USER GUIDE AND SPECIFICATIONS

USB-9233

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

このドキュメントの日本語版については、ni.com/jp/manuals を参照してください。(For a Japanese language version, go to ni.com/jp/manuals.)

This guide describes how to use the National Instruments USB-9233 and lists the device specifications.

Introduction

The NI USB-9233 data acquisition device provides a USB interface for four channels of 24-bit analog inputs with integrated signal conditioning. The USB-9233 consists of two components: an NI 9233 module and a USB-9162 USB carrier, as shown in Figure 1.

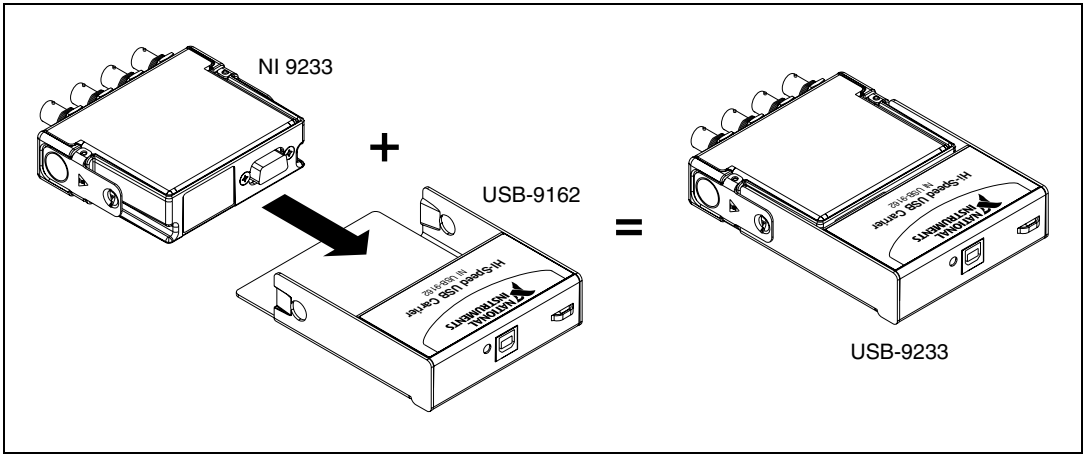


Figure 1. USB-9233 Components

Dimensions

Figure 2 shows the USB-9233 device dimensions.

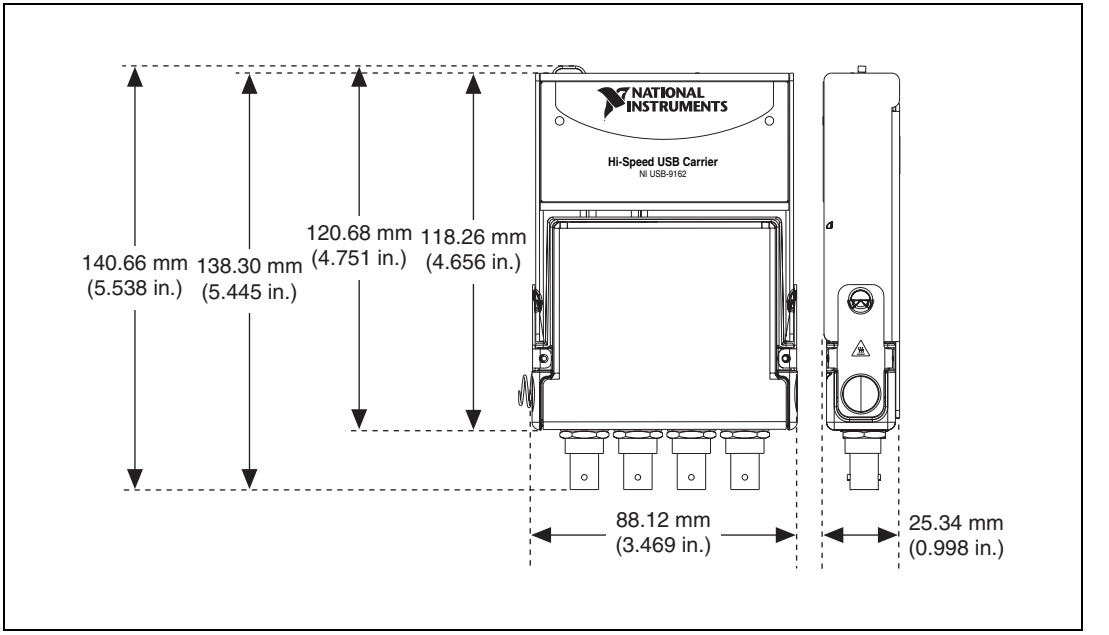


Figure 2. USB-9233 Device in Inches (Millimeters)

