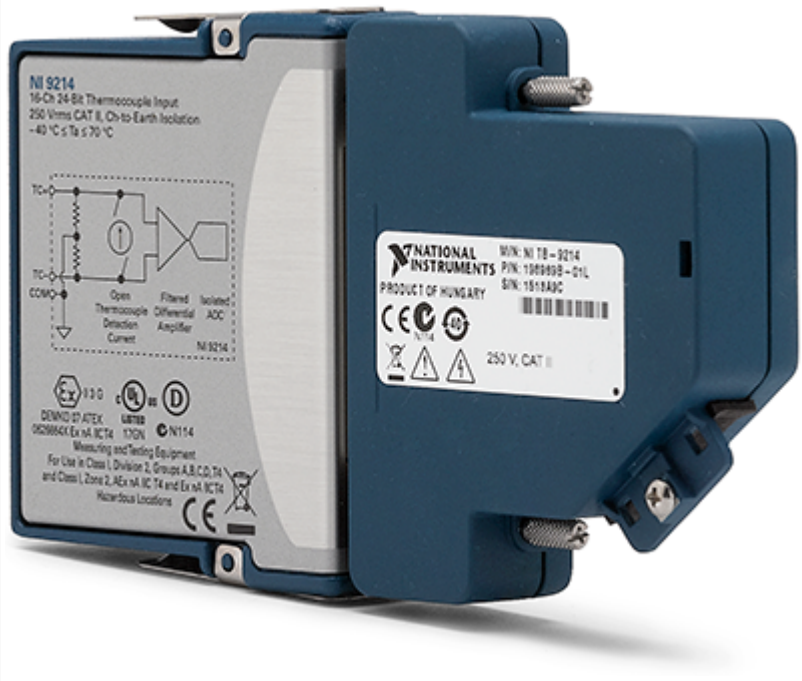
NI-9214 Specifications

2022-11-21

Contents

NI 9214 Datasheet



- Isothermal terminal block for measurement accuracy up to 0.45 °C
- 50 Hz/60 Hz noise rejection
- Up to 0.02 °C measurement sensitivity
- 250 V RMS, CAT II, channel-to-earth isolation

The NI 9214 is a high-density thermocouple module for CompactDAQ and CompactRIO systems. Designed for use in higher-channel-count systems that also need high accuracy, the NI 9214 increases overall accuracy with a front-mount terminal block (TB-9214), several CJC sensors in the terminal block, and a component layout that minimizes thermal gradients.

Kit Contents	• NI 9214 • NI TB-9214 Isothermal Terminal Block • NI 9214 Getting Started Guide
Accessories	• Spare NI TB-9214 Isothermal Terminal Block

C Series Thermocouple Module Comparison								
Product	Channels	Connectivity	Accuracy [1]	Max Sample Rate, Scanned [2]	Max Sample Rate, Simultaneous [3]	Max Sample Rate, All Filtered [4]	OTD[5]	Isolation [6]
NI 9210	4	Screw Terminal	0.8°C	14 S/s	–	2.3 Scans/s	Yes	Ch-Earth
		Mini-TC	0.84°C					
NI 9211	4	Screw Terminal	0.9°C	14 S/s	–	2.3 Scans/s	Yes	Ch-Earth
NI 9212	8	Screw Terminal	0.4°C	–	95 S/s/Ch	7.1 Scans/s	Yes	Ch-Ch
		Mini-TC	0.7°C					
NI 9213	16	Spring Terminal†	0.8°C	100 S/s	–	1.0 Scans/s	Yes	Ch-Earth
NI 9214	16	Screw Terminal	0.4°C	100 S/s	–	0.96 Scans/s	Select-able	Ch-Earth
NI 9219	4	Spring Terminal	1.6°C	–	50 S/s/Ch	7.1 Scans/s	No	Ch-Ch

[1]Typical at 23±5°C operating temperature, For J-type sensor measuring 100°C.
[2]This is the fastest rate of the module for a single channel. When scanning more than one channel, the sample rate is reduced, see data sheets for details.
[3]This is the fastest rate of the module; it can sample all channels simultaneously at this rate.
[4]This is the fastest rate of the module using all of its channels at the same time, with optimized rejection of standard power line frequencies. See data sheets for details about specific powerline frequencies.
[5]Open Thermocouple Detection.
[6]Ch-Ch isolation means that the channels are isolated from earth ground and from each other.
Ch-Earth isolation means that the channels are isolated from earth ground but not from each other.
†These connectors feature tool-less wire entry, meaning that solid core wires (AWG 26 - AWG 16) can be inserted without using a tool.

