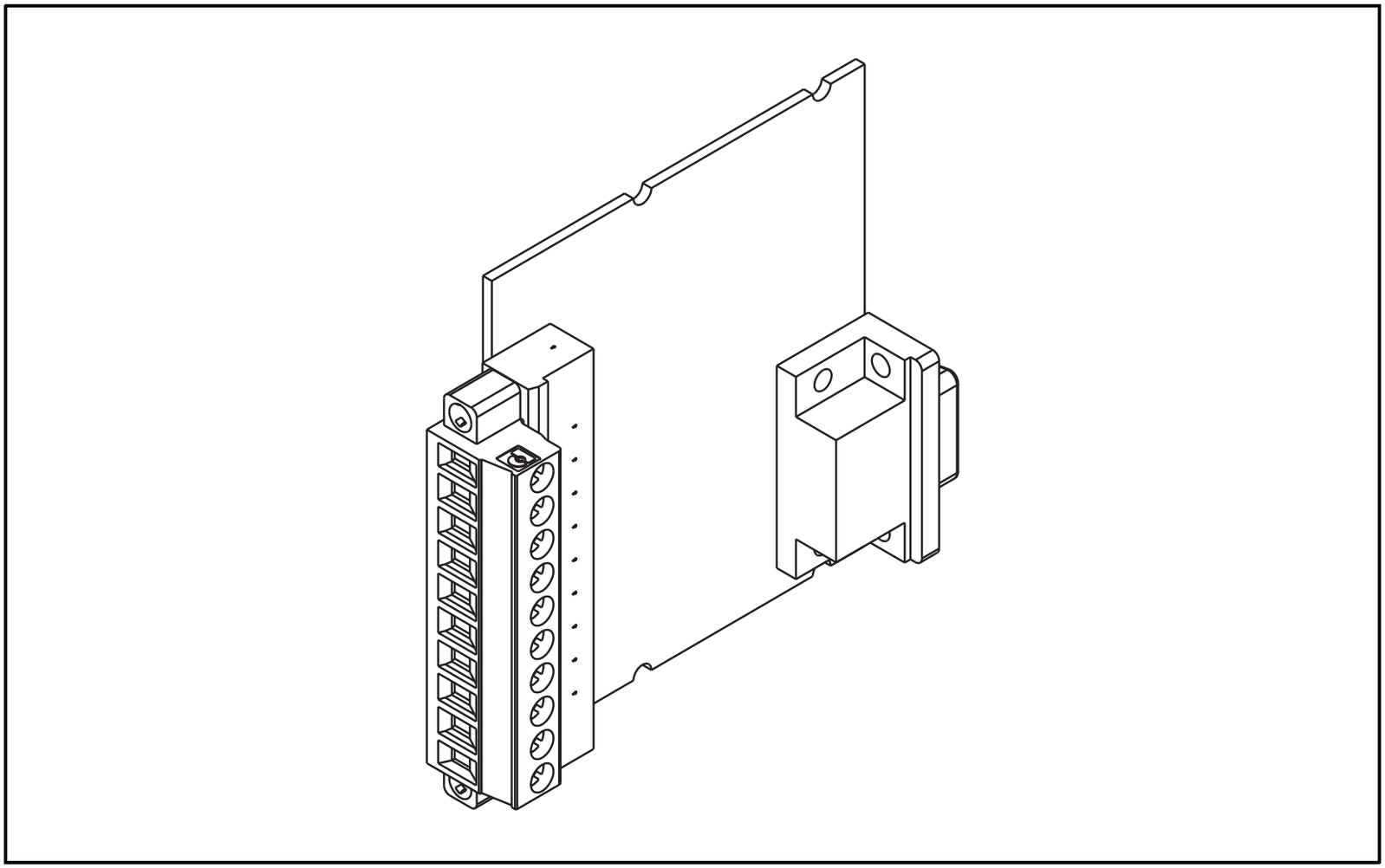
OPERATING INSTRUCTIONS AND SPECIFICATIONS

NI 9211E

4-Channel Thermocouple Input Module



NATIONAL INSTRUMENTS™

This document describes how to use the National Instruments 9211E and includes dimensions, terminal assignments, and specifications for the NI 9211E. 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 9211E. The end-product supplier is responsible for conformity to any and all compliance requirements.

Caution The NI 9211E must be installed inside a suitable enclosure prior to use. Hazardous voltages may be present.

NI 9211E Dimensions

The following figure shows the dimensions of the NI 9211E.

