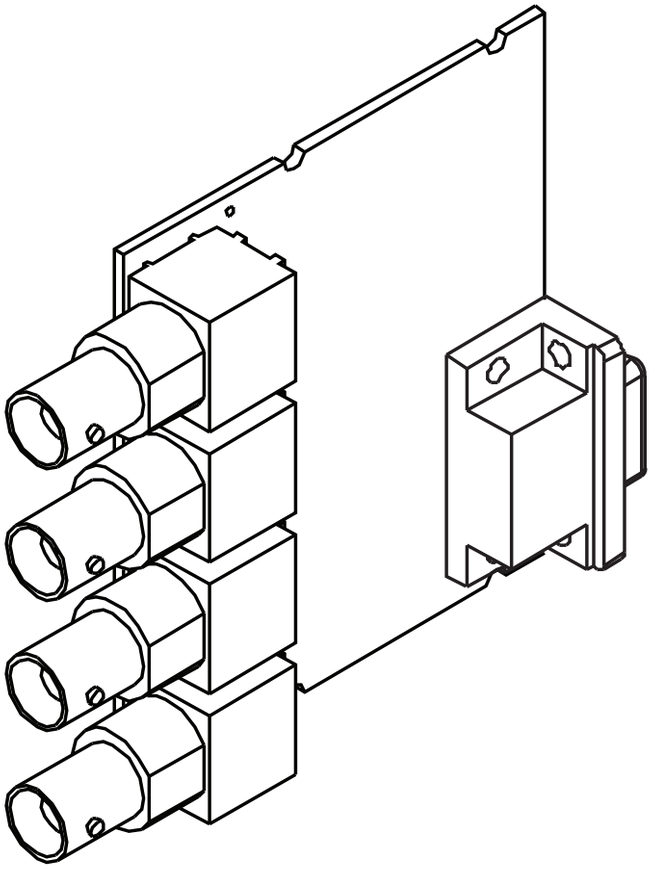
OPERATING INSTRUCTIONS AND SPECIFICATIONS

NI 9234E

4-Channel, ±5 V, 24-Bit Software-Selectable IEPE and AC/DC Analog Input Module



NATIONAL INSTRUMENTS™

This document describes how to use the National Instruments 9234E and includes dimensions, connector assignments, and specifications for the NI 9234E. Visit `ni.com/info` and enter `rdsoftwareversion` to determine which software you need for the modules you are using. For information about installing, configuring, and programming the system, refer to the system documentation. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

Caution National Instruments makes no electromagnetic compatibility (EMC) or CE marking compliance claims for the NI 9234E. The end-product supplier is responsible for conformity to any and all compliance requirements.

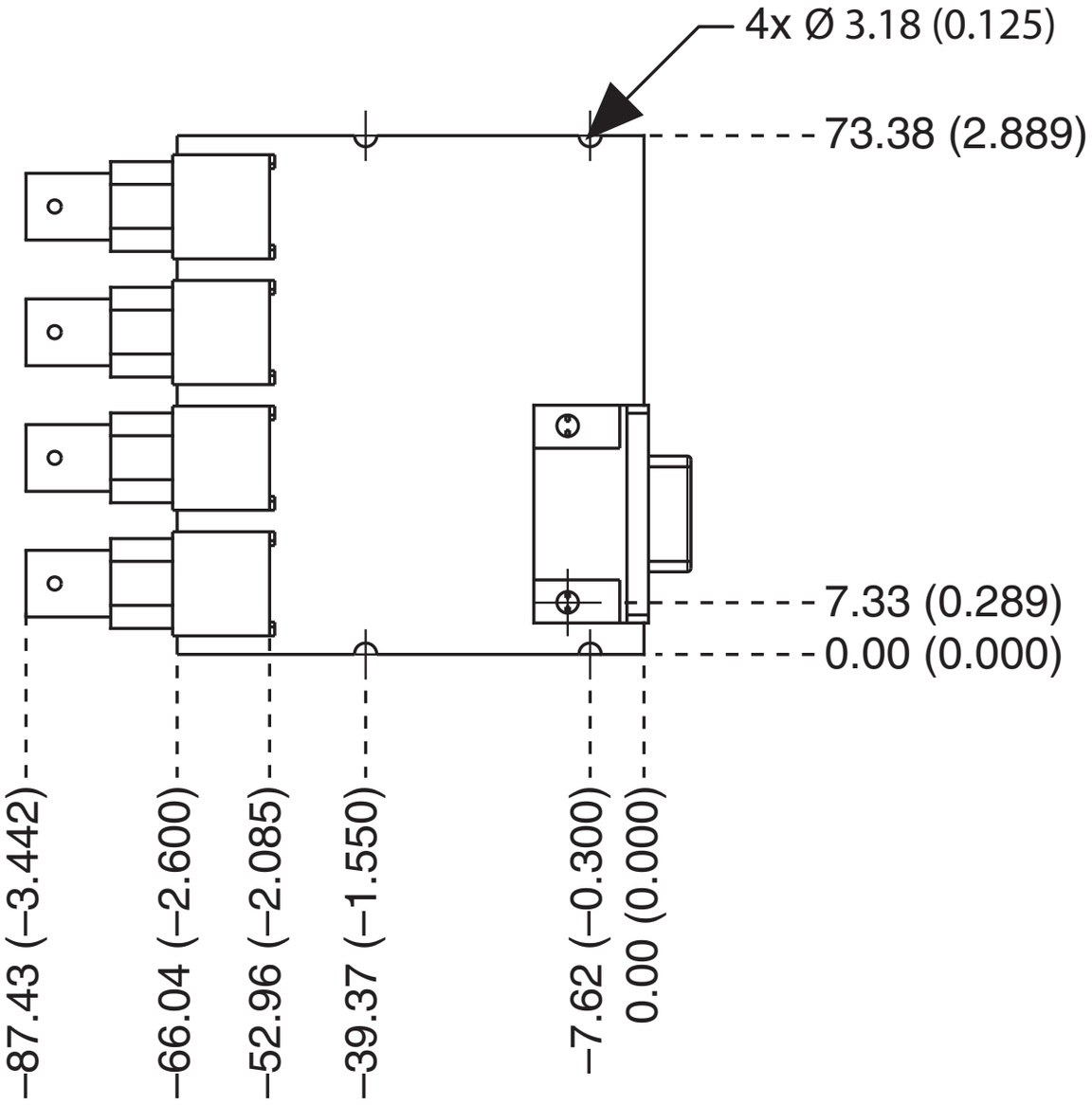
Caution The NI 9234E must be installed inside a suitable enclosure prior to use. Hazardous voltages may be present.

