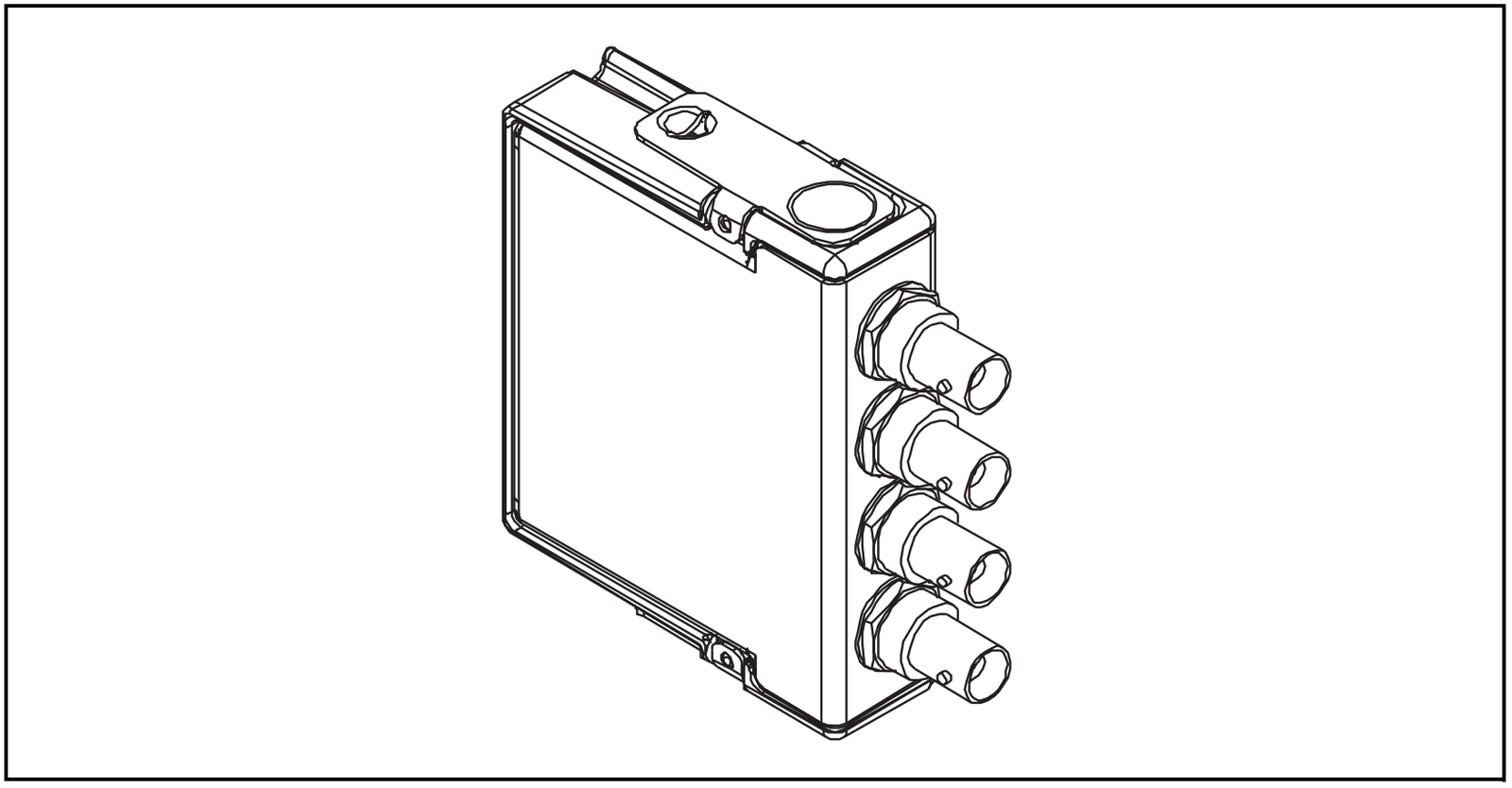
OPERATING INSTRUCTIONS

CompactRIO™ cRIO-9233

4-Channel, ±5 V, 24-Bit IEPE Analog Input Module



NATIONAL INSTRUMENTS™

These operating instructions describe how to use the National Instruments cRIO-9233. For information about installing, configuring, and programming the CompactRIO system, refer to the *CompactRIO Bookshelf* at **Start»All Programs»National Instruments»CompactRIO»Search the CompactRIO Bookshelf**.

Safety Guidelines

Operate the cRIO-9233 only as described in these operating instructions.

Hot Surface This icon denotes that the component may be hot. Touching this component may result in bodily injury.

Safety Guidelines for Hazardous Locations

The cRIO-9233 is suitable for use in Class I, Division 2, Groups A, B, C, and D hazardous locations; Class 1, Zone 2, AEx nC IIC T4 and Ex nC IIC T4 hazardous locations; and nonhazardous locations only. Follow these guidelines if you are installing the cRIO-9233 in a potentially explosive environment. Not following these guidelines may result in serious injury or death.

Caution Do *not* disconnect I/O-side wires or connectors unless power has been switched off or the area is known to be nonhazardous.

Caution Do *not* remove modules unless power has been switched off or the area is known to be nonhazardous.

Caution Substitution of components may impair suitability for Class I, Division 2.

Caution For Zone 2 applications, install the CompactRIO system in an enclosure rated to at least IP 54 as defined by IEC 60529 and EN 60529.