Safety Guidelines

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

Note Although the NI 9233 module may have more stringent certification standards than the USB-9233, when used with the USB-9162 carrier, the combined system may be limited. Refer to the *Specifications* section for more details.

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

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 and the area is known to be nonhazardous.

Caution The USB-9233 is not certified for use in hazardous locations.

Software

Software support for the USB-9233 is provided by NI-DAQmx.

The NI-DAQmx CD contains example programs that you can use to get started programming with the USB-9233. Refer to the *NI-DAQmx for USB Devices Getting Started Guide* that shipped with your device, and is also accessible from **Start»All Programs»National Instruments»NI-DAQ**, for more information.

Installing the USB-9233 Device

Installing the Software

Before installing the device, you must install the software you plan to use with the device. Refer to the *Software* section of this manual and the *NI-DAQmx for USB Devices Getting Started Guide* that shipped with your device, and is also accessible from **Start»All Programs»National Instruments»NI-DAQ**, for more information.

Installing the NI 9233 in the USB-9162 Carrier

The NI 9233 module and USB-9162 carrier are packaged separately. Refer to Figure 3, while completing the following assembly steps:

1. Make sure that no signals are connected to the NI 9233 module and that the USB cable is not connected to the device.
2. Remove the protective cover from the 15-pin DSUB connector.

3. Align the I/O module with the carrier, as shown in Figure 3.

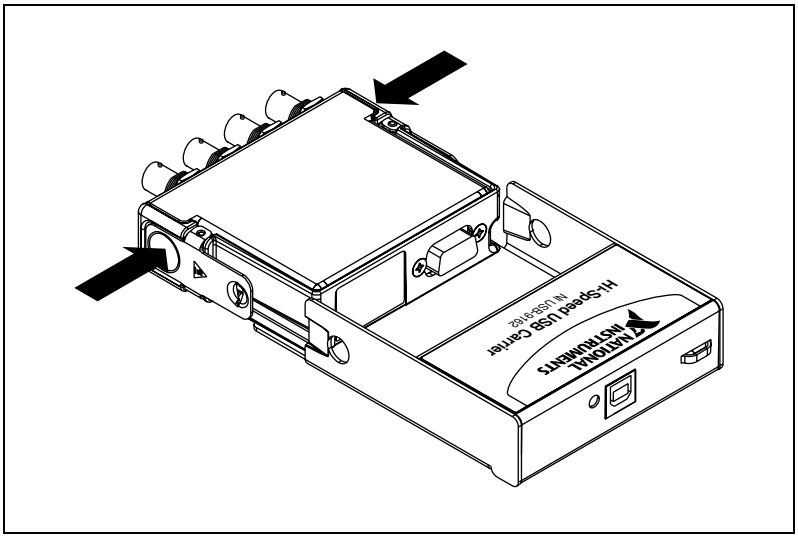


Figure 3. Module Installation

4. Squeeze the latches and insert the NI 9233 module into the USB-9162 carrier.
5. Press firmly on the connector side of the NI 9233 module until the latches lock the module into place, as shown in Figure 4.

