0.1 V Range, 518400 Samples acquired at 2 S/s

Figure 3. Offset Cancellation Spectral Noise Density



Accuracy vs Number of Channels per ADC vs Sample Rate

The following graph shows the typical accuracy error difference between 1 channel per bank and multiple channels per bank.



Note As of January 2023, this graph is currently in work by NI and will be available in the next revision of this specification.

Noise versus Sampling Rate

Auto Zero None and Auto Zero Once

Figure 4. Noise versus Sample Rate (Single channel per ADC), Measured

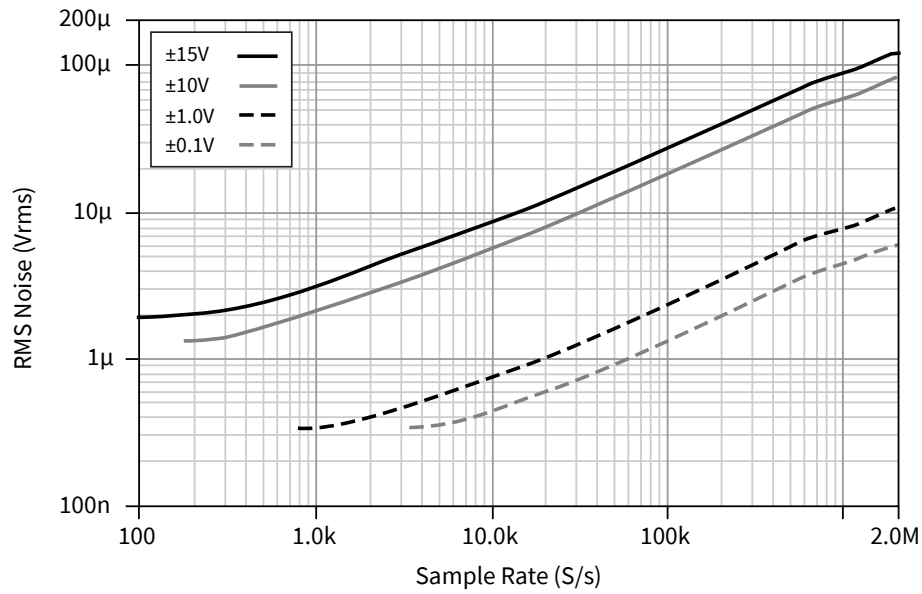
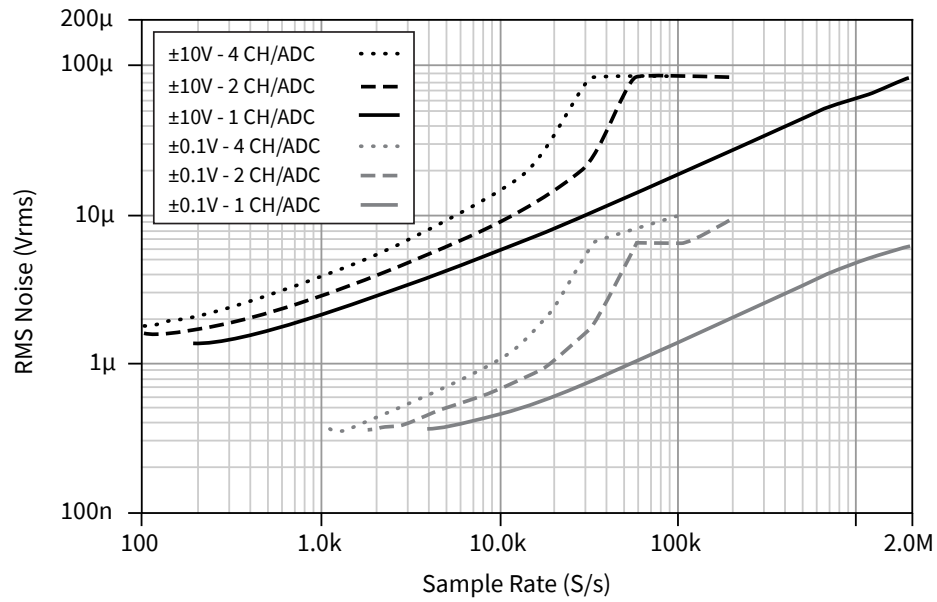


Figure 5. Noise versus Sample Rate (Multichannel per ADC), Measured



Auto Zero Every Sample

Figure 6. Noise versus Sample Rate (Single channel per ADC)

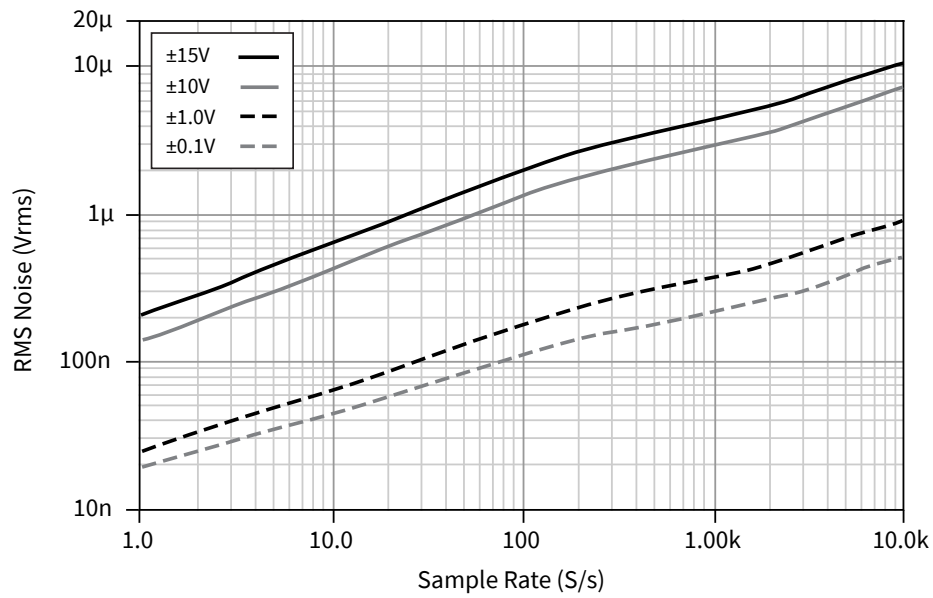
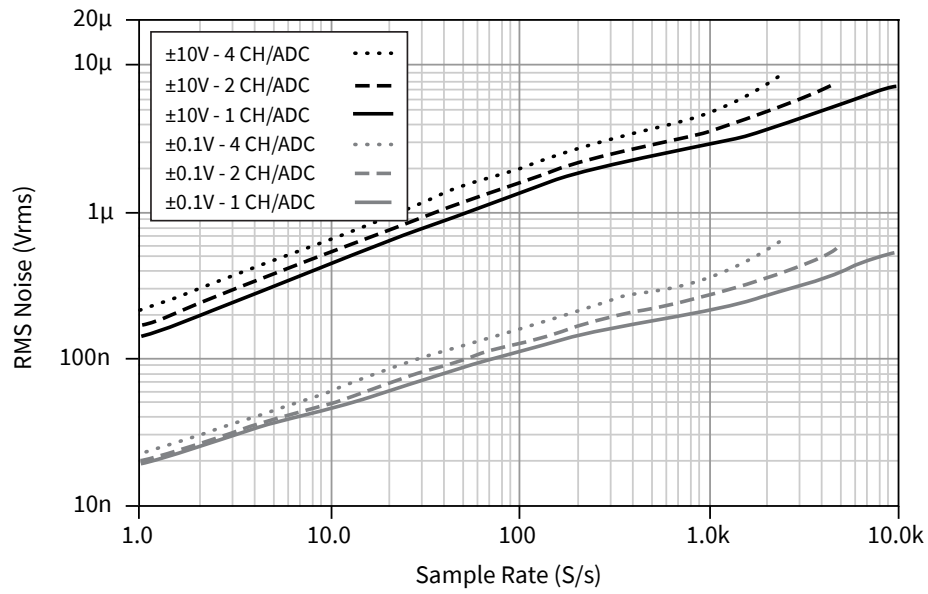


