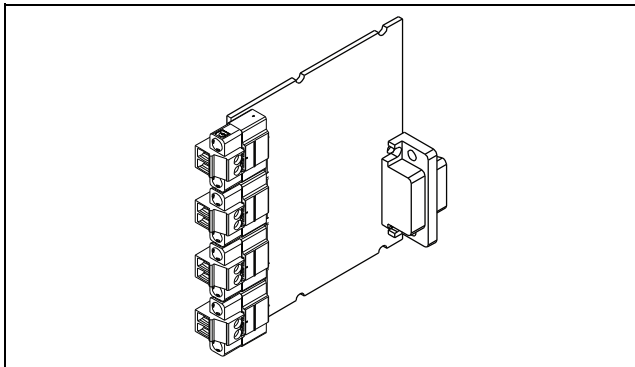


# OPERATING INSTRUCTIONS AND SPECIFICATIONS

## NI 9227E

4-Channel, 5 A<sub>rms</sub>, 24-Bit, Simultaneous,  
Channel-to-Channel Isolated Analog Input Module



This document describes how to use the National Instruments 9227E and includes dimensions, terminal assignments, and specifications for the NI 9227E. Visit [ni.com/info](http://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](http://ni.com/info) and enter `cseriesdoc` for information about C Series documentation.



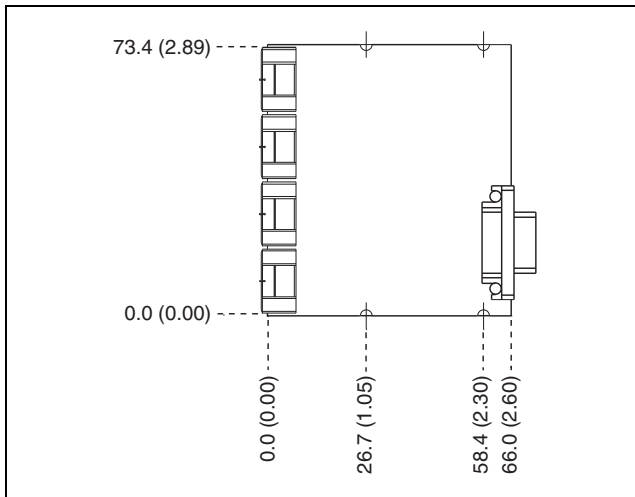
**Caution** National Instruments makes no electromagnetic compatibility (EMC) or CE marking compliance claims for the NI 9227E. The end-product supplier is responsible for conformity to any and all compliance requirements.



**Caution** The NI 9227E must be installed inside a suitable enclosure prior to use. Hazardous voltages may be present.

# NI 9227E Dimensions

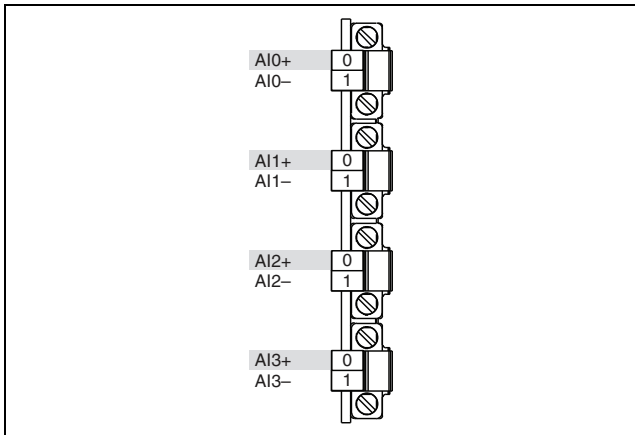
The following figure shows the dimensions of the NI 9227E.



**Figure 1.** NI 9227E Dimensions in Millimeters (Inches)

## Connecting the NI 9227E

The NI 9227E has four 2-terminal detachable screw-terminal connectors that provide connections for four simultaneously sampled, isolated analog input channels.