Special Conditions for Safe Use in Europe

This equipment has been evaluated as EEx nC IIC T4 equipment under DEMKO Certificate No. 03 ATEX 0324020X. Each module is marked ⟨Ex⟩ II 3G and is suitable for use in Zone 2 hazardous locations.

Wiring the cRIO-9233

The cRIO-9233 has four BNC connectors that provide connections for four simultaneously sampled analog input channels. Each channel has a BNC connector to which you can connect an integrated electronic piezoelectric (IEPE) sensor. The center pin of the connector, AI+, provides the DC excitation and AC signal connection. The shell of the connector, AI–, provides the excitation return path and AC signal ground reference. Refer to Figure 1 for the connector assignments for each channel.

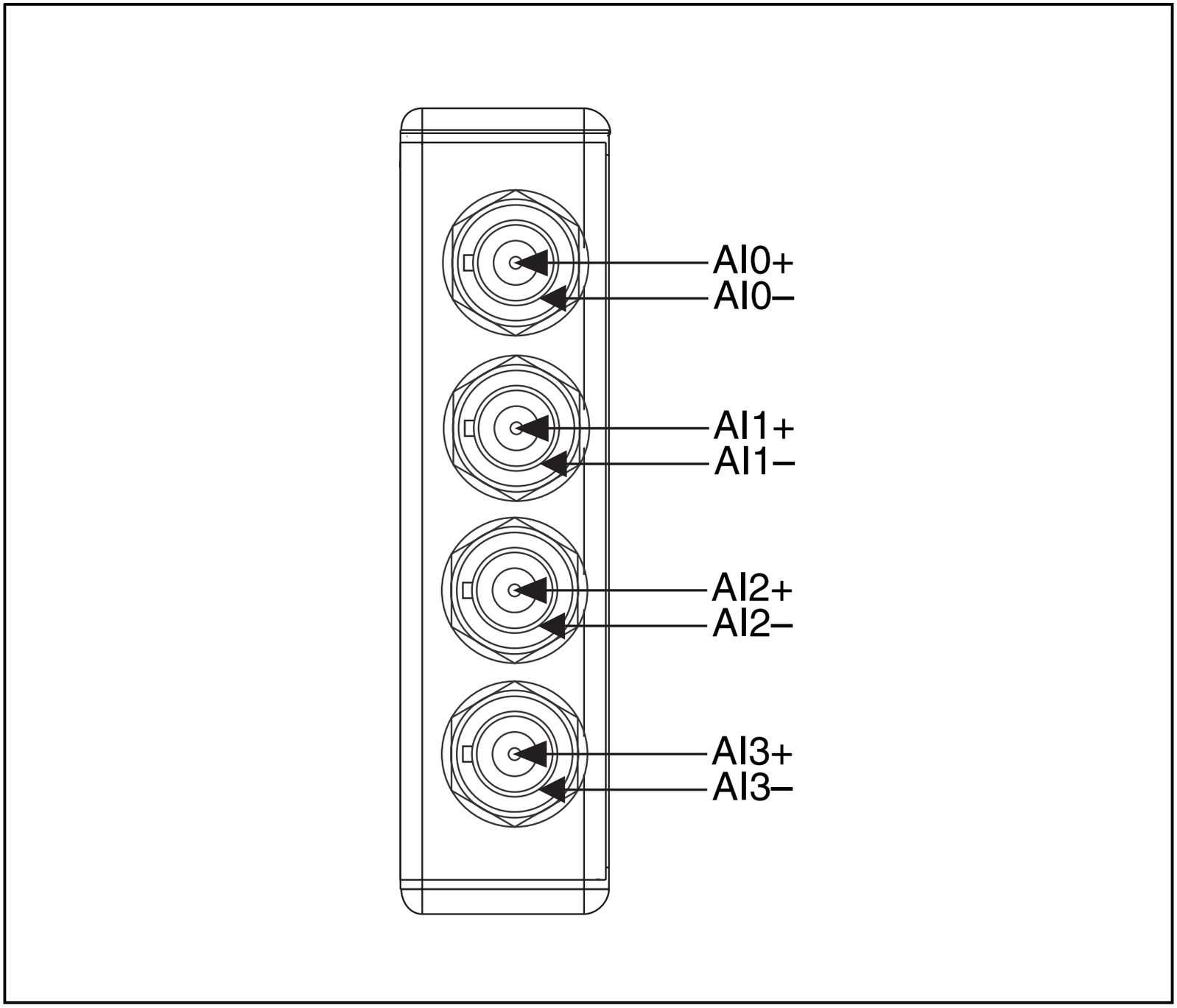


Figure 1. Connector Assignments

Connecting IEPE Sensors to the cRIO-9233

You can connect ground-referenced or floating IEPE sensors to the cRIO-9233. You can avoid picking up ground noise by using a floating connection. Typical IEPE sensors have a case that is electrically isolated from the IEPE electronics, so connecting the sensor to the cRIO-9233 results in a floating connection even though the case of the sensor is grounded. To further minimize ground noise, prevent the metal shells of the BNC connectors from touching each other, the CompactRIO modules, or the CompactRIO chassis.

If you make a ground-referenced connection between the IEPE sensor and the cRIO-9233, make sure the voltage on the AI– shell is in the common-mode range to ensure proper operation of the cRIO-9233. 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.

Figures 2 and 3 illustrate connecting a grounded and floating IEPE sensor to the cRIO-9233.