Caution Do not operate the NI 9234E in a manner not specified in these operating instructions. 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 National Instruments for repair.

NI 9234E Dimensions

The following figure shows the dimensions of the NI 9234E.

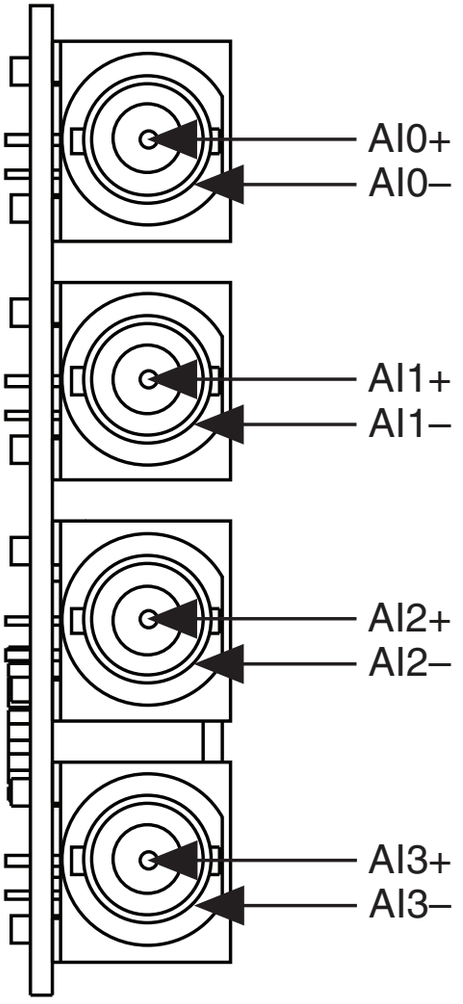
Figure 1. NI 9234E Dimensions in Millimeters (Inches)



Connecting the NI 9234E

The NI 9234E has four BNC connectors that provide connections to four simultaneously sampled analog input channels.

Figure 2. NI 9234E Connector Assignments



Each channel has a BNC connector to which you can connect a signal source. You can also enable excitation current on a per-channel basis to connect Integrated Electronics Piezoelectric (IEPE) sensors. Refer to the *NI 9234E Circuitry* section for more information. The center pin of the connector, AI+, provides the DC excitation, when enabled, and the positive input signal connection. The shell of the connector, AI-, provides the excitation return path and the signal ground reference.

Connecting Signal Sources to the NI 9234E

You can connect ground-referenced or floating signal sources to the NI 9234E. To avoid picking up ground noise, use a floating connection. To further minimize ground noise, prevent the metal shells of the BNC connectors from coming in contact with each other, the modules, or the chassis.

If you make a ground-referenced connection between the signal source and the NI 9234E, make sure the voltage on the AI- shell is in the common-mode range to ensure proper operation of the NI 9234E. The AI- shell is protected against accidental contact with overvoltages within the overvoltage protection range. Refer to the *Specifications* section for more information about operating voltages and overvoltage protection.