Figure 7. Noise versus Sample Rate (Multichannel per ADC)



Chopping

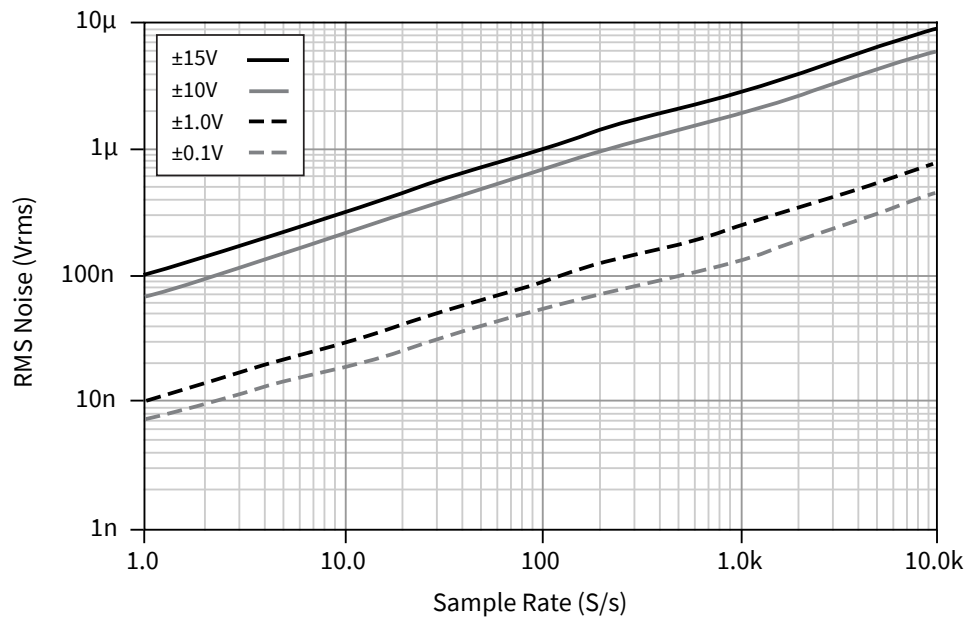
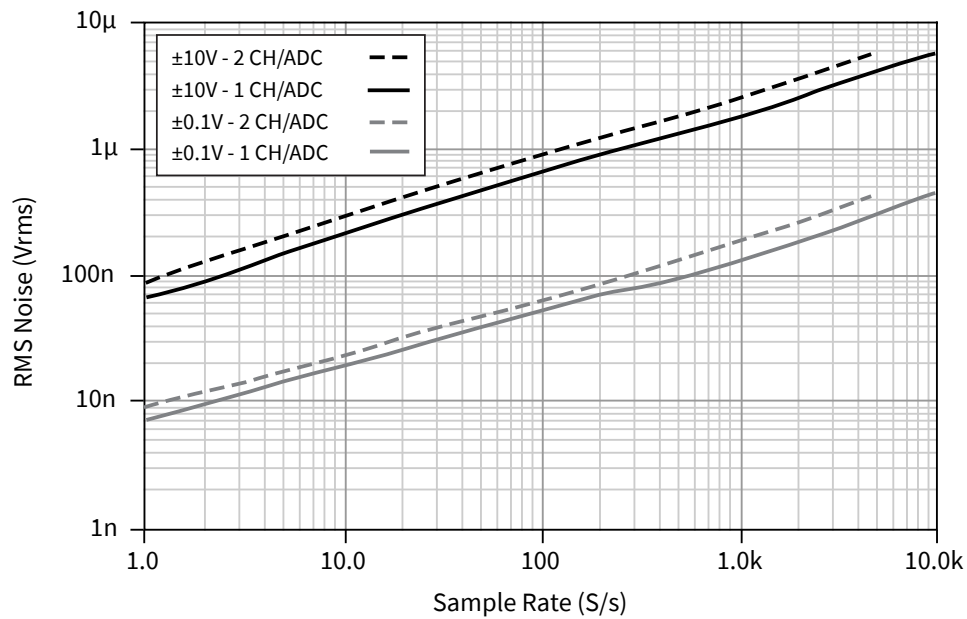
Figure 8. Noise versus Sample Rate (Single channel per ADC)

Figure 9. Noise versus Sample Rate (Multichannel per ADC)



Digital Filter Frequency Response



Note Applies to sampling rates ≤ 1 MS/s for all configurations that use a single channel per ADC.