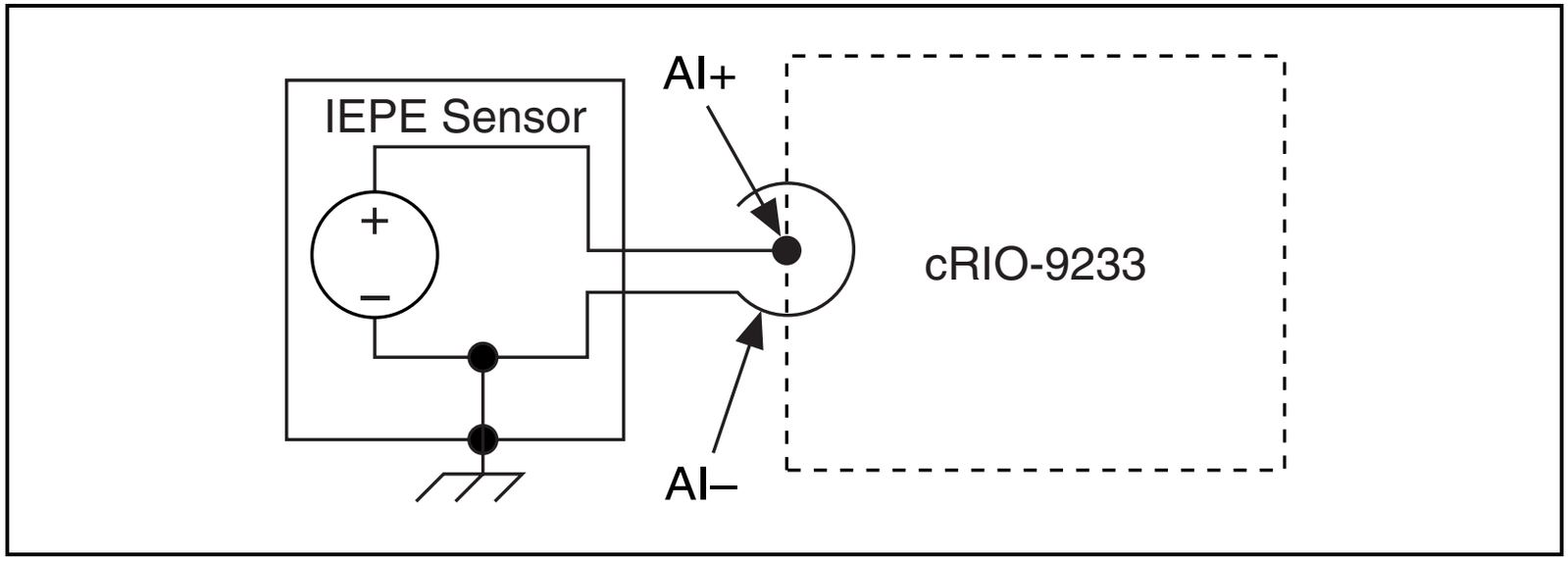


Figure 2. Connecting a Grounded IEPE Sensor to the cRIO-9233

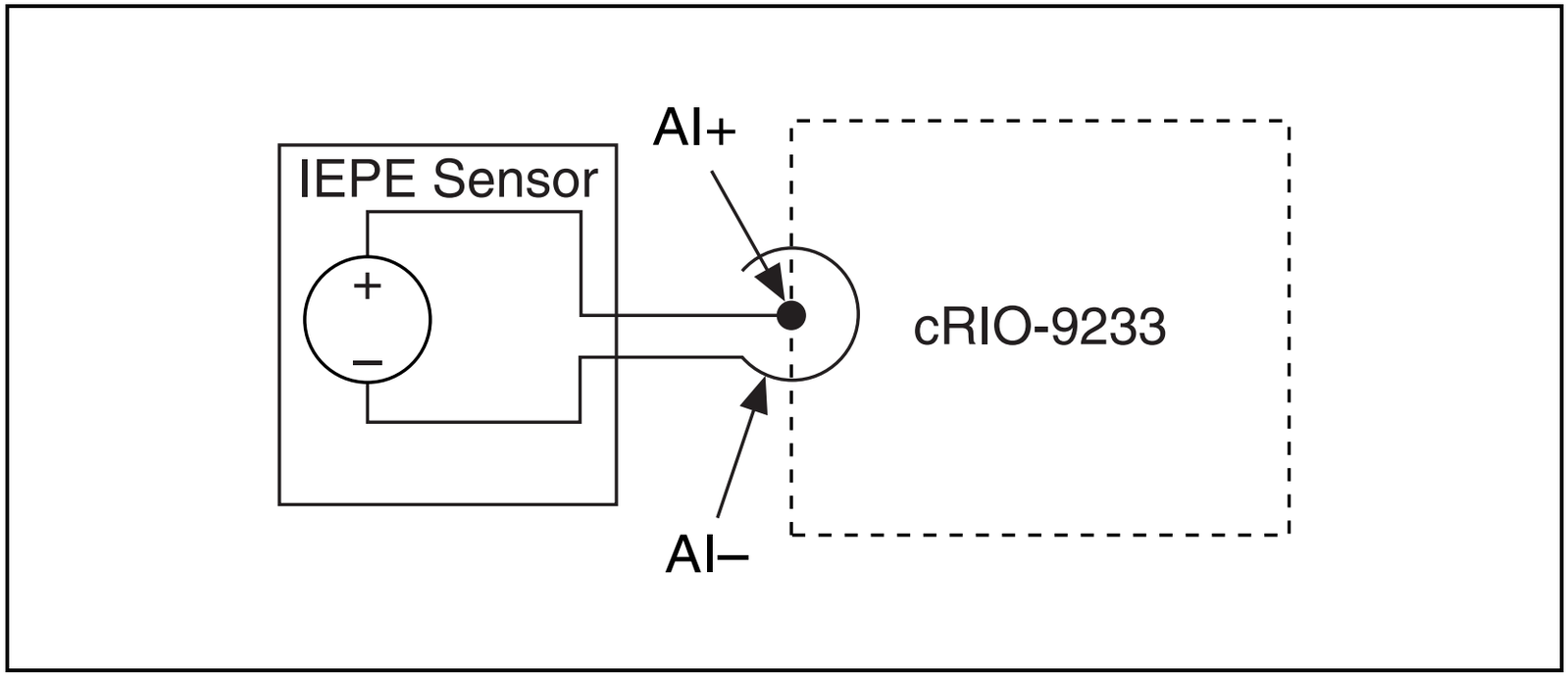


Figure 3. Connecting a Floating IEPE Sensor to the cRIO-9233

cRIO-9233 Circuitry

The cRIO-9233 analog input channels are referenced to chassis ground through a 50 Ω resistor. To minimize ground noise, make sure that the CompactRIO chassis ground is connected to earth ground. Each channel is protected from overvoltages. The cRIO-9233 provides an IEPE excitation current for each input signal. The signal is AC coupled, buffered, and conditioned. The signal is then sampled