

**ภาคผนวก ก**

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## 0.1 Data sheet NI cDAQ-9188

### Introduction

This user guide describes how to use the National Instruments CompactDAQ 9188 chassis and lists specifications.

The NI cDAQ-9188 Ethernet chassis are designed for use with C Series I/O modules. The NI cDAQ-9188 chassis is capable of measuring a broad range of analog and digital I/O signals and sensors using an Ethernet interface. For module specifications, refer to the documentation included with your C Series I/O module(s) or go to [ni.com/manuals](http://ni.com/manuals).

Figure 1 shows the NI cDAQ-9188 chassis.

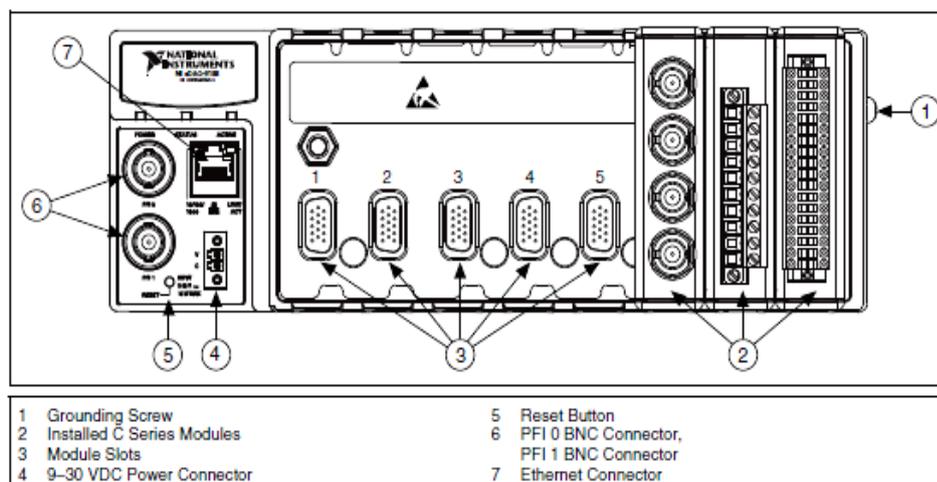


Figure 1. NI cDAQ-9188 Chassis

### Safety Guidelines

Operate the NI cDAQ-9188 chassis only as described in this user guide.



**Note** Because some C Series I/O modules may have more stringent certification standards than the NI cDAQ-9188 chassis, the combined system may be limited by individual component restrictions. Refer to the *NI cDAQ-9188 Chassis Interface* section of this document for more details.



**Caution** The NI cDAQ-9188 chassis is *not* certified for use in hazardous locations.



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

### 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<sub>pk</sub> 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.

## Specifications

These specifications are for the NI cDAQ-9188 chassis only. These specifications are typical at 25 °C unless otherwise noted. For the C Series I/O module specifications, refer to the documentation for the C Series I/O modules you are using.

### Analog Input

Input FIFO size .....	127 samples per slot
Sample rate <sup>1</sup>	
Maximum .....	Determined by the C Series I/O modules
Timing accuracy <sup>2</sup> .....	50 ppm of sample rate
Timing resolution <sup>2</sup> .....	12.5 ns
Number of channels supported .....	Determined by the C Series I/O modules

### Analog Output

Numbers of channels supported	
In hardware-timed task using onboard regeneration .....	16
In hardware-timed task not using onboard regeneration .....	Determined by the C Series I/O modules
In non-hardware-timed task .....	Determined by the C Series I/O modules
Maximum update rate	
Regeneration .....	1.6 MS/s (multi-channel, aggregate)
Non-regeneration .....	Determined by the C Series I/O modules
Timing accuracy .....	50 ppm of sample rate
Timing resolution .....	12.5 ns
Output FIFO size	
Onboard regeneration .....	8,191 samples shared among channels used
Non-regeneration .....	127 samples per slot
AO waveform modes .....	Non-periodic waveform, periodic waveform regeneration mode from onboard memory, periodic waveform regeneration from host buffer including dynamic update

### Digital Waveform Characteristics

Waveform acquisition (DI) FIFO .....	127 samples per slot
Waveform generation (DO) FIFO	



**Note** If modules are installed in slots 1–4, FIFO is 2047 samples per slot for all slots. If any module is installed in slots 5–8, FIFO is 1023 samples per slot for all eight slots.