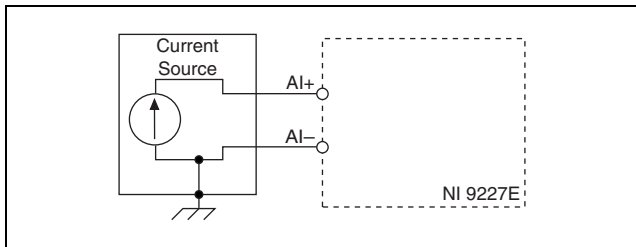
**Figure 2.** NI 9227E Terminal Assignments

You can connect ground-referenced or floating current sources to the NI 9227E. Connect the positive side of the current source to the AI+ terminal, and connect the negative side of the current source to the AI- terminal. If you make a ground-referenced connection between the current source and the NI 9227E, make sure the voltage on the AI+ and AI- connections are in the channel-to-earth safety voltage range to ensure proper operation of the NI 9227E. Refer to the *Specifications* section for more information about operating voltages.

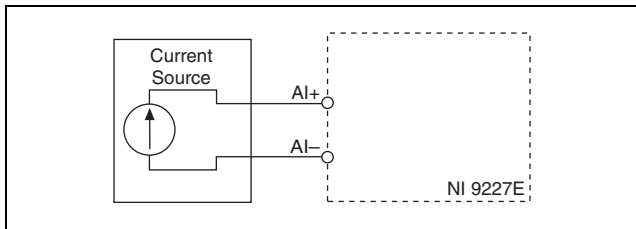


**Note** You must use 2-wire ferrules to create a secure connection when connecting more than one wire to a single terminal on the NI 9227E.

Refer to Figures 3 and 4 for illustrations of how to connect grounded and floating current sources to the NI 9227E.



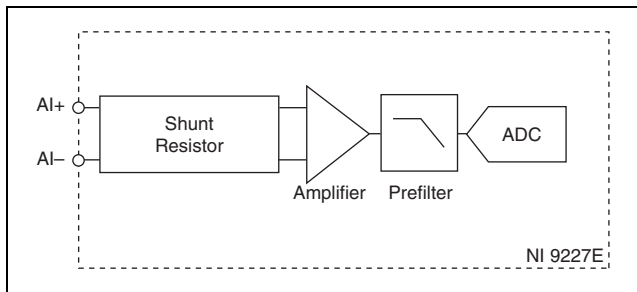
**Figure 3.** Connecting a Grounded Current Source to the NI 9227E



**Figure 4.** Connecting a Floating Current Source to the NI 9227E

The NI 9227E analog input channels are floating with respect to earth ground and each other. The incoming analog signal on each channel is conditioned, buffered, and then sampled by a 24-bit Delta-Sigma ADC.

Each channel provides an independent signal path and ADC, enabling you to sample all four channels simultaneously. Refer to Figure 5 for an illustration of the circuitry for one channel of the NI 9227E.



**Figure 5.** Input Circuitry for One Channel of the NI 9227E

# Understanding NI 9227E Filtering

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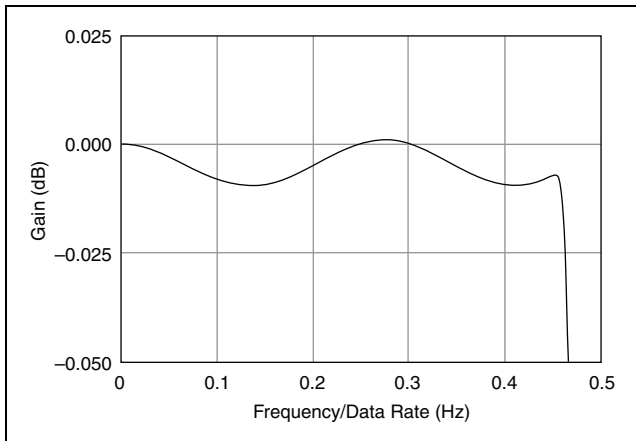
The NI 9227E uses a combination of analog and digital filtering to provide an accurate representation of in-band signals while rejecting out-of-band signals. The filters discriminate between signals based on the frequency range, or bandwidth, of the signal. The three important bandwidths to consider are the passband, the stopband, and the alias-free bandwidth.