by a 24-bit ADC. Each channel on the cRIO-9233 has an independent track-and-hold amplifier that enables you to sample all four channels simultaneously. The cRIO-9233 IEPE excitation current and AC coupling are always enabled except when the module is in Transducer Electronic Data Sheet (TEDS) mode.

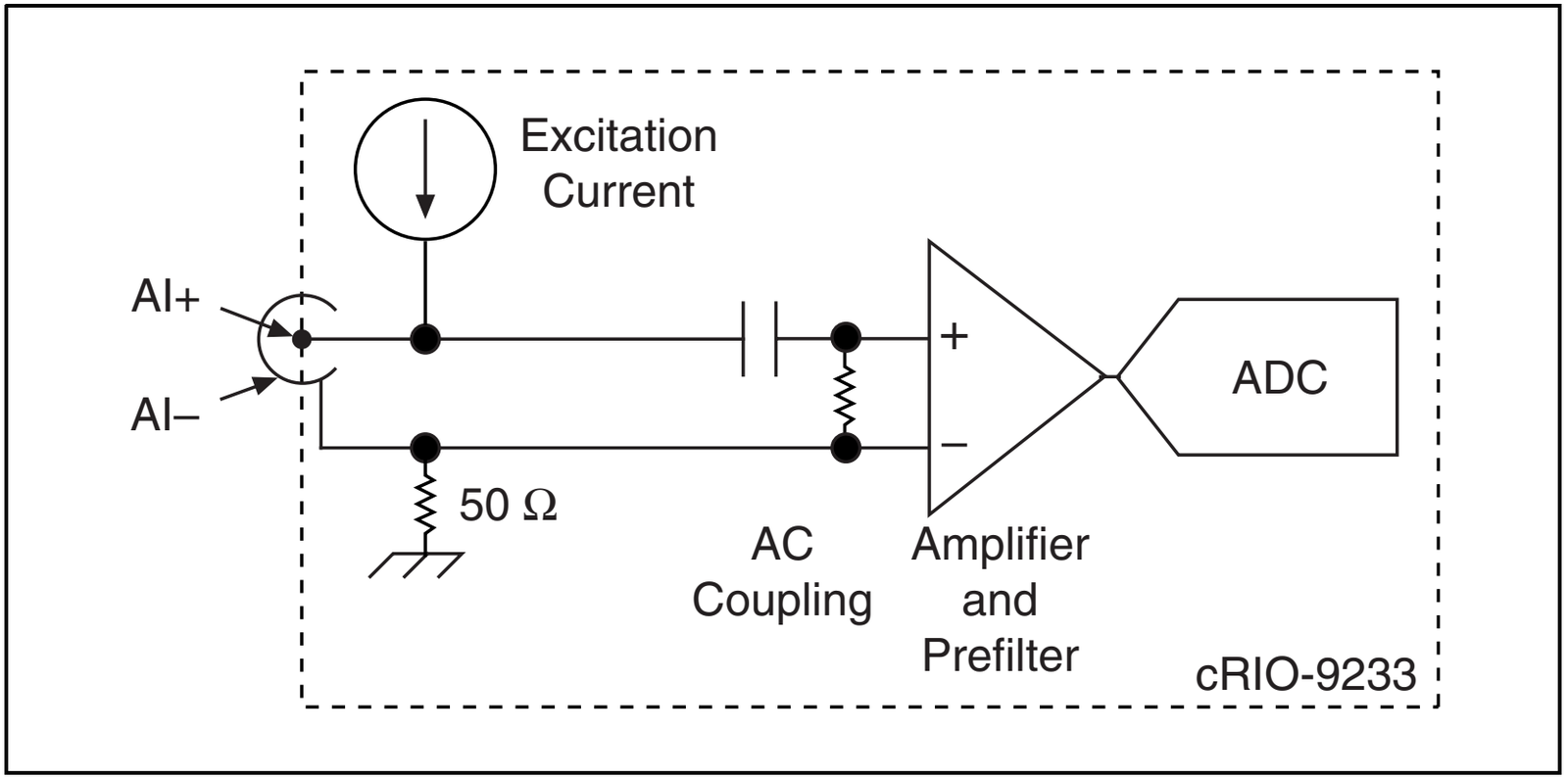


Figure 4. Input Circuitry for One Channel

The cRIO-9233 returns uncalibrated binary data. You can apply calibration coefficients and convert the data to engineering units in software. Refer to the *CompactRIO Bookshelf* for more information about converting cRIO-9233 data.

