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**USB-9162**

# USER GUIDE AND SPECIFICATIONS

# NI USB-9233

## 4-Channel, $\pm 5$ V, 24-Bit IEPE Analog Input Device

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

This user 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 NI USB-9233 consists of two components: an NI 9233 module and an NI USB-9162 carrier, as shown in Figure 1.

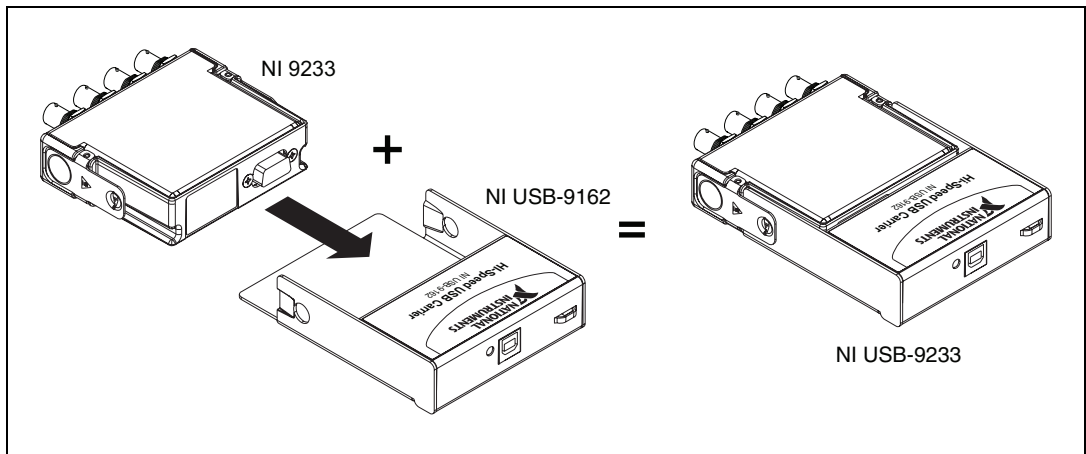


Figure 1. NI USB-9233 Components

# Dimensions

Figure 2 shows the NI USB-9233 device dimensions.

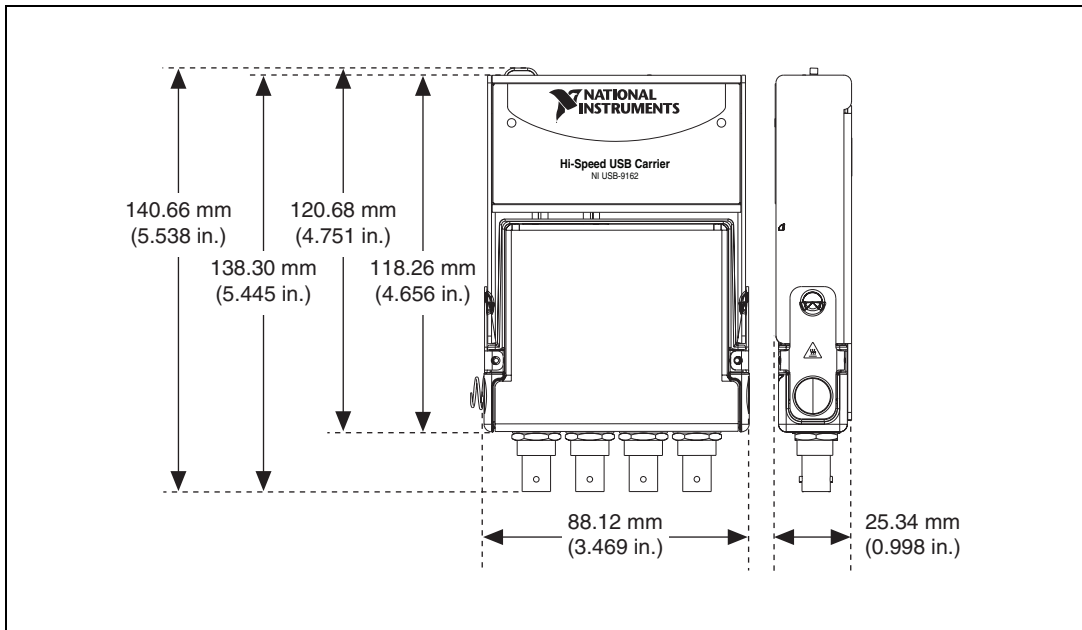


Figure 2. NI USB-9233 Device in Millimeters (Inches)

## Safety Guidelines

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



**Note** Although the NI 9233 module may have more stringent certification standards than the NI 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 NI USB-9233 is not certified for use in hazardous locations.

