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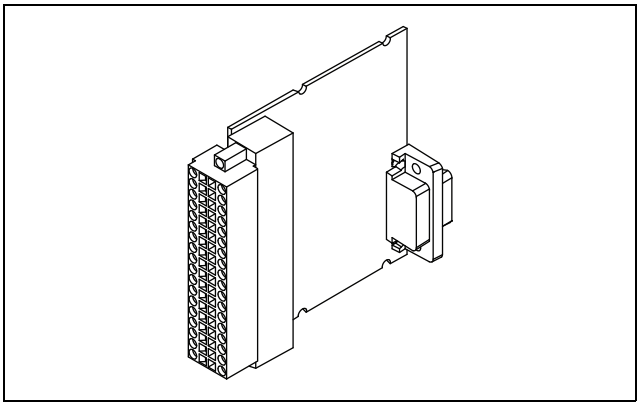
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Find the *National Instruments sbRIO-9213* at our website: *Click HERE*

OPERATING INSTRUCTIONS AND SPECIFICATIONS

NI 9213E

16-Channel Thermocouple Input Module



NATIONAL INSTRUMENTS

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This document describes how to use the National Instruments 9213E and includes dimensions, terminal assignments, and specifications for the NI 9213E. Visit `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` 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 9213E. The end-product supplier is responsible for conformity to any and all compliance requirements.

Caution The NI 9213E must be installed inside a suitable enclosure prior to use. Hazardous voltages may be present.

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NI 9213E Dimensions

The following figure shows the dimensions of the NI 9213E.

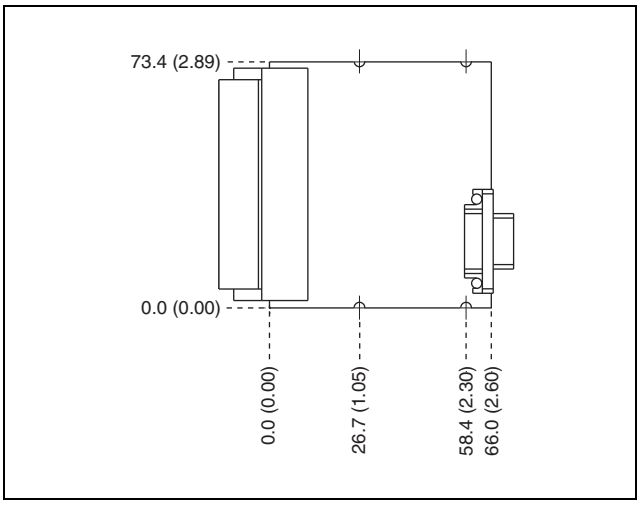


Figure 1. NI 9213E Dimensions in Millimeters (Inches)

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Connecting the NI 9213E

The NI 9213E has a 36-terminal detachable spring-terminal connector that provides connections for 16 thermocouple channels.

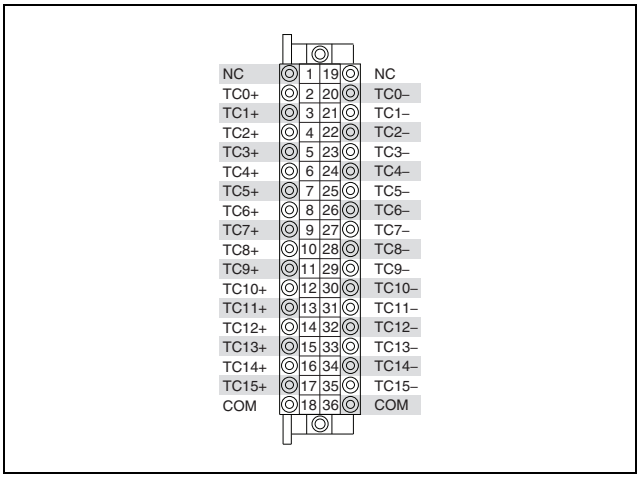


Figure 2. NI 9213E Terminal Assignments

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You can connect thermocouple input signals to the NI 9213E. Connect the positive lead of the thermocouple to the TC+ terminal and the negative lead of the thermocouple to the TC– terminal. If you are unsure which of the thermocouple leads is positive and which is negative, check the thermocouple documentation or the thermocouple wire spool.

The NI 9213E also has two common terminals, COM, that are internally connected to the isolated ground reference of the module. If you are using a shielded thermocouple, connect COM to the shield and the shield to a common-mode voltage reference of the thermocouple. A common-mode voltage reference is a voltage that is within ±1.2 V of the common-mode voltage of the thermocouple. If you are using a floating thermocouple or a thermocouple within ±1.2 V of earth ground, connect COM and the shield to earth ground. The shield grounding methodology can vary depending on the application. Refer to Figure 3 for an illustration of a typical shielding configuration.

