CompactRIO™ cRIO-9211

4-Channel Thermocouple Input Module

NATIONAL INSTRUMENTS™
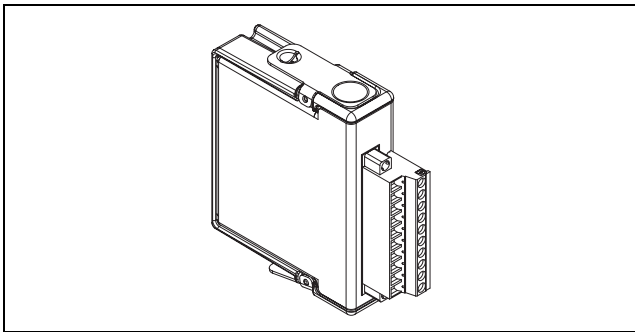
These operating instructions describe how to use the National Instruments cRIO-9211. For information about installing, configuring, and programming the CompactRIO system, refer to the *CompactRIO Bookshelf* at **Start»Program Files»National Instruments»CompactRIO»Search the CompactRIO Bookshelf**.

Safety Guidelines

Operate the cRIO-9211 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.

Safety Guidelines for Hazardous Locations

The cRIO-9211 is suitable for use in Class I, Division 2, Groups A, B, C, and D hazardous locations; Class 1, Zone 2, AEx nC IIC T4 and Ex nC T4 hazardous locations; and nonhazardous locations only. Follow these guidelines if you are installing the cRIO-9211 in a potentially explosive environment. Not following these guidelines may result in serious injury or death.

⚠ **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 or the area is known to be nonhazardous.

⚠ **Caution** Substitution of components may impair suitability for Class I, Division 2.

⚠ **Caution** For Zone 2 applications, install the CompactRIO system in an enclosure rated to at least IP 54 as defined by IEC 60529 and EN 60529.

Special Conditions for Safe Use in Europe

This equipment has been evaluated as EEx nC IIC T4 equipment under DEMKO Certificate No. 03 ATEX 0324020X. Each module is marked ⟨Ex⟩ II 3G and is suitable for use in Zone 2 hazardous locations.

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_{peak} 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.
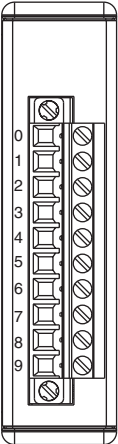
⚠️ **Caution** When module terminals are live with hazardous voltages, make sure that the terminals are *not* accessible. You can use the cRIO-9932 connector kit or put the CompactRIO chassis in a suitably rated enclosure.

Wiring the cRIO-9211

The cRIO-9211 has a 10-terminal, detachable screw-terminal connector that provides connections for four thermocouple input channels. Each channel has a terminal to which you can connect the positive lead of the thermocouple, TC+, and a terminal to which you can connect the negative lead of the thermocouple, TC–. The cRIO-9211 also has a common terminal, COM, that is internally connected to the isolated ground reference of the module. Refer to Table 1 for the terminal assignments for each channel.

Table 1. 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)

Connecting Thermocouple Input Signals to the cRIO-9211

You can connect thermocouple input signals to the cRIO-9211. Connect the positive lead of the thermocouple to the TC+ terminal and the negative lead 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. If you are using shielded wiring, connect one end of the shield to the COM terminal.
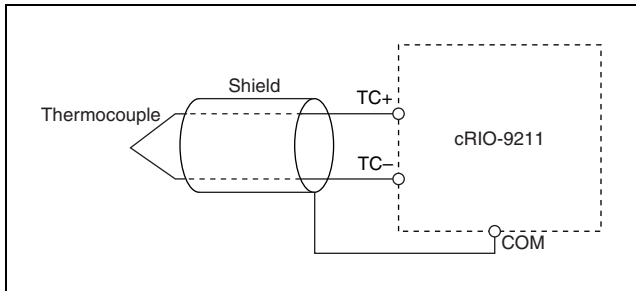

Figure 1. Connecting a Thermocouple Input Signal to the cRIO-9211

Refer to the *CompactRIO Bookshelf* for more information about reading temperatures from the cRIO-9211 channels.