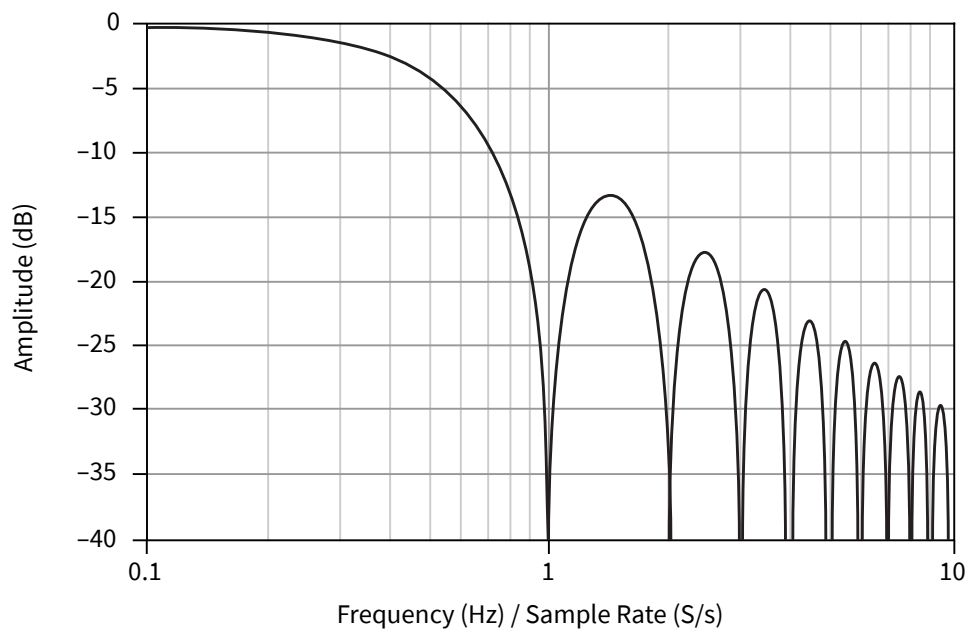


Note Applies to sampling rates ≤ 200 kS/s (aggregate) for all configurations that use multiple channels per ADC.



Note Does not apply to Hardware-Timed Single Point, On-Demand, and External Sample Clock modes.

Figure 10. Digital Filter Frequency Response



Dynamic Characteristics

Spectral Noise Density

Input voltage noise density at 1 kHz.	
0.1 V	$6.2\text{nV}/\sqrt{\text{Hz}}$
1.0 V	$12\text{nV}/\sqrt{\text{Hz}}$
10 V	$94\text{nV}/\sqrt{\text{Hz}}$
15 V	$136\text{ nV}/\sqrt{\text{Hz}}$
Input current noise density at 1 k Hz	$0.5\text{pA}/\text{Hz}$

Auto Zero None and Auto Zero Once

Figure 11. 2 MS/s Spectral Noise Density (Single channel per ADC)

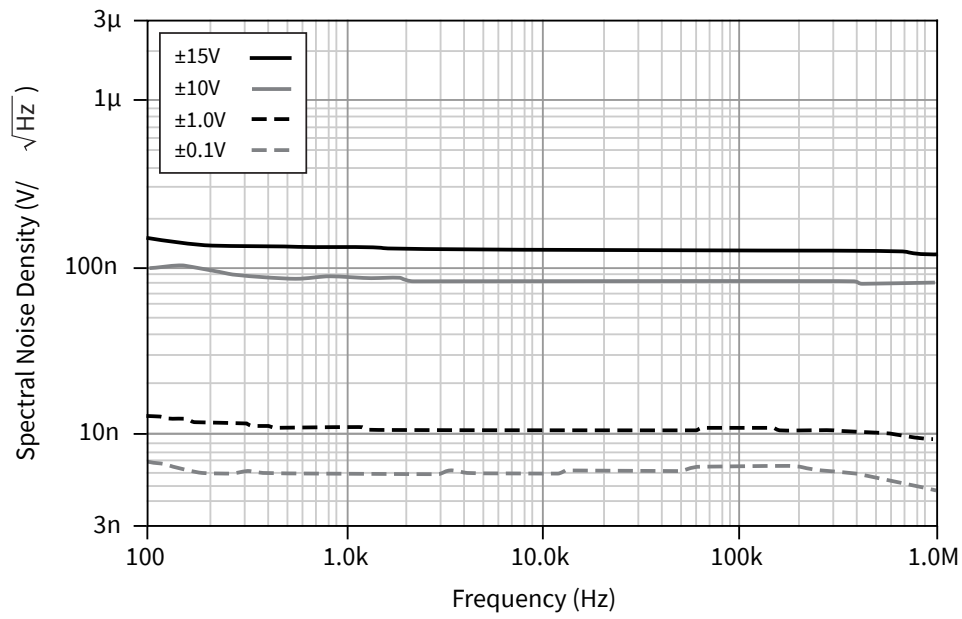


Figure 12. 20 kS/s Spectral Noise Density (Single channel per ADC)

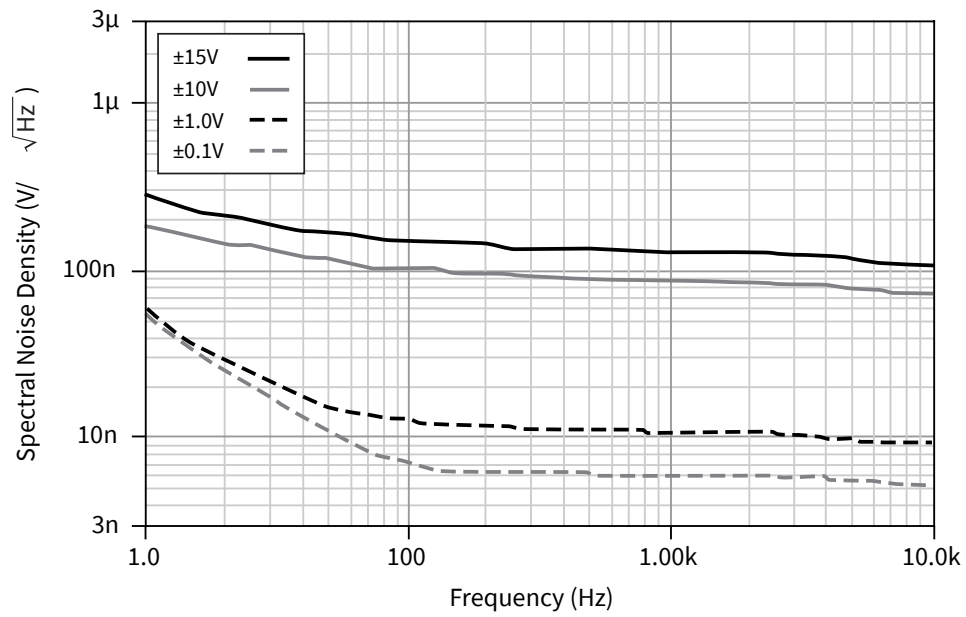


Figure 13. 20 kS/s Spectral Noise Density (Multichannel per ADC)

