NI 9250 Datasheet

2022-07-06

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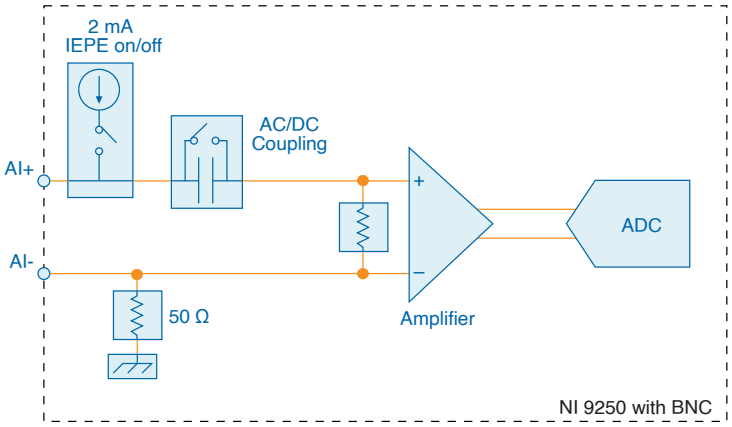
NI-9250 Circuitry



- Input signals on each channel are buffered, conditioned, and then sampled by an ADC.
- Each AI channel provides an independent signal path to the ADC, enabling you to sample all channels simultaneously.
- AI channels are referenced to earth ground through a protected 50 Ω resistor.
- AC/DC coupling is software-selectable.
- For AI channels set to AC coupling, IEPE excitation current is software-selectable.
- The module protects each channel from overvoltages.

Note The NI-9250 also has TEDS circuitry. For more information about TEDS, visit ni.com/info and enter the Info Code rdteds.

Filtering

The NI-9250 uses a combination of analog and digital filtering to provide an accurate representation of in-band signals and reject out-of-band signals. The filters discriminate between signals based on the frequency range, or bandwidth, of the

signal. The three important bandwidths to consider are the passband, the stopband, and the anti-imaging bandwidth.
The NI-9250 represents signals within the passband, as quantified primarily by passband ripple and phase nonlinearity. All signals that appear in the alias-free bandwidth are either unaliased signals or signals that have been filtered by at least the amount of the stopband rejection.

Passband

The signals within the passband have frequency-dependent gain or attenuation. The small amount of variation in gain with respect to frequency is called the passband flatness. The digital filters of the NI-9250 adjust the frequency range of the passband to match the data rate. Therefore, the amount of gain or attenuation at a given frequency depends on the data rate.

Stopband

The filter significantly attenuates all signals above the stopband frequency. The primary goal of the filter is to prevent aliasing. Therefore, the stopband frequency scales precisely with the data rate. The stopband rejection is the minimum amount of attenuation applied by the filter to all signals with frequencies within the stopband.

Alias-Free Bandwidth

Any signals that appear in the alias-free bandwidth are not aliased artifacts of signals at a higher frequency. The alias-free bandwidth is defined by the ability of the filter to reject frequencies above the stopband frequency. The alias-free bandwidth is equal to the data rate minus the stopband frequency.

Data Rates

The frequency of a master timebase ($\mathbf{f_M}$) controls the data rate ($\mathbf{f_S}$) of the NI-9250 .
The NI-9250 includes an internal master timebase with a frequency of 13.1072 MHz. Using the internal master timebase of 13.1072 MHz results in data rates of 102.4 kS/s, 51.2 kS/s, 25.6 kS/s, 17.067 kS/s, and so on down to 267 S/s, depending on the decimation rate and the value of the clock divider. However, the data rate must remain within the appropriate data rate range.

The following equation provides the available data rates of the NI-9250 :

$$f_s = \frac{f_M}{4 \times a \times b}$$

where **a** is the decimation rate (32, 64, 128, 256, 512, 1024), and **b** is the clock divider (integer between 1 and 12).

Note

$\frac{f_M}{b}$ must be greater than or equal to 1 MHz.