cRIO-9211 Circuitry

The cRIO-9211 channels share a common ground that is isolated from other modules in the CompactRIO system. Each channel has an impedance between the TC+ and COM terminals and between the TC– and COM terminals. Each channel is filtered, 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. Refer to the *CompactRIO Bookshelf* for more information about detecting open thermocouples in software.
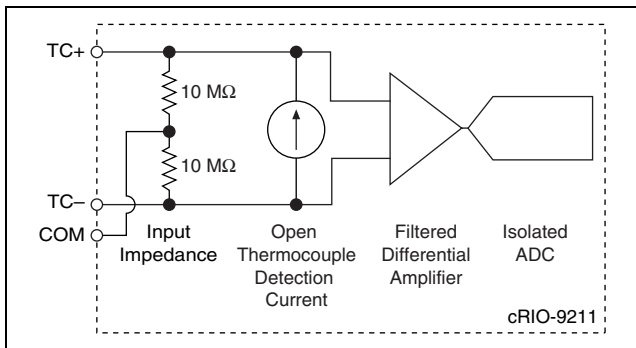
Figure 2. Input Circuitry for One Channel

Effects of Source Impedance on Voltage Measurement Accuracy

The resistors shown in Figure 2 produce an input impedance at the terminals of the cRIO-9211. If thermocouples are connected to the cRIO-9211, 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. Refer to the *Specifications* section for more information about errors resulting from source impedance.

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.

Using the Autozero Channel

The cRIO-9211 has an internal autozero channel for measuring the offset error. If the ambient temperature of the cRIO-9211 is less than 15 °C or more than 35 °C, use this channel to read the offset error. Subtract the offset error from the data read from the cRIO-9211 thermocouple input channels. For more information about reading from the autozero channel, refer to the *CompactRIO Bookshelf*.

Measurement Accuracy for the Different Types of Thermocouples

Figures 3, 4, 5, 6, and 7 show the typical and maximum errors for the different thermocouple types when used with the cRIO-9211 over the full temperature range. The figures also show the maximum error for the thermocouple types with the cRIO-9211 at room temperature, 15 to 35 °C. The figures account for gain errors, offset errors, differential and integral nonlinearity, quantization errors, noise errors, and isothermal errors. The figures do not account for the accuracy of the thermocouple itself.

Temperature gradients across the cRIO-9211 terminals affect the cold-junction temperature accuracy. Refer to the *Cold-Junction Temperature Measurement Accuracy* section for more information about temperature gradients.
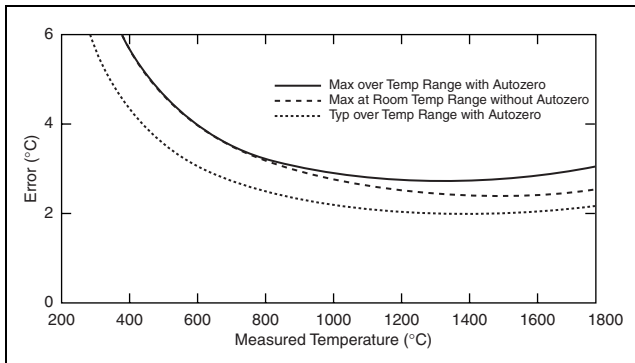
Figure 3. Type B Errors
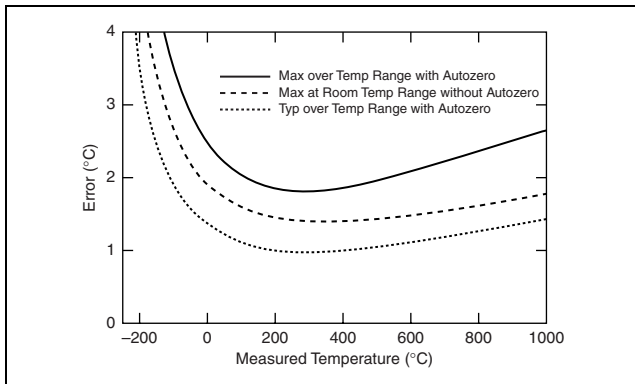
Figure 4. Type E and T Errors
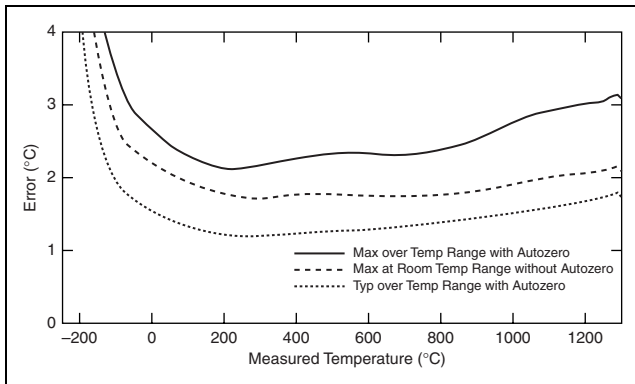
Figure 5. Type J and N Errors
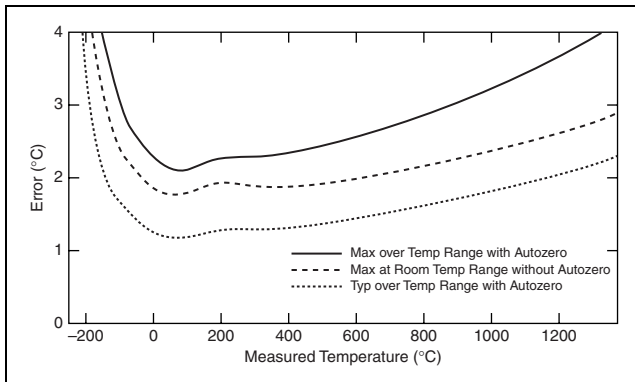
Figure 6. Type K Errors
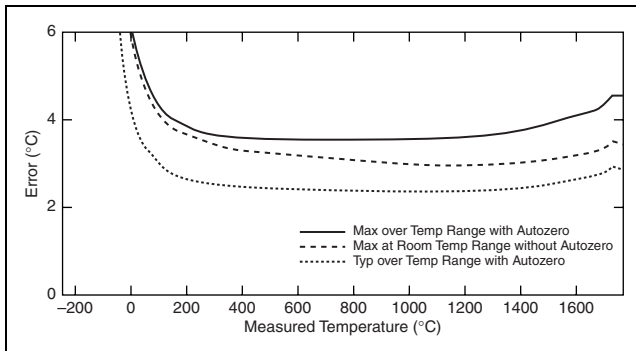
Figure 7. Type R and S Errors