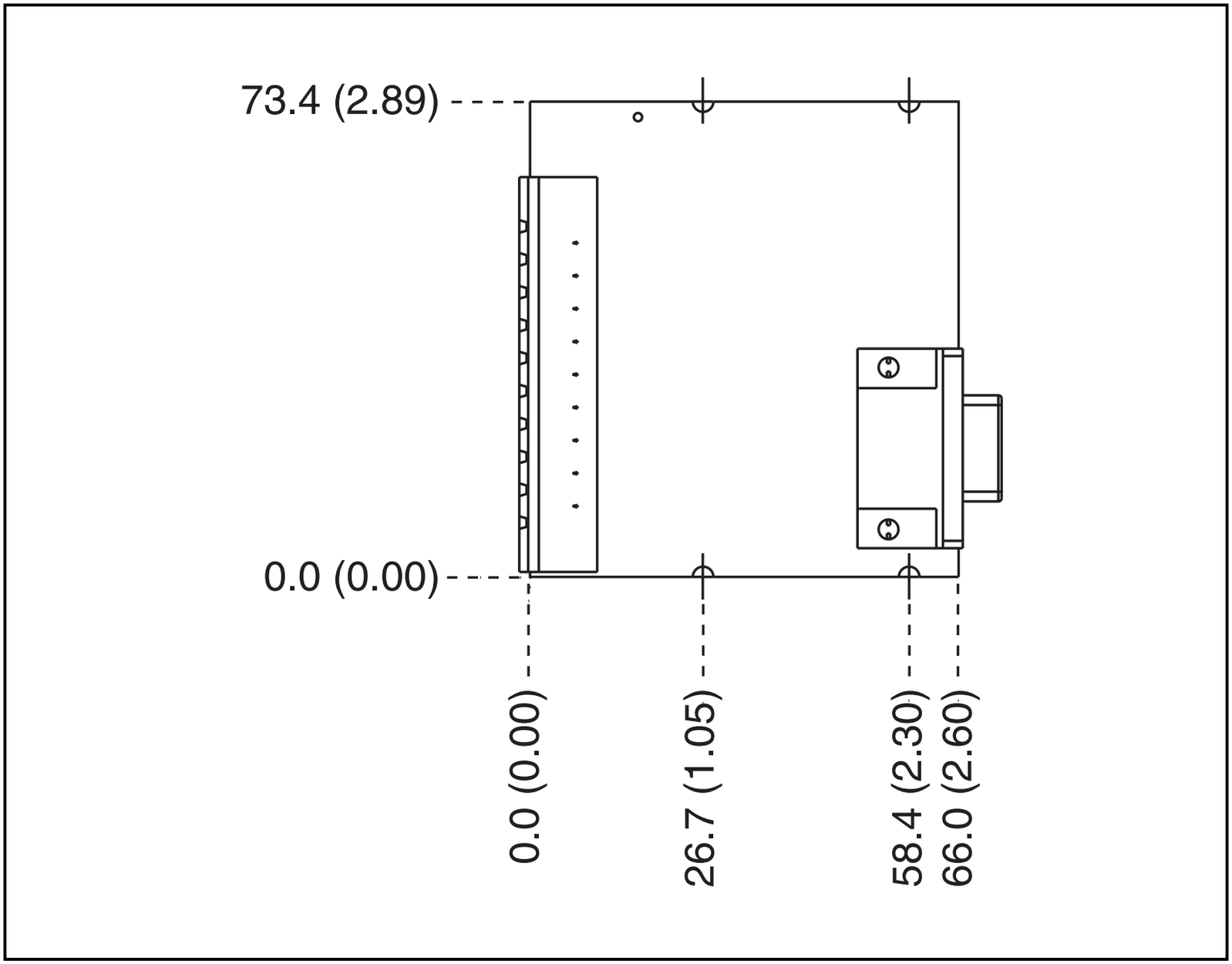


Figure 1. NI 9211E Dimensions in Millimeters (Inches)

Connecting the NI 9211E

The NI 9211E has a 10-terminal, detachable screw-terminal connector that provides connections for 4 thermocouple channels.