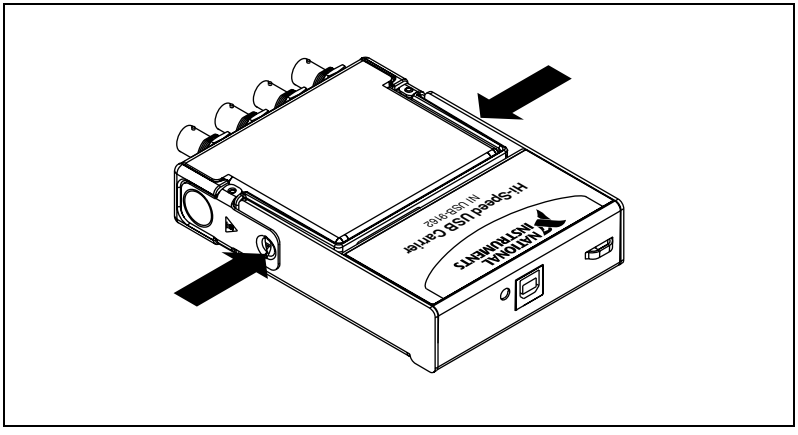


Figure 4. Locking Module into Place

6. Connect the USB cable to the assembled USB-9233.

Mounting the USB-9233 to a Panel

Threaded inserts are located in the USB-9233 for mounting it to a panel. Refer to Figure 5 for dimensions.

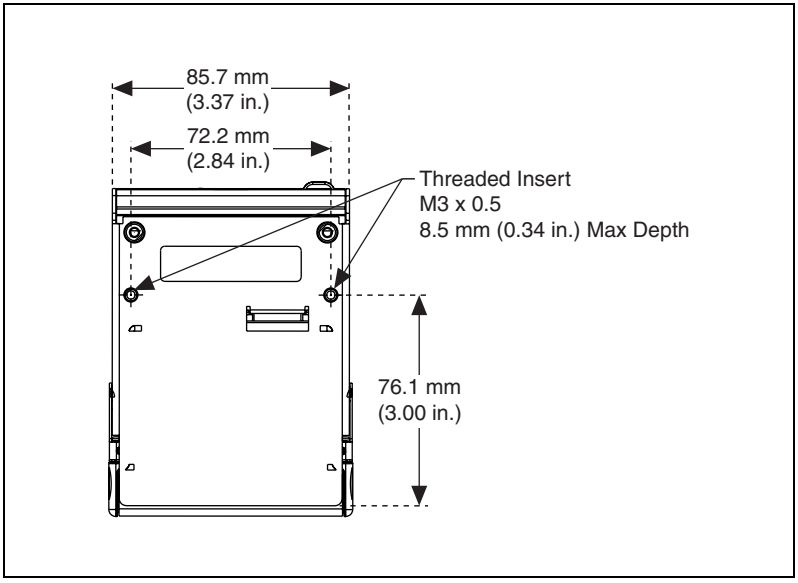


Figure 5. Module Dimensions

Connecting the USB-9233 to a Computer

Plug one end of the USB cable into the USB-9233 and the other end into an available USB port on the computer. Refer to the *NI-DAQmx for USB Devices Getting Started Guide* that shipped with your device, and is also accessible from **Start»All Programs»National Instruments»NI-DAQ**, for more information.

LED Indicator

The LED indicator indicates device status.

Table 1. LED State/Device Status

LED State	Device Status
Not lit	Device not connected or in suspend.
On, not blinking	Device connected, but no module installed.
Single-blink	Operating normally.

Table 1. LED State/Device Status (Continued)

LED State	Device Status
Double-blink	Connected to USB full speed. Device performance might be affected. Refer to the *Specifications* section for more information.
Quadruple-blink	Device error. Refer to `ni.com/support`.

Wiring the USB-9233

The USB-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 6 for the connector assignments for each channel.