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 terminals so that they are at a different temperature than the cold-junction compensation sensor used to measure the cold junction. The thermal gradient generated across the terminals can cause the terminals of different channels to be at different

temperatures, so the resulting measurement creates errors not only in absolute accuracy but also in the relative accuracy between channels. If the CompactRIO system is mounted as recommended in the chassis installation instructions, the cRIO-9211 accuracy specifications include the errors caused by the gradient across the module terminals.

Minimizing Thermal Gradients

Thermocouple wire can be a significant source of thermal gradients if it conducts heat or cold directly to terminal junctions. To minimize these errors, mount the CompactRIO system as described in the installation instructions for your chassis and follow these guidelines:

- Use small-gauge thermocouple wire. Smaller wire transfers less heat to or from the measuring junction.

- Run thermocouple wiring together near the screw-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.

Sleep Mode

You can enable sleep mode for the CompactRIO system in software. Typically, when a system is in sleep mode, you cannot communicate with the modules. In sleep mode, the system minimizes power consumption. The system thermal dissipation may decrease. Refer to the *Specifications* section for more information about power consumption and thermal dissipation. Refer to the *CompactRIO Bookshelf* for more information about enabling sleep mode in software.

Specifications

The following specifications are typical for the range –40 to 70 °C 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

Voltage measurement range .... ±80 mV

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 70 °C .... 0.6 °C (1.1 °F) typ, 1.3 °C (2.3 °F) max

    –40 to 70 °C .... 1.7 °C (3.1 °F) max

Conversion time .... 70 ms per channel; 420 ms total for all channels including the autozero and cold-junction channels

Input bandwidth (–3 dB) .... 15 Hz

Noise rejection .... 85 dB min at 50/60 Hz

Overvoltage protection .... ±30 V between any input and common

Differential input impedance .... 20 MΩ

Input current .... 50 nA

Input noise .... 1 μV_{rms}

Gain error .... 0.05% max at 25 °C,
0.06% typ at −40 to 70 °C,
0.1% max at −40 to 70 °C

Offset error (with autozeroing) .... 15 μV typ, 20 μV max

Gain error from
source impedance .... 0.05 ppm per Ω source impedance due to input impedance

Offset error from
source impedance .... 0.05 μV typ, 0.07 μV max per Ω source impedance due to input current

MTBF .... 633,012 hours at 25 °C;
Bellcore Issue 6, Method 1,
Case 3, Limited Part Stress
Method

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

Power Requirements

Power consumption from chassis

Active mode .... 170 mW max

Sleep mode .... 4 mW max

Thermal dissipation (at 70 °C)

Active mode .... 170 mW max

Sleep mode .... 4 mW max

Physical Characteristics

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

Screw-terminal wiring .... 12 to 24 AWG copper conductor wire with 10 mm (0.39 in.) of insulation stripped from the end

Torque for screw terminals .... 0.5 to 0.6 N · m (4.4 to 5.3 lb · in.)