There are multiple combinations of clock dividers and decimation rates that yield the same data rate. The software always picks the highest decimation rate for the selected data rate. The following table lists available data rates with the internal master timebase.

f_s (kS/s)	Decimation Rate	Clock Divider
102.400	32	1
51.200	64	1
34.133	32	3
25.600	128	1
20.480	32	5
17.067	64	3
14.629	32	7
12.800	256	1
11.378	32	9
10.240	64	5
9.309	32	11
8.533	128	3
7.314	64	7
6.400	512	1
5.689	64	9
5.120	128	5
4.655	64	11
4.267	256	3
3.657	128	7

f_s (kS/s)	Decimation Rate	Clock Divider
3.200	1024	1
2.844	128	9
2.560	256	5
2.327	128	11
2.133	512	3
1.829	256	7
1.600	1024	2
1.422	256	9
1.280	512	5
1.164	256	11
1.067	1024	3
0.914	512	7
0.800	1024	4
0.711	512	9
0.640	1024	5
0.582	512	11
0.533	1024	6
0.457	1024	7
0.400	1024	8
0.356	1024	9
0.320	1024	10
0.291	1024	11
0.267	1024	12

Table 2. Available Data Rates with the Internal Master Timebase

The NI-9250 also can accept an external master timebase or export its own master timebase. To synchronize the data rate of an NI-9250 with other modules that use master timebases to control sampling, all of the modules must share a single master timebase source. When using an external timebase with a frequency other than 13.1072 MHz, the NI-9250 has a different set of data rates. Refer to the software help for information about configuring the master timebase source for the NI-9250 .

Note The cRIO-9151R Series Expansion chassis does not support sharing timebases between modules.

NI-9250 Specifications

The following specifications are typical for the range -40 °C to 70 °C unless otherwise noted.

Caution Do not operate the NI-9250 in a manner not specified in this document. Product misuse can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to NI for repair.

Input Characteristics

Number of channels	2 analog input channels
ADC resolution	24 bits
Type of ADC	Delta-Sigma with analog prefiltering
Sampling mode	Simultaneous
Input coupling	Software-selectable AC/DC
Type of TEDS supported	IEEE 1451.4 TEDS Class I
TEDS capacitive drive	5,000 pF

Internal master timebase (f_M)

Frequency	13.1072 MHz
Accuracy	±100 ppm maximum

Data rate range (f_S)

Using internal master timebase

Minimum	267 S/s

Maximum	102.4 kS/s

Using external master timebase

Minimum	244.141 S/s
Maximum	102.734 kS/s

Data rate	$f_s = \frac{f_M}{4 \times a \times b}$
Input delay[1]	$34/\mathbf{f_s} + 2.7\ \mu s$
Overvoltage protection	±30 V maximum on one channel at a time

Input impedance

AI+ to chassis	2 MΩ || 280 pF
AI- to chassis	50 Ω

Input voltage range

Minimum	±5 Vpk
Typical	±5.1 Vpk
Scaling coefficient	608,896 pV/LSB

Maximum input voltage

AI+ to Ground	±5.14 Vpk
AI- to Ground (Common Mode)	±0.11 V

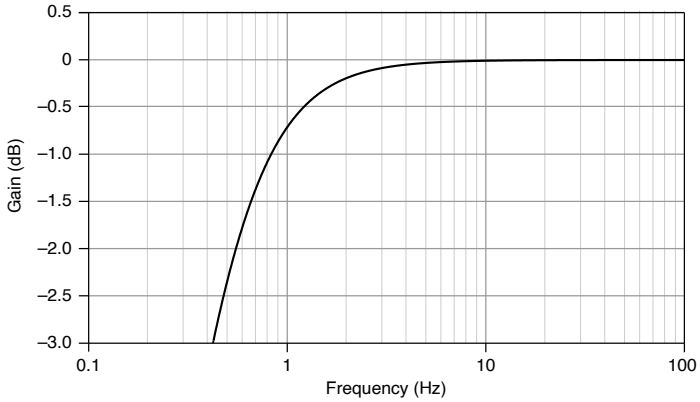
IEPE excitation current (software-selectable on/off)

Minimum	2 mA
Typical	2.1 mA

IEPE excitation noise	70 nArms at 102.4 kS/s
IEPE compliance voltage[2]	19 V maximum

High pass filter cutoff frequency (AC)	
-3 dB	0.43 Hz
-0.1 dB	2.77 Hz

Figure 1. High Pass Filter Frequency Response



Measurement Conditions	Percent of Reading (Gain Error)	Percent of Range[3] (Offset Error)
Maximum (-40 °C to 70 °C)	±0.20%	±0.15%
Typical (23 °C, ±5 °C)	±0.05%	±0.025%