The cRIO-9233 also has TEDS circuitry. For more information about TEDS, go to `ni.com/info` and enter `rdteds`.

Understanding cRIO-9233 Filtering

The cRIO-9233 uses a combination of analog and digital filtering to provide an accurate representation of desirable 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 cRIO-9233 represents signals within the passband as accurately as possible, as quantified primarily by passband ripple and phase nonlinearity. The filters reject frequencies within the stopband as much as possible, as quantified by stopband rejection. 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 frequency is called the *passband ripple*. The digital filters of the cRIO-9233 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 5 shows typical passband ripples for two different data rates.

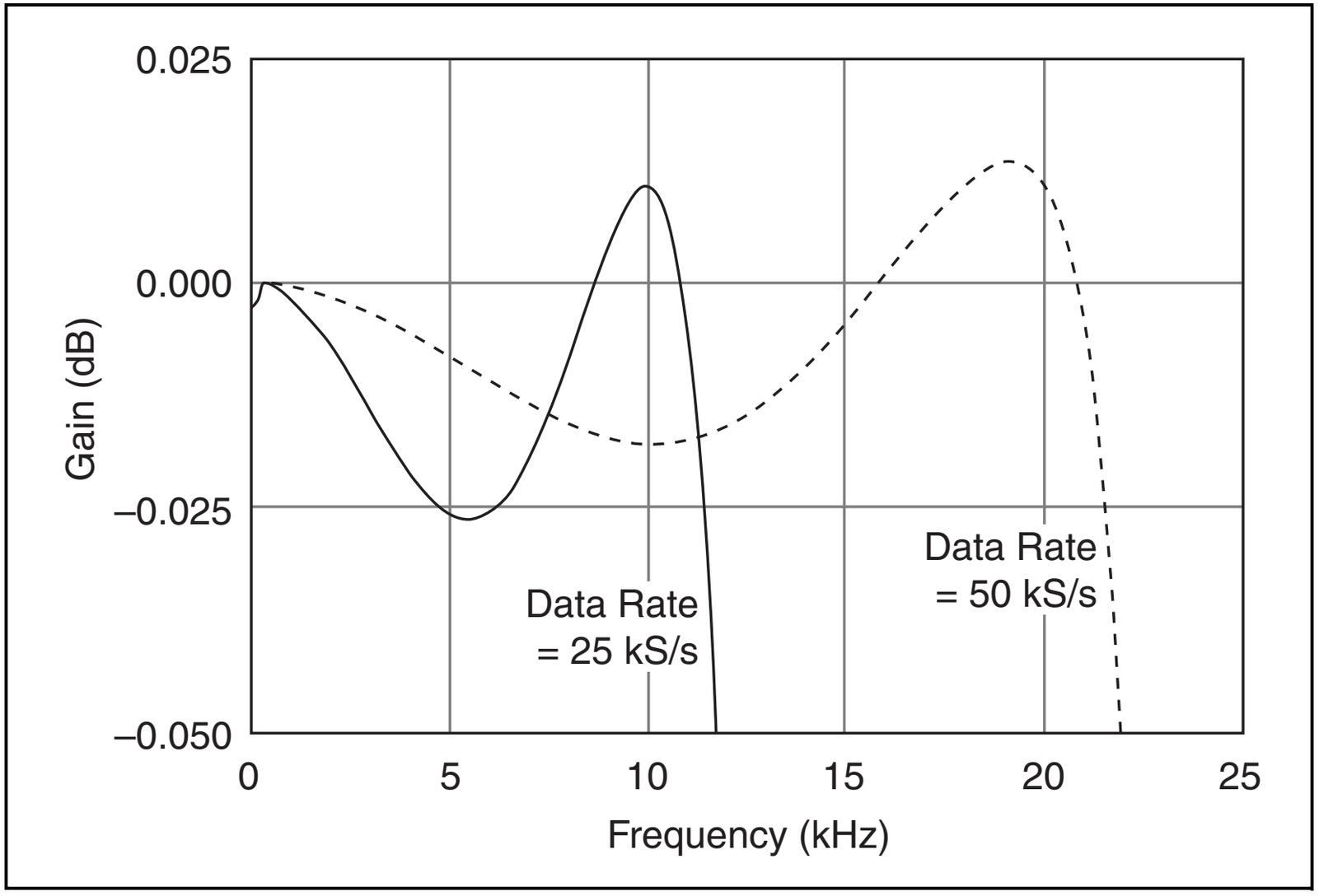


Figure 5. Typical Passband Response

The relative phases of these signals also have a frequency-dependent delay. The variation in the phase delay with

frequency is called the *phase nonlinearity*. Figure 6 shows the phase nonlinearity for data rates above 25 kS/s and at or below 25 kS/s. The phase nonlinearity scales directly with the oversample rate, so the two curves normalize the signal frequency to the data rate.