# Related Documentation

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Each application software package and driver includes information about writing applications for taking measurements and controlling measurement devices. The following references to documents assume you have NI-DAQmx 8.7 or later, and where applicable, version 7.1 or later of the NI application software.

## NI-DAQmx for Windows

The *DAQ Getting Started Guide* describes how to install your NI-DAQmx for Windows software, your NI-DAQmx-supported DAQ device, and how to confirm that your device is operating properly. Select **Start»All Programs»National Instruments»NI-DAQ»DAQ Getting Started Guide**.

The *NI-DAQ Readme* lists which devices are supported by this version of NI-DAQ. Select **Start»All Programs»National Instruments»NI-DAQ»NI-DAQ Readme**.

The *NI-DAQmx Help* contains general information about measurement concepts, key NI-DAQmx concepts, and common applications that are applicable to all programming environments. Select **Start»All Programs»National Instruments»NI-DAQ»NI-DAQmx Help**.

## LabVIEW

If you are a new user, use the *Getting Started with LabVIEW* manual to familiarize yourself with the LabVIEW graphical programming environment and the basic LabVIEW features you use to build data acquisition and instrument control applications. Open the *Getting Started with LabVIEW* manual by selecting **Start»All Programs»National Instruments»LabVIEW»LabVIEW Manuals** or by navigating to the `labview\manuals` directory and opening `LV_Getting_Started.pdf`.

Use the *LabVIEW Help*, available by selecting **Help»Search the LabVIEW Help** in LabVIEW, to access information about LabVIEW programming concepts, step-by-step instructions for using LabVIEW, and reference information about LabVIEW VIs, functions, palettes, menus, and tools. Refer to the following locations on the Contents tab of the *LabVIEW Help* for information about NI-DAQmx:

- **Getting Started»Getting Started with DAQ**—Includes overview information and a tutorial to learn how to take an NI-DAQmx measurement in LabVIEW using the DAQ Assistant.
- **VI and Function Reference»Measurement I/O VIs and Functions**—Describes the LabVIEW NI-DAQmx VIs and properties.

- **Taking Measurements**—Contains the conceptual and how-to information you need to acquire and analyze measurement data in LabVIEW, including common measurements, measurement fundamentals, NI-DAQmx key concepts, and device considerations.

## LabWindows/CVI

The **Data Acquisition** book of the *LabWindows/CVI Help* contains measurement concepts for NI-DAQmx. This book also contains *Taking an NI-DAQmx Measurement in LabWindows/CVI*, which includes step-by-step instructions about creating a measurement task using the DAQ Assistant. In LabWindows™/CVI™, select **Help»Contents**, then select **Using LabWindows/CVI»Data Acquisition**.

The **NI-DAQmx Library** book of the *LabWindows/CVI Help* contains API overviews and function reference for NI-DAQmx. Select **Library Reference»NI-DAQmx Library** in the *LabWindows/CVI Help*.

## Measurement Studio

If you program your NI-DAQmx-supported device in Measurement Studio using Visual C++, Visual C#, or Visual Basic .NET, you can interactively create channels and tasks by launching the DAQ Assistant from MAX or from within Visual Studio .NET. You can generate the configuration code based on your task or channel in Measurement Studio. Refer to the *DAQ Assistant Help* for additional information about generating code. You also can create channels and tasks, and write your own applications in your ADE using the NI-DAQmx API.

For help with NI-DAQmx methods and properties, refer to the NI-DAQmx .NET Class Library or the NI-DAQmx Visual C++ Class Library included in the *NI Measurement Studio Help*. For general help with programming in Measurement Studio, refer to the *NI Measurement Studio Help*, which is fully integrated with the Microsoft Visual Studio .NET help. To view this help file in Visual Studio .NET, select **Measurement Studio»NI Measurement Studio Help**.