Table 2. Accuracy in DC Coupling

Offset error (AC coupling)	±0.025%

Stability of Accuracy	
Gain drift	5.5 ppm/°C
Offset drift	33 µV/°C

Passband, -0.1 dB	
Frequency	0.4 * $\mathbf{f_s}$

Flatness (peak-to-peak)	
DC to 20 kHz	0.03 dB maximum, 0.02 dB typical
DC to 40 kHz	0.09 dB maximum, 0.06 dB typical

Phase linearity

DC coupling

DC to 20 kHz	0.03° maximum
DC to 40 kHz	0.21° maximum

AC coupling

100 Hz to 40 kHz	0.21° maximum

Channel-to-channel mismatch

Gain

DC to 20 kHz	0.065 dB maximum
DC to 40 kHz	0.11 dB maximum

Phase (f_{in} in kHz)	f_{in} * 0.035° maximum

Stopband

Frequency	0.499 * f_s
Rejection	105 dB

Alias free bandwidth	0.5 * f_s

Alias rejection, at oversample rate

f_s = 102.4 kS/s	100 dB at 3.2768 MHz
f_s = 267 S/s	80 dB at 273 kHz

Data Rate (S/s)	ADC Decimation Ratio	AC or DC Coupling (µVrms)	IEPE Mode with AC Coupling (µVrms)
102,400	32	9.9	13.2
51,200	64	6.7	8.7
25,600	128	4.7	6.1
12,800	256	3.4	4.3

Data Rate (S/s)	ADC Decimation Ratio	AC or DC Coupling (µVrms)	IEPE Mode with AC Coupling (µVrms)
6,400	512	2.5	3.1
3,200	1,024	2.0	2.3

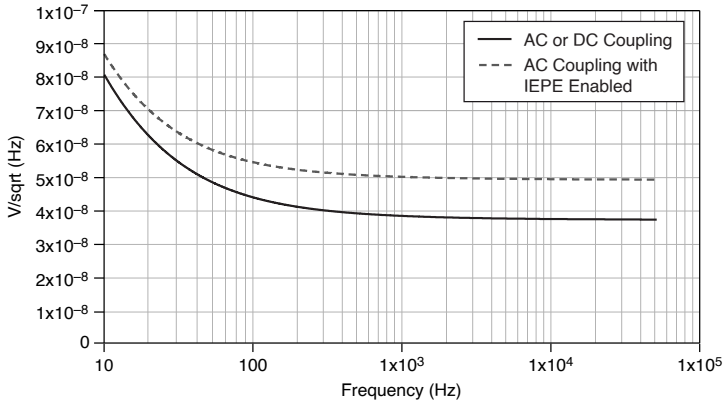
Table 3. Idle Channel Noise

Note The noise specifications assume the NI-9250 is using the internal master timebase frequency of 13.1072 MHz.

Spectral noise density

AC or DC coupling	$\frac{38\ nV}{\sqrt{Hz}}$ at 1 kHz
IEPE mode with AC coupling	$\frac{50\ nV}{\sqrt{Hz}}$ at 1 kHz

Figure 2. Spectral Noise Density versus Frequency



Data Rate (S/s)	ADC Decimation Ratio	AC or DC Coupled (dBFS)	IEPE Mode with AC Coupling (dBFS)[4]
102,400	32	111	108
51,200	64	114	112
25,600	128	117	115
12,800	256	120	118
6,400	512	123	121

Data Rate (S/s)	ADC Decimation Ratio	AC or DC Coupled (dBFS)	IEPE Mode with AC Coupling (dBFS)[4]
3,200	1,024	125	123

Table 4. Dynamic Range (At 1 kHz Input Frequency, -60 dBF amplitude, BW=0.5 * f_s)

Crosstalk (CH to CH)	
f_{in} ≤ 1 kHz	-145 dB
f_{in} ≤ 20 kHz	-125 dB
f_{in} ≤ 40 kHz	-120 dB
CMRR, f_{in} ≤ 1 kHz	53 dB minimum
Intermodulation distortion (IMD)[5]	
SMPTE 60 Hz + 7 kHz	-101 dB
CCIF 14 kHz + 15 kHz	-103 dB
Non-harmonic SFDR[6]	138 dBFS
Total Harmonic Distortion (THD) at -1 dBFS	
f_s = 51.2 kS/s	
1 kHz	-111 dBc
20 Hz to 22 kHz	-109 dBc
f_s = 102.4 kS/s	
8 kHz	-107 dBc
20 Hz to 44 kHz	-100 dBc