NI C Series Overview

NI provides more than 100 C Series modules for measurement, control, and communication applications. C Series modules can connect to any sensor or bus and allow for high-accuracy measurements that meet the demands of advanced data acquisition and control applications.

- Measurement-specific signal conditioning that connects to an array of sensors and signals

- Isolation options such as bank-to-bank, channel-to-channel, and channel-to-earth ground
- -40 °C to 70 °C temperature range to meet a variety of application and environmental needs
- Hot-swappable

The majority of C Series modules are supported in both CompactRIO and CompactDAQ platforms and you can move modules from one platform to the other with no modification.

CompactRIO

CompactRIO combines an open-embedded architecture with small size, extreme ruggedness, and C Series modules in a platform powered by the NI LabVIEW reconfigurable I/O (RIO) architecture. Each system contains an FPGA for custom timing, triggering, and processing with a wide array of available modular I/O to meet any embedded application requirement.

CompactDAQ

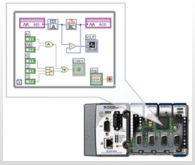
CompactDAQ is a portable, rugged data acquisition platform that integrates connectivity, data acquisition, and signal conditioning into modular I/O for directly interfacing to any sensor or signal. Using CompactDAQ with LabVIEW, you can easily customize how you acquire, analyze, visualize, and manage your measurement data.

Software

LabVIEW Professional Development System for Windows

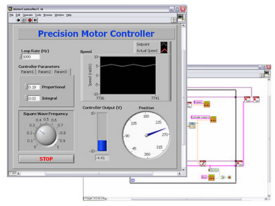
- Use advanced software tools for large project development
- Generate code automatically using DAQ Assistant and Instrument I/O Assistant
- Use advanced measurement analysis and digital signal processing
- Take advantage of open connectivity with DLLs, ActiveX, and .NET objects
- Build DLLs, executables, and MSI installers

NI LabVIEW FPGA Module



- Design FPGA applications for NI RIO hardware
- Program with the same graphical environment used for desktop and real-time applications
- Execute control algorithms with loop rates up to 300 MHz
- Implement custom timing and triggering logic, digital protocols, and DSP algorithms
- Incorporate existing HDL code and third-party IP including Xilinx IP generator functions
- Purchase as part of the LabVIEW Embedded Control and Monitoring Suite

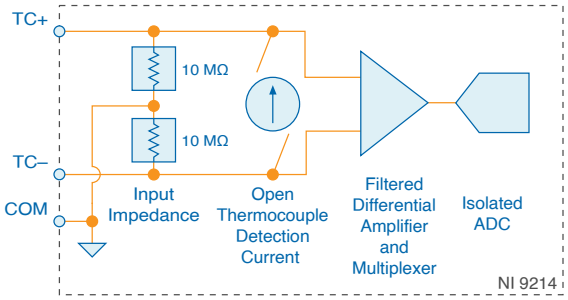
NI LabVIEW Real-Time Module



- Design deterministic real-time applications with LabVIEW graphical programming
- Download to dedicated NI or third-party hardware for reliable execution and a wide selection of I/O
- Take advantage of built-in PID control, signal processing, and analysis functions
- Automatically take advantage of multicore CPUs or set processor affinity manually
- Take advantage of real-time OS, development and debugging support, and board support

NI LabVIEW Real-Time Module	
	▪ Purchase individually or as part of a LabVIEW suite

NI 9214 Circuitry



- Each channel passes through a differential filer and a multiplexer before being sampled by a 24-bit ADC.
- The channels share a common ground, COM, that is isolated from other modules in the system.

Common-Mode Voltage

The NI-9214 common-mode range is the maximum voltage between any channel and COM. If COM is left floating, the internal common-mode voltage of the input circuitry is the average of all the inputs. The NI-9214 measures the common-mode voltage level of each channel and returns a warning in the software if the signal is outside the common-mode voltage range.

Open Thermocouple Detection

Each channel 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.

Input Impedance

Each channel has a resistor that produces an input impedance 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.

Timing Modes

The NI-9214 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.

Thermocouple Measurement Accuracy

Thermocouple measurement errors depend partly on the following factors:

- Type of thermocouple
- Accuracy of the thermocouple
- Temperature that you are measuring
- Resistance of the thermocouple wires
- Cold-junction temperature

For the best accuracy performance, follow these guidelines:

- Set up the NI-9214 according to the getting started guide on ni.com/manuals to minimize thermal gradients across the NI-9214 terminals.
- Null the lead-wire resistance to compensate for offset errors.
- Use the autozero channel to compensate for offset errors.