Refer to Figures 3 and 4 for illustrations of connecting grounded and floating signal sources to the NI 9234E.

Figure 3. Connecting a Grounded Signal Source to the NI 9234E

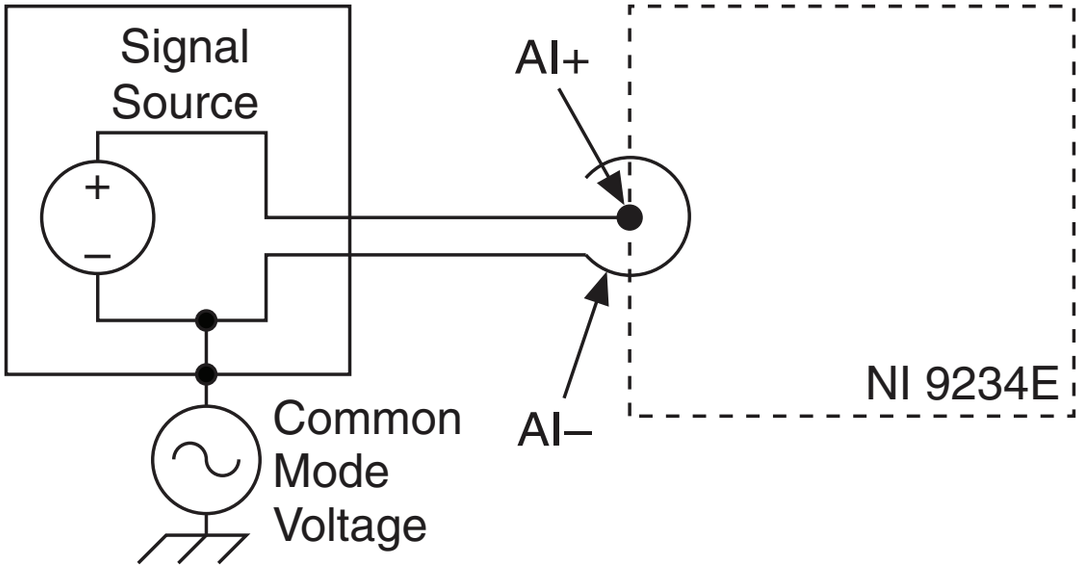
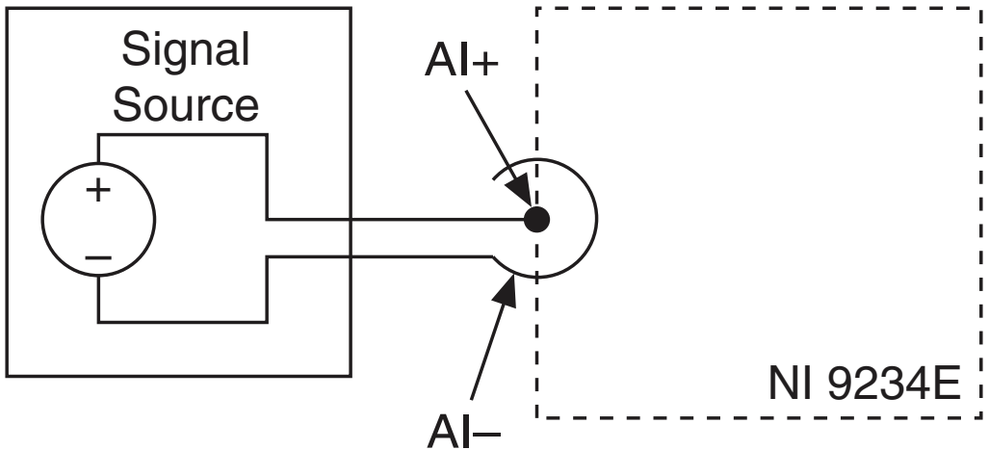