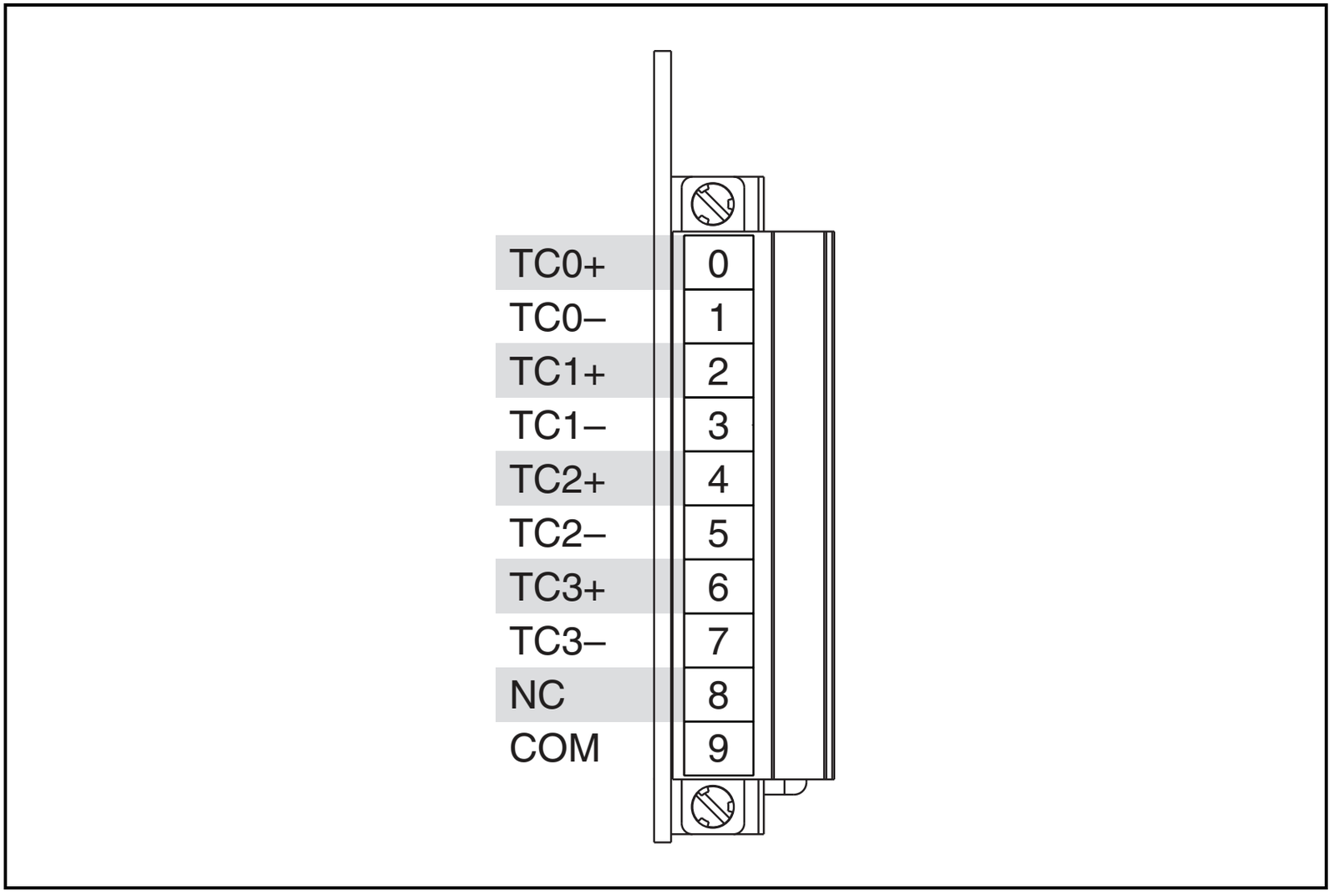


Figure 2. NI 9211E Terminal Assignments

You can connect thermocouple input signals to the NI 9211E. 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. If you are using shielded wiring, connect one end of the shield to the COM terminal. The COM terminal is internally connected to the isolated ground reference of the module. Refer to Figure 3 for an illustration of a typical shielding configuration.

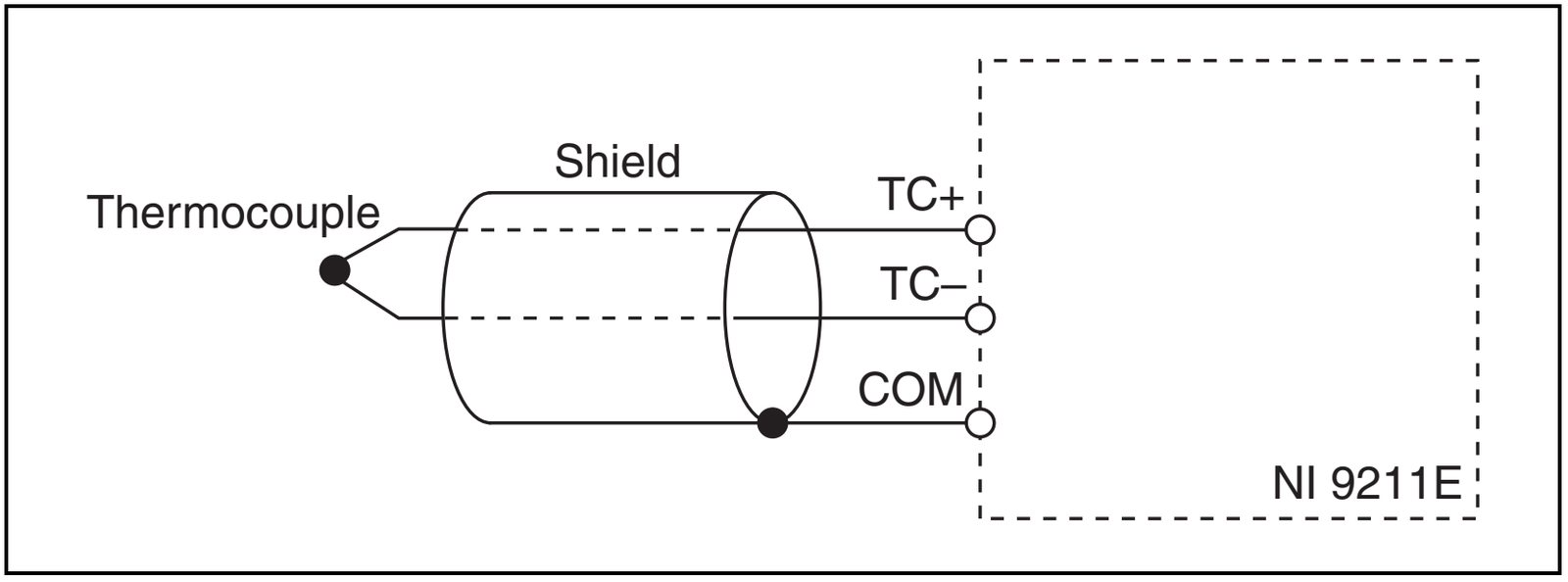


Figure 3. Connecting a Shielded Thermocouple Input Signal to the NI 9211E

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 9211E.

The NI 9211E channels share a common ground isolated from other modules in the system. Each channel passes through a filter and then a 24-bit analog-to-digital converter (ADC) samples the channel. 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 4 for an illustration of the circuitry for one channel of the NI 9211E.

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.