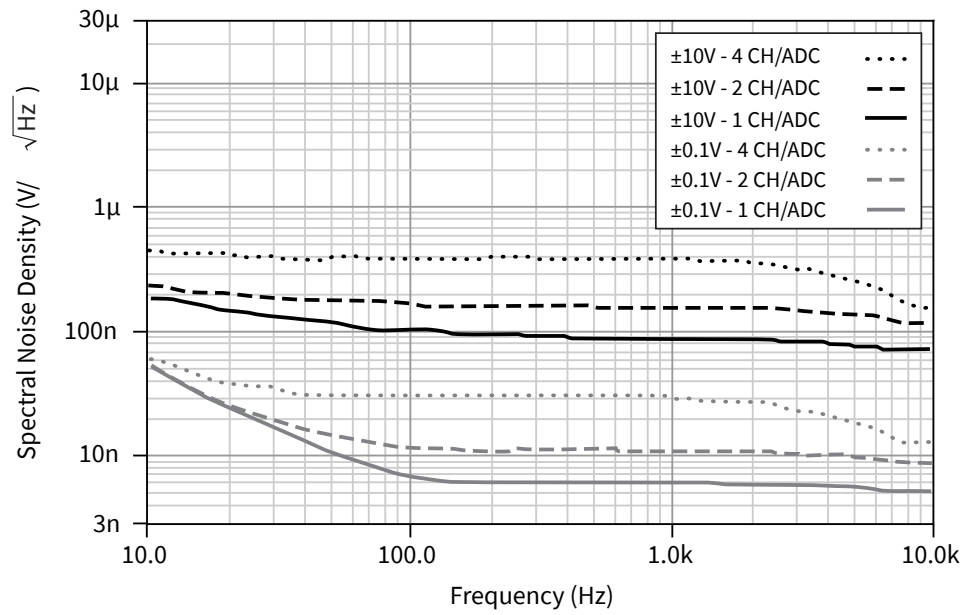


Figure 14. 2 kS/s Spectral Noise Density (Single channel per ADC)

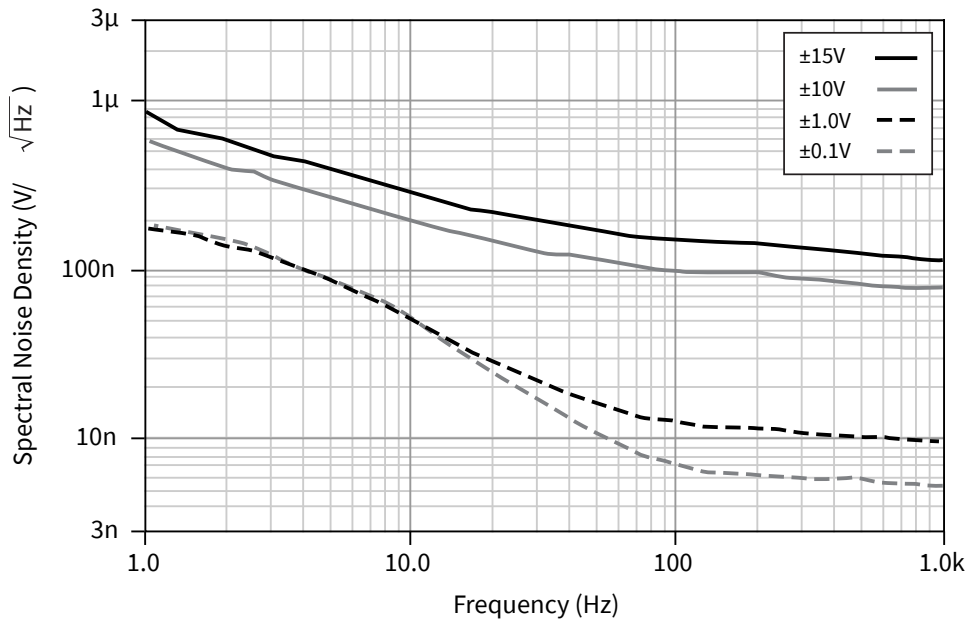
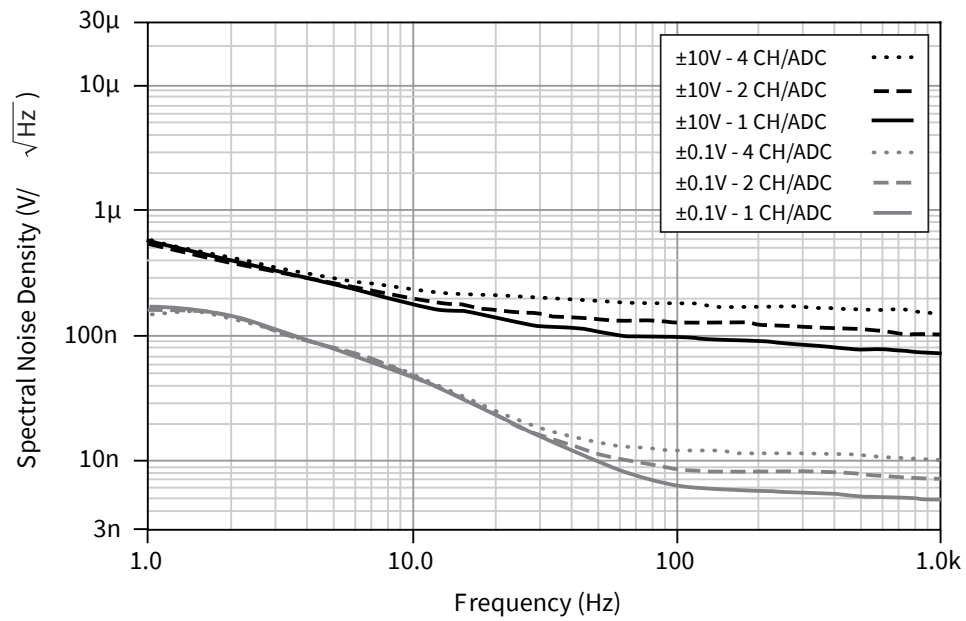