Figure 3. FFT of -1 dBFS, 1 kHz Tone Sampled at 51.2 kS/s (Unaveraged Computation of 65,536 Samples)

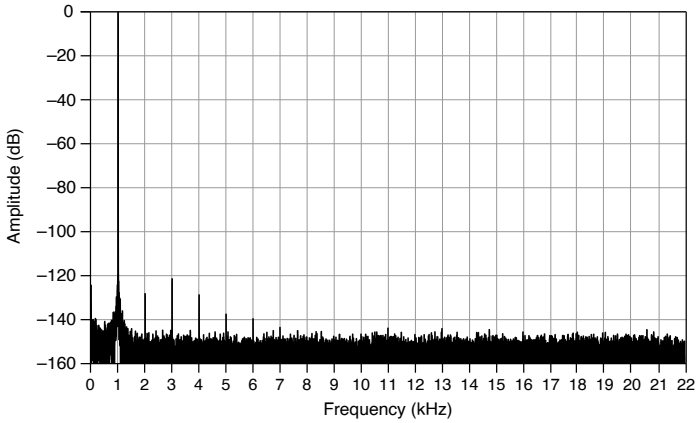


Figure 4. FFT of -1 dBFS, 8 kHz Tone Sampled at 102.4 kS/s (Unaveraged Computation of 262,144 Samples)

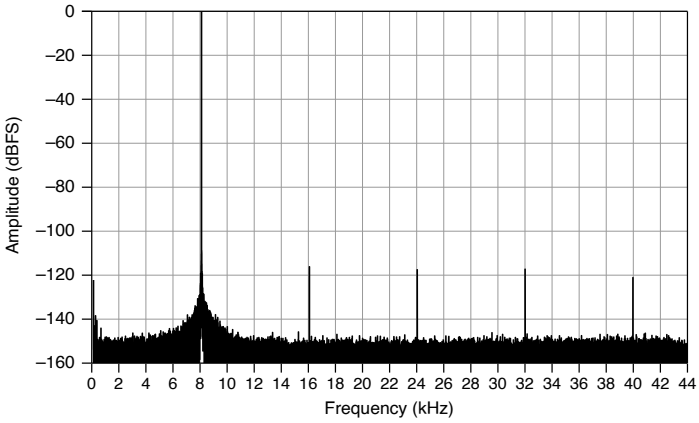
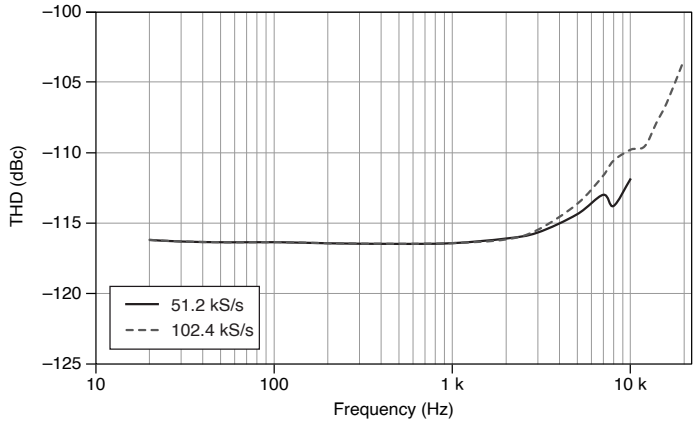


