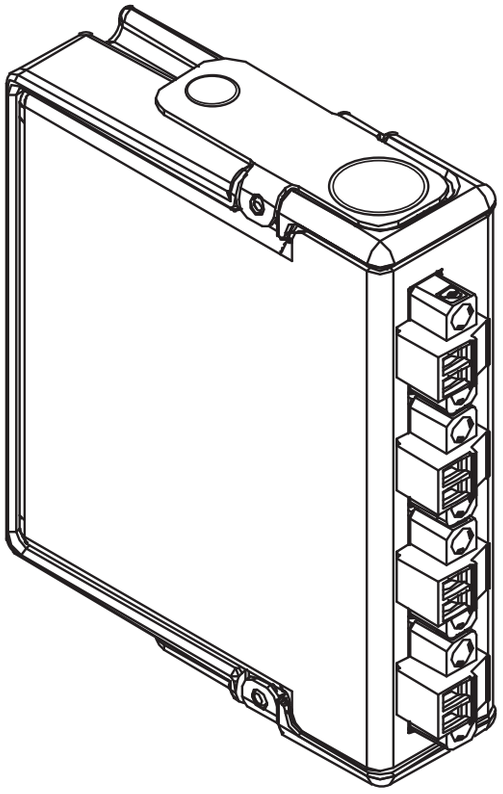
OPERATING INSTRUCTIONS AND SPECIFICATIONS

NI 9227

4-Channel, 5 A_{rms}, 24-Bit, Simultaneous, Channel-to-Channel Isolated Analog Input Module

Français Deutsch 日本語 한국어 简体中文

ni.com/manuals

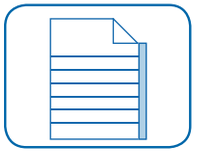


NATIONAL INSTRUMENTS™

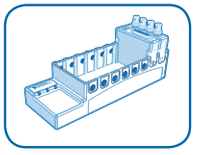
This document describes how to use the National Instruments 9225 and includes specifications and pin assignments for the NI 9225.

Note The safety guidelines and specifications in this document are specific to the NI 9225. The other components in the system might not meet the same safety ratings and specifications. Refer to the documentation for each component in the system to determine the safety ratings and specifications for the entire system.

Related Information



NI CompactDAQ & NI CompactRIO Documentation
ni.com/info ⇨ cseriesdoc



Chassis Compatibility
ni.com/info ⇨ compatibility

Software Support
ni.com/info ⇨ softwareversion

Services
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Safety Guidelines

Operate the NI 9227 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.

Hazardous Voltage This icon denotes a warning advising you to take precautions to avoid electrical shock.

Caution Do not operate the NI 9242 in a manner not specified in this manual. 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.

Safety Guidelines for Hazardous Voltages

If hazardous voltages are connected to the module, take the following precautions. A hazardous voltage is a voltage greater than 42.4 V_{pk} or 60 VDC to earth ground.

Caution Ensure that hazardous voltage wiring is performed only by qualified personnel adhering to local electrical standards.

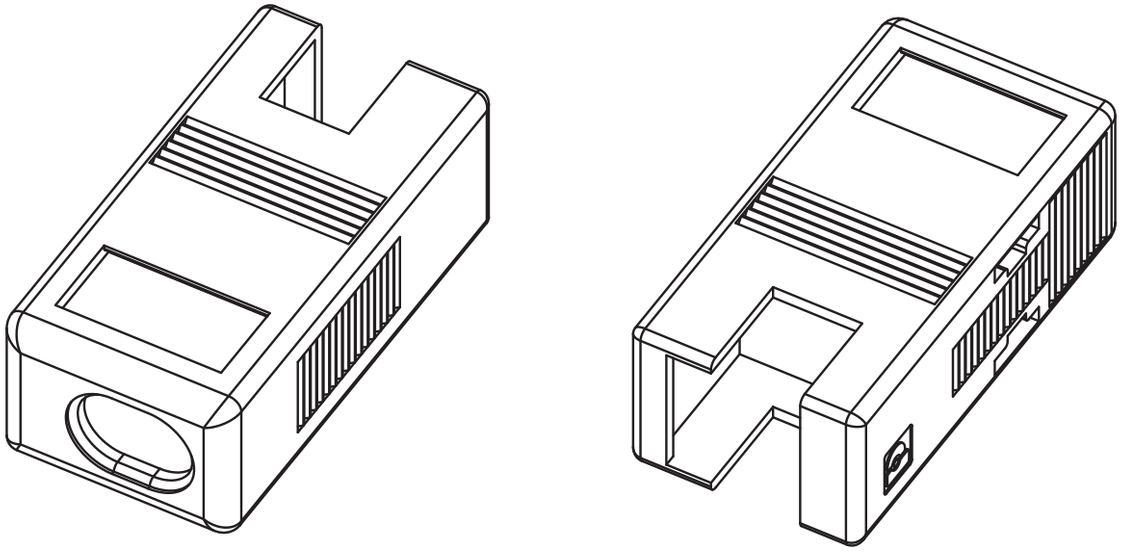
Caution Do *not* mix hazardous voltage circuits and human-accessible circuits on the same module.