Slots 1–4 .....	2,047 samples
Slots 5–8 .....	1,023 samples

<sup>1</sup> Performance dependent on type of installed C Series I/O modules and number of channels in the task.

<sup>2</sup> Does not include group delay. Refer to C Series I/O module documentation for more information.

Digital input sample clock frequency	
Streaming to application memory .....	System-dependent
Finite .....	0 to 10 MHz
Digital output sample clock frequency	
Streaming from application memory .....	System-dependent
Regeneration from FIFO .....	0 to 10 MHz
Finite .....	0 to 10 MHz
Digital output or digital input	
sample clock source .....	Any PFI, analog sample or convert clock, analog output sample clock, Ctr <i>n</i> Internal Output, and many other sources

### General-Purpose Counter/Timers

Number of counter/timers .....	4
Resolution .....	32 bits
Counter measurements .....	Edge counting, pulse, semi-period, period, two-edge separation, pulse width
Position measurements .....	X1, X2, X4 quadrature encoding with Channel Z reloading; two-pulse encoding
Output applications .....	Pulse, pulse train with dynamic updates, frequency division, equivalent time sampling
Internal base clocks .....	80 MHz, 20 MHz, 100 kHz
External base clock frequency .....	0 to 20 MHz
Base clock accuracy .....	50 ppm
Output frequency .....	0 to 20 MHz
Inputs .....	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down
Routing options for inputs .....	Any PFI, analog trigger, many internal signals
FIFO .....	Dedicated 127-sample FIFO

### Frequency Generator

Number of channels .....	1
Base clocks .....	10 MHz, 20 MHz, 100 kHz
Divisors .....	1 to 16 (integers)
Base clock accuracy .....	50 ppm
Output is available on any PFI terminal.	

**Module PFI Characteristics**

Functionality .....	Static digital input, static digital output, timing input, and timing output
Timing output sources.....	Many analog input, analog output, counter, digital input, and digital output timing signals
Timing input frequency.....	0 to 20 MHz
Timing output frequency.....	0 to 20 MHz

**Chassis PFI Characteristics**

Max input or output frequency .....	1 MHz
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	Minimum	Maximum
Positive Going Threshold Voltage	1.43	2.28
Negative Going Threshold Voltage	0.86	1.53
Hysteresis	0.48	0.87

Maximum input voltage.....	25 V
Minimum input voltage.....	-20 V
Cable length .....	3 m (10 ft.)
Cable impedance.....	50 $\Omega$
Connector.....	BNC
Output voltage	
High .....	5.25 V maximum
Sourcing 100 $\mu$ A .....	4.65 V minimum
Sourcing 2 mA.....	3.60 V minimum
Low	
Sinking 100 $\mu$ A .....	0.10 V maximum
Sinking 2 mA .....	0.64 V maximum
Power-on state.....	High impedance

**External Digital Triggers**

Source .....	Any PFI terminal or chassis PFI terminal
Polarity.....	Software-selectable for most signals
Analog input function .....	Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Analog output function .....	Start Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Counter/timer functions .....	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down

## USER GUIDE AND SPECIFICATIONS

# NI USB-9211/9211A

### 4-Channel, 24-Bit Thermocouple Input Devices

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-9211/9211A devices and lists the specifications.

## Introduction

The NI USB-9211/9211A data acquisition device provides a USB interface for four channels of 24-bit thermocouple inputs with integrated signal conditioning.

The NI USB-9211 consists of two components: an NI 9211 module and an NI USB-9161 carrier, as shown in Figure 1. The NI USB-9211A consists of two components: an NI 9211 module and an NI USB-9162 carrier, as shown in Figure 1.