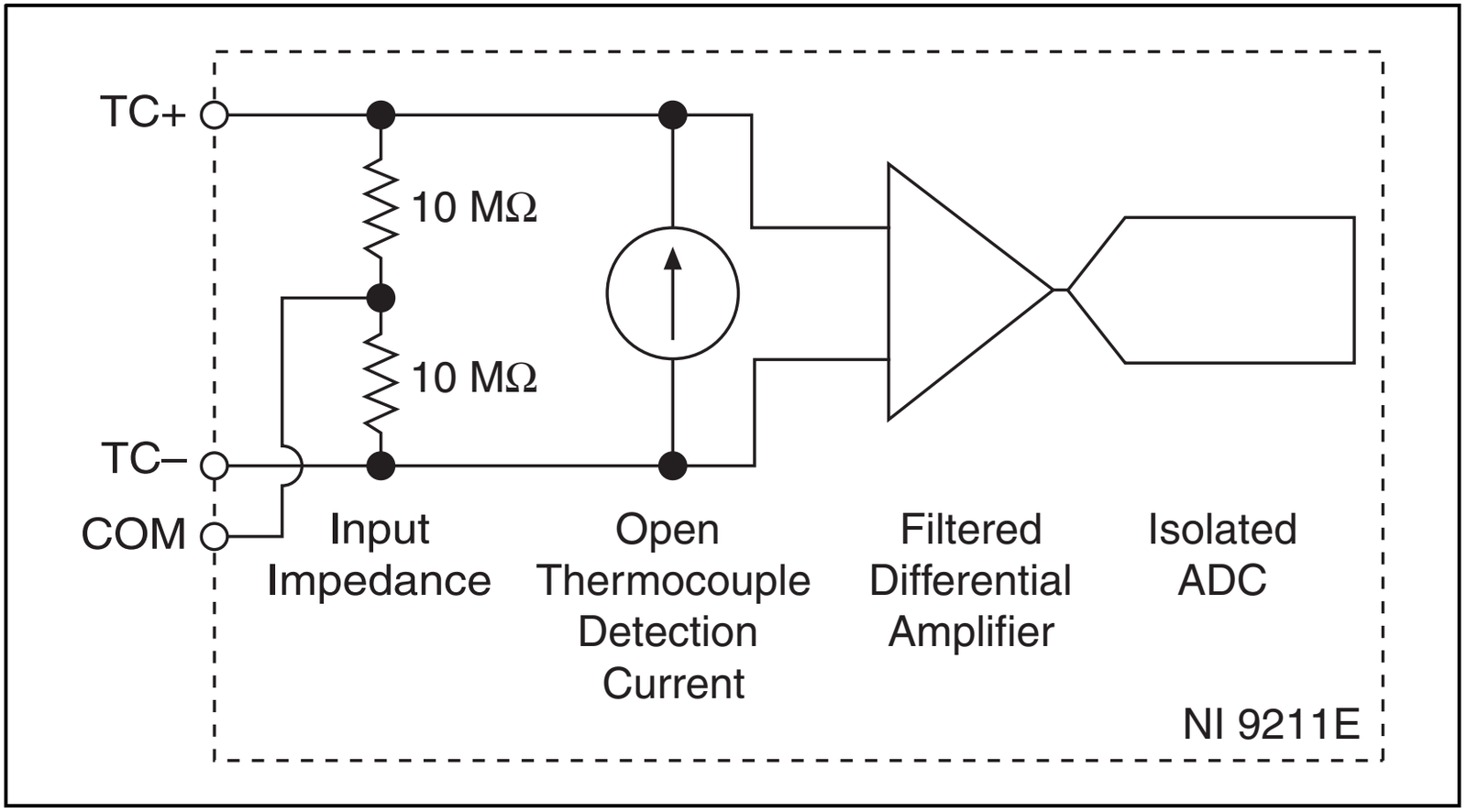


Figure 4. Input Circuitry for One Channel of the NI 9211E

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 of each thermocouple type when connected to the NI 9211E. The errors do not account for the accuracy of the thermocouple itself.

For the best accuracy results, keep temperature gradients across NI 9211E terminals to a minimum. Refer to the *Minimizing Thermal Gradients* section 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 9211E 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. 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.

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 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 as the thermocouple wires.

- Minimize adjacent heat sources and air flow across the terminals.
- Keep the ambient temperature as stable as possible.

Using the Autozero Channel

The NI 9211E has an internal autozero channel for measuring the offset error. If the ambient temperature of the NI 9211E 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 each NI 9211E thermocouple input 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.

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 85 °C internal to any enclosures unless otherwise noted. Accuracy within typical use can vary based on chassis, mounting parameters, other modules present in the system, and installed accessories.

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
Sampling mode	Scanned
Voltage measurement range	±80 mV
Temperature measurement ranges	Works over temperature ranges defined by NIST (J, K, T, E, N, B, R, S thermocouple types)

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

Common-mode voltage range

- Channel-to-COM ..... ±1.5 V
- COM-to-earth ground ..... ±250 V

Common-mode rejection ratio (0 to 60 Hz)

- Channel-to-COM ..... 95 dB
- COM-to-earth ground ..... >170 dB

Input bandwidth (–3 dB) ..... 15 Hz

Noise rejection (at 50 and 60 Hz) ..... 85 dB min

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

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 85 °C,
0.1% max at –40 to 85 °C

Offset error (with autozero channel on)..... 15 µV typ, 20 µV max

Gain error from source impedance..... Add 0.05 ppm per Ω when source impedance >50 Ω

Offset error from source impedance..... Add 0.05 µV typ, 0.07 µV max per Ω when source impedance >50 Ω

Cold-junction compensation sensor accuracy[1]

- 0 to 85 °C ..... 0.6 °C typ, 1.3 °C max
- –40 to 85 °C ..... 1.7 °C max

[1] The maximum errors assume an isothermal error of 1.0 °C. Refer to the *Cold-Junction Temperature Measurement Accuracy* section for more information.