Figure 15. 2 kS/s Spectral Noise Density (Multichannel per ADC)



Auto Zero Every Sample

Figure 16. 2 kS/s Spectral Noise Density (Single channel per ADC)

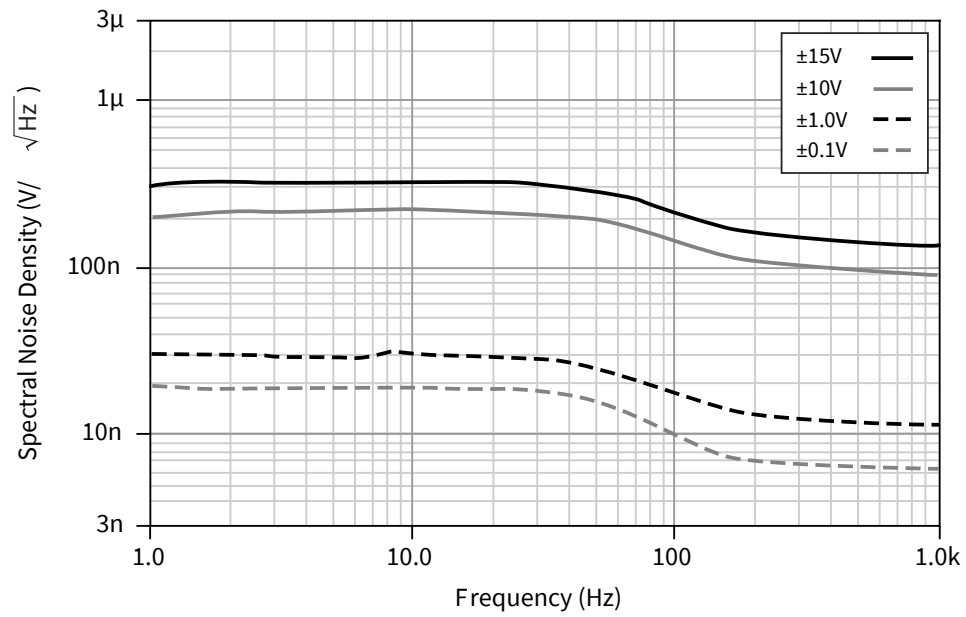
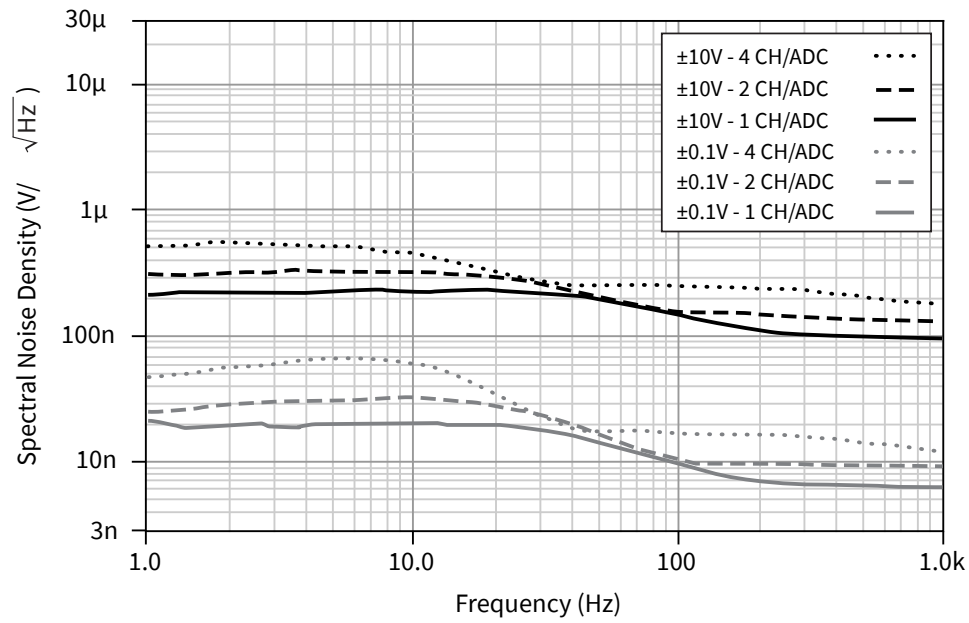


Figure 17. 2 kS/s Spectral Noise Density (Multichannel per ADC)



Chopping

Figure 18. 2 kS/s Spectral Noise Density (Single channel per ADC)