Cold-Junction Accuracy

Heat dissipated by adjacent C Series modules or nearby heat sources can cause errors in thermocouple measurements by heating the NI-9214 terminals to a different temperature than the cold-junction compensation sensor. Thermal

gradient across the terminals can cause the terminals of different NI-9214 channels to be at different temperatures, which creates accuracy errors and affects the relative accuracy between channels.

The temperature measurement accuracy specifications include errors caused by the thermal gradient across the NI-9214 terminals for configurations with the NI-9214 terminals facing forward or upward.

Autozero Channel

The NI-9214 has an internal autozero channel, which can be subtracted from each thermocouple reading to compensate for offset errors. Use of the autozero channel is optional, however the NI-9214 specifications assume that autozero is applied to every sample. Refer to the documentation for the software that you are using with the NI-9214 for information about using the autozero channel.

NI 9214 Specifications

The following specifications are typical for the range -40 °C to 70 °C unless otherwise noted. The specifications are for the NI 9214 used in conjunction with an TB-9214.

> **Caution** Do not operate the NI-9214 in a manner not specified in this document. Product misuse can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to NI for repair.

Warm-up time[1]	15 minutes

Input Characteristics

Number of channels	
NI 9214	16 thermocouple channels, 1 internal autozero channel
TB-9214	3 internal cold-junction compensation channels

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)

Timing Mode	Conversion Time (Per Channel)	Sample Rate[2] (All Channels[3])
High-resolution	52 ms	0.96 S/s
High-speed	735 µs	68 S/s

Common-mode voltage range

Channel-to-COM	±1.2 V minimum
COM-to-earth ground	±250 V

Common-mode rejection ratio

High-resolution mode (at DC and 50 Hz to 60 Hz)

Channel-to-COM	100 dB
COM-to-earth ground	170 dB

High-speed mode (at 0 Hz to 60 Hz)

Channel-to-COM	70 dB
COM-to-earth ground	120 dB

Thermocouple signal input bandwidth

High-resolution mode	14.4 Hz
High-speed mode	80 Hz

Open thermocouple settling time when switching OTD on/off	6 s

High-resolution noise rejection (at 50 Hz and 6 Hz)	65 dB
Overvoltage proection	±30 V between any two inputs
Differential input impedance	20 MΩ

Input noise

High-resolution mode

RMS	220 nVrms
Crest factor	6

High-speed mode

RMS	2.8 µVrms
Crest factor	10

Gain error

High-resolution mode	0.03% typical at 25 °C, 0.15% maximum at -40 °C to 70 °C
High-speed mode	0.04% typical at 25 °C, 0.16% maximum at -40 °C to 70 °C

Offset error

High-resolution mode	2 µV typical, 8 µV maximum
High-speed mode	15 µV typical, 23 µV maximum

Offset error from source impedance with OTD enabled	Add 0.2 µV per Ω

Input current

OTD enabled	200 nA
OTD disabled	400 pA

OTD bias current drift	200 pA/°C maximum

Cold-junction compensation accuracy[4]

23 ±5 °C	0.25 °C typical

-20 °C to 70 °C	0.6 °C maximum
-40 °C to 70 °C	0.9 °C maximum

Temperature Measurement Accuracy

Measurement sensitivity[5]

High-resolution mode

Types J, K, T, E, N	0.01 °C
Types R, S	0.03 °C
Type B	0.04 °C

High-speed mode

Types J, K, T, E	0.10 °C
Type N	0.11 °C
Types R, S	0.36 °C
Type B	0.48 °C

The following thermocouple measurement tables and graphs show the module accuracy for each thermocouple type under the following conditions:

- Autozero is enabled.
- Open thermocouple detection is disabled.
- 0 V common-mode voltage.

The tables include all measurement errors of the module and terminal block including RMS noise. The tables do not include the accuracy of the thermocouple itself.