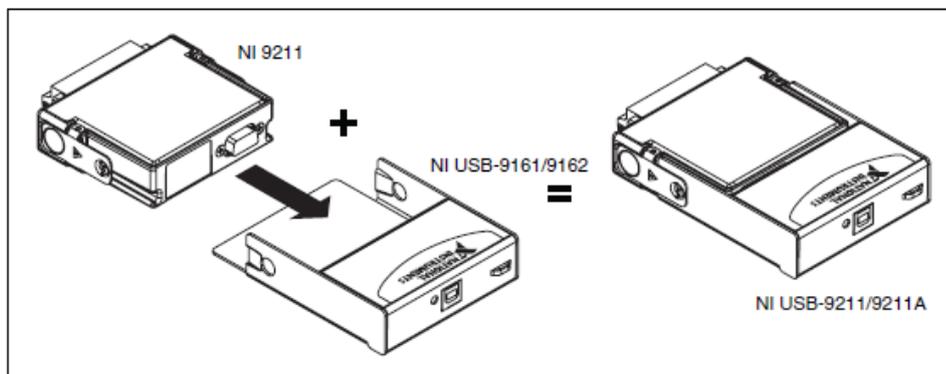
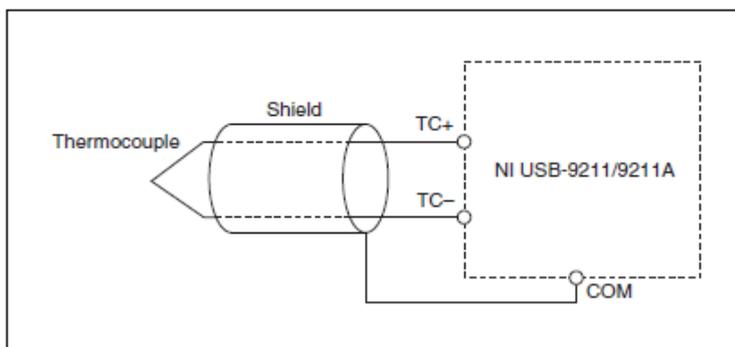


Figure 1. NI USB-9211/9211A Components



**Figure 6.** Connecting a Thermocouple Input Signal to the NI USB-9211/9211A

Refer to Table 3 for the terminal assignments for each channel.

**Table 3.** Terminal Assignments

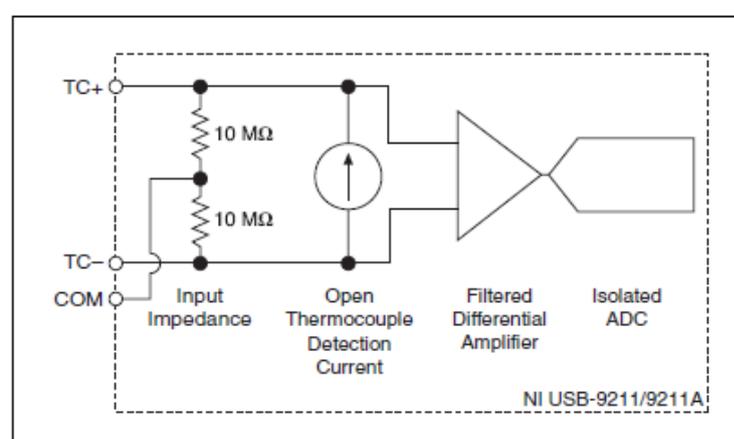
Module	Terminal	Signal
	0	TC0+
	1	TC0-
	2	TC1+
	3	TC1-
	4	TC2+
	5	TC2-
	6	TC3+
	7	TC3-
	8	No connection
	9	Common (COM)

## NI USB-9211/9211A Circuitry

The NI USB-9211/9211A channels share a common ground that is isolated from the chassis and the host computer. Each channel has an impedance between the TC+ and COM terminals and between the TC- and COM terminals. Each channel is filtered and then sampled by a 24-bit analog-to-digital converter (ADC). There is a current source between the TC+ and TC- terminals. If an open thermocouple is connected to the channel, the current source forces a full-scale voltage across the terminals.

### Effects of Source Impedance on Voltage Measurement Accuracy

The resistors shown in Figure 9 produce an input impedance at the terminals of the NI USB-9211/9211A.



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

If thermocouples are connected to the NI USB-9211/9211A, the gain and offset errors resulting from the source impedance of the thermocouples are negligible for most applications. Other voltage sources with a higher source impedance can introduce more significant errors. For more information about errors resulting from source impedance, refer to the [Specifications](#) section.

## Determining Temperature Measurement Accuracy and Minimizing Errors

Temperature measurement errors depend in part on the thermocouple type, the temperature being measured, the accuracy of the thermocouple, and the cold-junction temperature.