To create an application in Visual C++, Visual C#, or Visual Basic .NET, follow these general steps:

1. In Visual Studio .NET, select **File»New»Project** to launch the New Project dialog box.
2. Find the Measurement Studio folder for the language you want to create a program in.
3. Choose a project type. You add DAQ tasks as a part of this step.

## ANSI C without NI Application Software

The *NI-DAQmx Help* contains API overviews and general information about measurement concepts. Select **Start»All Programs»National Instruments»NI-DAQ»NI-DAQmx Help**.

The *NI-DAQmx C Reference Help* describes the NI-DAQmx Library functions, which you can use with National Instruments data acquisition devices to develop instrumentation, acquisition, and control applications. Select **Start»All Programs»National Instruments»NI-DAQ»NI-DAQmx C Reference Help**.

## .NET Languages without NI Application Software

With the Microsoft .NET Framework version 1.1 or later, you can use NI-DAQmx to create applications using Visual C# and Visual Basic .NET without Measurement Studio. You need Microsoft Visual Studio .NET 2003 or Microsoft Visual Studio 2005 for the API documentation to be installed.

The installed documentation contains the NI-DAQmx API overview, measurement tasks and concepts, and function reference. This help is fully integrated into the Visual Studio .NET documentation. To view the NI-DAQmx .NET documentation, go to **Start»Programs»National Instruments»NI-DAQ»NI-DAQmx .NET Reference Help**. Expand **NI Measurement Studio Help»NI Measurement Studio .NET Class Library»Reference** to view the function reference. Expand **NI Measurement Studio Help»NI Measurement Studio .NET Class Library»Using the Measurement Studio .NET Class Libraries** to view conceptual topics for using NI-DAQmx with Visual C# and Visual Basic .NET.

To get to the same help topics from within Visual Studio, go to **Help»Contents**. Select **Measurement Studio** from the **Filtered By** drop-down list and follow the previous instructions.

## Device Documentation and Specifications

NI-DAQmx includes the Device Document Browser, which contains online documentation for supported DAQ, SCXI, and switch devices, such as help files describing device pinouts, features, and operation, and PDF files of the printed device documents. You can find, view, and/or print the documents for each device using the Device Document Browser at any time by inserting the CD. After installing the Device Document Browser, device documents are accessible from **Start»All Programs»National Instruments»NI-DAQ»Browse Device Documentation**.



**Note** You can also download these documents at [ni.com/manuals](http://ni.com/manuals).

## Training Courses

If you need more help getting started developing an application with NI products, NI offers training courses. To enroll in a course or obtain a detailed course outline, refer to [ni.com/training](http://ni.com/training).

## Technical Support on the Web

For additional support, refer to [ni.com/support](http://ni.com/support) or [zone.ni.com](http://zone.ni.com).

## Installing the Software

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Software support for the NI USB-9233 for Windows Vista/XP/2000 is provided by NI-DAQmx. The *DAQ Getting Started Guide*, which you can download at [ni.com/manuals](http://ni.com/manuals), offers NI-DAQmx users step-by-step instructions for installing software and hardware, configuring channels and tasks, and getting started developing an application.

## Installing Other Software

If you are using other software, refer to the installation instructions that accompany your software.

## Example Programs

The NI-DAQmx CD contains example programs that you can use to get started programming with the NI 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 NI USB-9233 Device

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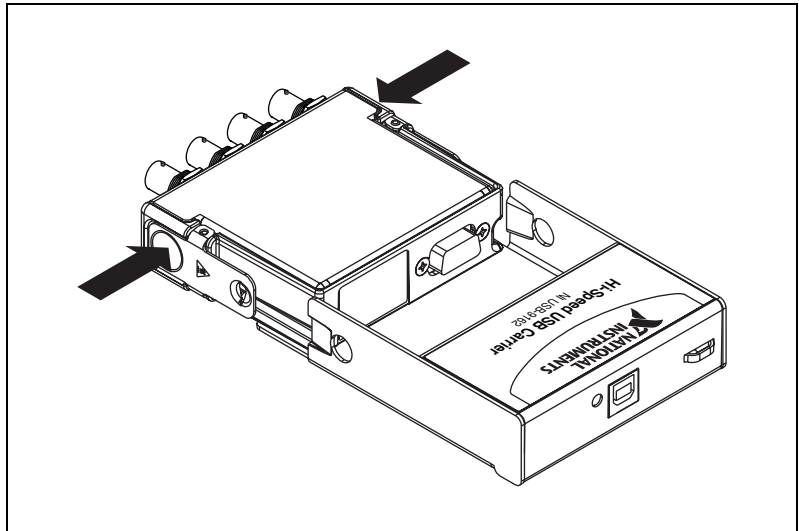
Before installing the device, you must install the software you plan to use with the device. Refer to the *Installing the Software* section of this guide and the documentation included with the software for more information.