MTBF ..... 633,012 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]

With autozero channel on

Types J, K, T, E, N ..... <0.07 °C

Types B ..... <0.25 °C

Types R, S ..... <0.60 °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.

With autozero channel off

Types J, K, T, E, N ..... <0.05 °C

Type B ..... <0.20 °C

Types R, S ..... <0.45 °C

Figures 5, 6, 7, 8, and 9 show the typical and maximum errors[1] for each thermocouple type when used with the NI 9211E over the full temperature range. The figures also display the maximum errors for the thermocouple types with the NI 9211E 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.

[1] The maximum errors assume an isothermal error of 1.0 °C. Refer to the *Cold-Junction Temperature Measurement Accuracy* section for more information.

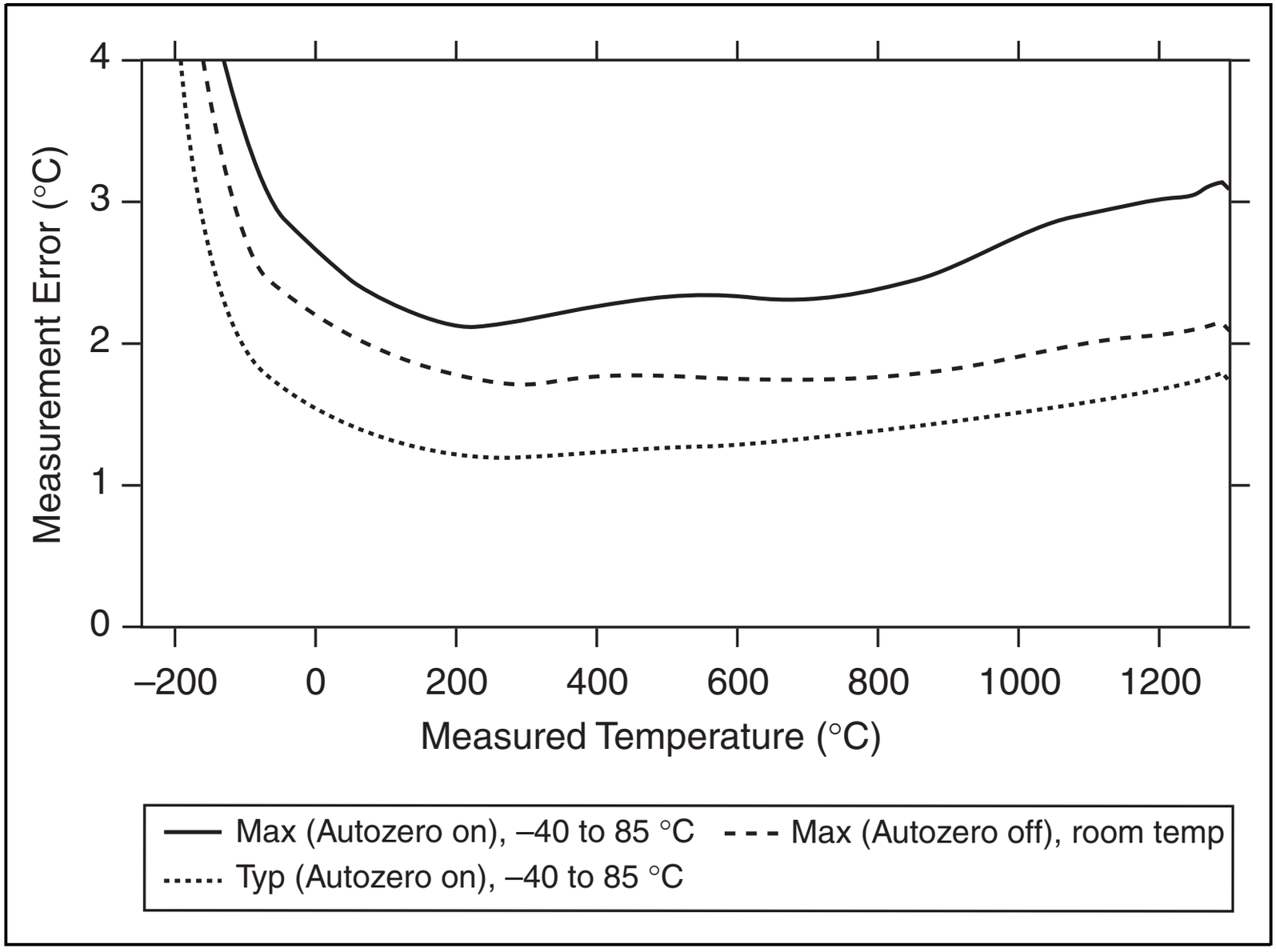


Figure 5. Thermocouple Type J and N Errors

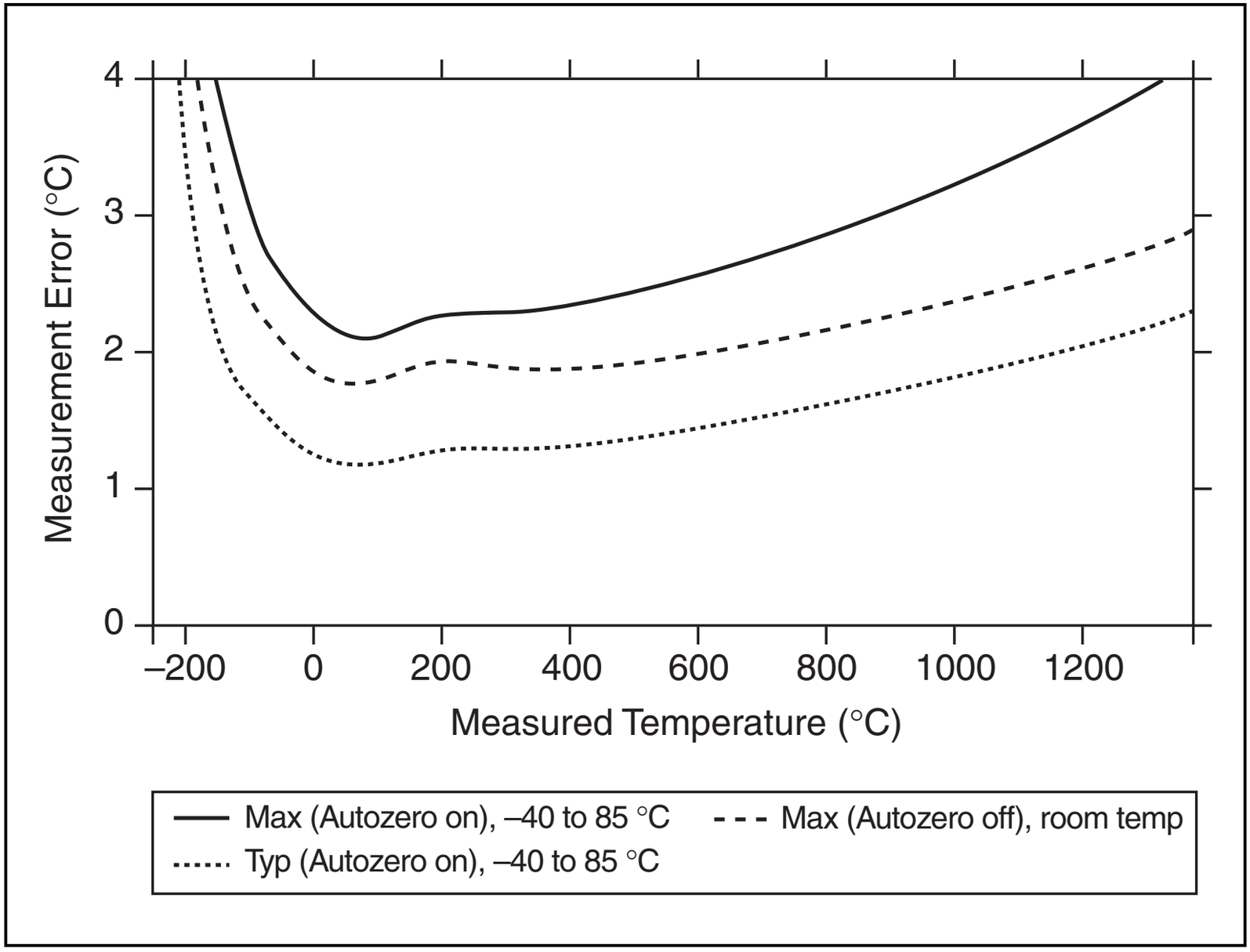


Figure 6. Thermocouple Type K Errors

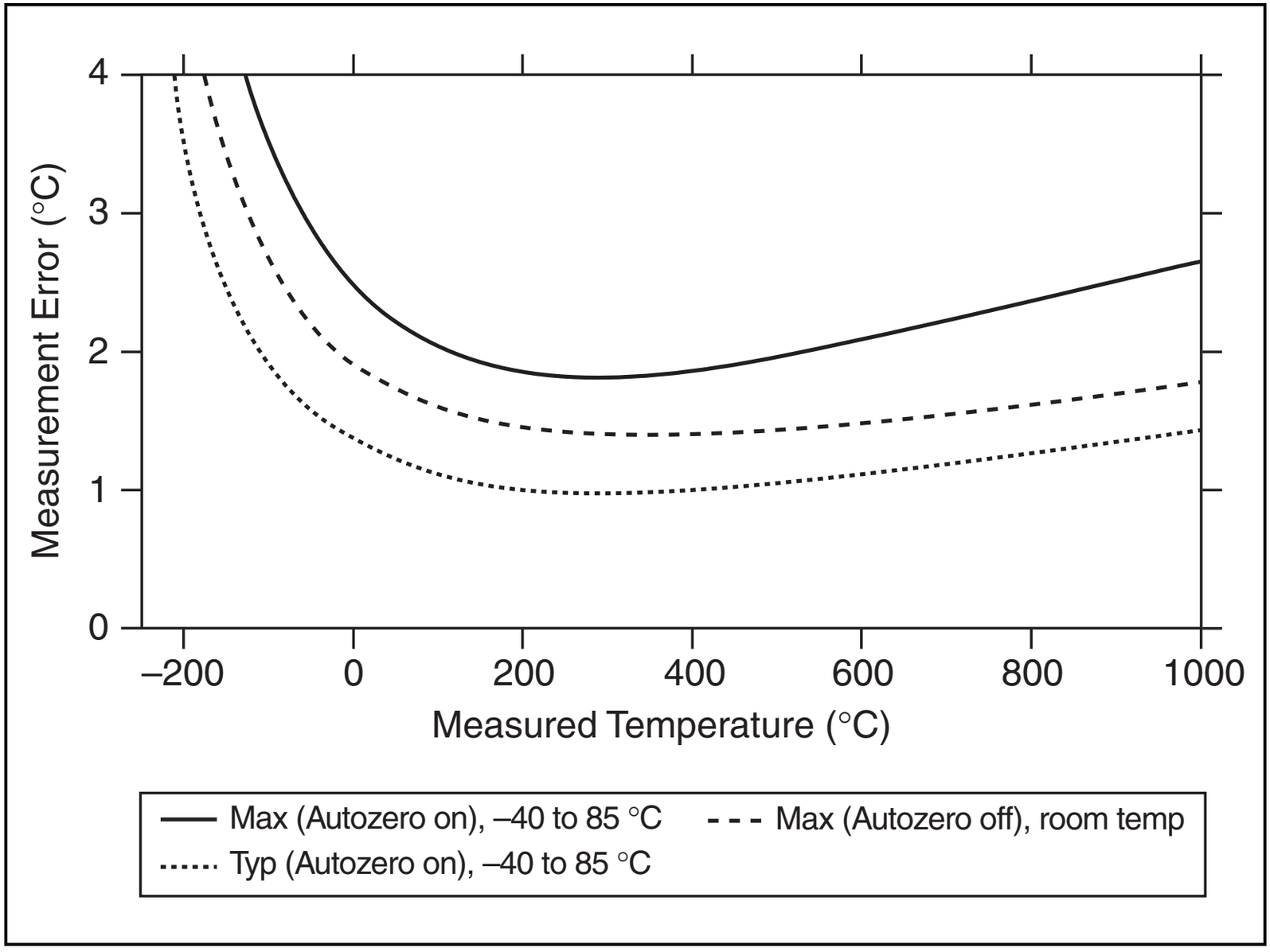


Figure 7. Thermocouple Type T and E Errors

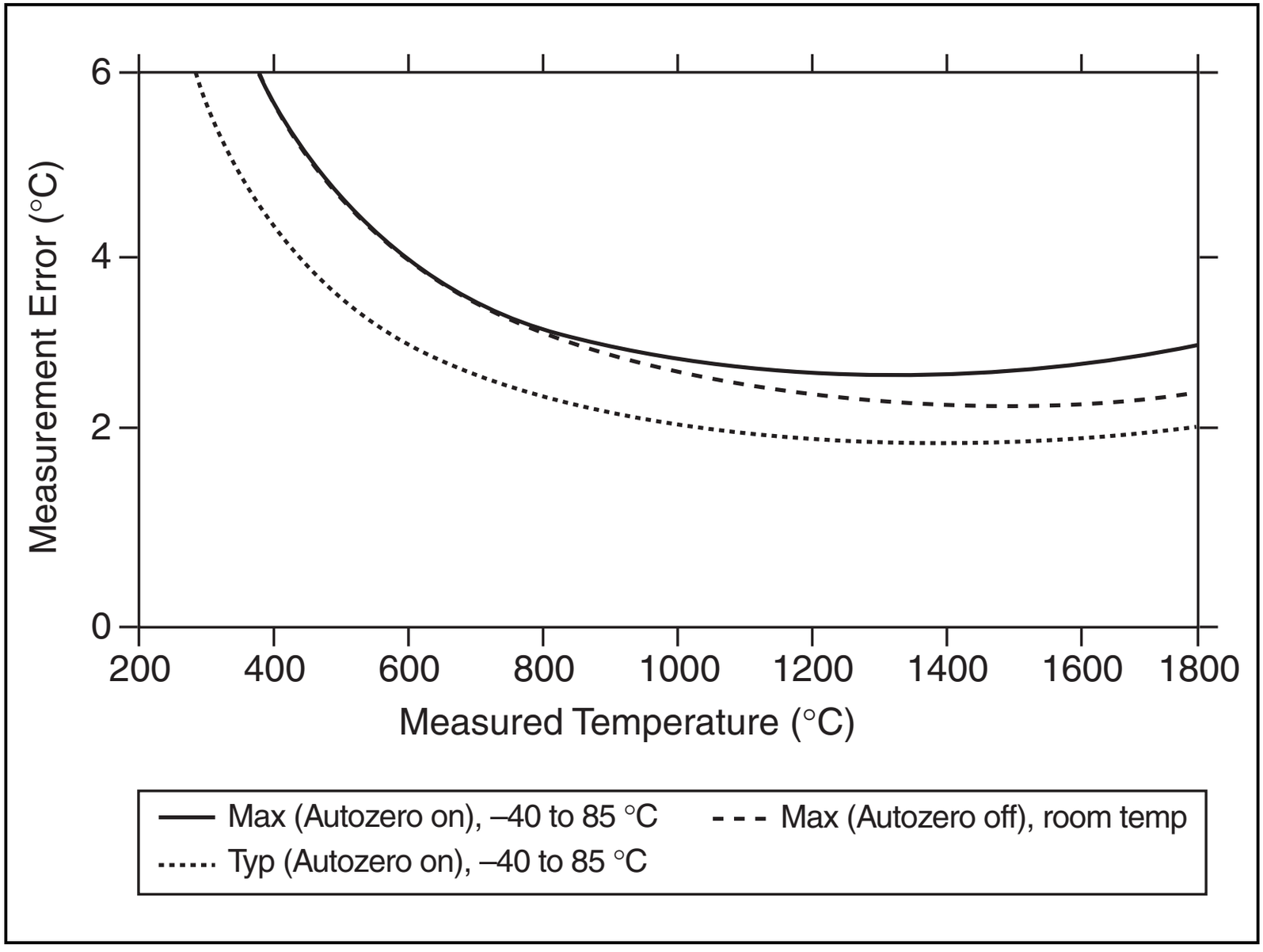


Figure 8. Thermocouple Type B Errors

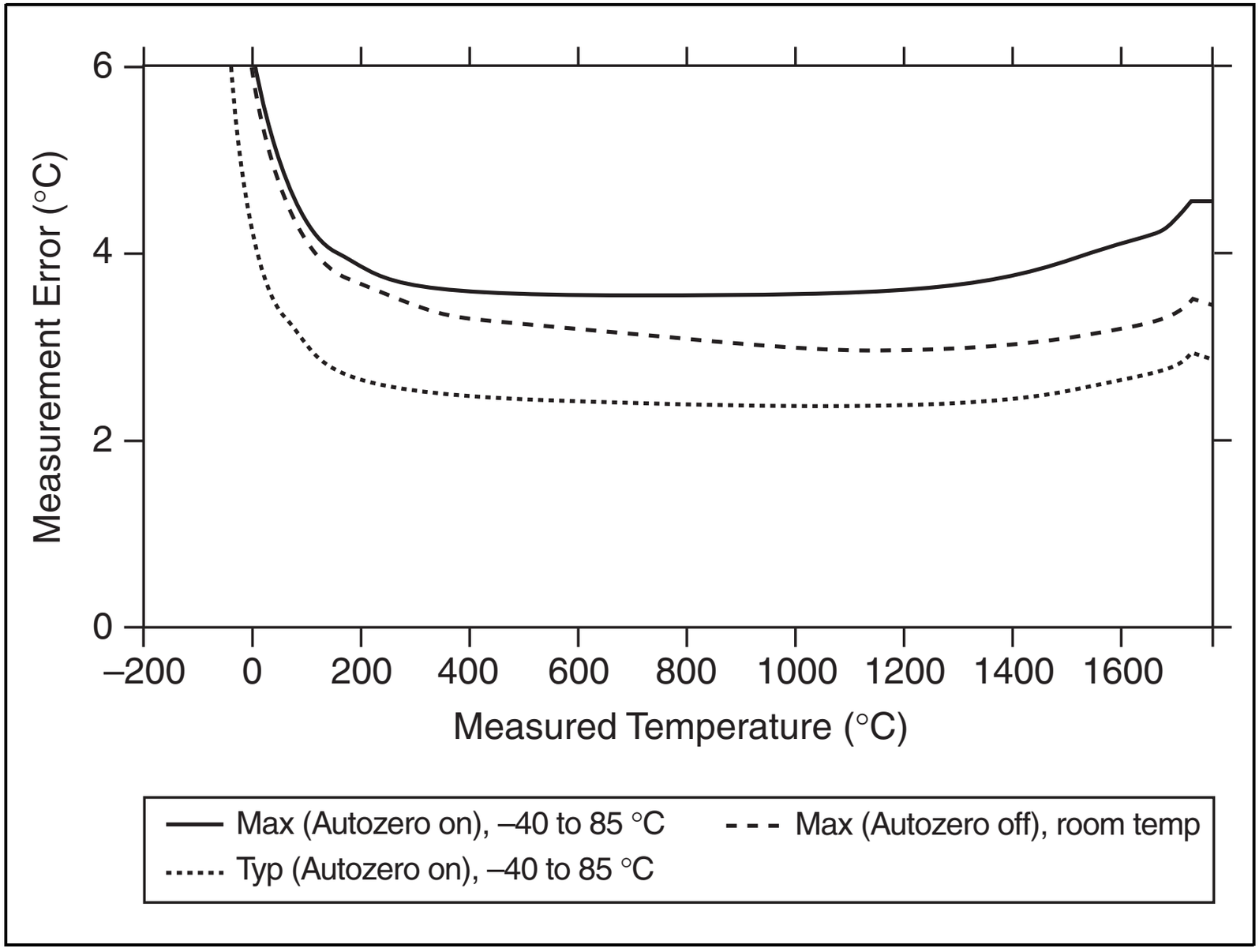


Figure 9. Thermocouple Type R and S Errors

Power Requirements

Power consumption from chassis

Active mode ..... 170 mW max

Sleep mode ..... 4 mW max

Thermal dissipation (at 85 °C)

Active mode ..... 170 mW max

Sleep mode ..... 4 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.

