NI 9214 and TB-9214

16 TC, ±78 mV, 24 Bit, 68 S/s Aggregate, Isothermal Terminal Block

- 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 Vrms, 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

NATIONAL INSTRUMENTS

C SERIES THERMOCOUPLE MODULE COMPARISON							
Product Name	Channels	Maximum Accuracy* (°C)	Sample Rate	Software Selectable OTD	Autozero	Connectivity	Isolation Continuous
NI 9211	4	2.11	14 S/s	No	Yes	Screw Terminal	250 Vrms Ch-Earth
NI 9212	8	1.29	95 S/s/ch	No	No	Isothermal Terminal Block	250 Vrms Ch-Ch
NI 9213	16	2.25	75 S/s	No	Yes	Spring Terminal	250 Vrms Ch-Earth
NI 9214	16	1.24	68 S/s	Yes	Yes	Isothermal Terminal Block	250 Vrms Ch-Earth

* For a J type thermocouple at 100 °C using high-resolution mode when applicable.

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
- Purchase individually or as part of a LabVIEW suite

NI 9214 Circuitry
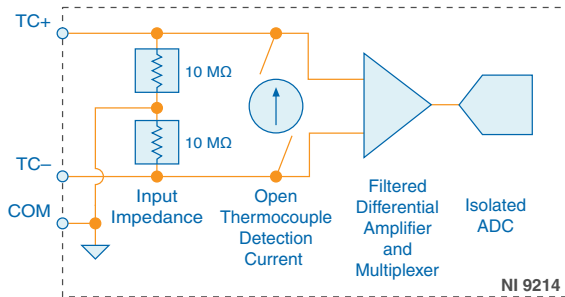
- Each channel passes through a differential filer and a multiplexer before being sampled by a 24-bit ADC.
- The channels share a common ground, COM, that is isolated from other modules in the system.

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

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[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.

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.

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[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.

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	0.53	1.70	1.70	1.49	2.79	2.79
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 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	0.50	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 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
-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
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 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	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 5. Thermocouple Type B 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

Figure 1. Thermocouple Error, Typical (High-Resolution), 23 °C ±5 °C
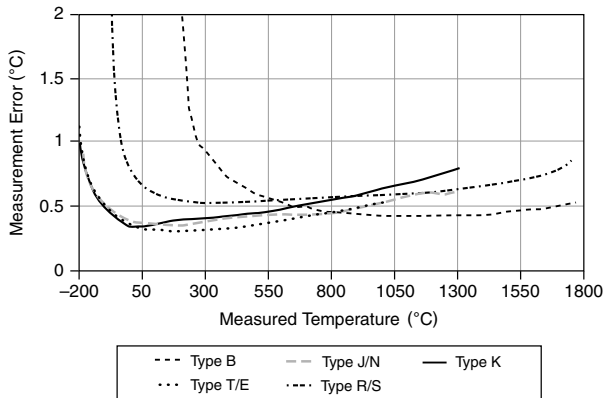
Figure 2. Thermocouple Error, Maximum (High-Resolution), -20 °C to 70 °C
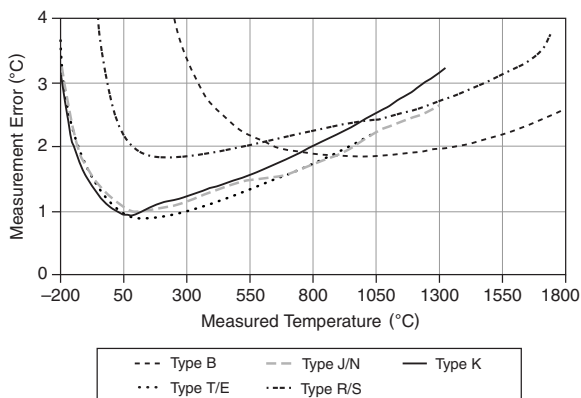
Power Requirements

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

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

Tip 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	
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 Vrms, Measurement Category II
Withstand	2,300 Vrms, 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 9214 to signals or use for measurements within Measurement Categories III or IV.

Hazardous Locations

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

Safety 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 61010-1

- EN 60079-0:2012, EN 60079-15:2010
- IEC 60079-0: Ed 6, IEC 60079-15; Ed 4
- UL 60079-0; Ed 6, UL 60079-15; Ed 4
- CSA 60079-0:2011, CSA 60079-15:2012

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* 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 $C \, \epsilon$

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 2014/34/EU; Potentially Explosive Atmospheres (ATEX)

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

Shock and Vibration

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

Operating vibration	
Random (IEC 60068-2-64)	5 g_{rms}, 10 Hz to 500 Hz
Sinusoidal (IEC 60068-2-6)	5 g, 10 Hz 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

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 60068-2-78)	10% RH to 90% RH, noncondensing
Storage humidity (IEC 60068-2-78)	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 *Minimize Our Environmental Impact* 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 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 9214 at *ni.com/calibration*.

Calibration interval	1 year