Caution Make sure that devices and circuits connected to the module are properly insulated from human contact.

Caution When module terminals are hazardous voltage LIVE (>42.4 V_{pk}/60 VDC), you must ensure that devices and circuits connected to the module are properly insulated from human contact. You must use the NI 9971 connector backshell kit to ensure that the terminals are *not* accessible.

Figure 1 shows the NI 9971 connector backshell.

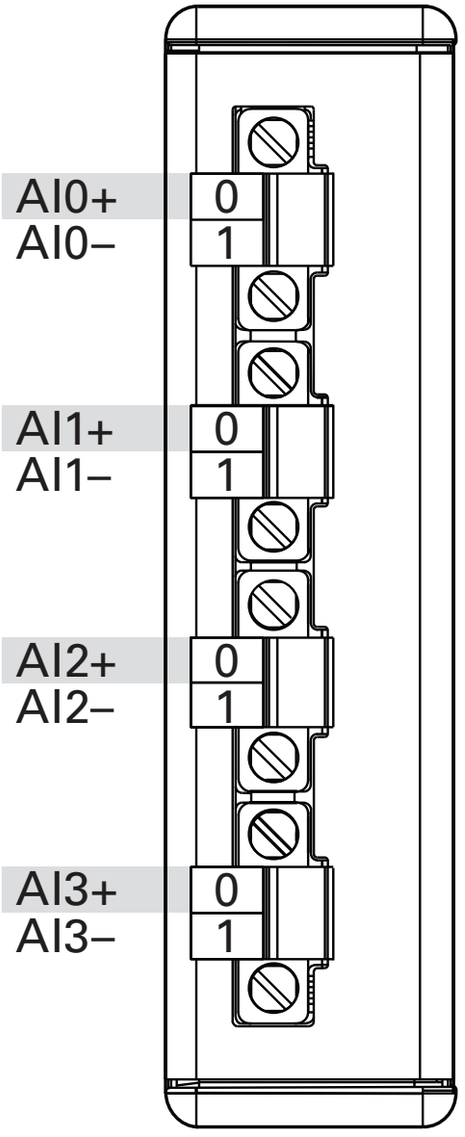
Figure 1. NI 9971 Connector Backshell



Connecting the NI 9227

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

Figure 2. NI 9227 Terminal Assignments



You can connect ground-referenced or floating current sources to the NI 9227. 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 9227, 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 9227. 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 9227.

