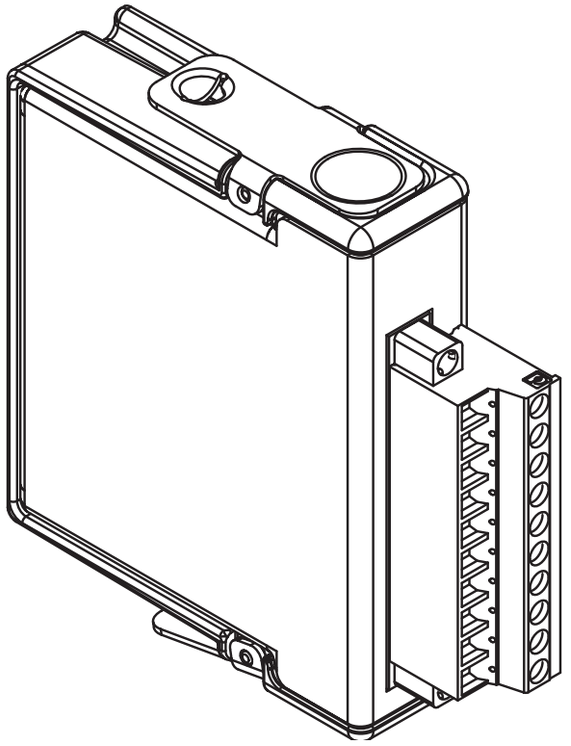
OPERATING INSTRUCTIONS

NI 9211

4-Channel Thermocouple Input Module

このドキュメントの日本語版については、ni.com/manualsja を参照してください。(For a Japanese language version, go to ni.com/manualsja.)



NATIONAL INSTRUMENTS™

These operating instructions describe how to use the National Instruments NI 9211. For information about installing, configuring, and programming your system, refer to your system documentation. To determine which software you need for the modules you are using, go to `ni.com/info` and enter `rdsoftwareversion`.

Note The safety guidelines and specifications in this document are specific to the NI 9211. The other components in your system may not meet the same safety ratings and specifications. Refer to the documentation for each component in your system to determine the safety ratings and specifications for the entire system.

Safety Guidelines

Operate the NI 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 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 9932 connector backshell kit to ensure that the terminals are *not* accessible.

Figure 1 shows the NI 9932 connector backshell.