## Specifications

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The following specifications are typical at 25 °C, unless otherwise noted. All voltages are relative to COM unless otherwise noted.

### Input Characteristics

Number of channels .....	4 thermocouple channels, 1 internal autozero channel, 1 internal cold-junction compensation channel
ADC resolution .....	24 bits
Type of ADC.....	Delta-sigma
Input range .....	±80 mV (not software selectable)
Common-mode range	
Channel-to-COM .....	±1.5 V
Common-to-earth ground .....	±250 V
Common-mode rejection ratio (0 to 60 Hz)	
Channel-to-common .....	95 dB
Common-to-earth ground .....	>170 dB
Temperature measurement ranges .....	Works over temperature ranges defined by NIST (J, K, R, S, T, N, E, and B thermocouple types)
Cold-junction compensation sensor accuracy	
0 to 60 °C .....	0.6 °C (1.1 °F) typ, 1.3 °C (2.3 °F) max
Conversion time .....	70 ms per channel; 420 ms total for all channels including the autozero and cold-junction channels

0.3 Data sheet NI 9225

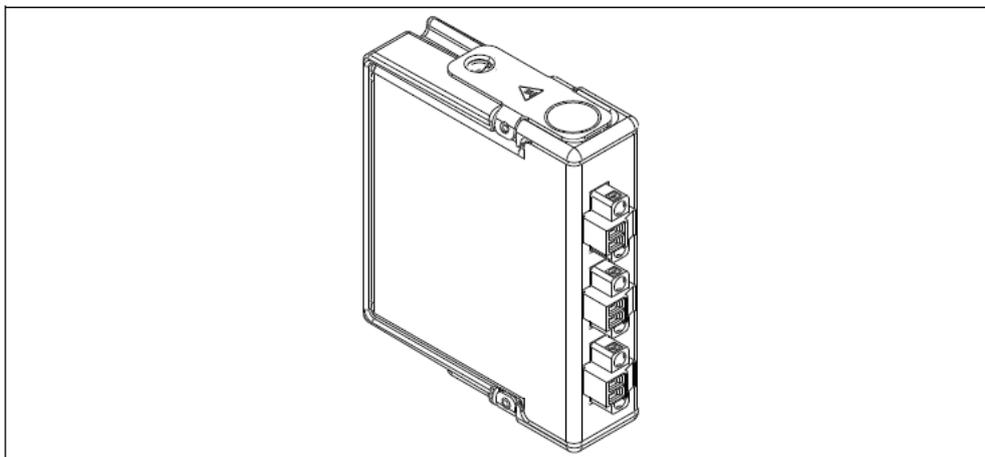
## OPERATING INSTRUCTIONS AND SPECIFICATIONS

# NI 9225

**3-Channel, 300 V<sub>rms</sub>, 24-Bit, Simultaneous,  
Channel-to-Channel Isolated Analog Input Module**

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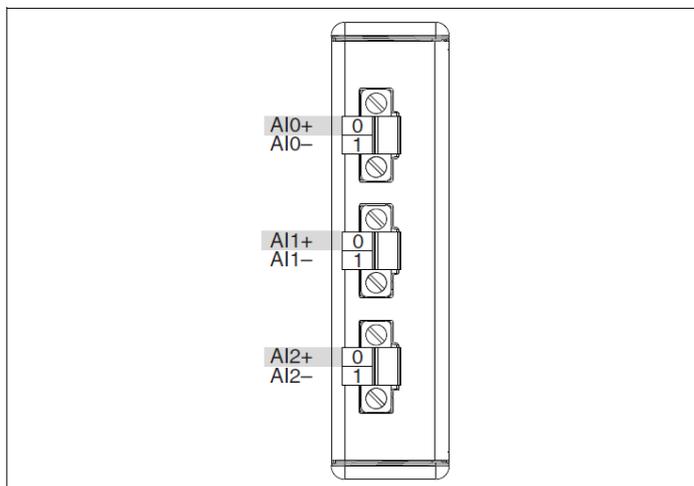
[ni.com/manuals](http://ni.com/manuals)