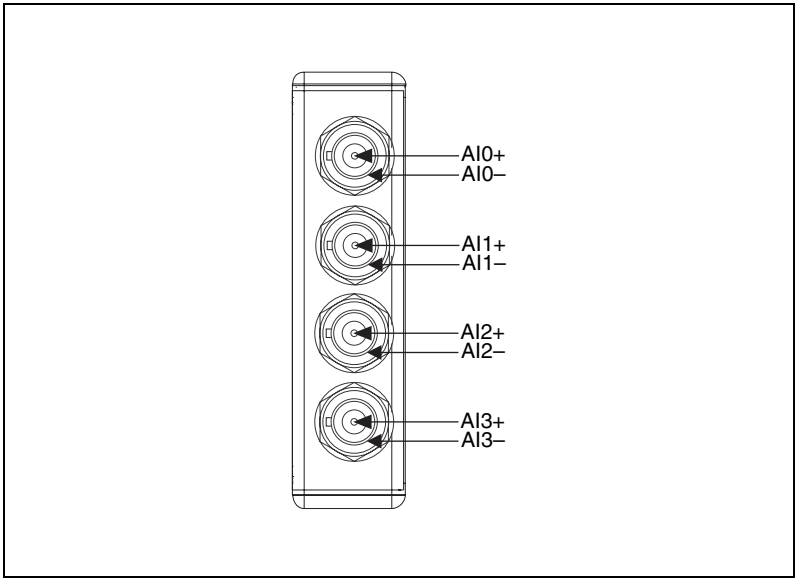


Figure 6. Connector Assignments

Connecting IEPE Sensors to the USB-9233

You can connect ground-referenced or floating IEPE sensors to the USB-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 USB-9233 results in a floating connection even though the case of the sensor is grounded.

If you make a ground-referenced connection between the IEPE sensor and the USB-9233, make sure the voltage on the AI– shell is in the common-mode range to ensure proper operation of the USB-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 7 and 8 illustrate connecting a grounded and floating IEPE sensor to the USB-9233.

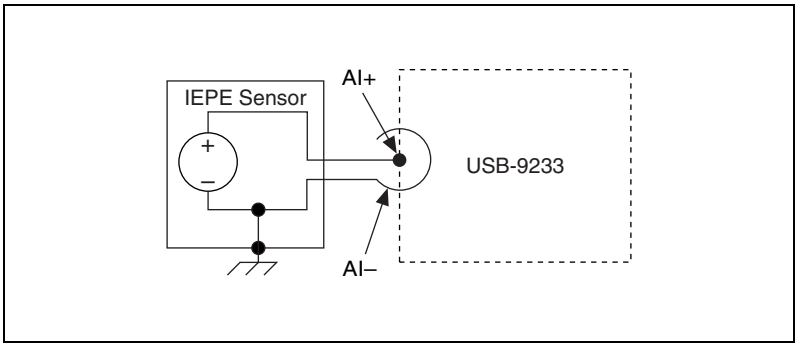


Figure 7. Connecting a Grounded IEPE Sensor to the USB-9233

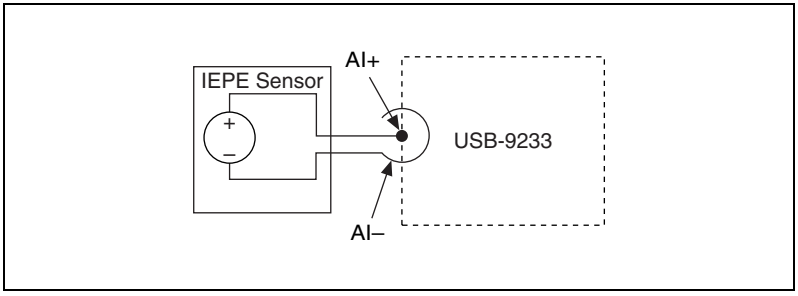


Figure 8. Connecting a Floating IEPE Sensor to the USB-9233

The USB-9233 analog input channels are referenced to chassis ground through a 50 Ω resistor. Because the chassis ground for the USB-9233 is provided through the USB cable, the grounding of the host computer can affect your measurement. Each channel is protected from overvoltages. The USB-9233 provides an IEPE excitation current for each input signal. The signal is AC coupled, buffered, and conditioned. The signal is then sampled by 24-bit ADCs. The USB-9233 IEPE excitation current and AC coupling are always enabled.