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

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

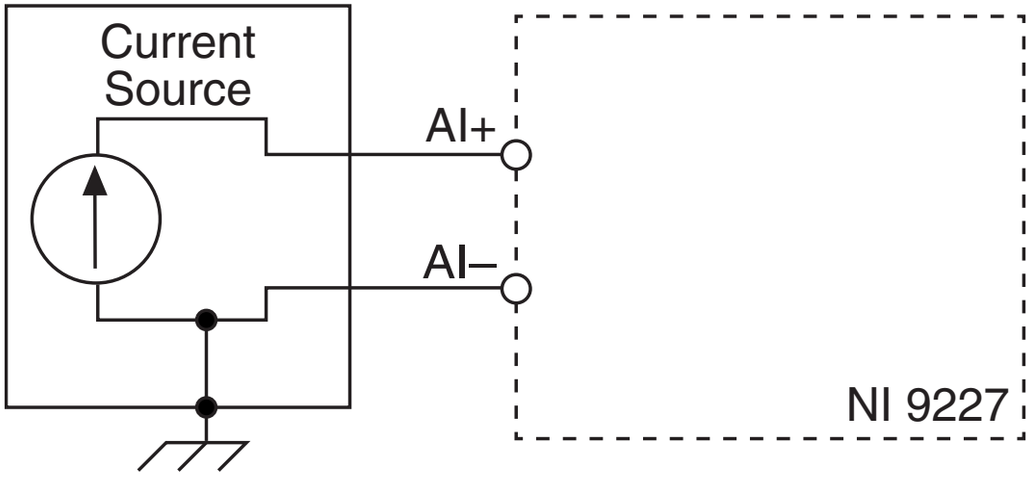
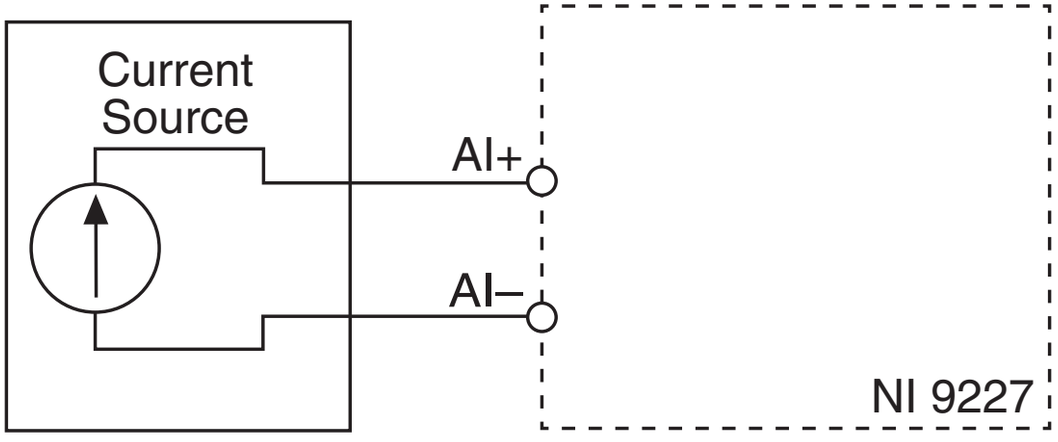


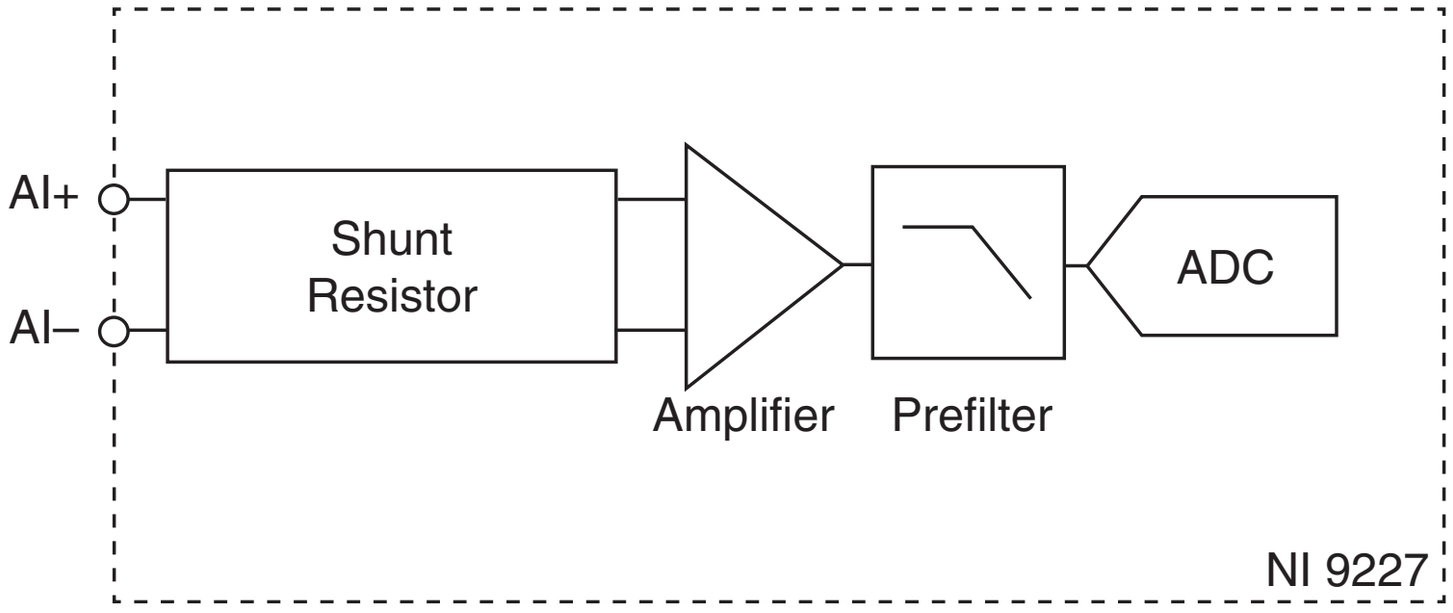
Figure 4. Connecting a Floating Current Source to the NI 9227



The NI 9227 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 9227.