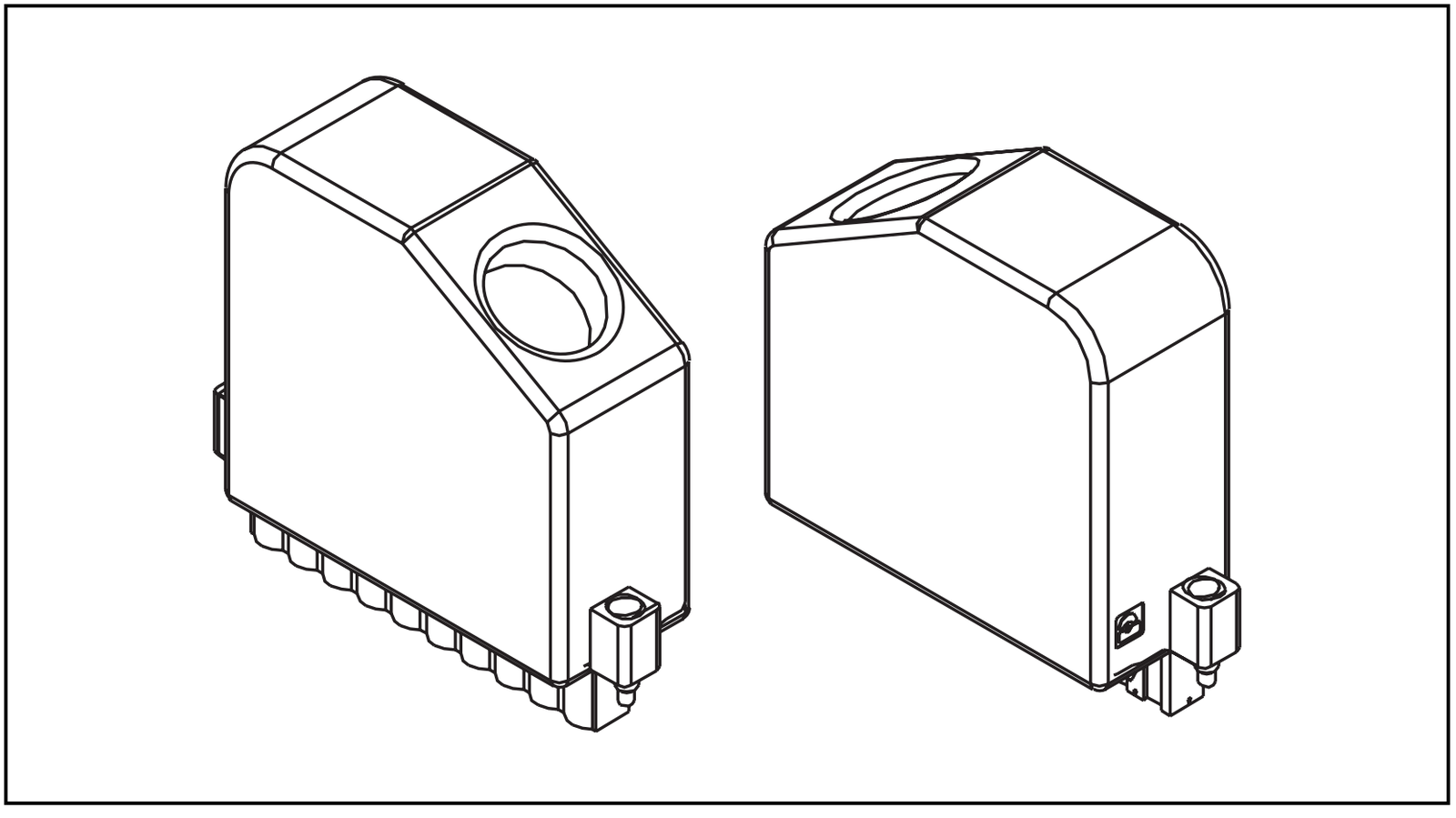


Figure 1. NI 9932 Connector

Safety Guidelines for Hazardous Locations

The NI 9211 is suitable for use in Class I, Division 2, Groups A, B, C, D, T4 hazardous locations; Class I, Zone 2, AEx nC IIC T4 and Ex nC IIC T4 hazardous locations; and nonhazardous locations only. Follow these guidelines if you are installing the NI 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 your system in an enclosure rated to at least IP 54 as defined by IEC 60529 and EN 60529.

Caution For Zone 2 applications, connected signals must be within the following limits:

Capacitance.....0.2 µF max

Special Conditions for Hazardous Locations Use in Europe

This equipment has been evaluated as EEx nC IIC T4 equipment under DEMKO Certificate No. 02 ATEX 0324020X. Each module is marked ⟨Ex⟩ II 3G and is suitable for use in Zone 2 hazardous locations.

Special Conditions for Marine Applications

Some modules are Lloyd's Register (LR) Type Approved for marine applications. To verify Lloyd's Register certification, go to `ni.com/certification` for the LR certificate, and look for the Lloyd's Register mark on the module.

Caution To meet radio frequency emission requirements for marine applications, use shielded cables and install the system in a metal enclosure. Suppression ferrites must be installed on power supply inputs near power entries to modules and controllers. Power supply and module cables must be separated on opposite sides of the enclosure, and must enter/exit through opposing enclosure walls.

Wiring the NI 9211

The NI 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 NI 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.

Wiring for High Vibration Applications

National Instruments recommends using ferrules for terminating wires to the detachable screw-terminal connector or using the NI 9932 backshell kit to protect the connections when you use the NI 9211 in high vibration applications. Refer to Figure 2 for an illustration.

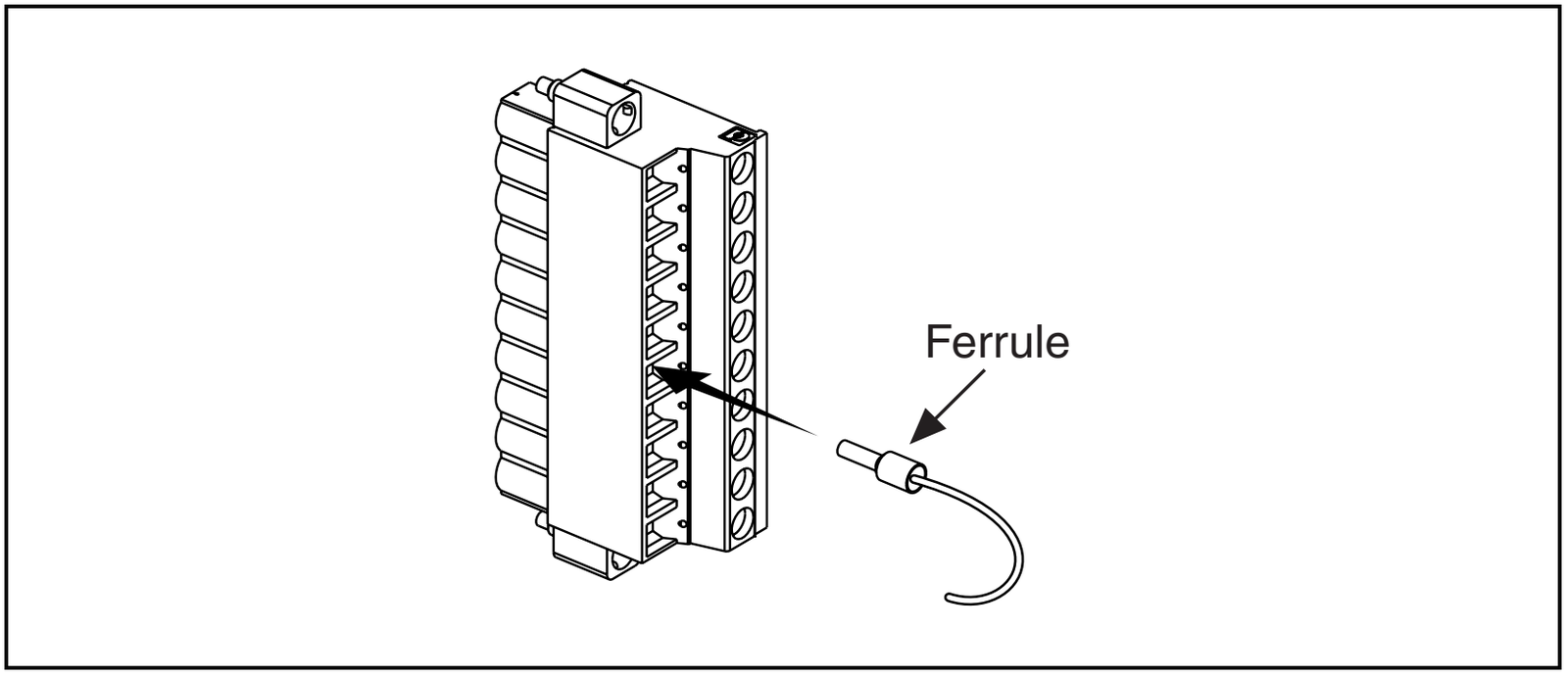
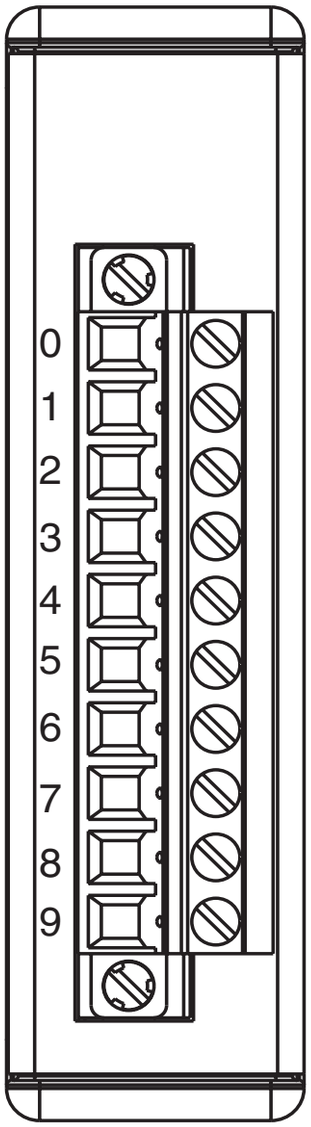