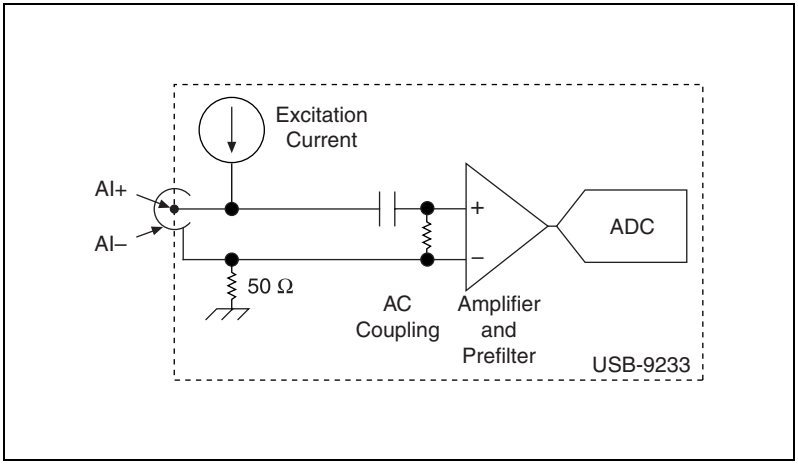


Figure 9. Input Circuitry for One Channel

Understanding USB-9233 Filtering

The USB-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 USB-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 USB-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 10 shows typical passband ripples for two different data rates.

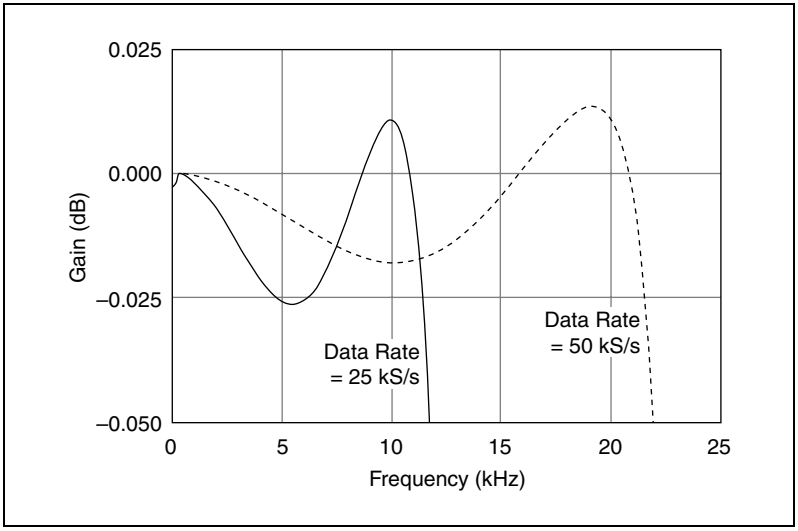


Figure 10. Typical Passband Response

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 11 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.

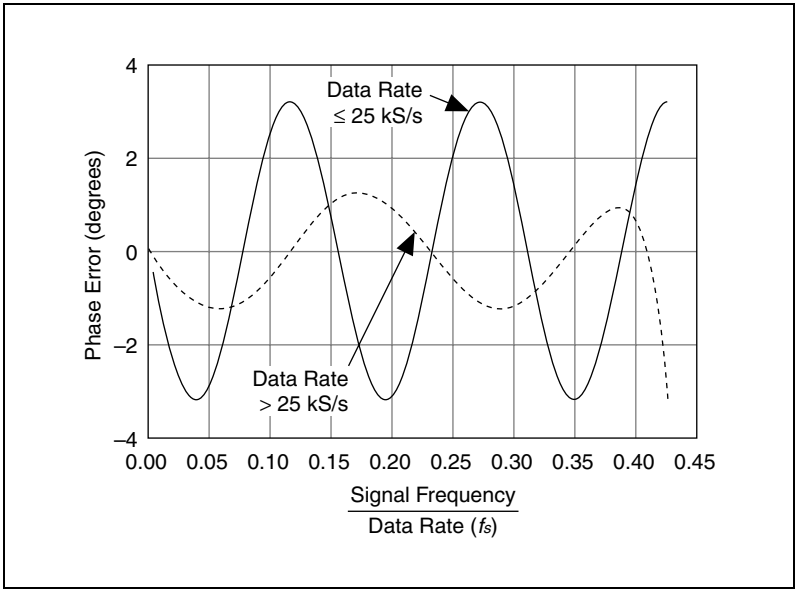


Figure 11. Phase Nonlinearity

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 USB-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.