Temperature	High-Resolution			High-Speed		
	Typical	Maximum		Typical	Maximum	
	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C
-100 °C	0.53	1.70	1.70	1.49	2.79	2.79

Temperature	High-Resolution			High-Speed		
	Typical	Maximum		Typical	Maximum	
	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C
0 °C	0.40	1.24	1.26	1.17	2.12	2.12
100 °C	0.37	1.00	1.24	1.05	1.76	2.00
300 °C	0.39	1.16	1.41	0.96	1.78	1.98
500 °C	0.44	1.44	1.69	0.97	1.96	2.17
700 °C	0.45	1.58	1.80	1.03	2.24	2.42
900 °C	0.50	1.89	2.10	1.12	2.59	2.77
1100 °C	0.59	2.33	2.57	1.24	2.99	3.18

Table 1. Thermocouple Type J/N Measurement Accuracy (°C)

Temperature	High-Resolution			High-Speed		
	Typical	Maximum		Typical	Maximum	
	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C
-100 °C	0.50	1.56	1.56	1.17	2.33	2.33
0 °C	0.36	1.06	1.10	0.86	1.64	1.66
100 °C	0.37	0.95	1.20	0.87	1.50	1.76
300 °C	0.42	1.23	1.49	0.95	1.81	2.08
700 °C	0.52	1.82	2.08	1.11	2.46	2.72
900 °C	0.60	2.21	2.48	1.25	2.91	3.19
1100 °C	0.69	2.64	2.93	1.41	3.42	3.71
1400 °C	0.85	3.40	3.71	1.70	4.32	4.64

Table 2. Thermocouple Type K Measurement Accuracy (°C)

Temperature	High-Resolution			High-Speed		
	Typical	Maximum		Typical	Maximum	
	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C
-100 °C	0.54	1.76	1.76	1.25	2.59	2.59
0 °C	0.37	1.17	1.17	0.88	1.77	1.77
100 °C	0.33	0.89	1.04	0.77	1.38	1.53
300 °C	0.33	1.00	1.17	0.69	1.41	1.53
500 °C	0.37	1.25	1.42	0.69	1.60	1.77

Temperature	High-Resolution			High-Speed		
	Typical	Maximum		Typical	Maximum	
	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C
700 °C	0.43	1.58	1.74	0.78	1.96	2.13
900 °C	0.49	1.94	2.11	0.90	2.37	2.55

Table 3. Thermocouple Type T/E Measurement Accuracy (°C)

Temperature	High-Resolution			High-Speed		
	Typical	Maximum		Typical	Maximum	
	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C
0 °C	0.81	2.80	2.80	4.50	6.85	6.85
100 °C	0.61	1.94	1.94	3.30	4.91	4.91
300 °C	0.54	1.84	1.84	2.74	4.26	4.27
700 °C	0.57	2.15	2.15	2.54	4.32	4.32
900 °C	0.59	2.31	2.31	2.47	4.38	4.38
1100 °C	0.60	2.48	2.48	2.42	4.47	4.47
1400 °C	0.67	2.86	2.86	2.49	4.85	4.85

Table 4. Thermocouple Type R/S Measurement Accuracy (°C)

Temperature	High-Resolution			High-Speed		
	Typical	Maximum		Typical	Maximum	
	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C	23 °C ± 5 °C	-20 °C to 70 °C	-40 °C to 70 °C
0 °C	—	—	—	—	—	—
100 °C	—	—	—	—	—	—
300 °C	0.94	3.40	3.45	7.36	10.40	10.45
700 °C	0.51	1.97	2.00	3.46	5.21	5.23
900 °C	0.46	1.86	1.88	2.88	4.52	4.54
1100 °C	0.43	1.89	1.89	2.55	4.19	4.21
1400 °C	0.45	2.04	2.05	2.33	4.10	4.11

Table 5. Thermocouple Type B Measurement Accuracy (°C)

Figure 1. Thermocouple Error, Typical (High-Resolution), 23 °C±5 °C

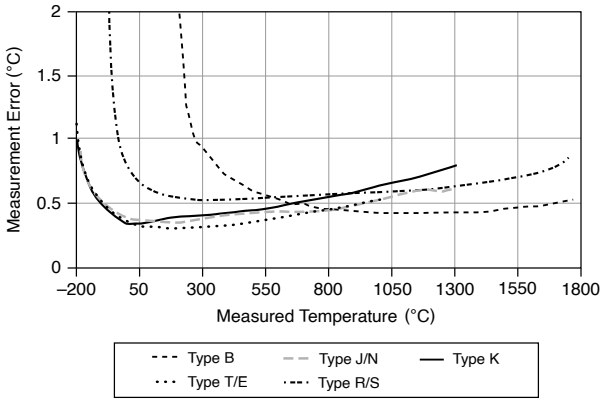
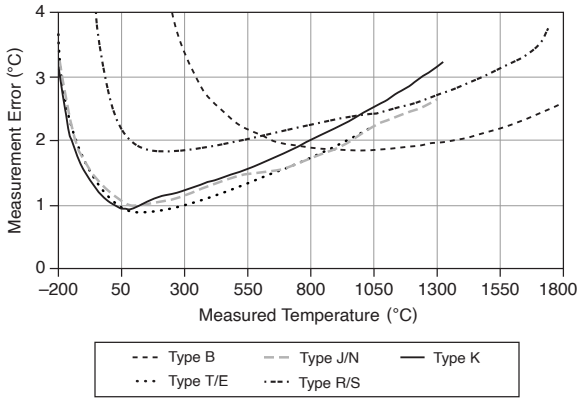