The NI 9227E 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 9227E 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 6 shows typical passband flatness for the NI 9227E.





**Figure 6.** Typical Passband Flatness for the NI 9227E

## 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 9227E 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 9227E Data Rates

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The frequency of a master timebase ( $f_M$ ) controls the data rate ( $f_s$ ) of the NI 9227E. The NI 9227E includes an internal master timebase with a frequency of 12.8 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 9227E 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 9227E. Visit [ni.com/info](http://ni.com/info) and enter `cseriesdoc` for information about C Series documentation.

The following equation provides the available data rates of the NI 9227E:

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

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 12.8 MHz, the result is data rates of 50 kS/s, 25 kS/s, 16.667 kS/s, and so on down to 1.613 kS/s, depending on the value of  $n$ . When using an external timebase with a frequency other than 12.8 MHz, the NI 9227E has a different set of data rates.



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

## Sleep Mode

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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](http://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

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The following specifications are typical for the range  $-40$  to  $85$  °C internal to any enclosures unless otherwise noted. All voltages are relative to the AI- signal on each channel 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
Internal master timebase ( $f_M$ )	
Frequency .....	12.8 MHz
Accuracy .....	$\pm 100$ ppm max

Data rate range ( $f_s$ ) using internal master timebase

Minimum..... 1.613 kS/s

Maximum ..... 50 kS/s

Data rate range ( $f_s$ ) using external master timebase

Minimum..... 390.625 S/s

Maximum ..... 51.2 kS/s

Data rates<sup>1</sup> ( $f_s$ ) .....  $\frac{f_M \div 256}{n}$ ,  $n = 1, 2, \dots, 31$

Safe operating input range<sup>2</sup> .....  $5 A_{\text{rms}}$

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<sup>1</sup> The data rate must remain within the appropriate data rate range. Refer to the [Understanding NI 9227E Data Rates](#) section for more information.

<sup>2</sup> The maximum recommended continuous RMS current value applied simultaneously on all four channels to keep the power dissipation inside the module within safe operating limits.

Overcurrent handling <sup>1</sup> .....	10 A <sub>rms</sub> for 1 s max with 19 s minimum cool down time at 5 A <sub>rms</sub>
Instantaneous measuring range <sup>2</sup>	
Minimum .....	14.051 A peak
Typical .....	14.977 A peak, at 23 ±5 °C
Typical scaling coefficient .....	1.785397 μA/LSB
Input coupling .....	DC
Input impedance (AI+ to AI-) .....	12 mΩ
Input noise ( $f_s = 50$ kS/s) .....	400 μA <sub>rms</sub>

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<sup>1</sup> Overcurrent conditions to keep the module operating within specified limits.

<sup>2</sup> The maximum DC current that produces a non-saturated reading.

### Accuracy at safe operating range of 5 A<sub>rms</sub>

<b>Measurement Conditions</b>	<b>Percent of Reading (Gain Error)</b>	<b>Percent of Range* (Offset Error)</b>
Calibrated max (-40 to 85 °C)	±0.37%	±0.18%
Calibrated typ (23 °C, ±5 °C)	±0.1%	±0.05%
Uncalibrated max (-40 to 85 °C)	±5.0%	±2.4%
Uncalibrated typ (23 °C, ±5 °C)	±2.5%	±1.0%
* Range equals 7.07 A peak (5 A <sub>rms</sub> ).		

### Accuracy at operating range of 10 A<sub>rms</sub>

<b>Measurement Conditions</b>	<b>Percent of Reading (Gain Error)</b>	<b>Percent of Range* (Offset Error)</b>
Calibrated max (-40 to 85 °C)	±0.38%	±0.19%
* Range equals 7.07 A peak (5 A <sub>rms</sub> ).		