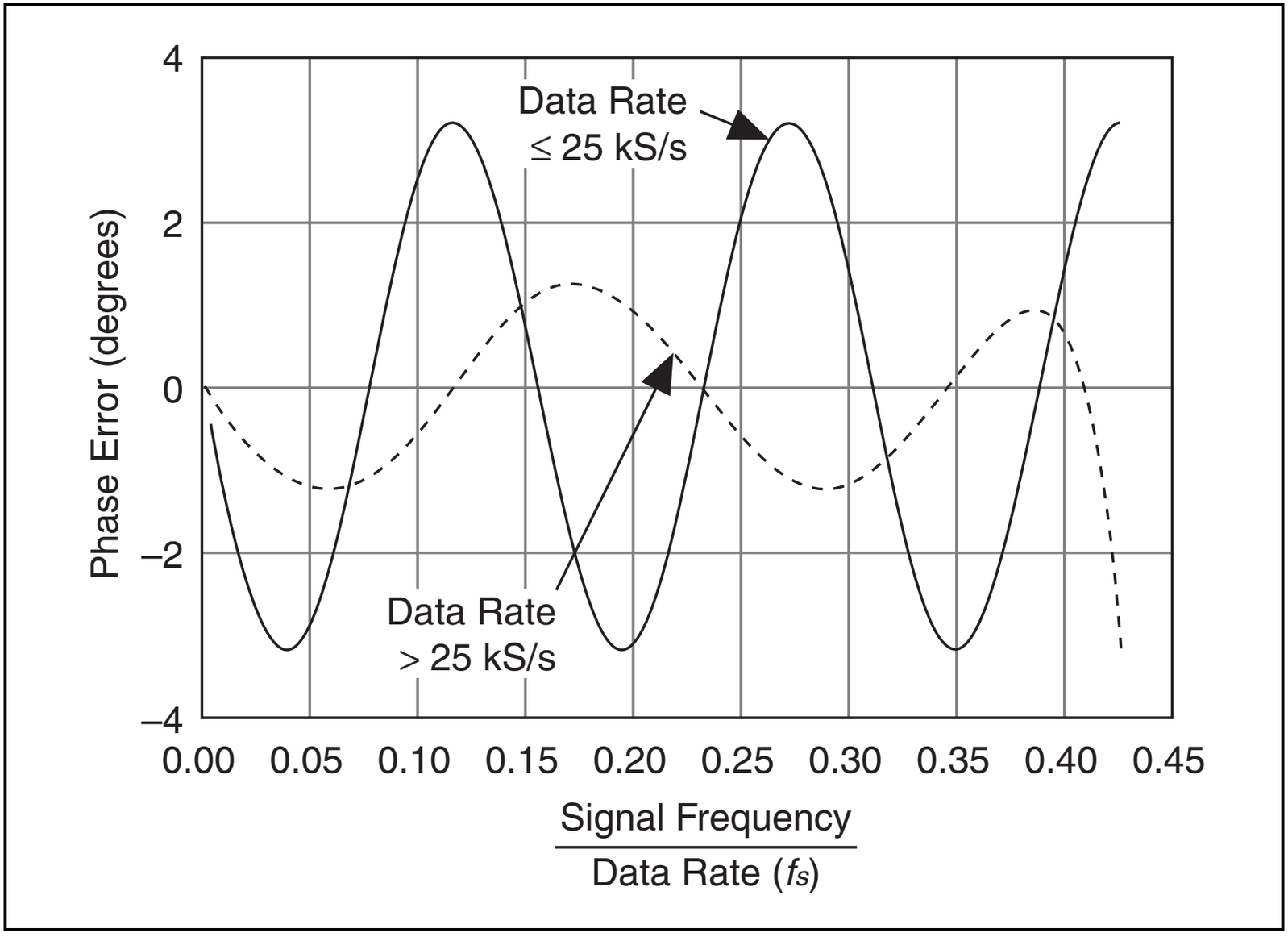


Figure 6. Phase Nonlinearity

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 that would be aliased into the alias-free bandwidth.

Alias-Free Bandwidth

Any signal that appears in the alias-free bandwidth of the cRIO-9233 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 equals the data rate minus the stopband frequency.

Sleep Mode

You can enable sleep mode for the CompactRIO system in software. In sleep mode, the system consumes less power and may dissipate less heat. Typically, when a system is in sleep mode, you cannot communicate with the modules. Refer to the *Specifications* section for more information about power consumption and thermal dissipation. Refer to the *CompactRIO Bookshelf* for more information about enabling sleep mode in software.

NI-RIO Software

For information about determining which software you need for the modules you are using, go to `ni.com/info` and enter `rdniriosoftware`.

Specifications

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

Input Characteristics

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

ADC resolution ..... 24 bits

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

Data rate (f_s)

- Minimum ..... 2 kS/s
- Maximum ..... 50 kS/s

Master timebase (internal)