Figure 2. 10-pin Detachable Screw-Terminal Connector with a Ferrule

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 NI 9211

You can connect thermocouple input signals to the NI 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.

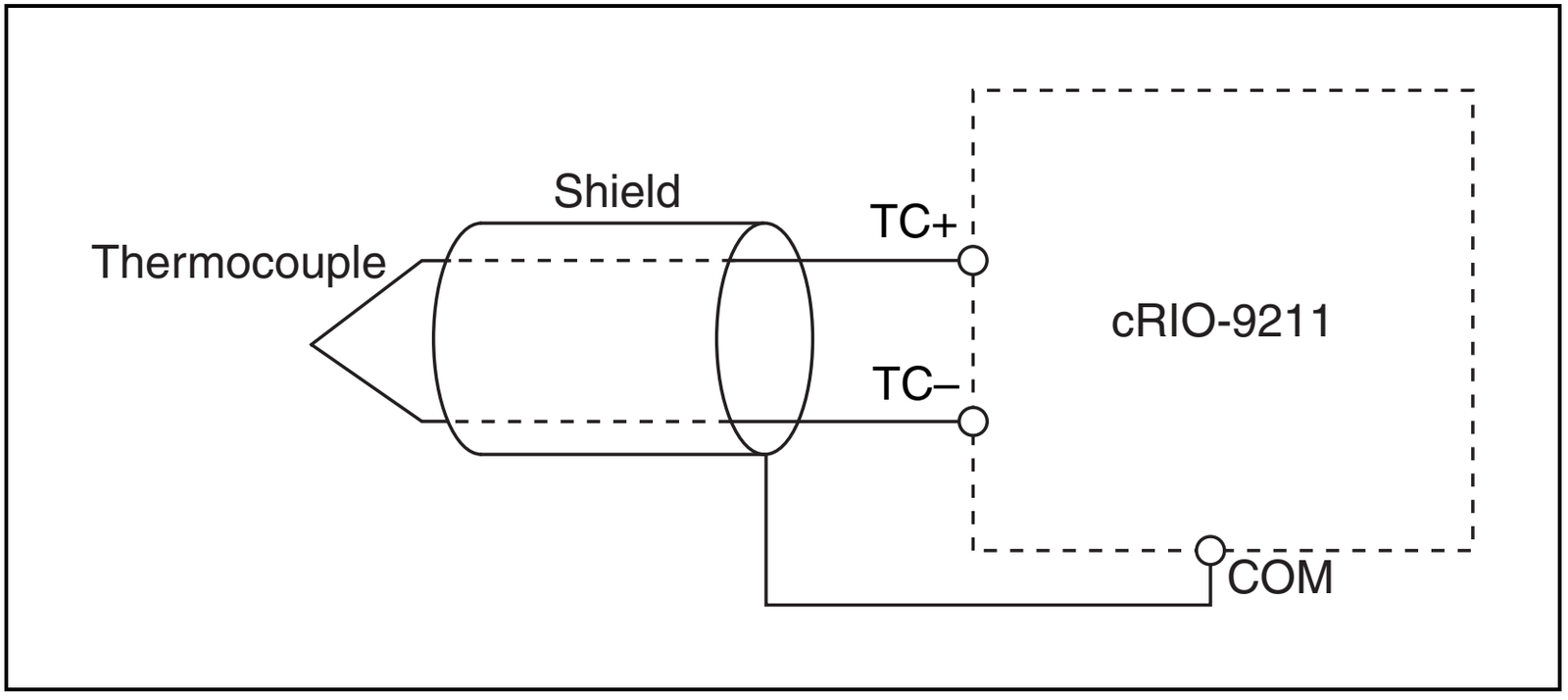


Figure 3. Connecting a Thermocouple Input Signal to the NI 9211

Refer to your software documentation for more information about reading temperatures from the NI 9211 channels.