Specifications

The following specifications are typical for the range 0 to 60 °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 rates (*fs*) available for the internal clock source (kS/s)[1]:

2.000	2.381	2.941	3.846	5.556	10.000	33.333
2.083	2.500	3.125	4.167	6.250	12.500	50.000
2.174	2.632	3.333	4.545	7.143	16.667	
2.273	2.778	3.571	5.000	8.333	25.000	

Master timebase (internal)

- Frequency..... 12.8 MHz
- Accuracy ..... ±100 ppm max

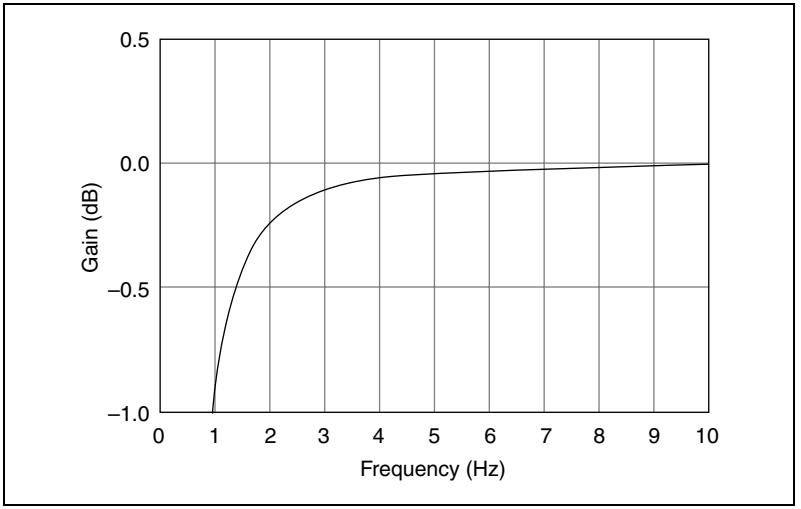
Input coupling ..... AC

AC cutoff frequency

- –3 dB..... 0.5 Hz typ
- –0.1 dB ..... 4.2 Hz max

AC cutoff frequency response

[1] Full performance requires the use of a USB 2.0 high speed host controller and USB 2.0 hubs.



AC voltage full-scale range

Typical.....±5.4 V_{peak}

Minimum.....±5 V_{peak}

Maximum.....±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.

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

where $V_{common\text{-}mode}$ is the common-mode voltage of the USB-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

≤25 kS/s ..... $12.8 \div f_s$

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

Accuracy (0 to 60 °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

	Passband			
f_s	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°

	Stopband		Oversample Rate	Alias-Free Bandwidth
f_s	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} ≤ 1 kHz

Typical.....80 dB, f_{in} ≤ 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, –0 to 55 °C	10 kHz, 25 to 55 °C	10 kHz, –0 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

Power Requirements

Current consumption from USB.....500 mA, max

Suspend mode.....2.5 mA, max

Bus Interface

USB specification .....USB 2.0 high speed

Physical Characteristics

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

Dimensions..... 14.1 cm × 8.6 cm × 2.5 cm
(5.55 in. × 3.37 in. × 0.99 in.)

Weight..... Approx. 275 g (9.7 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 USB-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

The USB-9233 is not certified for use in hazardous locations.

Environmental

The NI 9233 module is intended for indoor use only. For outdoor use, mount the system in a suitably rated enclosure.

Operating temperature
(IEC60068-2-1, IEC 60068-2-2)..... 0 to 60 °C

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

Ingress protection .....IP 30

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

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.

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 USB-9233 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, 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 800 433 3488, 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 41190000,
Israel 972 0 3 6393737, Italy 39 02 413091, Japan 81 3 5472 2970,
Korea 82 02 3451 3400, Lebanon 961 0 1 33 28 28,
Malaysia 1800 887710, 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 7 495 783 68 51,
Singapore 1800 226 5886, Slovenia 386 3 425 42 00,
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 02 2377 2222, Thailand 662 278 6777,
United Kingdom 44 0 1635 523545

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