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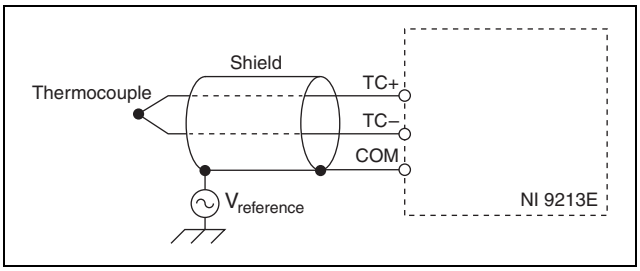


Figure 3. Connecting a Shielded Thermocouple Input Signal to the NI 9213E

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Connecting Wires to the NI 9213E Connector

Use a flathead screwdriver with a blade smaller than 2.3 × 1.0 mm (0.09 × 0.04 in.) to connect wires to the detachable spring-terminal connector. Insert the screwdriver into a spring clamp activation slot and press a wire into the corresponding connector terminal, then remove the screwdriver to clamp the wire into the terminal. Refer to the *Specifications* section for more information about spring-terminal wiring. Refer to Figure 4 for an illustration of connecting wires to the NI 9213E.

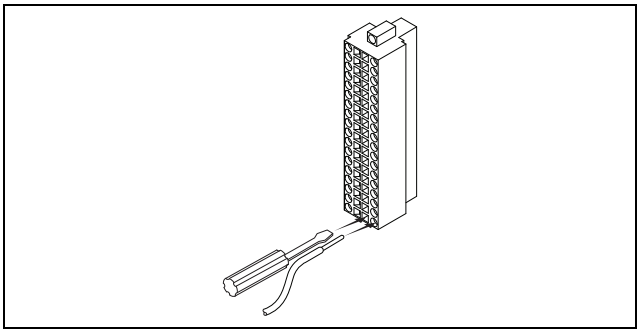


Figure 4. Connecting Wires to the NI 9213E Connector

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NI 9213E Circuitry

Each channel of the NI 9213E passes through a differential filter and then is multiplexed and sampled by a 24-bit analog-to-digital converter (ADC). Each channel also has an open thermocouple detection (OTD) circuit, which consists of 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. Refer to Figure 5 for an illustration of the input circuitry for one channel of the NI 9213E.

The NI 9213E multiplexes 16 thermocouple input channels, 1 cold-junction compensation (CJC) channel, and 1 autozero channel to a single ADC. Each channel has a resistor that produces an input impedance between the TC+ and COM terminals and between the TC– and COM terminals. The gain and offset errors resulting from the source impedance of connected thermocouples are negligible for most applications. Thermocouples with a higher lead resistance can introduce more significant errors. Refer to the *Specifications* section for more information about errors resulting from source impedance.

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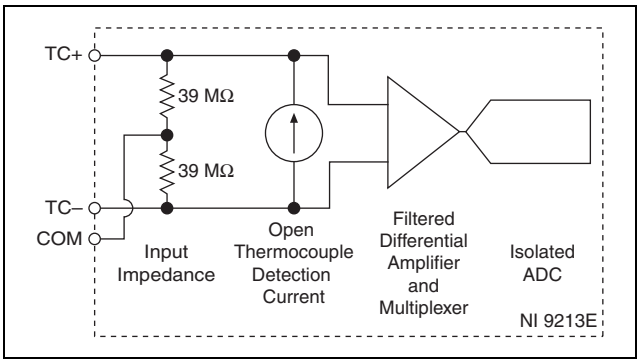


Figure 5. Input Circuitry for One Channel of the NI 9213E

The channels share a common ground, COM, that is isolated from other modules in the system. The NI 9213E common-mode range is the maximum voltage between any channel and COM. If COM is not connected, then the common-mode voltage range is the maximum voltage between any two channels. The NI 9213E measures the common-mode voltage level of each channel and returns a warning in the software if the signal is outside the

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common-mode voltage range. Refer to the *Specifications* section for more information about the common-mode voltage range.