NI 9211 Circuitry

The NI 9211 channels share a common ground that is isolated from other modules in the system. 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. Refer to your software documentation for more information about detecting open thermocouples in software.

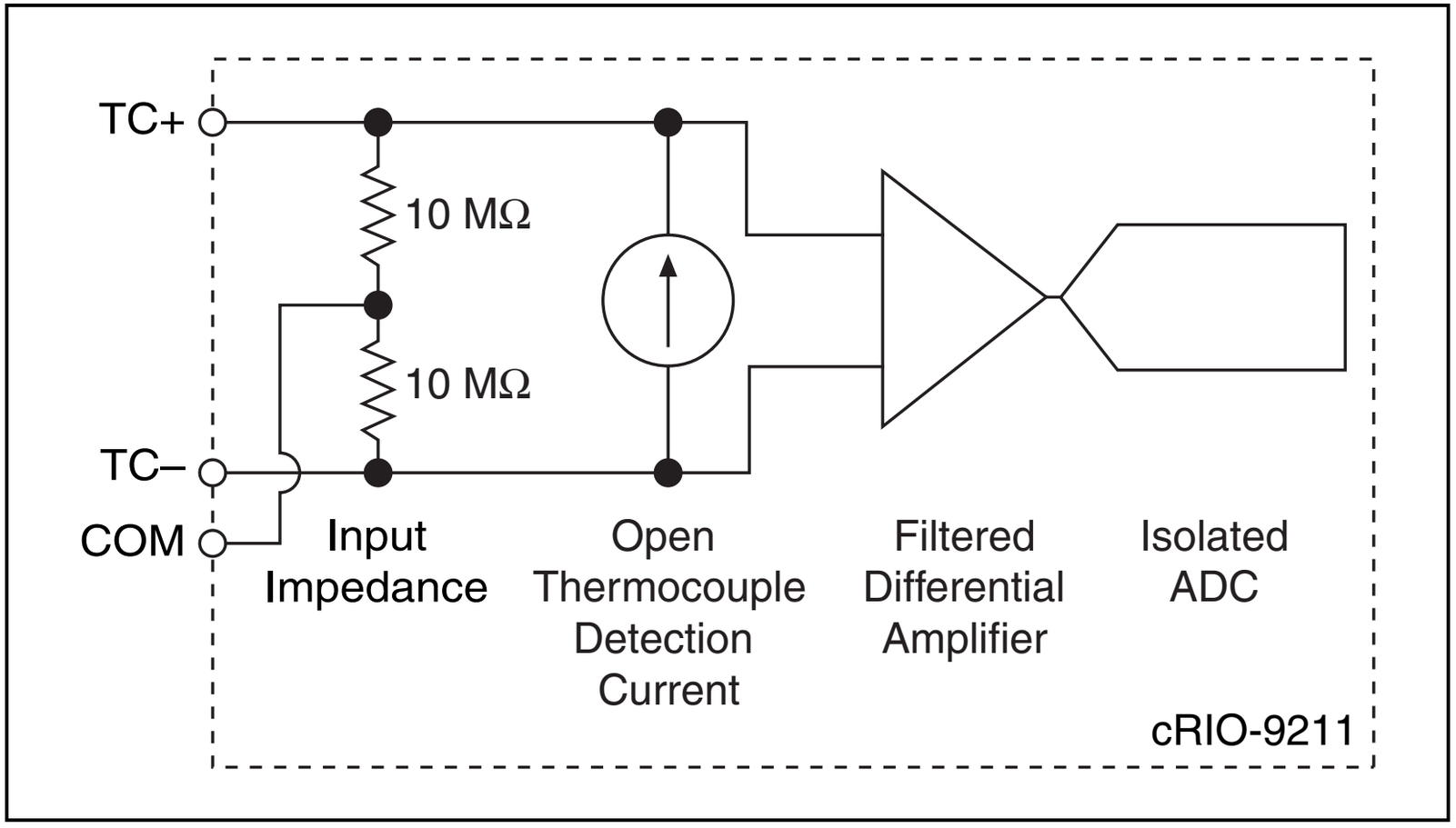


Figure 4. Input Circuitry for One Channel

Effects of Source Impedance on Voltage Measurement Accuracy

The resistors shown in Figure 4 produce an input impedance at the terminals of the NI 9211. If thermocouples are connected to the NI 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 NI 9211 has an internal autozero channel for measuring the offset error. If the ambient temperature of the NI 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 NI 9211 thermocouple input channels. For more information about reading from the autozero channel, refer to your software documentation.

Measurement Accuracy for the Different Types of Thermocouples

Figures 5, 6, 7, 8, and 9 show the typical and maximum errors for the different thermocouple types when used with the NI 9211 over the full temperature range. The figures also show the maximum error for the thermocouple types with the NI 9211 at room temperature, which is 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 NI 9211 terminals affect the cold-junction temperature accuracy. Refer to the *Cold-Junction Temperature Measurement Accuracy* section for more information about temperature gradients.