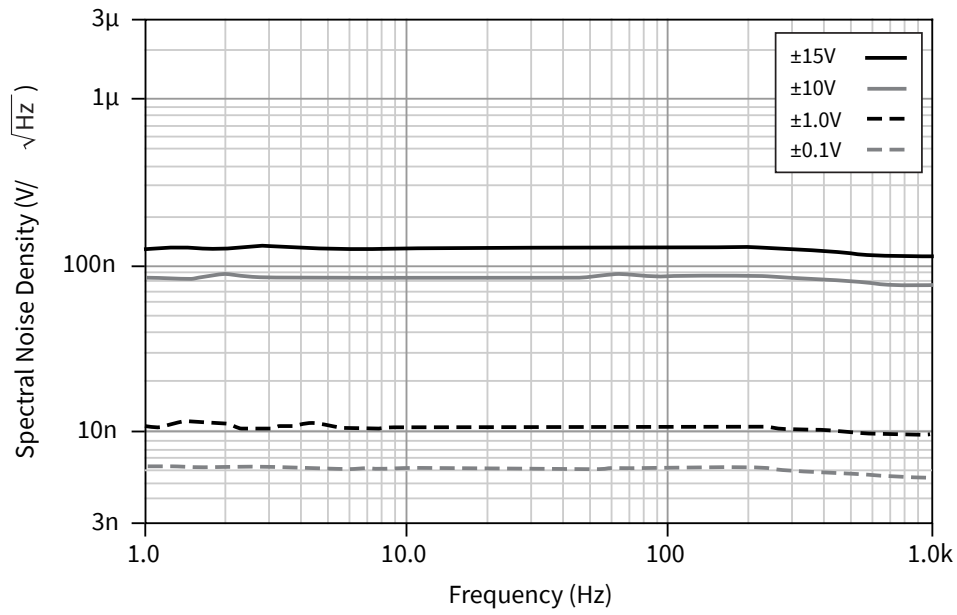
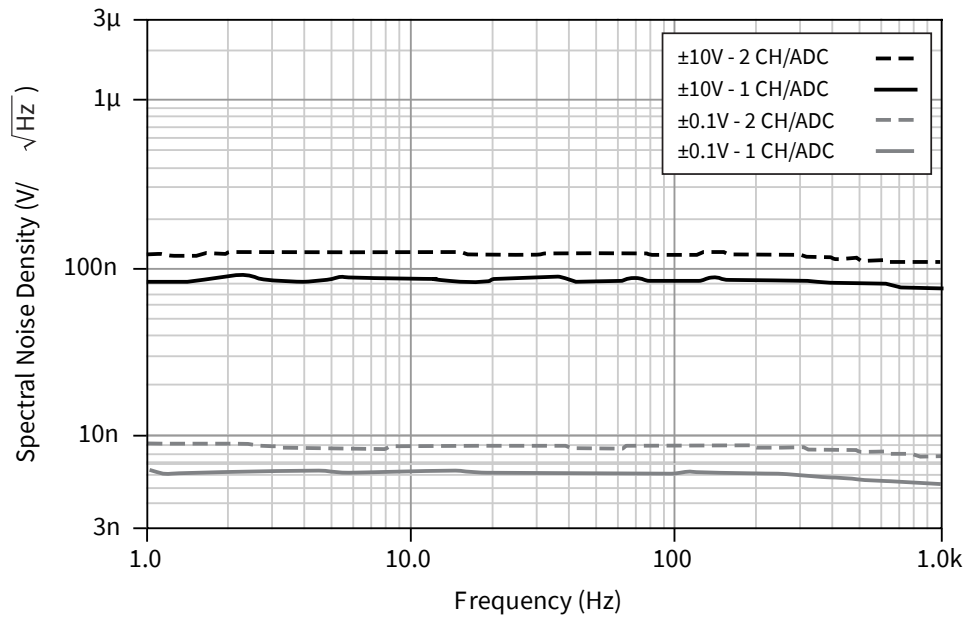


Figure 19. 2 kS/s Spectral Noise Density (Multichannel per ADC)

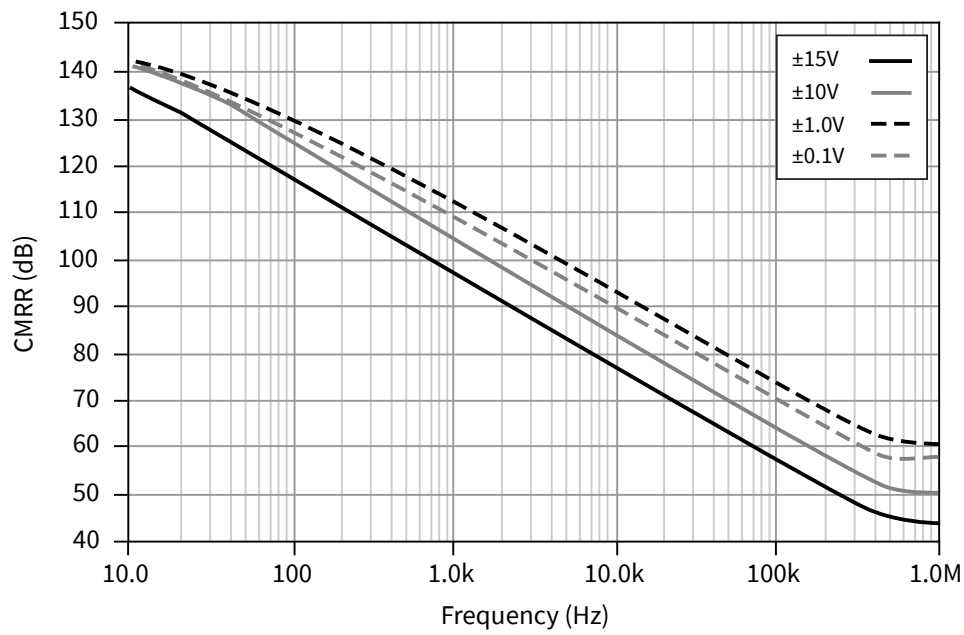


Common-Mode Rejection Ratio (CMRR)

DC	> 160 dBc
DC - 100 Hz	

0.1 V, 1.0 V	> 126 dBc
10 V	> 120 dBc
15 V	> 114 dBc

Figure 20. Common-Mode Rejection Ratio



Crosstalk, Input Channel Separation



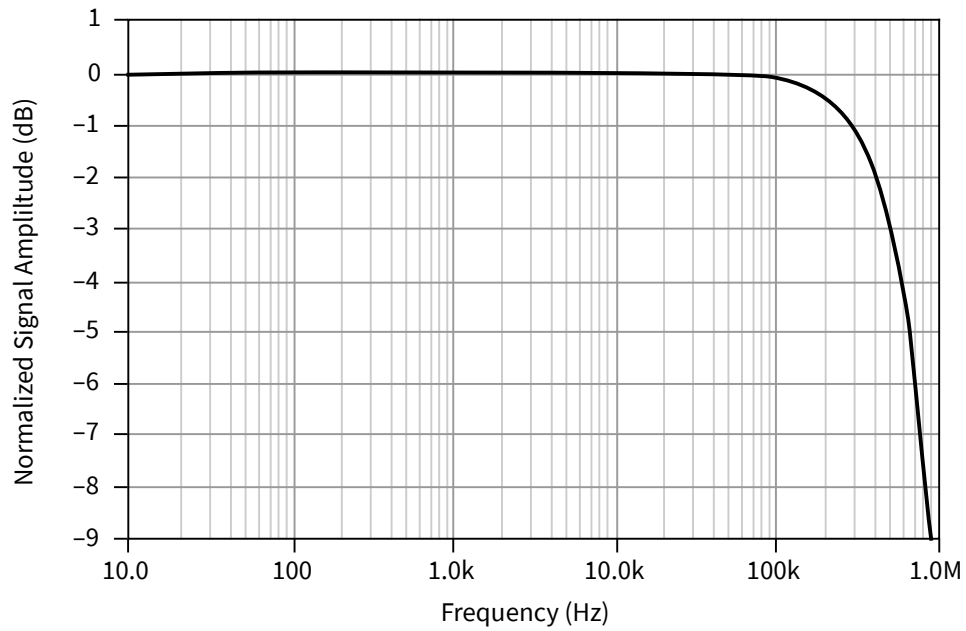
Note To maintain crosstalk performance use separation and/or shielding between signal cables.