The NI 9213E supports high-resolution and high-speed timing modes. High-resolution timing mode optimizes accuracy and noise and rejects power line frequencies. High-speed timing mode optimizes sample rate and signal bandwidth. Refer to the *Specifications* section for more information about the high-resolution and high-speed timing modes. Refer to the software help for information about setting the timing mode, or conversion time, in software. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

Temperature Measurement Accuracy Considerations

Temperature measurement errors depend partly on the thermocouple type, the accuracy of the thermocouple, the temperature being measured, and the cold-junction temperature. Refer to the *Temperature Measurement Accuracy* section in the *Specifications* for the errors for each thermocouple type when connected to the NI 9213E. The errors do not account for the accuracy of the thermocouple itself.

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For the best accuracy results, keep temperature gradients across NI 9213E terminals to a minimum and enable the autozero channel. Refer to the *Minimizing Thermal Gradients* and *Using the Autozero Channel* sections for more information.

Cold-Junction Temperature Measurement Accuracy

Heat dissipated by adjacent modules or other nearby heat sources can cause errors in thermocouple measurements by heating up the NI 9213E terminals to a different temperature than the cold-junction compensation sensor. The thermal gradient across the terminals can cause the terminals of different channels to be at different temperatures, in which case the resulting measurement creates errors not only in absolute accuracy but also in the relative accuracy between channels. Refer to the *Specifications* section for the cold-junction compensation accuracy specifications. The thermocouple accuracy specifications include the errors caused by the thermal gradient across the module terminals. Refer to the *Temperature Measurement Accuracy* section in the *Specifications* for the thermocouple accuracy specifications. Visit `ni.com/info` and enter `cjcdatascaling` for more information about isothermal errors and scaling CJC data.

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Minimizing Thermal Gradients

Thermal gradients can be caused by changes in the ambient air temperature near the front connector or by the thermocouple wire if it conducts heat or cold directly to the terminal junctions. For the best accuracy results, follow these guidelines for minimizing thermal gradients:

- Use small-gauge thermocouple wire. Smaller wire transfers less heat to or from the terminal junction.
- Run thermocouple wiring together near the spring-terminal connector to keep the wires at the same temperature.
- Avoid running thermocouple wires near hot or cold objects.
- If you connect any extension wires to thermocouple wires, use wires made of the same conductive material as the thermocouple wires.
- Minimize adjacent heat sources and air flow across the terminals.
- Keep the ambient temperature as stable as possible.

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- Keep the module in a stable and consistent orientation.
- Allow the thermal gradients to settle after a change in system power or in ambient temperature. A change in system power can happen when the system powers on, the system comes out of sleep mode, or you insert/remove modules.

Using the Autozero Channel

The NI 9213E has an internal autozero channel to compensate for the offset error. The NI 9213E specifications all assume the autozero channel is on for every sample, however, you can choose not to use the autozero channel in software. When the autozero channel is on, the NI 9213E measures the autozero channel and subtracts that measurement from the measurement of each thermocouple channel. Refer to the software help for information about using the autozero channel. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

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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.

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Specifications

The following specifications are typical for the range –40 to 85 °C internal to any enclosures unless otherwise noted.

Input Characteristics

Number of channels	16 thermocouple channels, 1 internal autozero channel, 1 internal cold-junction compensation channel
ADC resolution	24 bits
Type of ADC	Delta-Sigma
Sampling mode	Scanned
Voltage measurement range	±78.125 mV
Temperature measurement ranges	Works over temperature ranges defined by NIST (J, K, T, E, N, B, R, S thermocouple types)

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Timing modes

Timing Mode	Conversion Time (Per Channel)	Sample Rate* (All Channels†)
High-resolution	55 ms	1 S/s
High-speed	740 µs	75 S/s

* If you are using fewer than all channels, the sample rate might be faster. The maximum sample rate = 1/(*Conversion Time* × *Number of Channels*), or 100 S/s, whichever is smaller. Sampling faster than the maximum sample rate may result in the degradation of accuracy.
† Including the autozero and cold-junction channels.

Common-mode voltage range

Channel-to-COM..... ±1.2 V min

COM-to-earth ground..... ±250 V

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Common-mode rejection ratio

- High-resolution mode (at DC and 50–60 Hz)
  - Channel-to-COM ..... 100 dB
  - COM-to-earth ground ..... >170 dB
- High-speed mode (at 0–60 Hz)
  - Channel-to-COM ..... 70 dB
  - COM-to-earth ground ..... >150 dB