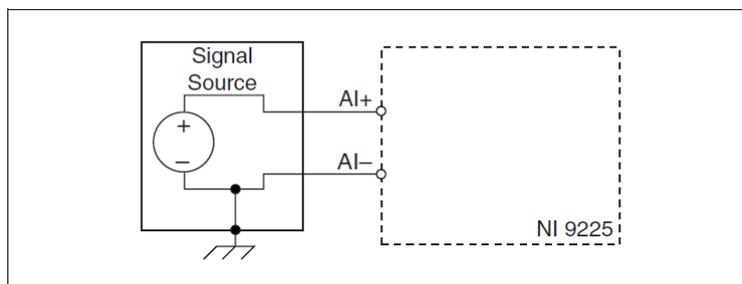
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## Connecting the NI 9225

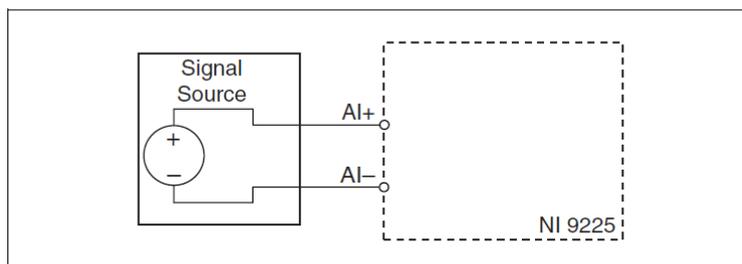
The NI 9225 has three 2-terminal detachable screw-terminal connectors that provide connections for three simultaneously sampled, isolated analog input channels.



**Figure 2.** NI 9225 Terminal Assignments



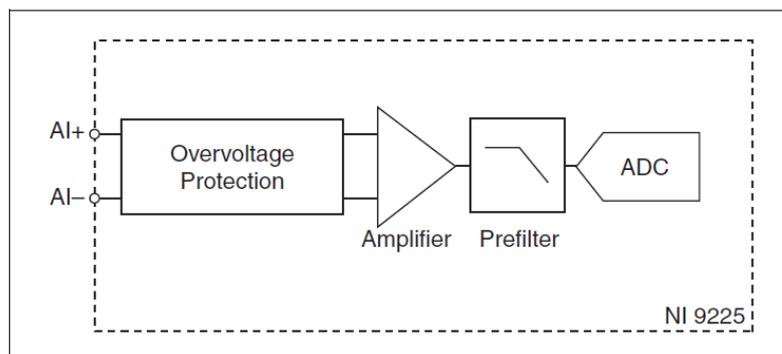
**Figure 3.** Connecting a Grounded Signal Source to the NI 9225



**Figure 4.** Connecting a Floating Signal Source to the NI 9225

The NI 9225 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 three channels simultaneously. Refer to Figure 5 for an illustration of the circuitry for one channel of the NI 9225.



**Figure 5.** Input Circuitry for One Channel of the NI 9225

## 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.

### Input Characteristics

Number of channels.....	3 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..... 390.6 S/s

Maximum ..... 51.2 kS/s

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

Operating voltage ranges<sup>2</sup>

Minimum..... 294 V<sub>rms</sub>

Typical ..... 300 V<sub>rms</sub>

Typical scaling coefficient ..... 50.66  $\mu$ V/LSB

Overvoltage protection .....  $\pm$ 450 VDC

Input coupling ..... DC

Input impedance (AI+ to AI-) ..... 1 M $\Omega$

<sup>1</sup> The data rate must remain within the appropriate data rate range. Refer to the [Understanding NI 9225 Data Rates](#) section for more information.

<sup>2</sup> Refer to the [Safety Guidelines](#) section for more information about safe operating voltages.

### Accuracy

Measurement Conditions	Percent of Reading (Gain Error)	Percent of Range* (Offset Error)
Calibrated max (–40 to 70 °C)	$\pm$ 0.23%	$\pm$ 0.05%
Calibrated typ (25 °C, $\pm$ 5 °C)	$\pm$ 0.05%	$\pm$ 0.008%
Calibrated max (25 °C, $\pm$ 15 °C)	$\pm$ 0.084%	$\pm$ 0.016%
Uncalibrated max (–40 to 70 °C)	$\pm$ 1.6%	$\pm$ 0.66%
Uncalibrated typ (25 °C, $\pm$ 5 °C)	$\pm$ 0.4%	$\pm$ 0.09%
* Range equals 425 V.		