## Stability

Gain drift .....  $\pm 21$  ppm/ $^{\circ}\text{C}$

Offset drift .....  $\pm 51$   $\mu\text{A}/^{\circ}\text{C}$

## Post calibration gain match

(channel-to-channel,  $f_{in} = 20$  kHz)....  $\pm 130$  mdB max

## Crosstalk

( $f_{in} = 1$  kHz) .....  $-90$  dB

( $f_{in} = 50$  Hz) .....  $-115$  dB

## Phase match

Channel-to-channel, max .....  $0.1^{\circ}/\text{kHz}$

Module-to-module, max .....  $0.1^{\circ}/\text{kHz} + 360^{\circ} \cdot f_{in}/f_M$

Phase linearity ( $f_s = 50$  kS/s) .....  $0.1^{\circ}$  max

Input delay .....  $38.4/f_s + 3.2$   $\mu\text{s}$

## Passband

Frequency .....  $0.453 \cdot f_s$

Flatness ( $f_s = 50$  kS/s) .....  $\pm 100$  mdB max

## Stopband

Frequency .....	$0.547 \cdot f_s$
Rejection.....	100 dB
Alias-free bandwidth .....	$0.453 \cdot f_s$
-3 dB bandwidth ( $f_s = 50$ kS/s) .....	24.609 kHz
CMRR ( $f_{in} = 50$ Hz) .....	150 dB
SFDR ( $f_{in} = 1$ kHz, -60 dBFS).....	110 dB
Total Harmonic Distortion (THD) ( $f_{in} = 1$ kHz, -1 dBFS).....	-95 dB
MTBF .....	Contact NI for Bellcore MTBF or MIL-HDBK-217F specifications.

## Power Requirements

### Power consumption from chassis

Active mode .....	730 mW max
Sleep mode .....	50 $\mu$ W max

## Thermal dissipation (at 85 °C)<sup>1</sup>

Active mode .....	1.23 W max
Sleep mode .....	500 mW 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](http://ni.com/dimensions) and search by module number.

Screw-terminal wiring .....	16 to 28 AWG copper conductor wire with 7 mm (0.28 in.) of insulation stripped from the end
Torque for screw terminals .....	0.22 to 0.25 N · m (1.95 to 2.21 lb · in.)

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<sup>1</sup> Measured with 5 A<sub>rms</sub> on each channel.

Ferrules .....	0.25 mm <sup>2</sup> to 0.5 mm <sup>2</sup>
Weight.....	47 g (1.7 oz)

## Safety

### Isolation Voltages

Connect only voltages that are within the following limits.

#### Channel-to-channel

Continuous .....	250 V <sub>rms</sub> , Measurement Category II, (Basic insulation)
Withstand.....	1,390 V <sub>rms</sub> , verified by a 5 s dielectric withstand test

#### Channel-to-earth ground

Continuous .....	250 V <sub>rms</sub> , Measurement Category II, (Double insulation)
Withstand.....	2,300 V <sub>rms</sub> , verified by a 5 s dielectric withstand test

Measurement Category II is for measurements performed on circuits directly connected to the electrical distribution system. This category refers to local-level electrical distribution, such as that provided by a standard wall outlet, for example, 115 V for U.S. or 230 V for Europe.



**Caution** Do *not* connect the NI 9227E to signals or use for measurements within Measurement Categories 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](http://ni.com/certification), search by model number or product line, and click the appropriate link in the Certification column.

## Environmental

National Instruments C Series modules are intended for indoor use only but may be used outdoors if installed in a suitable enclosure. 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 to 85 °C

Storage temperature

(IEC 60068-2-1, IEC 60068-2-2) ..... -40 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

Maximum altitude.....2,000 m

Pollution Degree .....2

## 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 *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 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](http://ni.com/environment/weee).

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## Calibration

You can obtain the calibration certificate and information about calibration services for the NI 9227E 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, visit the Worldwide Offices section of [ni.com/niglobal](http://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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