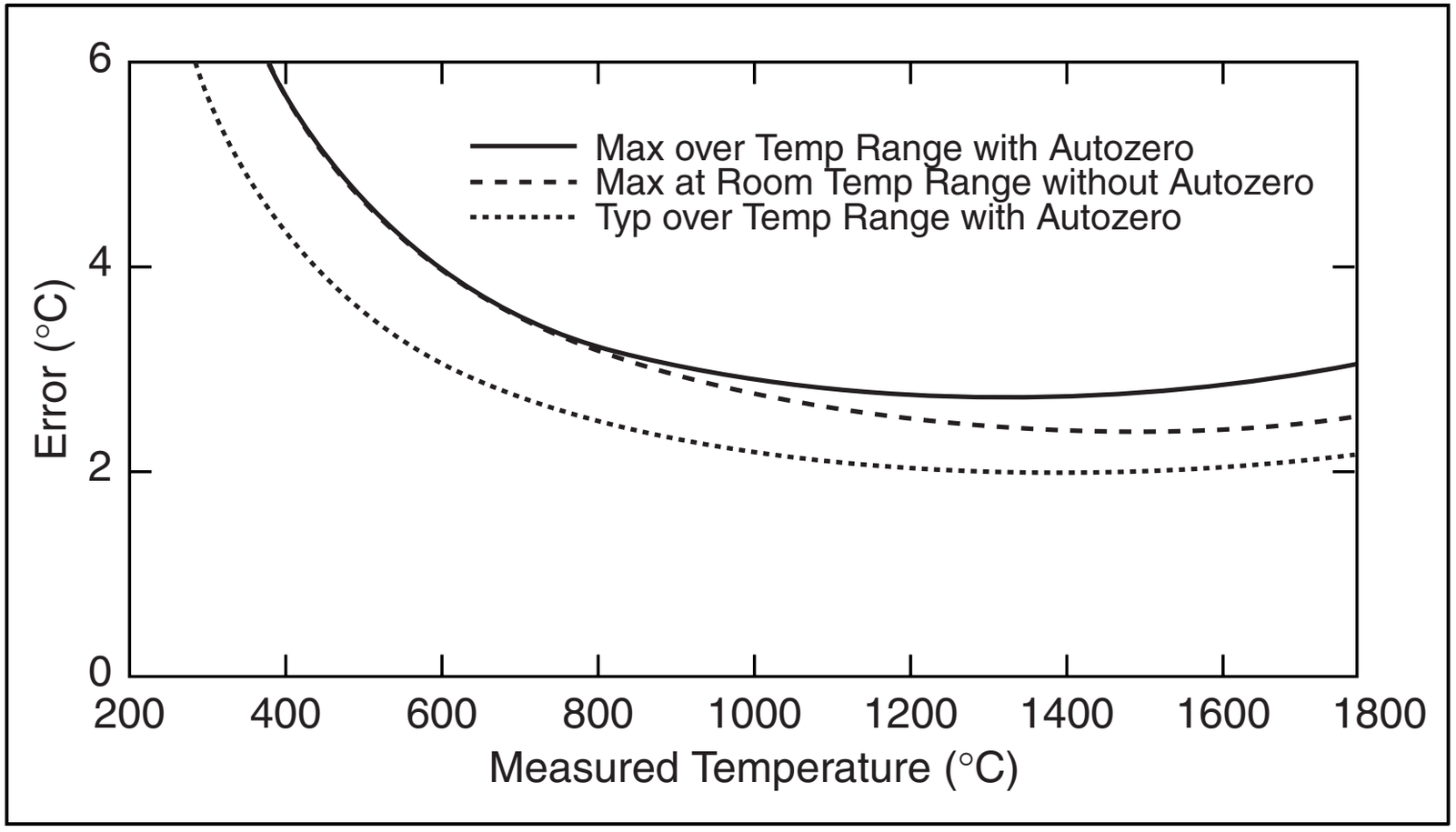


Figure 5. Type B Errors

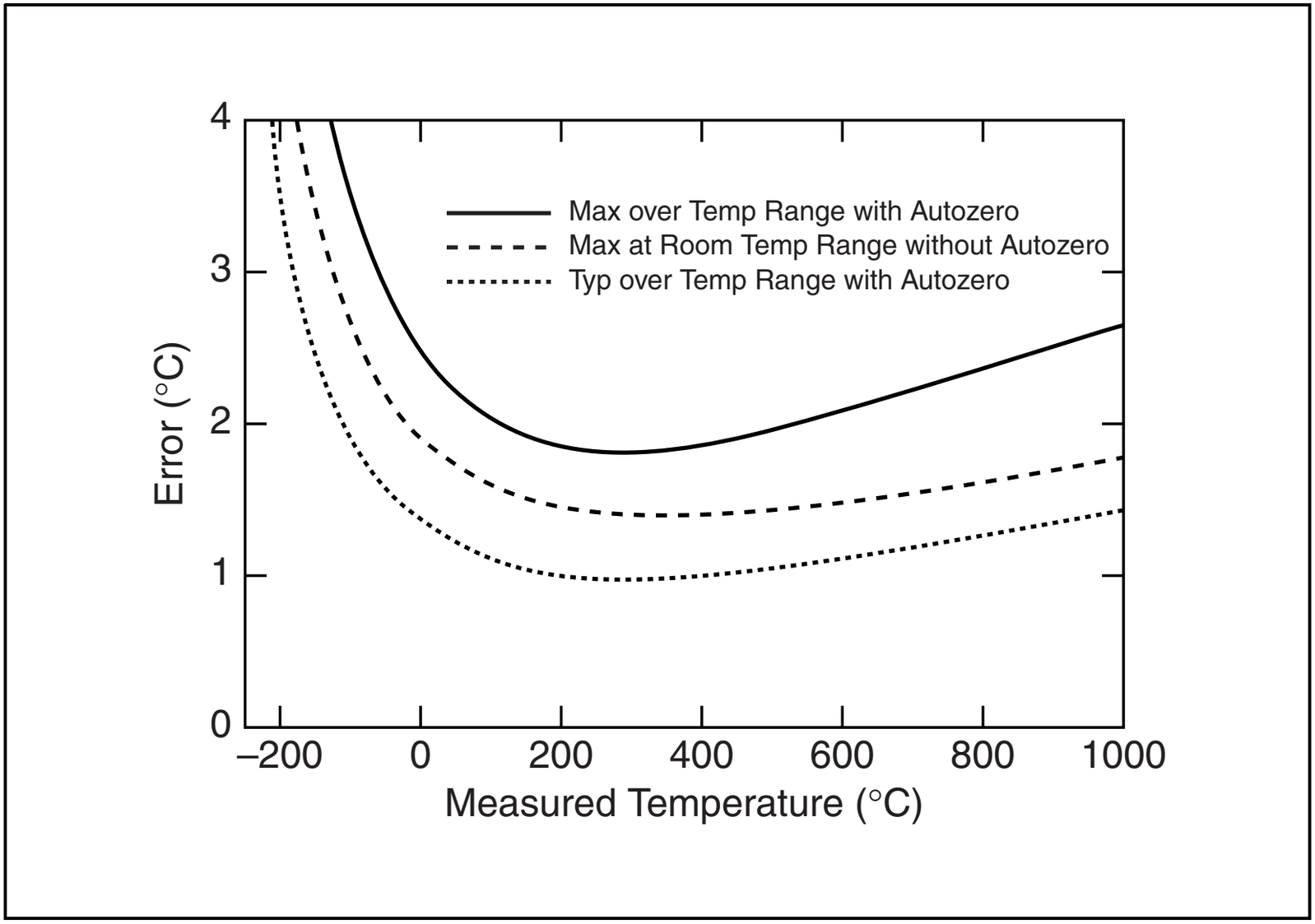


Figure 6. Type E and T Errors

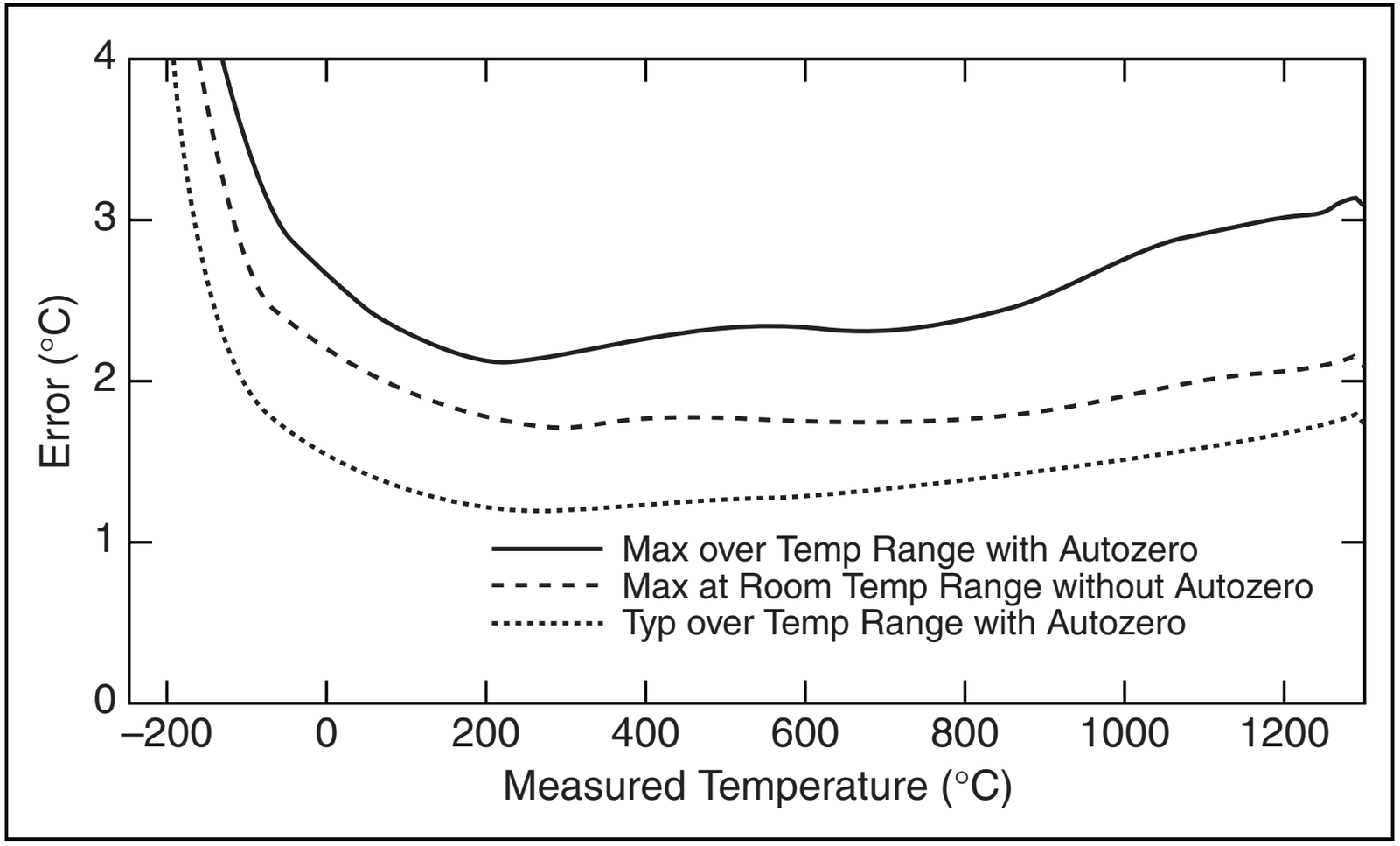


Figure 7. Type J and N Errors

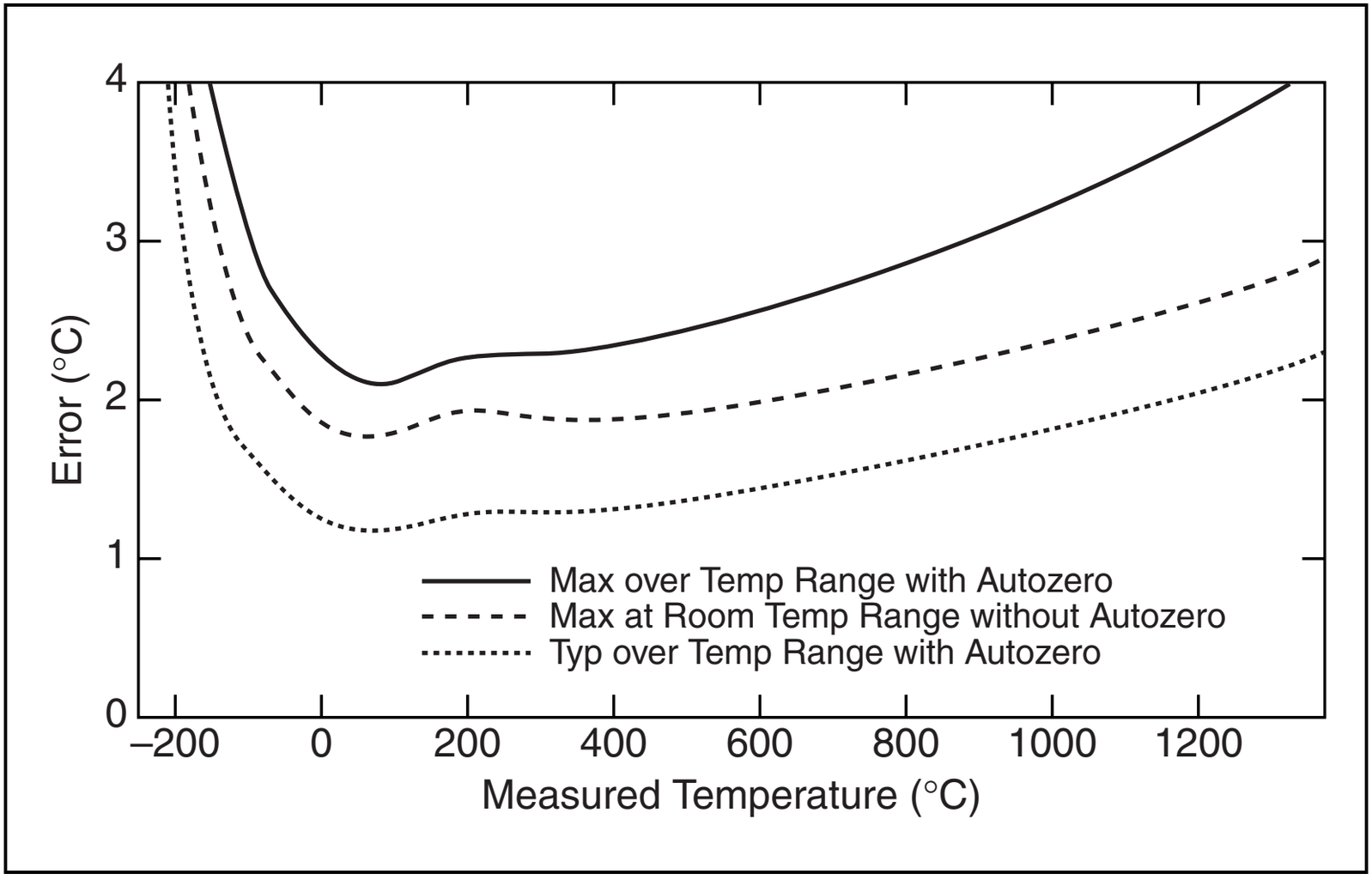


Figure 8. Type K Errors

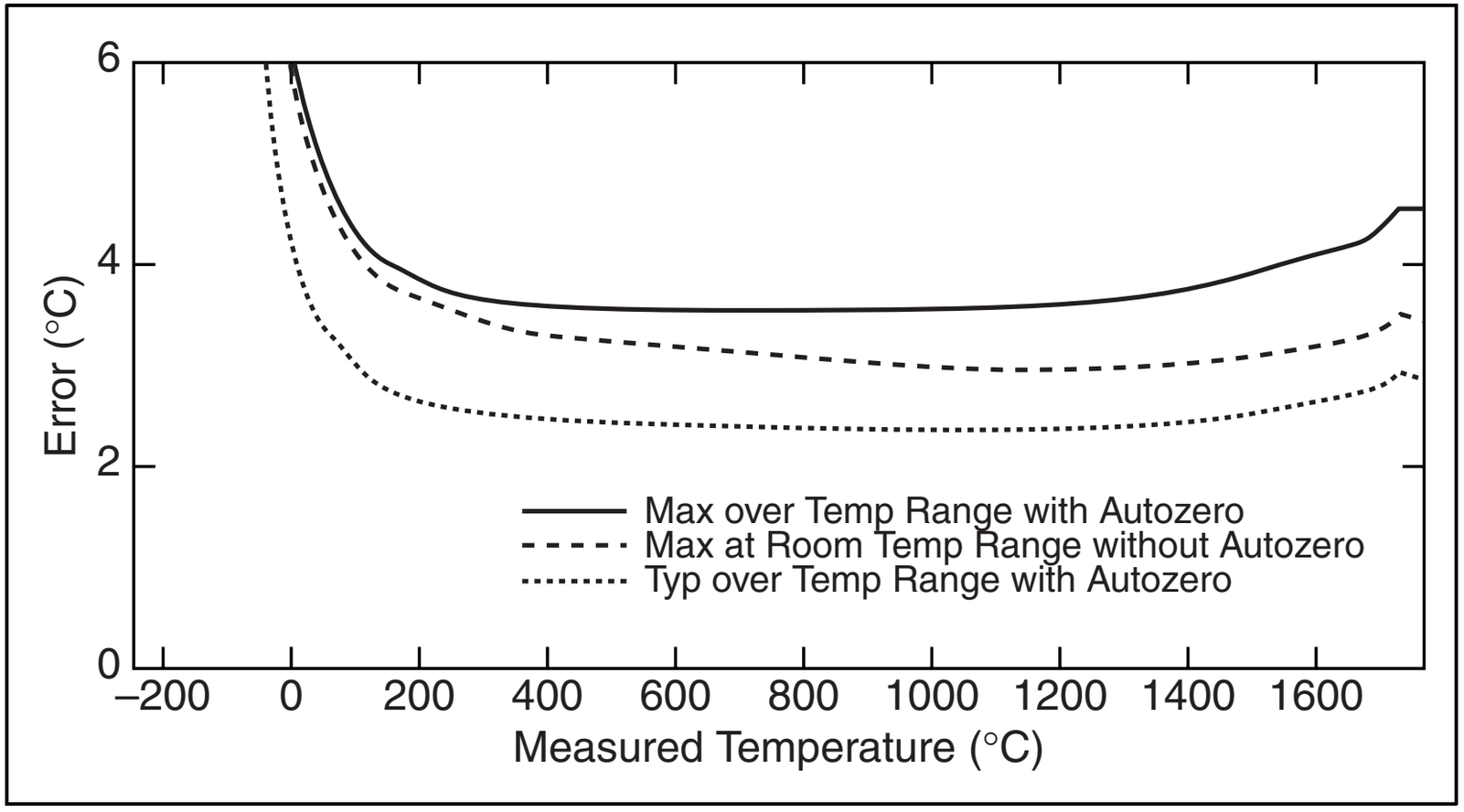


Figure 9. Type R and S Errors

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 system is mounted as recommended in the chassis installation instructions, the NI 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 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

This module supports a low-power sleep mode. Support for sleep mode at the system level depends on the chassis that it is plugged into. Refer to your chassis documentation for information regarding support