Frequency ..... 12.8 MHz

Accuracy..... ±100 ppm max

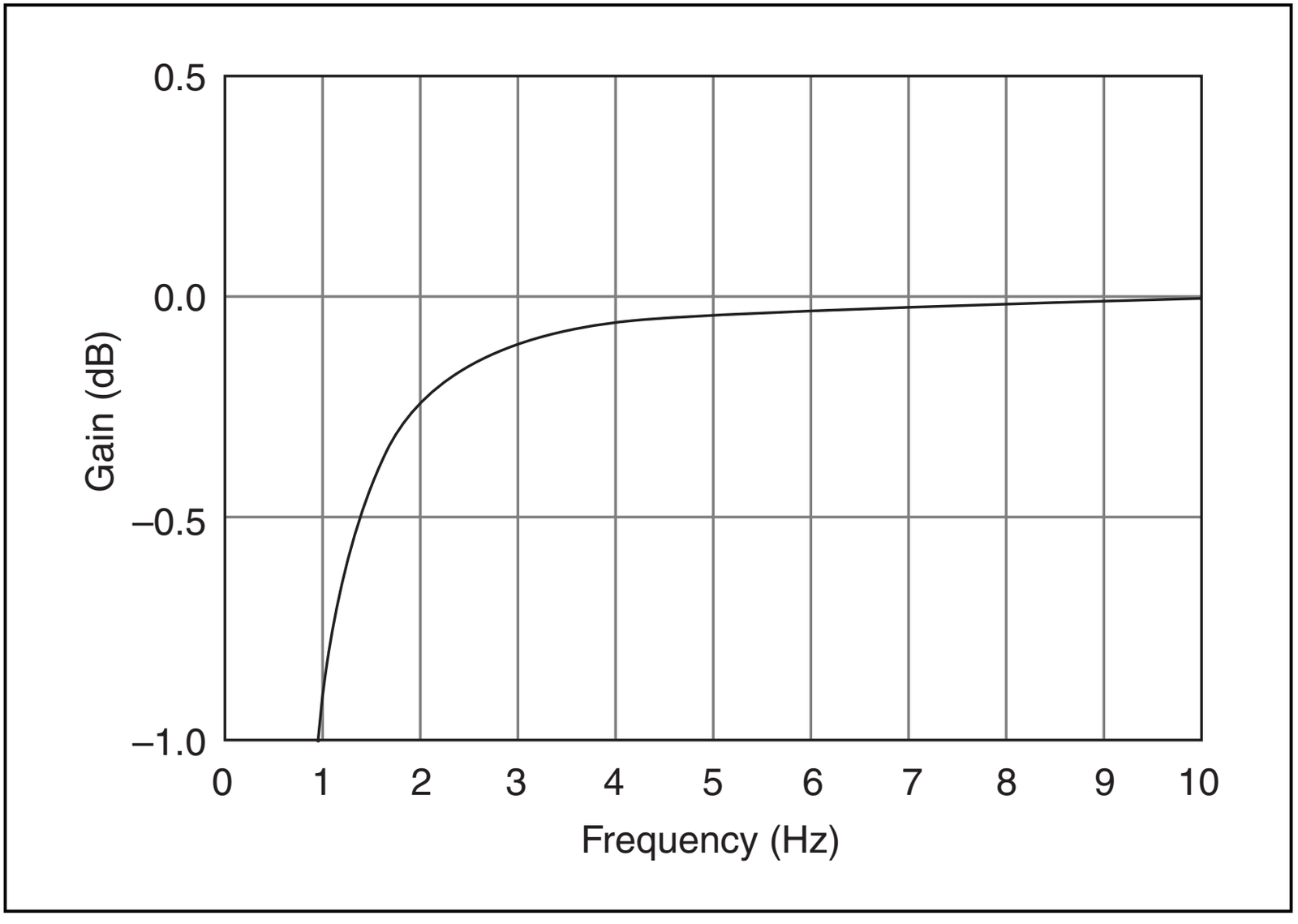
Input coupling..... AC

AC cutoff frequency

–3 dB ..... 0.5 Hz typ

–0.1 dB ..... 4.2 Hz max

AC cutoff frequency response



AC voltage full-scale range

Typical ..... $\pm 5.4\ V_{peak}$

Minimum ..... $\pm 5\ V_{peak}$

Maximum ..... $\pm 5.8\ V_{peak}$

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

IEPE excitation current

Minimum ..... 2.0 mA

Typical ..... 2.2 mA

IEPE compliance voltage ..... 19 V max

Use the following equation to make sure that your configuration meets the IEPE compliance voltage range.

$V_{common\text{-}mode} + V_{bias} + V_{full\text{-}scale}$ must be 0 to 19 V,

where $V_{common\text{-}mode}$ is the common-mode voltage of the cRIO-9233,

V_{bias} is the bias voltage of the accelerometer, and

$V_{full\text{-}scale}$ is the full-scale voltage of the accelerometer.

Overvoltage protection (with respect to chassis ground)

For an IEPE sensor connected
to AI+ and AI– ..... ±30 V

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

Input delay (in seconds)

≤25 kS/s ..... $12.8 \div f_s$

>25 kS/s ..... $9.8 \div f_s$

Accuracy (–40 to 70 °C)

Error	Accuracy
Calibrated max	±0.3 dB
Calibrated typ	±0.1 dB
Uncalibrated max	±0.6 dB

Accuracy drift

Typical ..... 0.001 dB/°C

Maximum ..... 0.0045 dB/°C

Channel-to-channel matching

Gain

Maximum ..... 0.27 dB

Typical ..... 0.07 dB

Phase (f_{in} in kHz) ..... $f_{in} \cdot 0.077° + 0.067°$

Dynamic characteristics

f_s	Passband			
	Freq	**Flatness (pk-to-pk max)**	**Freq**	**Phase Nonlinearity**
≤25 kS/s	$0.45 \cdot f_s$	0.05 dB	$0.45 \cdot f_s$	±3.4°
>25 kS/s	$0.42 \cdot f_s$	0.05 dB	$0.41 \cdot f_s$	±1.3°

f_s	Stopband		**Oversample Rate**	**Alias-Free Bandwidth**
	Freq	**Attenuation**		
≤25 kS/s	$0.58 \cdot f_s$	95 dB	$128 \cdot f_s$	$0.42 \cdot f_s$
>25 kS/s	$0.68 \cdot f_s$	92 dB	$64 \cdot f_s$	$0.32 \cdot f_s$

Crosstalk

Paired channels
(0 and 1, 2 and 3).....–100 dB at 1 kHz

Nonpaired channels.....–110 dB at 1 kHz

Common-mode rejection ratio (CMRR)