## Installing the NI 9233 in the NI USB-9162 Carrier

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

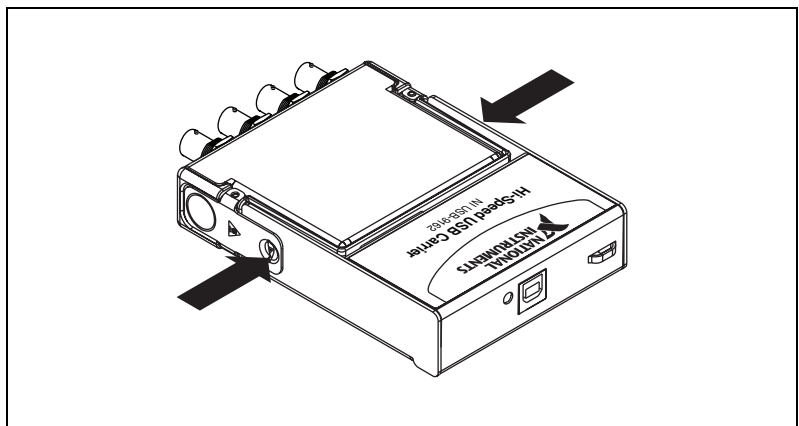
1. Make sure that no signals are connected to the NI 9233 module and that the USB cable is not connected to the device.
2. Remove the protective cover from the 15-pin D-SUB connector.

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 NI 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



## Mounting the NI USB-9233 to a Panel

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

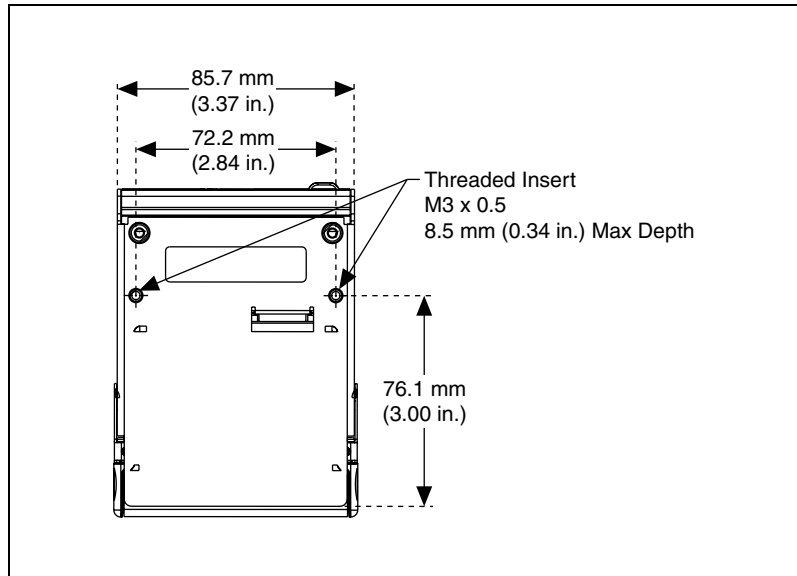


Figure 5. Module Dimensions in Millimeters (Inches)

## Connecting the NI USB-9233 to a Computer

Plug one end of the USB cable into the NI 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 NI USB-9233 device has a green LED next to the USB connector. The LED indicator indicates device status, as listed in Table 1. When the device is connected to a USB port, the LED blinks steadily to indicate that the device is initialized and is receiving power from the connection.