Input bandwidth

- High-resolution mode..... 14.4 Hz
- High-speed mode..... 78 Hz

High-resolution noise rejection (at 50 and 60 Hz) ..... 60 dB

Overvoltage protection ..... ±30 V between any two inputs

Differential input impedance ..... 78 MΩ

Input current..... 50 nA

Input noise

- High-resolution mode..... 200 nV_{rms}
- High-speed mode..... 7 μV_{rms}

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Gain error

High-resolution mode	0.03% typ at 25 °C, 0.07% typ at –40 to 85 °C, 0.15% max at –40 to 85 °C
High-speed mode	0.04% typ at 25 °C, 0.08% typ at –40 to 85 °C, 0.16% max at –40 to 85 °C

Offset error

High-resolution mode	4 µV typ, 6 µV max
High-speed mode	14 µV typ, 17 µV max

Offset error from source impedance	Add 0.05 µV per Ω, when source impedance >50 Ω

Cold-junction compensation accuracy[1]

0 to 85 °C	0.8 °C typ, 1.7 °C max
–40 to 85 °C	1.1 °C typ, 2.1 °C max

[1] The maximum errors assume an isothermal error of 1.3 °C. Refer to the *Cold-Junction Temperature Measurement Accuracy* section for more information.

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MTBF ..... 852,407 hours at 25 °C; Bellcore Issue 2, Method 1, Case 3, Limited Part Stress Method

Note Contact NI for Bellcore MTBF specifications at other temperatures or for MIL-HDBK-217F specifications.

Temperature Measurement Accuracy

Measurement sensitivity[1]

- High-resolution mode
  - Types J, K, T, E, N ..... <0.02 °C
  - Types B, R, S ..... <0.15 °C
- High-speed mode
  - Types J, K, T, E ..... <0.25 °C
  - Type N ..... <0.35 °C
  - Type B ..... <1.2 °C
  - Types R, S ..... <2.8 °C

[1] Measurement sensitivity represents the smallest change in temperature that a sensor can detect. It is a function of noise. The values assume the full measurement range of the standard thermocouple sensor according to ASTM E230-87.

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Figures 6, 7, 8, 9, and 10 show the errors for each thermocouple type when connected to the NI 9213E with the autozero channel on. The figures display the maximum errors[1] over a full temperature range and typical errors at room temperature. The figures account for gain errors, offset errors, differential and integral nonlinearity, quantization errors, noise errors, 50 Ω lead wire resistance, and cold-junction compensation errors. The figures do not account for the accuracy of the thermocouple itself.

[1] The maximum errors assume an isothermal error of 1.3 °C. Refer to the *Cold-Junction Temperature Measurement Accuracy* section for more information.

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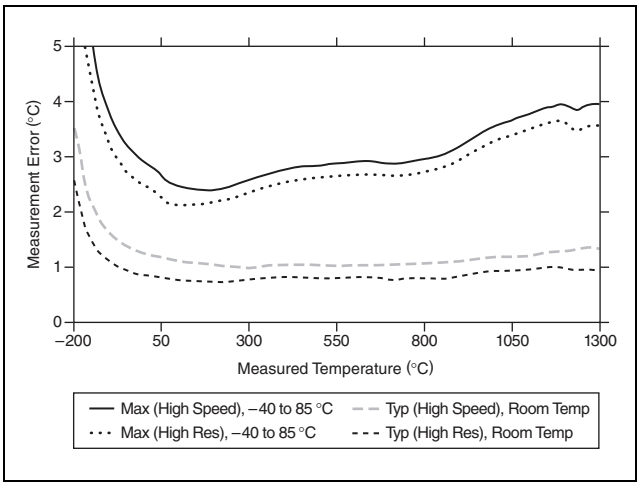


Figure 6. Thermocouple Types J and N Errors

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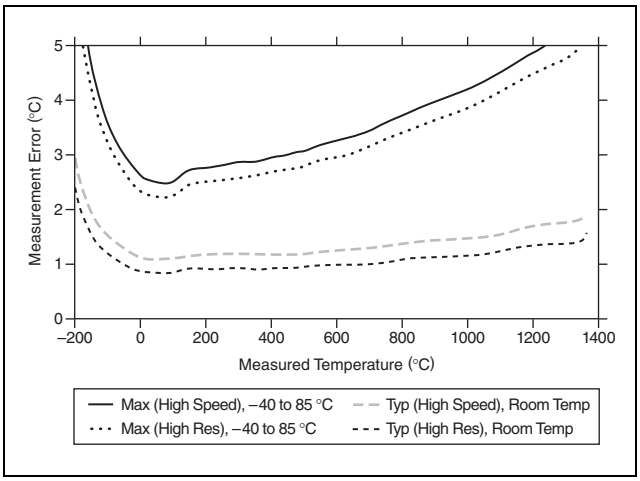