Figure 4. Connecting a Floating Signal Source to the NI 9234E

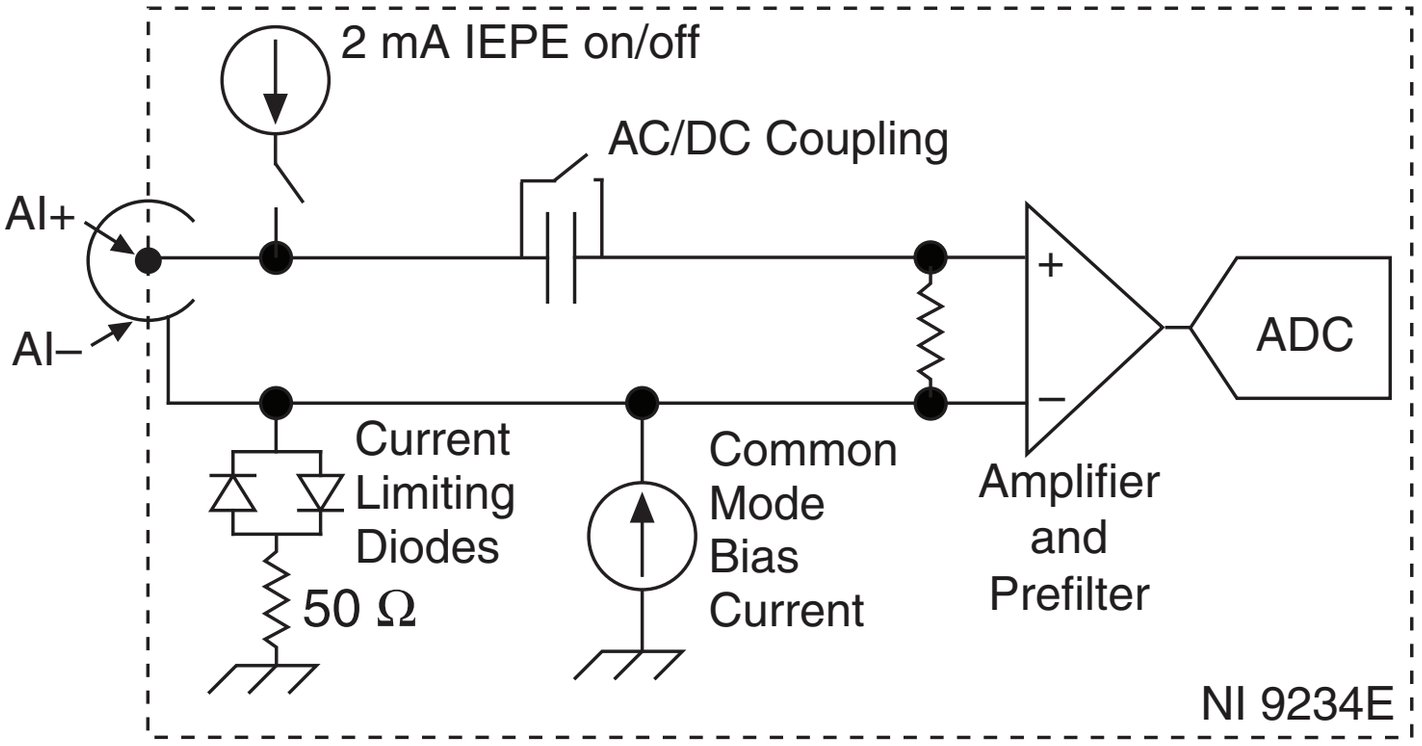


The NI 9234E can also provide an IEPE excitation current for each channel to measure ground-referenced or floating IEPE sensors. Typical IEPE sensors have a case that is electrically isolated from the IEPE electronics, so connecting the sensor to the NI 9234E results in a floating connection even though the case of the sensor is grounded.

NI 9234E Circuitry

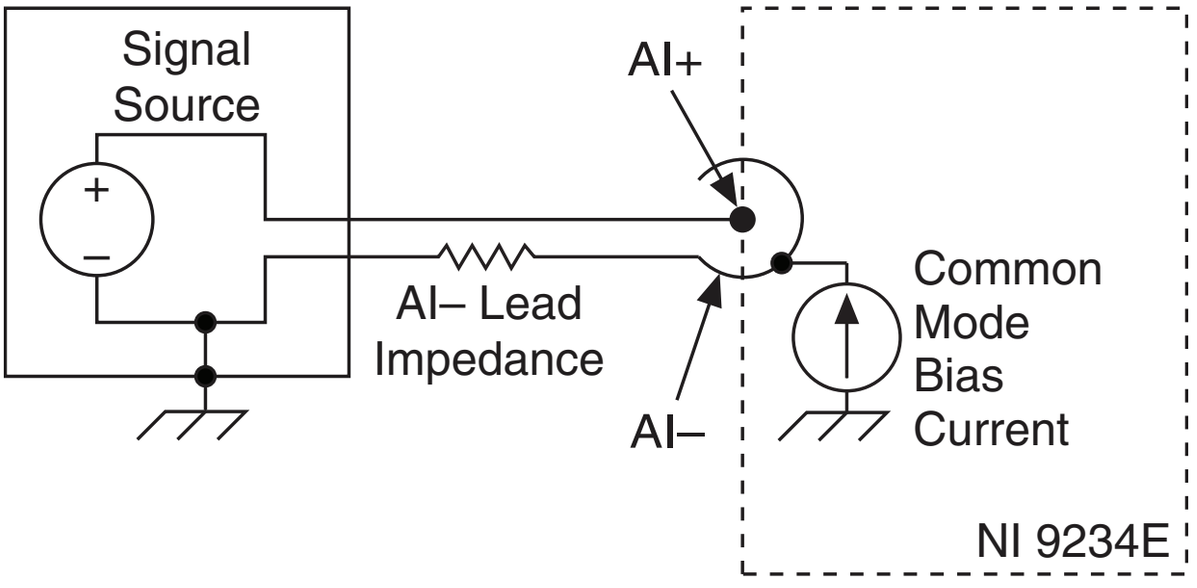
The NI 9234E analog input channels are referenced to chassis ground through a 50 Ω resistor. To minimize ground noise, make sure the chassis ground is connected to earth ground. Each channel is protected from overvoltages. The input signal on each channel is buffered, conditioned, and then sampled by a 24-bit Delta-Sigma ADC. You can configure each channel in software for AC or DC coupling. For channels set to AC coupling, you can turn the IEPE excitation current on or off. Refer to the software help for information about configuring channels on the NI 9234E.