Input noise ..... 2 mV<sub>rms</sub>

Stability

Gain drift .....  $\pm$ 10 ppm/°C

Offset drift .....  $\pm$ 970  $\mu$ V/°C

Post calibration gain match

(ch-to-ch, 20 kHz).....  $\pm$ 0.25 dB max

n.4 Data sheet NI 9227

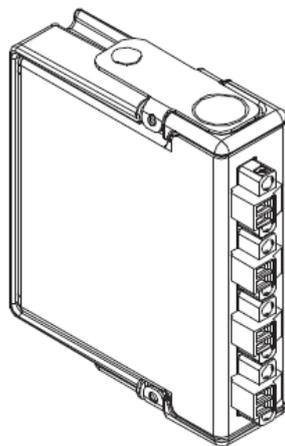
## OPERATING INSTRUCTIONS AND SPECIFICATIONS

# NI 9227

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

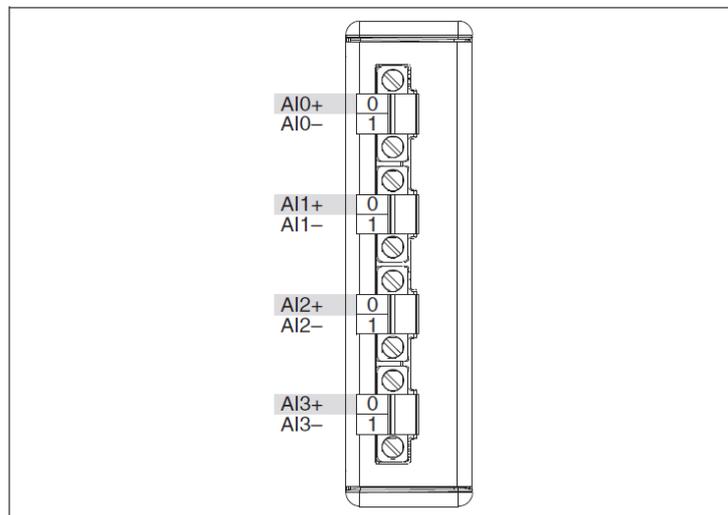
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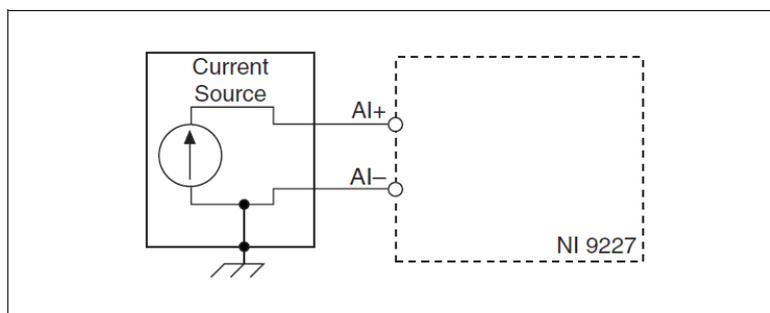


## Connecting the NI 9227

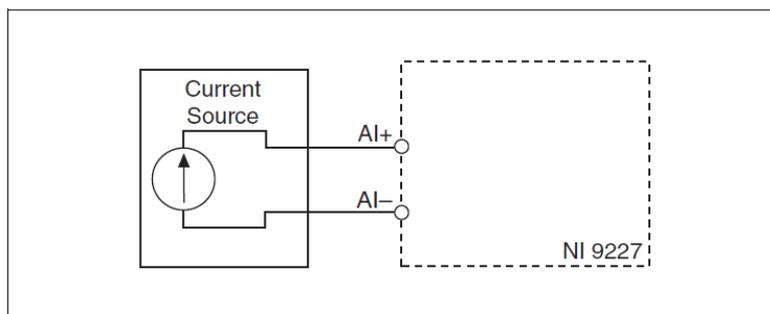
The NI 9227 has four 2-terminal detachable screw-terminal connectors that provide connections for four simultaneously sampled, isolated analog input channels.