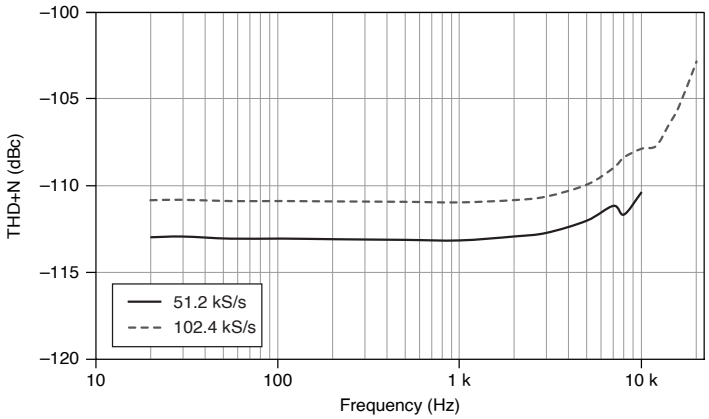
Figure 5. THD versus Frequency



Total Harmonic Distortion + Noise (THD+N) at -1 dBFS

f_s = 51.2 kS/s	
1 kHz	-110 dBc
20 Hz to 22 kHz	-108 dBc
f_s = 102.4 kS/s	
8 kHz	-106 dBc
20 Hz to 44 kHz	-100 dBc

Figure 6. THD+N versus Frequency



Power Requirements

Power consumption from chassis	
Active mode	0.96 W maximum
Sleep mode	53 µW maximum

Thermal dissipation (at 70 °C)	
Active mode	1.30 W maximum
Sleep mode	0.36 W maximum

Physical Characteristics

Dimensions	Visit ni.com/dimensions and search by module number.
Weight	140 g (4.9 oz)

Safety Voltages

Connect only voltages that are within the following limits:

Channel-to-earth ground	±30 V maximum, Measurement Category I

Isolation

Channel-to-channel	None
Channel-to-earth ground	None

Hazardous Locations Certifications

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx ec IIC T4 Gc
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Ex ec IIC T4 Gc
Europe (ATEX) and International (IECEx)	Ex ec IIC T4 Gc; ⟨Ex⟩ II 3 G UL 21 ATEX 2518X; IECEx UL 21.0013X

CE

Safety Compliance and Hazardous Locations Standards

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA C22.2 No. 61010-1
- EN 60079-0, EN 60079-7
- IEC 60079-0, IEC 60079-7

- UL 60079-0, UL 60079-7
- CSA C22.2 No. 60079-0, CSA C22.2 No. 60079-7

Note For safety certifications, refer to the product label or the Product Certifications and Declarations section.

Electromagnetic Compatibility Standards

This product meets the requirements of the following EMC standards for sensitive electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

Note For EMC declarations and certifications, and additional information, refer to the Online Product Certification section.

Notice Conducted RF interference on the I/O ports of the NI-9250 can adversely affect its measurement accuracy.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 2014/34/EU; Potentially Explosive Atmospheres (ATEX)

Product Certifications and Declarations

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for NI products, visit ni.com/product-certifications, search by model number, and click the appropriate link.

Shock and Vibration

To meet these specifications, you must panel mount the system.

Operating vibration	
Random	5 g RMS, 10 Hz to 500 Hz
Sinusoidal	5 g, 10 Hz to 500 Hz
Operating shock	30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations

Environmental

Refer to the manual for the chassis you are using for more information about meeting these specifications.

Operating temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 70 °C
Storage temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 85 °C
Ingress protection	IP40
Operating humidity (IEC 60068-2-30)	10% RH to 90% RH, noncondensing

Storage humidity (IEC 60068-2-30)	5% RH to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	5,000 m

Indoor use only.

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 **Engineering a Healthy Planet** 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.

EU and UK Customers

- Waste Electrical and Electronic Equipment (WEEE)—At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, 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.)

Calibration

You can obtain the calibration certificate and information about calibration services for the NI-9250 at ni.com/calibration.

Calibration interval	2 years

[1] 2.7 µs is applicable for DC to 40 kHz in DC coupling and 50 Hz to 40 kHz in AC coupling.

[2]

If you are using an IEPE sensor, use the following equation to make sure your configuration meets the IEPE compliance voltage range.
(Vcommon-mode + Vbias ± Vfull-scale) must be 0 V to 19 V
where

- Vcommon-mode is the common-mode voltage applied to the NI-9250
- Vbias is the bias voltage of the IEPE sensor
- Vfull-scale is the full-scale voltage of the IEPE sensor

[3] Range equals 5 Vpk

[4] Excluding IEPE current noise

[5] Test standards:

- SMPTE 60 Hz + 7 kHz, amplitude ratio 4:1 with total amplitude at 0 dBFS
- CCIF 14 kHz + 15 kHz, amplitude ratio 1:1 with each tone amplitude at -6 dBFS

Up to fifth order harmonic

[6] Tested with 1 kHz-60 dBFS input at 102.4 kS/s