Figure 5. NI 9234E Input Circuitry for One Channel



The NI 9234E uses common-mode bias current to bias the current-limiting diodes when IEPE current is turned off. When the NI 9234E is using grounded signal sources, this current causes an error that is dependent on the AI- lead impedance. This error is approximately 50 ppm of range and 15 ppm of reading per Ω of AI- impedance. The common-mode bias current causes an error only with grounded sources and is not an issue with floating signal sources. For best accuracy, use a floating connection or use low-impedance leads when connecting grounded signal sources.

Figure 6. Measurement Error Introduced by Common-Mode Bias Current



The NI 9234E also has TEDS circuitry. For more information about TEDS, go to `ni.com/info` and enter `rdteds`.

Understanding NI 9234E Filtering

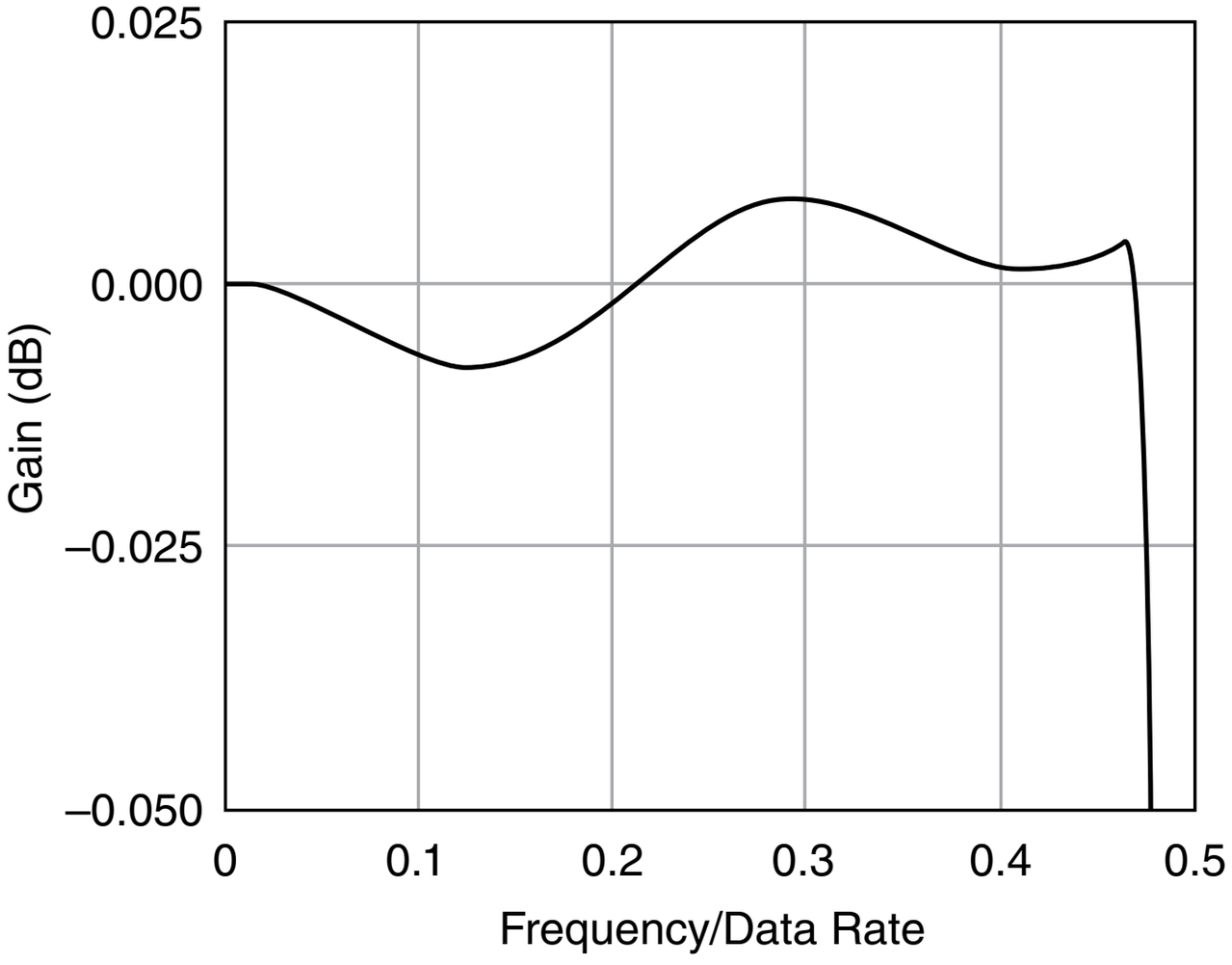
The NI 9234E uses a combination of analog and digital filtering to provide an accurate representation of in-band signals while rejecting out-of-band signals. The filters discriminate between signals based on the frequency range, or bandwidth, of the signal. The three important bandwidths to consider are the passband, the stopband, and the alias-free bandwidth.