**Figure 2.** NI 9227 Terminal Assignments



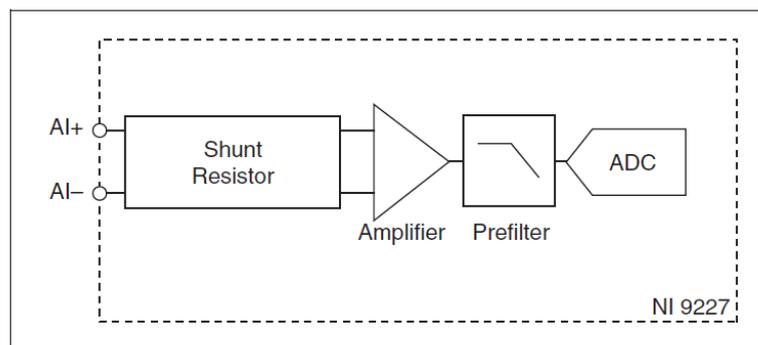
**Figure 3.** Connecting a Grounded Current Source to the NI 9227



**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

## 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 .....	$\pm 100$ 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> ( $f_s$ ) .....	$\frac{f_M \div 256}{n}$ , $n = 1, 2, \dots, 31$

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

Safe operating input range <sup>1, 2</sup> .....	5 A <sub>rms</sub>
Overcurrent handling <sup>3</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>4</sup>	
Minimum .....	14.051 A peak
Typical .....	14.977 A peak, at 23 $\pm$ 5 °C
Typical scaling coefficient .....	1.785397 $\mu$ A/LSB
Input coupling .....	DC
Input impedance (AI+ to AI-) .....	12 m $\Omega$
Input noise ( $f_s = 50$ kS/s) .....	400 $\mu$ A <sub>rms</sub>

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<sup>1</sup> Refer to the [Safety Guidelines](#) section for more information about safe operating voltages.

<sup>2</sup> 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.

<sup>3</sup> Overcurrent conditions to keep the module operating within specified limits.

<sup>4</sup> The maximum DC current that produces a non-saturated reading.

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

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 <sub>rms</sub> ).		

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

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 <sub>rms</sub> ).		

## 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°/kHz + 360° ·  $f_{in}/f_M$ Phase linearity ( $f_s = 50$  kS/s)..... 0.1° maxInput delay .....  $38.4/f_s + 3.2$  µs

## Passband

Frequency .....  $0.453 \cdot f_s$ Flatness ( $f_s = 50$  kS/s) ..... ±100 mdB max

n.5 Data sheet NI 9401

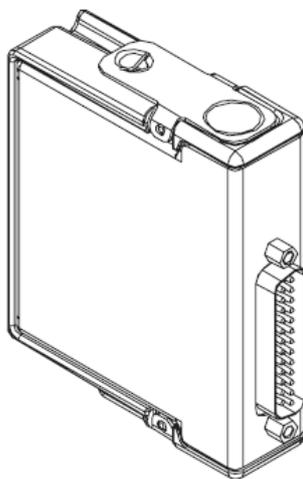
# OPERATING INSTRUCTIONS AND SPECIFICATIONS

## NI 9401

### 8-Channel, TTL Digital Input/Output Module

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[ni.com/manuals](http://ni.com/manuals)



## Connecting the NI 9401

The NI 9401 has a 25-pin DSUB connector that provides connections for eight digital input/output channels.

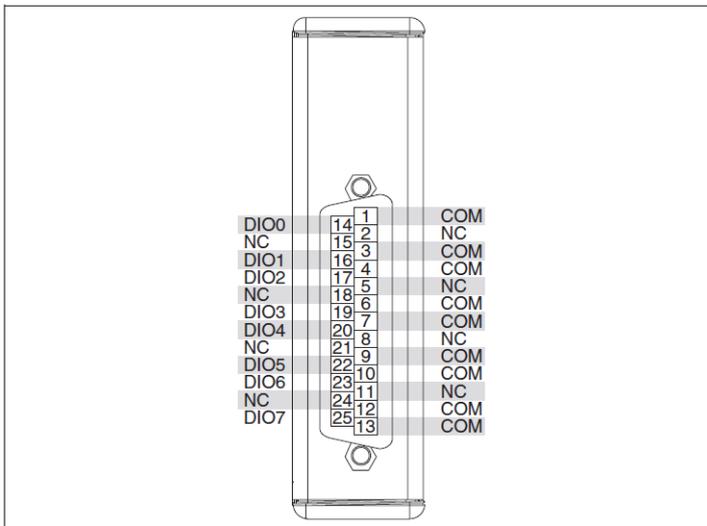


Figure 1. NI 9401 Pin Assignments

Figure 2 illustrates how to connect an SPI device to the NI 9401. In this example, the three channels assigned to output signals are on one port and the channel assigned to an input signal is on the other port.