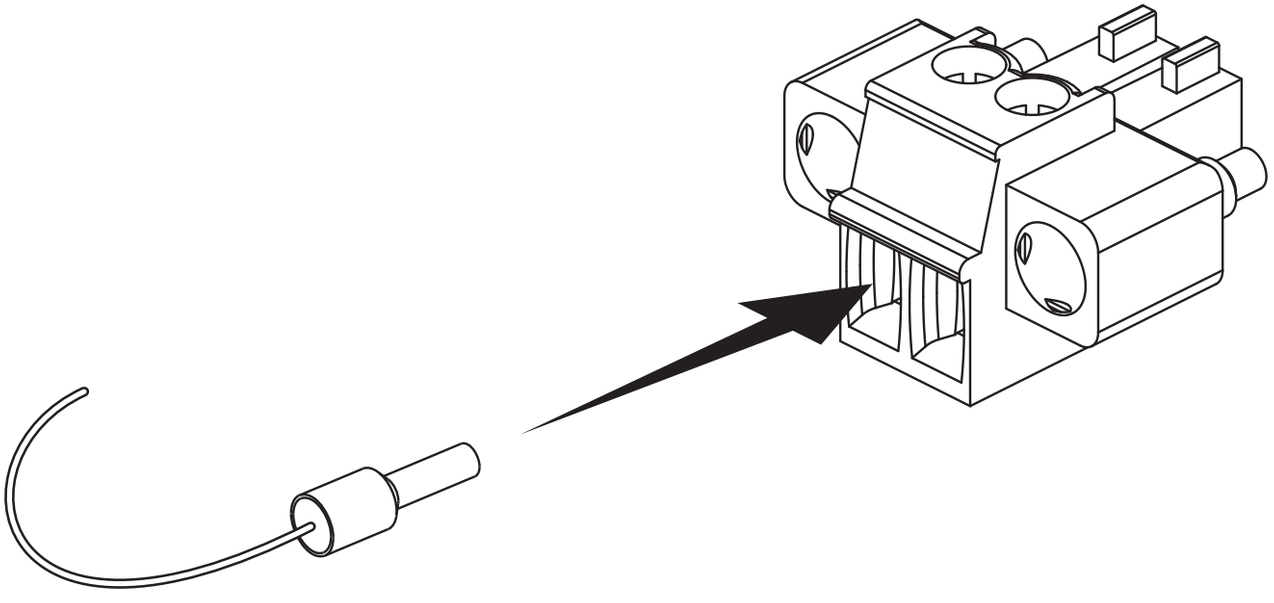
Figure 5. Input Circuitry for One Channel of the NI 9227



Wiring for High-Vibration Applications

If an application is subject to high vibration, National Instruments recommends that you either use ferrules to terminate wires to the detachable screw-terminal connector or use the NI 9971 backshell kit to protect the connections. Refer to Figure 6 for an illustration of using ferrules. Refer to Figure 1 for an illustration of the NI 9971 connector backshell.