Screw-terminal wiring ..... 12 to 24 AWG copper conductor wire with 7 mm (0.28 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 ..... 63 g (2.2 oz)

Safety

Safety Voltages

Connect only voltages that are within the following limits.

Channel-to-COM ..... ±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.

Caution Do *not* connect the NI 9211E 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

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

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

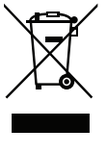
Pollution Degree 2

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 *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 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 9211E 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 43 662 457990-0,

Belgium 32 (0) 2 757 0020, Brazil 55 11 3262 3599,

Canada 800 433 3488, China 86 21 5050 9800,

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

Finland 358 (0) 9 725 72511, France 01 57 66 24 24,

Germany 49 89 7413130, India 91 80 41190000,

Israel 972 3 6393737, Italy 39 02 41309277, Japan 0120-527196,
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 22 328 90 10,
Portugal 351 210 311 210, Russia 7 495 783 6851,
Singapore 1800 226 5886, Slovenia 386 3 425 42 00,
South Africa 27 0 11 805 8197, Spain 34 91 640 0085,
Sweden 46 (0) 8 587 895 00, Switzerland 41 56 2005151,
Taiwan 886 02 2377 2222, Thailand 662 278 6777,
Turkey 90 212 279 3031, United Kingdom 44 (0) 1635 523545

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