Figure 2. Thermocouple Error, Maximum (High-Resolution), -20 °C to 70 °C



Power Requirements

Power consumption from chassis	
Active mode	300 mW maximum
Sleep mode	30 µW maximum

Thermal dissipation (at 70 °C)	
Active mode	630 mW maximum
Sleep mode	450 mW maximum

Physical Characteristics

Screw-terminal wiring

Gauge	0.05 mm^2 to 0.5 mm^2 (30 AWG to 20 AWG) copper conductor wire

Wire strip length

Outer insulation	51 mm (2.0 in.) of insulation stripped from the end
Inner insulation	5.1 mm (0.2 in.) of insulation stripped from the end

Temperature rating	90 °C, minimum
Torque for screw terminals	0.3 N · m (2.66 lb · in.)
Wires per screw terminal	One wire per screw terminal

TB-9214 securement

Securement type	Jackscrews provided
Torque for jackscrews	0.4 N · m (3.6 lb · in.)

Weight

NI 9214	141 g (5.0 oz)
TB-9214	102 g (3.6 oz)

Safety Voltages

Connect only voltages that are within the following limits:

Between any two terminals	±30 V maximum

Isolation

Channel-to-channel	None

Channel-to-earth ground

Continuous	250 V RMS, Measurement Category II

Withstand	2,300 V RMS, verified by a 5 s dielectric withstand test

Hazardous Locations

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nA IIC T4 Gc
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Ex nA IIC T4 Gc
Europe (ATEX) and International (IECEx)	Ex nA IIC T4 Gc DEMKO 07 ATEX 0626664X IECEx UL 14.0089X

Safety Compliance and Hazardous Locations Standards

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA C22.2 No. 61010-1
- EN 60079-0, EN 60079-7
- IEC 60079-0, IEC 60079-7
- UL 60079-0, UL 60079-7
- CSA C22.2 No. 60079-0, CSA C22.2 No. 60079-7

Note For safety certifications, refer to the product label or the Product Certifications and Declarations section.

Electromagnetic Compatibility

This device meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions

- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note For EMC declarations and certifications, refer to the Online Product Certification section.

CE Compliance CE

- 2014/34/EU; Potentially Explosive Atmospheres (ATEX)

Product Certifications and Declarations

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for NI products, visit ni.com/product-certifications, search by model number, and click the appropriate link.

Shock and Vibration

To meet these specifications, you must panel mount the system.

Operating vibration	
Random	5 g RMS, 10 Hz to 500 Hz
Sinusoidal	5 g, 10 Hz to 500 Hz
Operating shock	30 g, 11 ms half sine; 50 g, 3 ms half sine; 18 shocks at 6 orientations

Environmental

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 °C to 70 °C

Storage temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 85 °C
Ingress protection, NI 9214	IP40
Operating humidity (IEC 60068-2-30)	10% RH to 90% RH, noncondensing
Storage humidity (IEC 60068-2-30)	5% RH to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	2,000 m

Indoor use only.

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 **Engineering a Healthy Planet** 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.

EU and UK Customers

- **Waste Electrical and Electronic Equipment (WEEE)**—At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit ni.com/environment/weee.

电子信息产品污染控制管理办法（中国 RoHS）

- **中国 RoHS**— NI 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 NI 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 9214 at ni.com/calibration.

Calibration interval	1 year

[1] The warm-up time assumes the module is not in sleep mode, is facing forward or upward, and is in a constant ambient temperature. NI recommends allowing the full warm-up time.

[2] If you are using fewer than all channels, the sample rate might be faster. The maximum sample rate = 1/(**Conversion Time** x **Number of Channels**), or 100 S/s, whichever is smaller. Sampling faster than the maximum sample rate may result in the degradation of accuracy.

[3] Including the autozero and cold-junction compensation channels.

[4] Cold-junction compensation accuracy assumes that the thermocouple wires are 0.25 mm^2 (24 AWG) or smaller.

[5] Measurement sensitivity represents the smallest change in temperature that a sensor can detect. It is a function of noise. The values assume the median of the full measurement range of the standard thermocouple sensor according to NIST Monograph 175.