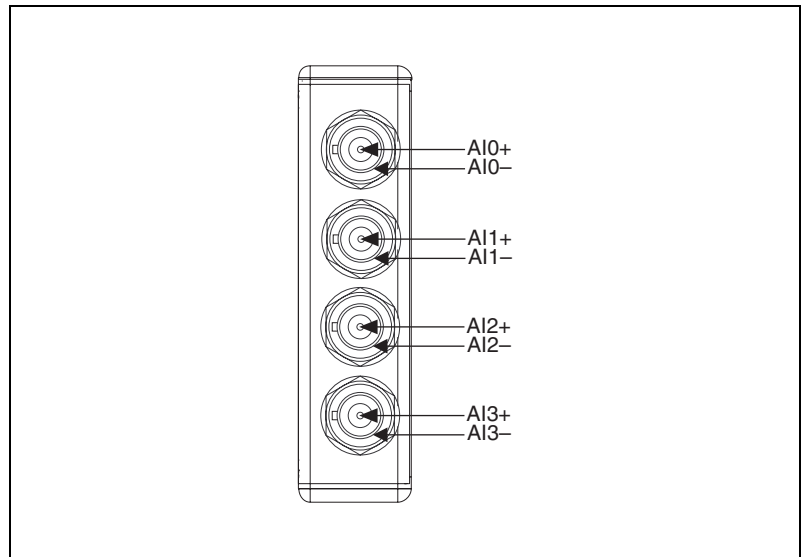
If the LED is not blinking, it may mean that the device is not initialized or the computer is in standby mode. In order for the device to be recognized, the device must be connected to a computer that has NI-DAQmx installed on it. If your device is not blinking, make sure your computer has the latest version of NI-DAQmx installed on it, and the computer is not in standby mode.

**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.
Double-blink	Connected to USB Full-Speed port. Device performance might be affected. Refer to the <a href="#">Specifications</a> section for more information.
Quadruple-blink	Device error. Refer to <a href="http://ni.com/support">ni.com/support</a> .

## Wiring the NI USB-9233 Device

The NI 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.

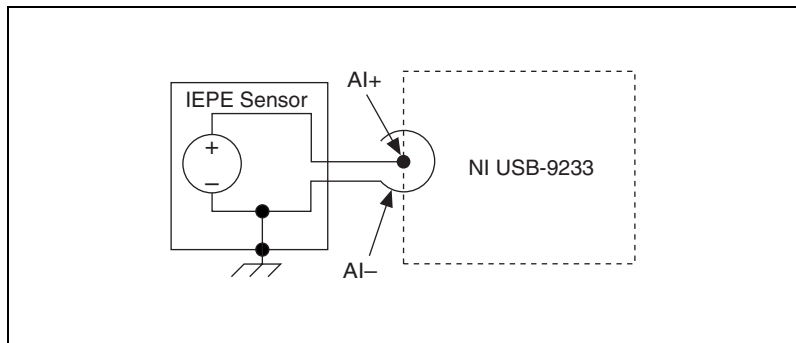


**Figure 6.** Connector Assignments

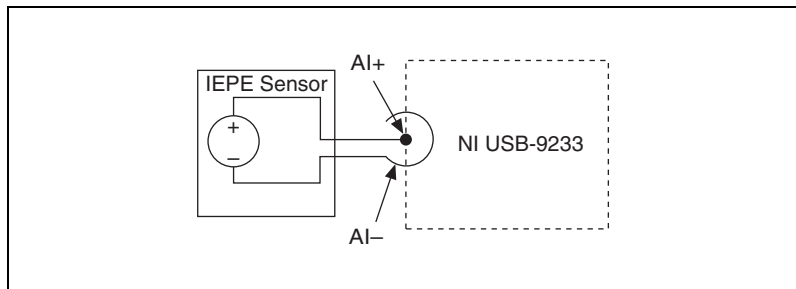
## Connecting IEPE Sensors to the NI USB-9233

You can connect ground-referenced or floating IEPE sensors to the NI 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 NI 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 NI USB-9233, make sure the voltage on the AI- shell is in the common-mode range to ensure proper operation of the NI 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 NI USB-9233.