TB-4309 (ST) and TB-4309 (MT)	
1 kHz	Typically ≤ -120 dBc
10 kHz	Typically ≤ -100 dBc
100 kHz	Typically ≤ -80 dBc
500 kHz	Typically ≤ -70 dBc

Bandwidth

-3.0 dB bandwidth	500 kHz
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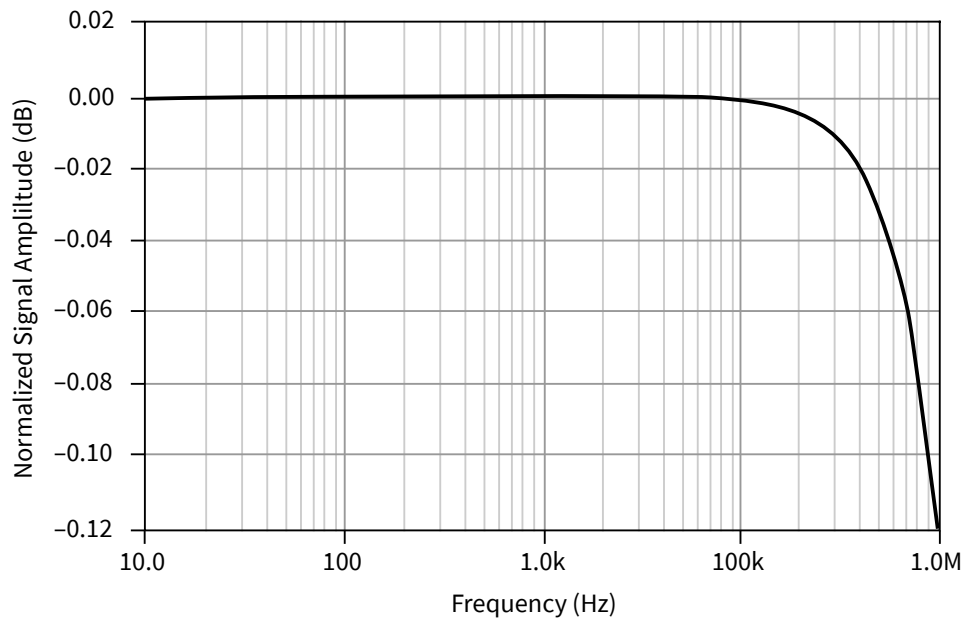
Figure 21. Magnitude Response



Flatness

DC - 20 kHz	-6.5 mdB
DC - 80 kHz	-100 mdB

Figure 22. Flatness

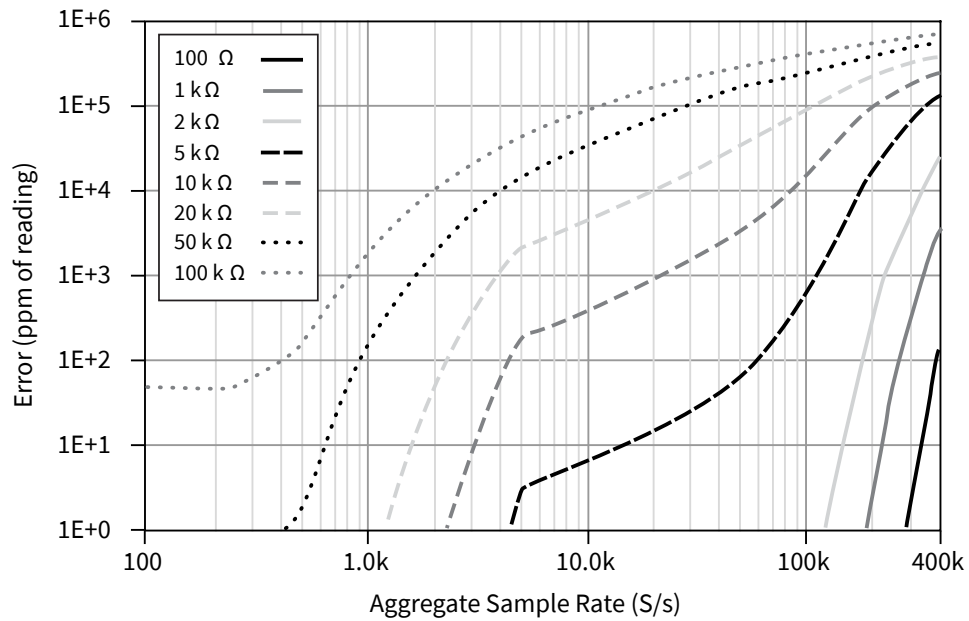


Source Impedance Error



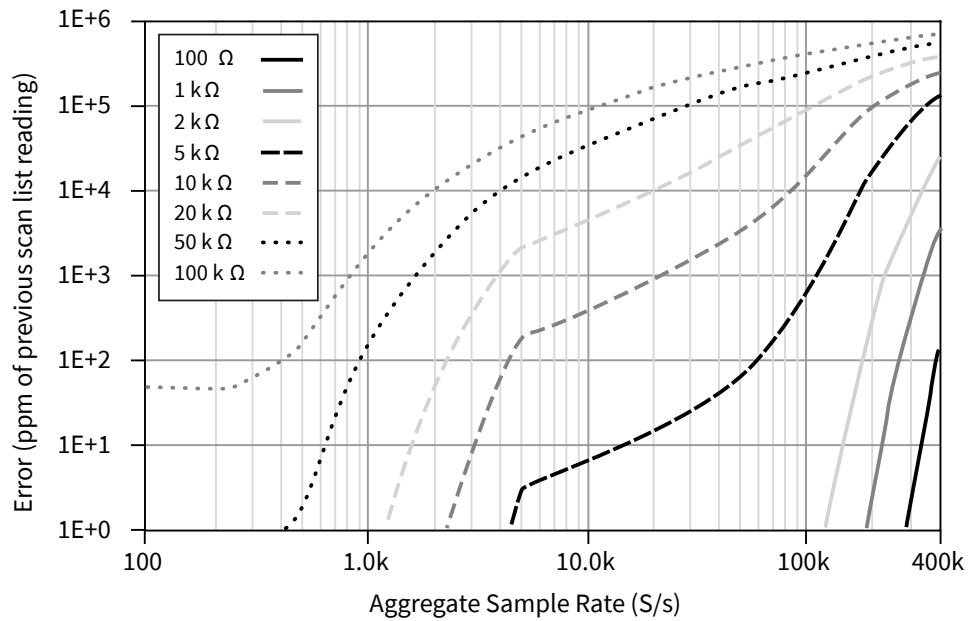
Note For best performance and to minimize settling time, keep the source impedance $\leq 50 \Omega$ from DC to 2 MHz.