Weight .... Approx. 150 g (5.3 oz)

Safety

Safety Voltages

Connect only voltages that are within these limits.

Channel-to-COM .... ±30 V max, Installation Category I

Installation Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such

voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Isolation

Channel-to-channel ....No isolation between channels

Channel-to-earth ground

Continuous ....250 V_{rms}

Withstand ....2,300 V_{rms}, 1 minute max

Safety Standards

The cRIO-9211 is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- EN 61010-1, IEC 61010-1

- UL 3111-1, UL 61010B-1

- CAN/CSA C22.2 No. 1010.1

Note For UL and other safety certifications, refer to the product label, or visit ni.com/hardref.nsf, search by

model number or product line, and click the appropriate link in the Certification column.

Hazardous Locations

U.S. (UL) .... Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nC IIC T4

Canada (C-UL) .... Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nC IIC T4

Europe (DEMKO)............................. EEx nC IIC T4

Environmental

CompactRIO modules are intended for indoor use only. For outdoor use, mount the CompactRIO system in a suitably rated enclosure. Refer to the installation instructions for the chassis you are using for more information about meeting these specifications.

Operating temperature .... −40 to 70 °C

Storage temperature .... −40 to 85 °C

Ingress protection............................. IP 40

Operating humidity............................ 10 to 90% RH, noncondensing

Storage humidity............................... 5 to 95% RH, noncondensing

Maximum altitude.............................. 2,000 m

Pollution Degree (IEC 60664) 2

Shock and Vibration

To meet these specifications, you must panel mount the CompactRIO system and affix ferrules to the end of the terminal wires.

Operating vibration,
random (IEC 60068-2-64) .... 5 g_{rms}, 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

Operating vibration,
sinusoidal (IEC 60068-2-6) .... 5 g, 10 to 500 Hz

Electromagnetic Compatibility

Emissions...EN 55011 Class A at 10 m
FCC Part 15A above 1 GHz

Immunity...Industrial levels per EN
61326-1:1997 + A2:2001,
Table A.1

EMC/EMI ....CE, C-Tick, and FCC Part 15
(Class A) Compliant

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

CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

Low-Voltage Directive (safety).........73/23/EEC

Electromagnetic Compatibility
Directive (EMC) 89/336/EEC

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/hardref.nsf, search by model number or product line, and click the appropriate link in the Certification column.

Calibration

You can obtain the calibration certificate and calibration procedures for the cRIO-9211 at ni.com/calibration.

National Instruments Contact Information

Go to ni.com/support for the most current manuals, examples, and troubleshooting information. For telephone support in the United States, create a 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:

Australia 1800 300 800, Austria 43 0 662 45 79 90 0,
Belgium 32 0 2 757 00 20, Brazil 55 11 3262 3599,
Canada (Calgary) 403 274 9391,
Canada (Montreal) 514 288 5722,
Canada (Ottawa) 613 233 5949, Canada (Québec) 514 694 8521,
Canada (Toronto) 905 785 0085,
Canada (Vancouver) 514 685 7530, China 86 21 6555 7838,
Czech Republic 420 2 2423 5774, Denmark 45 45 76 26 00,

Finland 385 0 9 725 725 11, France 33 0 1 48 14 24 24,
Germany 49 0 89 741 31 30, Greece 30 2 10 42 96 427,
India 91 80 51190000, Israel 972 0 3 6393737,
Italy 39 02 413091, Japan 81 3 5472 2970,
Korea 82 02 3451 3400, Malaysia 603 9131 0918,
Mexico 001 800 010 0793, Netherlands 31 0 348 433 466,
New Zealand 0800 553 322, Norway 47 0 66 90 76 60,
Poland 48 0 22 3390 150, Portugal 351 210 311 210,
Russia 7 095 783 68 51, Singapore 65 6226 5886,
Slovenia 386 3 425 4200, South Africa 27 0 11 805 8197,
Spain 34 91 640 0085, Sweden 46 0 8 587 895 00,
Switzerland 41 56 200 51 51, Taiwan 886 2 2528 7227,
Thailand 662 992 7519, United Kingdom 44 0 1635 523545

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