The NI 9234E represents signals within the passband, as quantified primarily by passband flatness 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 9234E 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. Figure 7 shows typical passband flatness for the NI 9234E.

Figure 7. NI 9234E Typical Passband Flatness



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 signal that appears in the alias-free bandwidth of the NI 9234E is not an aliased artifact 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, and it is equal to the data rate minus the stopband frequency.

Understanding NI 9234E Data Rates

The frequency of a master timebase (f_M) controls the data rate (f_s) of the NI 9234E. The NI 9234E includes an internal master timebase with a frequency of 13.1072 MHz, but the module also can accept an external master timebase or export its own master timebase. To synchronize the data rate of an NI 9234E with other modules that use master timebases to control sampling, all of the modules must share a single master timebase source. Refer to the software help for information about configuring the master timebase source for the NI 9234E. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

The following equation provides the available data rates of the NI 9234E:

$$f_s = \frac{f_M \div 256}{n}$$

where n is any integer from 1 to 31.

However, the data rate must remain within the appropriate data rate range. Refer to the *Specifications* section for more information about the data rate range. When using the internal master timebase of 13.1072 MHz, the result is data rates of 51.2 kS/s, 25.6 kS/s, 17.067 kS/s, and so on down to 1.652 kS/s, depending on the value of n. When using an external timebase with a frequency other than 13.1072 MHz, the NI 9234E has a different set of data rates.

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

Sleep Mode

This module supports a low-power sleep mode. Support for sleep mode at the system level depends on the chassis that the module is plugged into. Refer to the chassis manual for information about support for sleep mode. If the chassis supports sleep mode, refer to the software help for information about enabling sleep mode. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

Typically, when a system is in sleep mode, you cannot communicate with the modules. In sleep mode, the system consumes minimal power and may dissipate less heat than it does in normal mode. Refer to the *Specifications* section for more information about power consumption and thermal dissipation.

Specifications

The following specifications are typical for the range -40 °C to 85 °C internal to any enclosures unless otherwise noted.

Input Characteristics

Number of channels ..... 4 analog input channels

ADC resolution ..... 24 bits

Type of ADC ..... Delta-Sigma (with analog prefiltering)

Sampling mode ..... Simultaneous

Type of TEDS supported ..... IEEE 1451.4 TEDS Class I

Internal master timebase (f_M)

- Frequency ..... 13.1072 MHz
- Accuracy ..... ±50 ppm max

Data rate range (f_s) using internal master timebase

- Minimum ..... 1.652 kS/s
- Maximum ..... 51.2 kS/s

Data rate range (f_s) using external master timebase

Minimum ..... 0.391 kS/s

Maximum ..... 52.734 kS/s

Data rates[1] (f_s) ..... $\frac{f_M \div 256}{n}$, $n = 1, 2, \ldots, 31$

Input coupling ..... AC/DC (software-selectable)