Figure 7. Thermocouple Type K Errors

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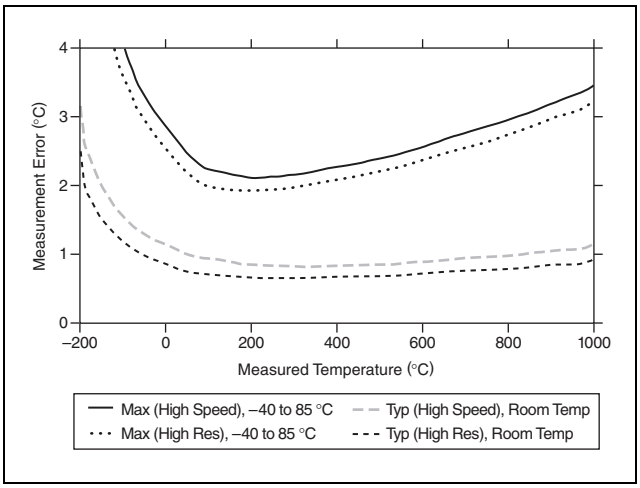


Figure 8. Thermocouple Types T and E Errors

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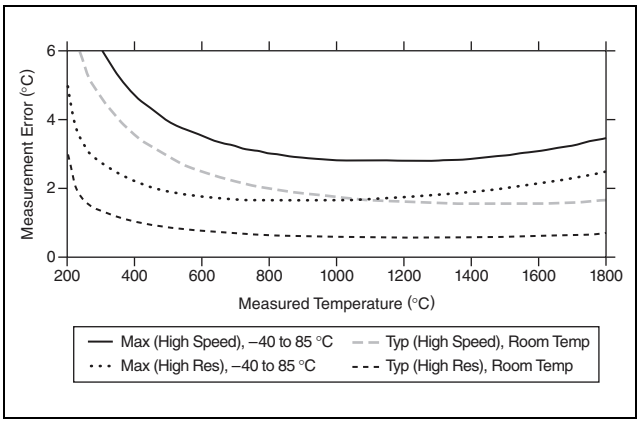


Figure 9. Thermocouple Type B Errors

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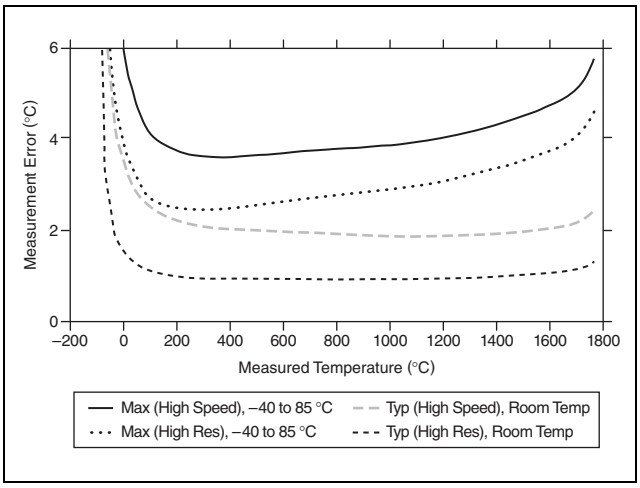


Figure 10. Thermocouple Types R and S Errors

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Power Requirements

Power consumption from chassis

- Active mode ..... 490 mW max
- Sleep mode ..... 25 µW max

Thermal dissipation (at 85 °C)

- Active mode ..... 840 mW max
- Sleep mode ..... 710 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` and search by module number.

Spring-terminal wiring..... 18 to 28 AWG copper conductor wire with 7 mm (0.28 in.) of insulation stripped from the end

Weight..... 59 g (2.1 oz)

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Safety

Safety Voltages

Connect only voltages that are within the following limits.

Between any two terminals..... ±30 V max

Isolation

- Channel-to-channel ..... None
- Channel-to-earth ground
  - Continuous ..... 250 V_{rms}, Measurement Category II, (Double insulation)
  - 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.

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Caution Do *not* connect the NI 9213E 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

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.

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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

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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 to the environment and to NI customers.

For additional environmental information, refer to the *NI and the Environment* 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 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`.

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Calibration

You can obtain the calibration certificate and information about calibration services for the NI 9213E at `ni.com/calibration`.

Calibration interval ..... 1 year

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Where to Go for Support

The National Instruments Web site is your complete resource for technical support. At `ni.com/support` you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. For telephone support in the United States, create your service request at `ni.com/support` and follow the calling instructions or dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

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Czech Republic 420 224 235 774, Denmark 45 45 76 26 00,
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