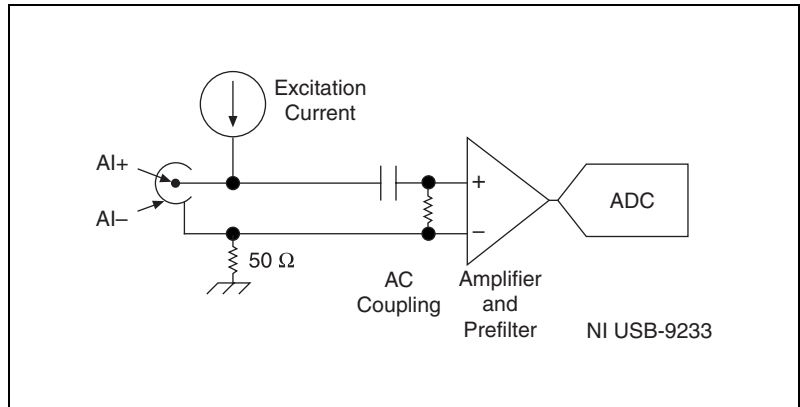
**Figure 7.** Connecting a Grounded IEPE Sensor to the NI USB-9233



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

# NI USB-9233 Circuitry

The NI USB-9233 analog input channels are referenced to chassis ground through a  $50\ \Omega$  resistor. Because the chassis ground for the NI 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 NI 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 NI USB-9233 IEPE excitation current and AC coupling are always enabled.



**Figure 9.** Input Circuitry for One Channel

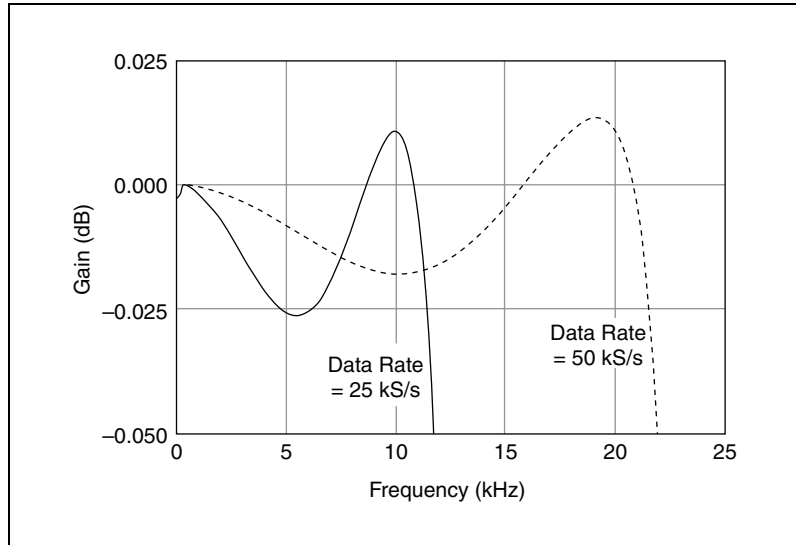
## Understanding NI USB-9233 Filtering

The NI 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 NI 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.

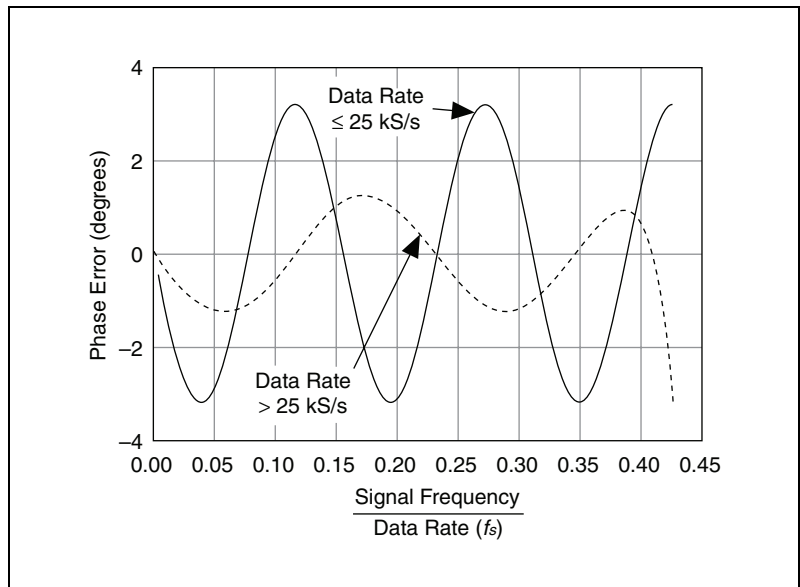
## Passband

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 NI 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 NI 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

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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 (*f<sub>s</sub>*) available for the internal clock source (kS/s)<sup>1</sup>:

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

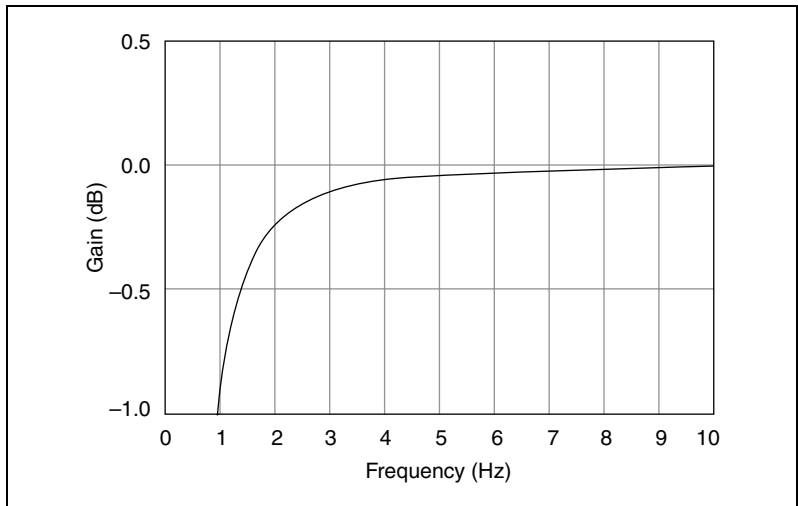
    –3 dB .....0.5 Hz typ

    –0.1 dB .....4.2 Hz max

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<sup>1</sup> Full performance requires the use of a USB 2.0 Hi-Speed host controller and USB 2.0 hubs.

### AC cutoff frequency response



### AC voltage full-scale range

Typical .....	$\pm 5.4 V_{\text{peak}}$
Minimum .....	$\pm 5 V_{\text{peak}}$
Maximum .....	$\pm 5.8 V_{\text{peak}}$

### Common-mode voltage

(AI- to earth ground) .....  $\pm 2 V$

### 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.

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

where

$V_{\text{common-mode}}$  is the common-mode voltage of the NI USB-9233,

$V_{\text{bias}}$  is the bias voltage of the accelerometer, and

$V_{\text{full-scale}}$  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 ÷  $f_s$

>25 kS/s.....9.8 ÷  $f_s$

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) ..... $f_{in} \cdot 0.077^\circ + 0.067^\circ$

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/ $\sqrt{\text{Hz}}$	400 nV/ $\sqrt{\text{Hz}}$	900 nV/ $\sqrt{\text{Hz}}$

### Input impedance

Differential (AC)..... >300 k $\Omega$

AI- (shield) to chassis ground ..... 50  $\Omega$

### 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 Hi-Speed

## Physical Characteristics

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

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

### 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 NI 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, CSA 61010-1



**Note** For UL and other safety certifications, refer to the product label or visit [ni.com/certification](http://ni.com/certification), search by model number or product line, and click the appropriate link in the Certification column.

### Hazardous Locations

The NI 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

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

- EN 61326 EMC requirements; Minimum Immunity
- EN 55011 Emissions; Group 1, Class A
- CE, C-Tick, ICES, and FCC Part 15 Emissions; Class A



**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:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)



**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](http://ni.com/certification), search by model number or product line, and click the appropriate link in the Certification column.

# Environmental Management

National Instruments is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial not only to the environment but also to NI customers.

For additional environmental information, refer to the *NI and the Environment* Web page at [ni.com/environment](http://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 their life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers and National Instruments WEEE initiatives, visit [ni.com/environment/weee.htm](http://ni.com/environment/weee.htm).

## 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](http://ni.com/environment/rohs_china)。(For information about China RoHS compliance, go to [ni.com/environment/rohs\\_china](http://ni.com/environment/rohs_china).)

# Calibration

You can obtain the calibration certificate for the NI USB-9233 at [ni.com/calibration](http://ni.com/calibration).

Calibration interval ..... 1 year

# Where to Go for Support

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The National Instruments Web site is your complete resource for technical support. At [ni.com/support](http://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](http://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 43 662 457990-0,  
Belgium 32 (0) 2 757 0020, Brazil 55 11 3262 3599,  
Canada 800 433 3488, China 86 21 5050 9800,  
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