Figure 23. Source Impedance Reading Error



Note Applies to all configurations that use multiple channels per ADC, Auto Zero Every Sample or Chopping.

Figure 24. Source Impedance Ghosting Error



Note Applies to all configurations that use multiple channels per ADC.

Figure 25. Source Impedance Offset Error



Note This figure is in work as of January 2023.

Onboard Calibration Reference

Voltage

Output voltage range	6.741 V – 7.298 V
Output current drive	±1 μ A
Temperature coefficient	±1 ppm/°C
Overvoltage protection	±30 V min

Frequency Timebase Characteristics

Resolution	10 ns
Accuracy	
Using internal timebase	±50 ppm
Using external timebase	Equal to accuracy of external timebase

Timing and Synchronization

Number of timing engines	1
Reference clock source	Onboard clock, backplane PXIe_CLK100

Digital Triggers

Purpose	Start trigger, reference trigger, pause trigger
Source	PFI 0, PFI 1, PXI_Trig <0..7>, PXI_Star, PXIe_DStar A, PXIe_DStar B
Polarity	Software-selectable
Debounce filter settings	Disable, 90 ns, 5.12 μ s, custom interval

Output Timing Signals

Source	Start trigger, reference trigger, pause trigger, sample clock
Destination	PFI 0, PFI 1, PXI_Trig <0..7>, PXIe_DStarC

PFI 0 and PFI 1 (Front Panel Digital Triggers)

Input	
Logic compatibility	3.3 V or 5 V
High, VIH	2.40 V minimum
Low, VIL	0.95 V maximum
Input impedance	10 k Ω
Input current ($0\text{ V} \leq V_{in} \leq 5\text{ V}$)	$\leq 500\ \mu\text{A}$

Overvoltage protection	±30 V minimum
Output	
High, VOH	3.43 V maximum
Sourcing 5 mA	2.88 V minimum
Low, VOL	
Sinking 5 mA	0.33 V maximum
Output impedance	50 Ω
Output current	±30 mA minimum
Overvoltage protection	±30 V minimum

General Specifications

Bus Interface

Form factor	x1 PXI Express peripheral module, specification rev 1.0 compliant
Slot compatibility	PXI Express or PXI Express hybrid slots
DMA channels	1, analog input

Power Requirements

+12 V	2 A maximum
+3.3 V	1 A maximum

Physical

Dimensions	16 cm × 10 cm (6.3 in. × 3.9 in.) 3U CompactPCI slot
Weight	238 g (8.4 oz)
I/O connector	96-pin male DIN 41612/IEC 60603-2 connector
Measurement Category ^[6]	I



Caution Do not use the PXle-4309 for connections to signals or for measurements within Categories II, III, or IV.



Caution The protection provided by the PXle-4309 can be impaired if it is used in a manner not described in this document.



Caution Clean the hardware with a soft, nonmetallic brush. Make sure that the hardware is completely dry and free from contaminants before returning it to service.

Environmental Specifications

Operating Environment

Ambient temperature range	0 °C to 55 °C (Tested in accordance with IEC 60068-2-1 and IEC 60068-2-2. Meets MIL-PRF-28800F Class 3 low temperature limit and MIL-PRF-28800F Class 2 high temperature limit.)
Relative humidity range	10% to 90%, noncondensing (Tested in accordance with IEC 60068-2-56.)
Maximum altitude	2,000 m (800 mbar)
Pollution Degree	2

Indoor use only.

Storage Environment

Ambient temperature range	-40 °C to 71 °C (Tested in accordance with IEC 60068-2-1 and IEC 60068-2-2. Meets MIL-PRF-28800F Class 3 limits.)
Relative humidity range	5% to 95%, noncondensing (Tested in accordance with IEC 60068-2-56.)

Shock and Vibration

Operating shock	30 g peak, half-sine, 11 ms pulse (Tested in accordance with IEC 60068-2-27. Meets MIL-PRF-28800F Class 2 limits.)
Random vibration	
Operating	5 Hz to 500 Hz, 0.3 grms

Non-operating	5 Hz to 500 Hz, 2.4 grms (Tested in accordance with IEC 60068-2-64. Non-operating test profile exceeds the requirements of MIL-PRF-28800F, Class 3.)
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Calibration

You can obtain the calibration certificate and information about calibration services for the PXle-4309 at ni.com/calibration.

Self-calibration	On software command, the module computes gain, offset, and linearity corrections relative to the high-precision internal voltage reference.
Self-calibration interval	Depending on required absolute accuracy, self-calibration is recommended whenever the current device temperature differs by more than the specified temperature range from the device temperature at which the last self-calibration was performed.
Calibration interval	2 years
Warm-up time	15 minutes

Online Product Certification


Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit ni.com/certification, search by model number or product line, and click the appropriate link in the Certification column.

Environmental Management


NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the Minimize Our Environmental Impact web page at ni.com/environment. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)

 At the end of the product life cycle, all products **must** be sent to a WEEE recycling center. For more information about WEEE recycling centers, National Instruments WEEE initiatives, and compliance with WEEE Directive 2002/96/EC on Waste and Electronic Equipment, visit ni.com/environment/weee.

电子信息产品污染控制管理办法（中国 RoHS）

-  中国 RoHS— NI 符合中国电子信息产品中限制使用某些有害物质指令(RoHS)。关于 NI 中国 RoHS 合规性信息，请登录 ni.com/environment/rohs_china。(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

¹ Up to 4 channels per ADC.

² Depends on the sample rate. Refer to the Noise versus Sampling Rate section for more information.

³ For multichannel, up to 4 channels per ADC. Refer to the PXIe-4309 User Manual for Maximum Sample Rates in Hardware-Timed Single point, On-Demand, and External Sample Clock modes.

⁴ Inputs shorted at terminal block screw terminals.

⁵ Inputs shorted at SCB-68 screw terminals using 2 m, 68-pin cable.

⁶ Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are not intended for direct connections to the MAINS building installations of Measurement Categories CAT II, CAT III, CAT IV.