Figure 6. 2-Terminal Detachable Screw-Terminal Connector with Ferrule



Understanding NI 9227 Filtering

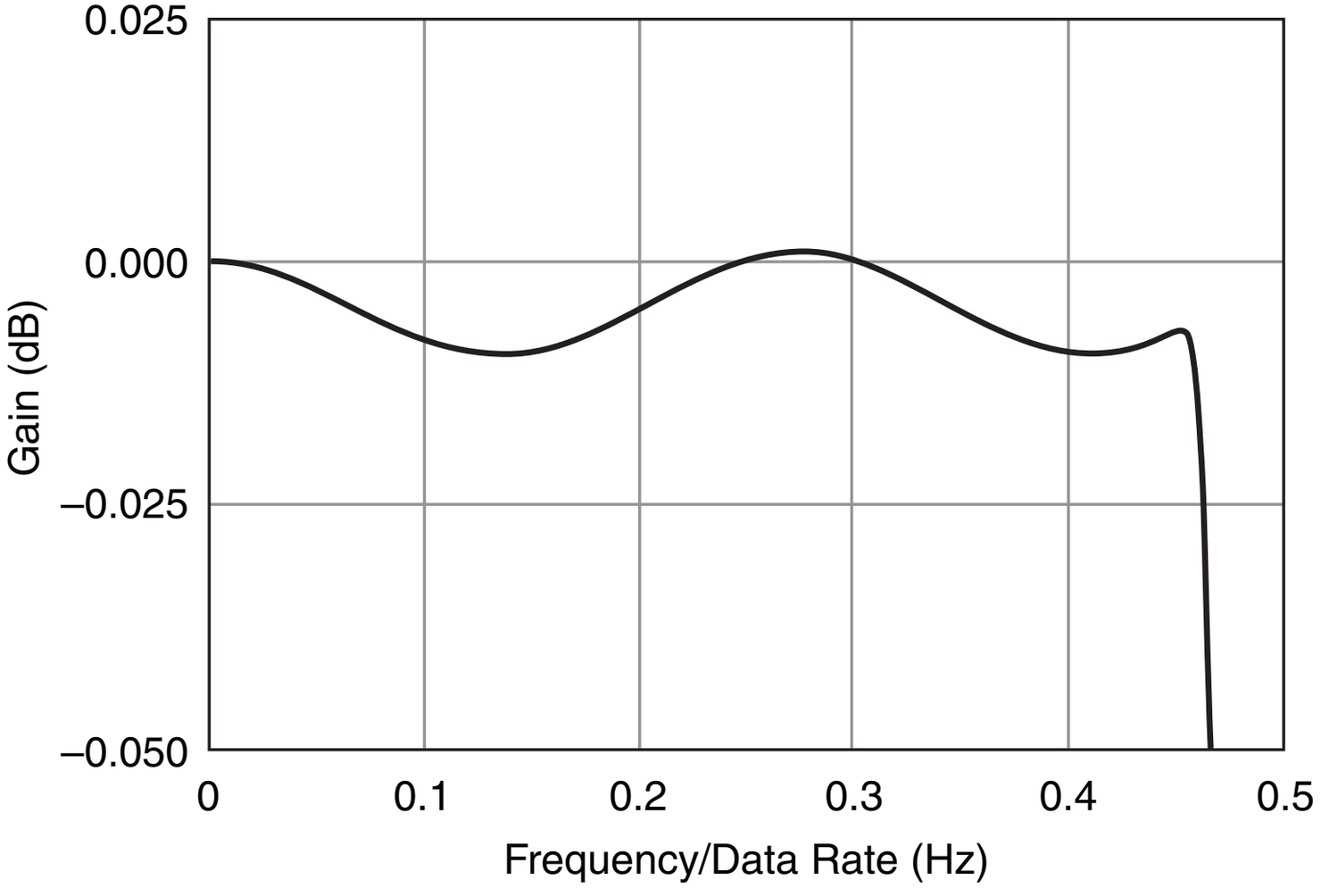
The NI 9227 uses a combination of analog and digital filtering to provide an accurate representation of in-band signals while rejecting out-of-band signals. The filters discriminate between signals based on the frequency range, or bandwidth, of the signal. The three important bandwidths to consider are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

The NI 9227 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 9227 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 9227.

Figure 7. Typical Passband Flatness for the NI 9227



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 9227 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 9227 Data Rates

The frequency of a master timebase (f_M) controls the data rate (f_s) of the NI 9227. The NI 9227 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 9227 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 9227. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

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

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

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 9227 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

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 to 70 °C unless otherwise noted. All voltages are relative to the AI- signal on each channel unless otherwise noted.

Caution The input terminals of this device are not protected for electromagnetic interference. As a result, this device may experience reduced measurement accuracy or other temporary performance degradation when connected cables are routed in an environment with radiated or conducted radio frequency electromagnetic interference. To limit radiated emissions and to ensure that this device functions within specifications in its operational electromagnetic environment, take precautions when designing, selecting, and installing measurement probes and cables.