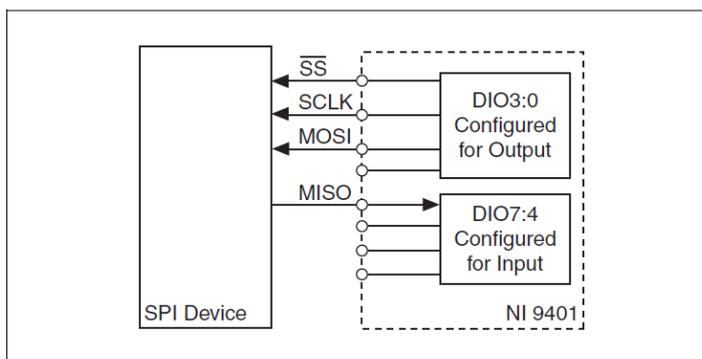


Figure 2. Connecting an SPI Device to the NI 9401

Figure 3 illustrates how to connect several types of digital devices to the NI 9401.

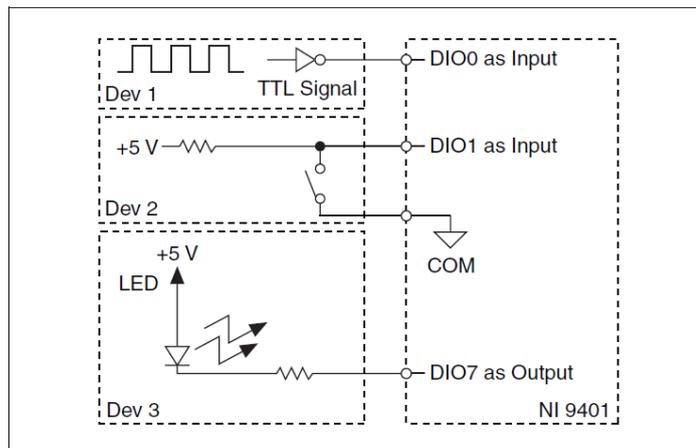


Figure 3. Connecting Digital Devices to the NI 9401

## Specifications

The following specifications are typical for the range  $-40$  to  $70$  °C unless otherwise noted. All voltages are relative to COM unless otherwise noted.

### Input/Output Characteristics

- Number of channels..... 8 DIO channels
- Default power-on line direction ..... Input
- Input/output type..... TTL, single-ended

## Digital logic levels

## Input

Voltage .....	5.25 V max
High, $V_{IH}$ .....	2 V min
Low, $V_{IL}$ .....	0.8 V max

## Output

High, $V_{OH}$ .....	5.25 V max
Sourcing 100 $\mu$ A .....	4.7 V min
Sourcing 2 mA.....	4.3 V min
Low, $V_{OL}$	
Sinking 100 $\mu$ A .....	0.1 V max
Sinking 2 mA.....	0.4 V max

## Maximum input signal switching frequency by number of input channels, per channel

8 input channels.....	9 MHz
4 input channels.....	16 MHz
2 input channels.....	30 MHz

## Maximum output signal switching frequency by number of output channels with an output load of 1 mA, 50 pF, per channel

8 output channels.....	5 MHz
4 output channels.....	10 MHz
2 output channels.....	20 MHz

I/O propagation delay ..... 100 ns max

I/O pulse width distortion ..... 10 ns typ

Input current ( $0 \text{ V} \leq V_{in} \leq 4.5 \text{ V}$ ).....  $\pm 250 \mu\text{A}$  typ

Input capacitance ..... 30 pF typ

Input rise/fall time..... 500 ns max

## Overvoltage protection,

channel-to-COM .....  $\pm 30 \text{ V}$  max on one channel at a time; however, continued use at this level will degrade the life of the module.