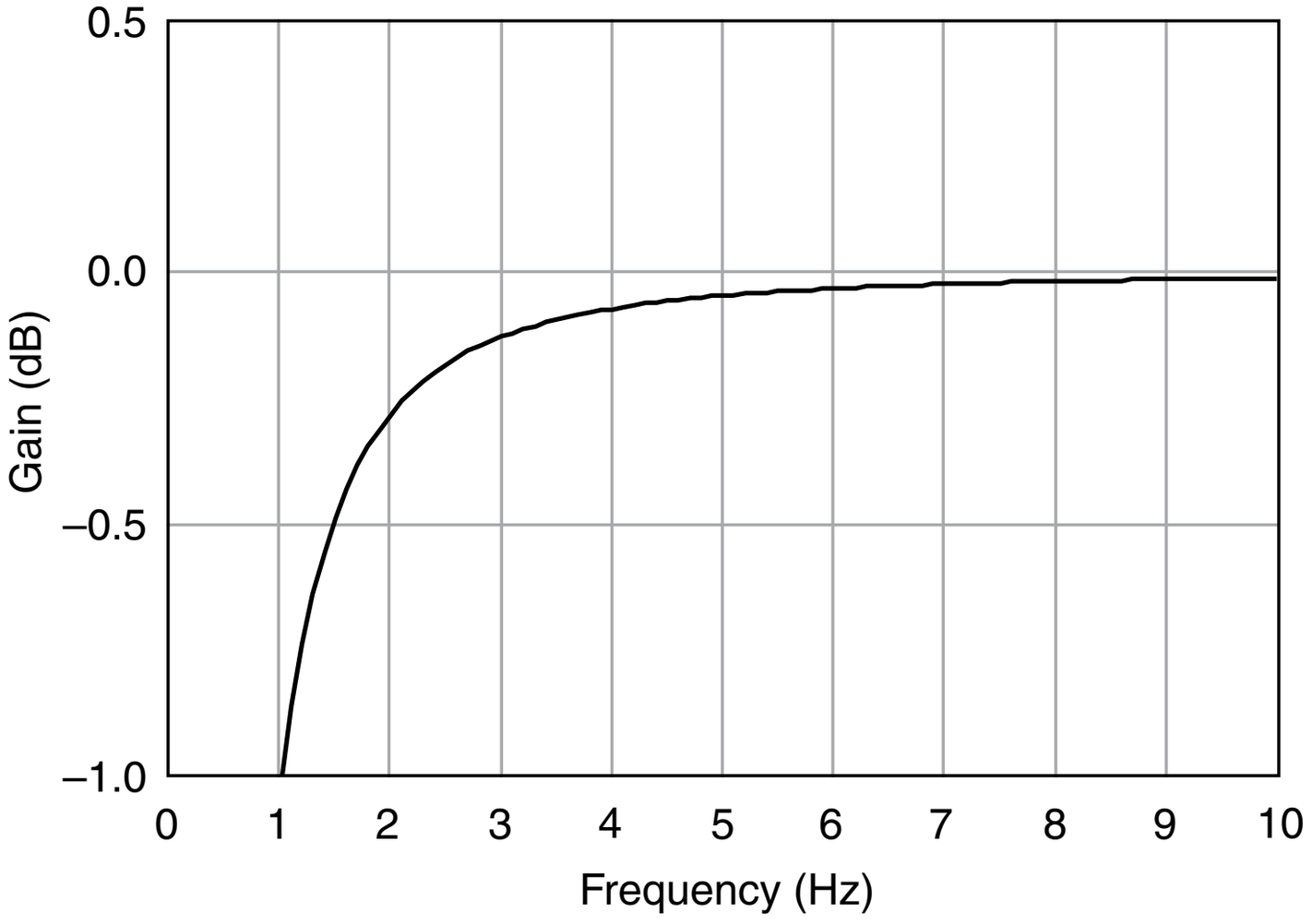
AC cutoff frequency

-3 dB ..... 0.5 Hz

-0.1 dB ..... 4.6 Hz max

[1] The data rate must remain within the appropriate data rate range. Refer to the *Understanding NI 9234E Data Rates* section for more information.

AC cutoff frequency response



Input range ..... ±5 V

AC voltage full-scale range

Minimum ..... ±5 V_{pk}

Typical ..... ±5.1 V_{pk}

Maximum ..... ±5.2 V_{pk}

Common-mode voltage range (AI- to earth ground) ..... ±2 V max

IEPE excitation current (software-selectable on/off)

Minimum ..... 2.0 mA

Typical ..... 2.1 mA

Power-on glitch ..... 90 µA for 10 µs

IEPE compliance voltage..... 19 V max

If you are using an IEPE sensor, use the following equation to make sure your configuration meets the IEPE compliance voltage range.

$$(V_{common\text{-}mode} + V_{bias} \pm V_{full\text{-}scale}) \text{ must be 0 to 19}$$

where $V_{common\text{-}mode}$ is the common-mode voltage applied to the NI 9234E

V_{bias} is the bias voltage of the IEPE sensor

$V_{\text{full-scale}}$ is the full-scale voltage of the IEPE sensor

Overvoltage protection (with respect to chassis ground)

For a signal source connected to AI+ and AI-..... ±30 V

For a low-impedance source connected to AI+ and AI-..... -6 V to 30 V

Input delay ..... $40.0/f_s + 3.2$ µs

Accuracy[1]

Measurement Conditions*	Percent of Reading (Gain Error)	Percent of Range† (Offset Error)
Calibrated max (-40 °C to 85 °C)	0.34%, ±0.03 dB	±0.14%, 7.1 mV
Calibrated typ (25 °C ±5 °C)	0.05%, ±0.005 dB	±0.006%, 0.3 mV
Uncalibrated max (-40 °C to 85 °C)	1.9%, ±0.16 dB	±0.27%, 13.9 mV
Uncalibrated typ (25 °C ±5 °C)	0.48%, ±0.04 dB	±0.04%, 2.3 mV

* Local ambient temperature. Refer to the *Environmental* section for more information about operatingtemperatures.