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 ..... ±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 ..... 51.36 kS/s

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

Safe operating input range[2, 3] ..... 5 A_{rms}

Overcurrent handling[4] ..... 10 A_{rms} for 1 s max
with 19 s minimum
cool down time at 5 A_{rms}

Instantaneous measuring range[5]

Minimum ..... 14.051 A peak

Typical ..... 14.977 A peak, at 23 ±5 °C

Typical scaling coefficient ..... 1.785397 µA/LSB

Input coupling ..... DC

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[1] The data rate must remain within the appropriate data rate range. Refer to the *Understanding NI 9227 Data Rates* section for more information.

[2] Refer to the *Safety Guidelines* section for more information about safe operating voltages.

[3] The maximum recommended continuous RMS current value applied simultaneously on all 4 channels to keep the power dissipation inside the module within safe operating limits.

[4] Overcurrent conditions to keep the module operating within specified limits.

[5] The maximum DC current that produces a non-saturated reading.

Input impedance (AI+ to AI-)..... 12 mΩ

Input noise (f_s = 50 kS/s)..... 400 μA_{rms}

Accuracy at safe operating range of 5 A_{rms}

Measurement Conditions	Percent of Reading (Gain Error)	Percent of Range* (Offset Error)
Calibrated max (-40 to 70 °C)	±0.37%	±0.18%
Calibrated typ (23 °C, ±5 °C)	±0.1%	±0.05%
Uncalibrated max (-40 to 70 °C)	±5.0%	±2.4%
Uncalibrated typ (23 °C, ±5 °C)	±2.5%	±1.0%
* Range equals 7.07 A peak (5 A_{rms}).		

Accuracy at operating range of 10 A_{rms}

Measurement Conditions	Percent of Reading (Gain Error)	Percent of Range* (Offset Error)
Calibrated max (-40 to 70 °C)	±0.38%	±0.19%
* Range equals 7.07 A peak (5 A_{rms}).		

Stability

Gain drift ..... ±21 ppm/°C

Offset drift ..... ±51 µA/°C

Post calibration gain match (channel-to-channel, f_{in} = 20 kHz).... ±130 mdB max

Crosstalk

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

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

Phase match

Channel-to-channel, max ..... 0.1°/kHz

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

Phase linearity (f_s = 50 kS/s) ..... 0.1° max

Input delay ..... $40\frac{5}{512}/f_s + 2.9\ \mu s$

Passband

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

Flatness (f_s = 50 kS/s) ..... ±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 µW max

Thermal dissipation (at 70 °C)[1]

Active mode ..... 1.23 W max

Sleep mode ..... 500 mW max

Physical Characteristics

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

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.

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.)

Ferrules ..... 0.25 mm^2 to 0.5 mm^2

Weight ..... 145 g (5.1 oz)

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[1] Measured with 5 A_{rms} on each channel.

Safety

Isolation Voltages

Connect only voltages that are within the following limits.

Channel-to-channel

Continuous	250 V_{rms}, Measurement Category II
Withstand	1,390 V_{rms}, verified by a 5 s dielectric withstand test

Channel-to-earth ground

Continuous	250 V_{rms}, Measurement Category II
Withstand	2,300 V_{rms}, 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 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:

- 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.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-2-1 (IEC 61326-2-1): Class A emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note For the standards applied to assess the EMC of this product, refer to the *Online Product Certification* section.

Note For EMC compliance, operate this device with shielded cables.

CE Compliance CE

This product meets the essential requirements of applicable European Directives as follows:

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

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit `ni.com/certification`, search by module number or product line, and click the appropriate link in the Certification column.

Shock and Vibration

To meet these specifications, you must panel mount the system and either affix ferrules to the ends of the terminal wires or use the NI 9971 backshell kit to protect the connections.

Operating vibration

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

Sinusoidal (IEC 60068-2-6) ..... 5 g, 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

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 70 °C

Storage temperature
(IEC 60068-2-1, 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 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 *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 9227 at `ni.com/calibration`.

Calibration interval ..... 1 year

Worldwide Support and Services

The National Instruments website 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.

Visit ni.com/services for NI Factory Installation Services, repairs, extended warranty, and other services.

Visit ni.com/register to register your National Instruments product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

A Declaration of Conformity (DoC) is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electromagnetic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting ni.com/certification. If your product supports calibration, you can obtain the calibration certificate for your product at ni.com/calibration.

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world. For telephone support in the United States, create your service request at ni.com/support or dial 1 866 ASK MYNI (275 6964). For telephone support outside the United States, visit the Worldwide Offices section of ni.com/niglobal to access the branch office websites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

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