Minimum ..... 54 dB, $f_{in} \leq 1$ kHz

Typical ..... 80 dB, $f_{in} \leq 1$ kHz

Spurious-free dynamic range (SFDR) ..... 120 dB (f_{in} = 1 kHz, −60 dB FS)

Idle channel noise and noise density

Idle Channel	50 kS/s	25 kS/s	2 kS/s
Noise	95 dB FS	98 dB FS	102 dB FS
Noise density	400 nV/√Hz	400 nV/√Hz	900 nV/√Hz

Input impedance

Differential (AC) ..... >300 kΩ

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

Distortion

Harmonic (THD)

	1 kHz, –40 to 70 °C	**10 kHz, 25 to 70 °C**	**10 kHz, –40 to 25 °C**
–1 dB FS	–90 dB	–80 dB	
–20 dB FS	–95 dB	–90 dB	–80 dB

Intermodulation (full-scale input)

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

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

MTBF ..... 397,465 hours at 25 °C; Bellcore Issue 6, Method 1, Case 3, Limited Part Stress Method

Note Contact NI for Bellcore MTBF specifications at other temperatures or for MIL-HDBK-217F specifications. Go to `ni.com/certification` and search by model number or product line for more

information about MTBF and other product certifications.

Power Requirements

Power consumption from chassis

Active mode ..... 620 mW max

Sleep mode ..... 0.5 mW max

Thermal dissipation

Active mode ..... 640 mW max

Sleep mode ..... 0.5 mW max

Physical Characteristics

If you need to clean the module, wipe it with a dry towel.

Weight..... Approx. 173 g (6.1 oz)

Safety

Safety Voltages

Connect only voltages that are within these limits.

Channel-to-earth ground..... ±30 V max

Isolation

Channel-to-channel ..... None

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

Safety Standards

The cRIO-9233 is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1
- CAN/CSA-C22.2 No. 61010-1

Note For UL and other safety certifications, refer to the product label, or visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Hazardous Locations

U.S. (UL) ..... Class I, Division 2,
Groups A, B, C, D, T4;
Class I, Zone 2,
AEx nC IIC T4

Canada (C-UL) ..... Class I, Division 2,
Groups A, B, C, D, T4;
Class I, Zone 2,
Ex nC IIC T4

Europe (DEMKO)..... EEx nC IIC T4

Environmental

CompactRIO modules are intended for indoor use only. For outdoor use, mount the CompactRIO system in a suitably rated enclosure. Refer to the installation instructions for the chassis you are using for more information about meeting these specifications.

Operating temperature
(IEC60068-2-1, IEC 60068-2-2) ..... –40 to 70 °C

Storage temperature
(IEC60068-2-1, IEC 60068-2-2) ..... –40 to 85 °C

Ingress protection..... IP 40

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

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

Maximum altitude..... 2,000 m

Pollution Degree (IEC 60664) 2

Shock and Vibration

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

Operating vibration,
random (IEC 60068-2-64) ..... 5 g_{rms}, 10 to 500 Hz

Operating shock
(IEC 60068-2-27)..... 30 g, 11 ms half sine,
50 g, 3 ms half sine,
18 shocks at 6 orientations

Operating vibration,
sinusoidal (IEC 60068-2-6) ..... 5 g, 10 to 500 Hz

Electromagnetic Compatibility

Emissions..... EN 55011 Class A at 10 m
FCC Part 15A above 1 GHz

Immunity..... Industrial levels per
EN 61326-1:1997 +
A2:2001, Table A.1

EMC/EMI ..... CE, C-Tick, and FCC Part 15 (Class A) Compliant

Note For EMC compliance, operate this device with double-shielded cabling.

FCC Compliance

Go to `ni.com/info` and enter `rdcriofcc` for information about using this product in compliance with FCC regulations.

CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

Low-Voltage Directive (safety)..... 73/23/EEC

Electromagnetic Compatibility Directive (EMC) 89/336/EEC

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain 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.

Calibration

You can obtain the calibration certificate for the cRIO-9233 at `ni.com/calibration`.

Calibration interval ..... 1 year

National Instruments Contact Information

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, contact your local branch office:

Australia 1800 300 800, Austria 43 0 662 45 79 90 0, Belgium 32 0 2 757 00 20, Brazil 55 11 3262 3599, Canada (Calgary) 403 274 9391, Canada (Ottawa) 613 233 5949, Canada (Québec) 450 510 3055, Canada (Toronto) 905 785 0085, Canada (Vancouver) 604 685 7530, China 86 21 6555 7838, Czech Republic 420 224 235 774, Denmark 45 45 76 26 00, Finland 385 0 9 725 725 11, France 33 0 1 48 14 24 24, Germany 49 0 89 741 31 30, India 91 80 51190000,

Israel 972 0 3 6393737, Italy 39 02 413091,
Japan 81 3 5472 2970, Korea 82 02 3451 3400,
Malaysia 603 9131 0918, Mexico 01 800 010 0793,
Netherlands 31 0 348 433 466, New Zealand 0800 553 322,
Norway 47 0 66 90 76 60, Poland 48 22 3390150,
Portugal 351 210 311 210, Russia 7 095 783 68 51,
Singapore 65 6226 5886, Slovenia 386 3 425 4200,
South Africa 27 0 11 805 8197, Spain 34 91 640 0085,
Sweden 46 0 8 587 895 00, Switzerland 41 56 200 51 51,
Taiwan 886 2 2528 7227, Thailand 662 992 7519,
United Kingdom 44 0 1635 523545

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