† Range = 5.1 V_{pk}

[1] Refer to the *NI 9234E Circuitry* section for information regarding grounded signal sources and measurement accuracy.

Gain drift

Typical ..... 0.14 mdB/°C (16 ppm/°C)

Maximum ..... 0.45 mdB/°C (52 ppm/°C)

Offset drift

Typical ..... 19.2 µV/°C

Maximum ..... 118 µV/°C

Channel-to-channel matching

Gain

Typical ..... 0.01 dB

Maximum ..... 0.04 dB

Phase (f_{in} in kHz) ..... $f_{in} \cdot 0.045° + 0.04$ max

Passband

Frequency ..... $0.45 \cdot f_s$

Flatness (f_s = 51.2 kS/s) ..... ±40 mdB (pk-to-pk max)

Phase nonlinearity
(f_s = 51.2 kS/s) ..... ±0.45° max

Stopband

Frequency ..... $0.55 \cdot f_s$

Rejection ..... 100 dB

Alias-free bandwidth ..... $0.45 \cdot f_s$

Oversample rate ..... $64 \cdot f_s$

Crosstalk (1 kHz) ..... -110 dB

CMRR ($f_{in} \leq$ 1 kHz)

Minimum ..... 40 dB

Typical ..... 47 dB

SFDR (f_{in} = 1 kHz, -60 dBFS) ..... 120 dB

Idle channel noise and noise density

Idle Channel	**51.2 kS/s**	**25.6 kS/s**	**2.048 kS/s**
Noise	97 dBFS	99 dBFS	103 dBFS
	50 μV_{rms}	40 μV_{rms}	25 μV_{rms}
Noise density	310 nV/√Hz	350 nV/√Hz	780 nV/√Hz

Input impedance

Differential ..... 305 kΩ

AI- (shield) to chassis ground .... 50 Ω

Total harmonic distortion (THD)

Input Amplitude	1 kHz	8 kHz
-1 dBFS	-95 dB	-87 dB
-20 dBFS	-95 dB	-80 dB

Intermodulation distortion (-1 dBFS)

DIN 250 Hz/8 kHz
4:1 amplitude ratio ..... -80 dB

CCIF 11 kHz/12 kHz
1:1 amplitude ratio ..... -93 dB

MTBF ..... 390,362 hours at 25 °C; Bellcore Issue 2, Method 1, Case 3, Limited Part Stress Method

Note Contact NI for Bellcore MTBF specifications at other temperatures or for MIL-HDBK-217F specifications.

Power Requirements

Power consumption from chassis

Active mode ..... 900 mW max

Sleep mode ..... 25 µW max

Thermal dissipation (at 85 °C)

Active mode ..... 930 mW max

Sleep mode ..... 25 µW max

Physical Characteristics

Use a dry, low-velocity stream of air to clean the module. If needed, use a soft-bristle brush for cleaning around components.

Note For two-dimensional drawings and three-dimensional models of the C Series module and connectors, visit `ni.com/dimensions` and search by module number.

Weight ..... 71 g (2.5 oz)

Safety

Safety Voltages

Connect only voltages that are within the following limits.

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

Isolation

Channel-to-channel ..... None

Channel-to-earth ground ..... None

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution Do *not* connect the NI 9234E to signals or use for measurements within Measurement Categories II, III, or IV.

Safety Standards

This product meets the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use when installed in a suitable enclosure:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Online Product Certification

To obtain product certifications and the Declaration of Conformity (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

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

Operating temperature[1]
(IEC 60068-2-1, IEC 60068-2-2) ..... -40 °C to 85 °C

Note Visit `ni.com/info` and enter the Info Code `sbRIOcooling` for information about NI sbRIO system operating temperatures.

Storage temperature
(IEC 60068-2-1, IEC 60068-2-2) ..... -40 °C to 85 °C

Operating humidity
(IEC 60068-2-56)..... 10% to 90% RH, noncondensing

Storage humidity
(IEC 60068-2-56)..... 5% to 95% RH, noncondensing

Pollution Degree 2

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[1] Local ambient temperature. Measure the local ambient temperature by placing thermocouples on both sides of the PCB, 5 mm (0.2 in.) from the board surface.

Maximum altitude.....2,000 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 *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)

EU Customers 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）

中国客户 National Instruments 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 National Instruments 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 9234E at ni.com/calibration.

Calibration interval ..... 1 year

Where to Go for Support

The National Instruments Web site is your complete resource for technical support. At ni.com/support you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. For telephone support in the United States, create your service request at `ni.com/support` and follow the calling instructions or dial 512 795 8248. For telephone support outside the United States, visit the Worldwide Offices section of `ni.com/niglobal` to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

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