for sleep mode functionality. You can enable sleep mode in software. Refer to your driver software documentation for more information.

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.

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 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.)

Ferrules ..... 0.25 mm^2 to 2.5 mm^2

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

Safety

Safety Voltages

Connect only voltages that are within these limits.

Channel-to-COM ..... ±30 V max

Isolation Voltages

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

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). Do not connect to signals or use for measurements within Measurement Categories III or IV.

Safety Standards

The NI 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 61010-1
- CAN/CSA-C22.2 No. 61010-1

Note For UL and other safety certifications, refer to the product label, or visit `ni.com/certification`, search by module 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, Ex nC IIC T4

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

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 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 your 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, you *must* operate this device with shielded cabling.

CE Compliance

This product meets the essential requirements of applicable European directives, as amended for CE markings, 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/certification`, search by module 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 NI 9211 at `ni.com/calibration`.

Calibration interval ..... 1 year

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:

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 800 433 3488, China 86 21 6555 7838,
Czech Republic 420 224 235 774, 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, India 91 80 41190000,
Israel 972 0 3 6393737, Italy 39 02 413091,

Japan 81 3 5472 2970, Korea 82 02 3451 3400,
Lebanon 961 0 1 33 28 28, Malaysia 1800 887710,
Mexico 01 800 010 0793, Netherlands 31 0 348 433 466,
New Zealand 0800 553 322, Norway 47 0 66 90 76 60,
Poland 48 22 3390150, Portugal 351 210 311 210,
Russia 7 095 783 68 51, Singapore 1800 226 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 02 2377 2222,
Thailand 662 278 6777, United Kingdom 44 0 1635 523545

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