

OPERATING INSTRUCTIONS

USB-9211

4-Channel 24-bit Thermocouple Input Module

These operating instructions describe how to use the National Instruments USB-9211.

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Introduction

The NI USB-9211 data acquisition device provides a USB interface for four channels of 24-bit thermocouple inputs with integrated signal conditioning. The USB-9211 consists of two components: a cRIO-9211 module and a USB-9161 USB carrier, as shown in Figure 1.

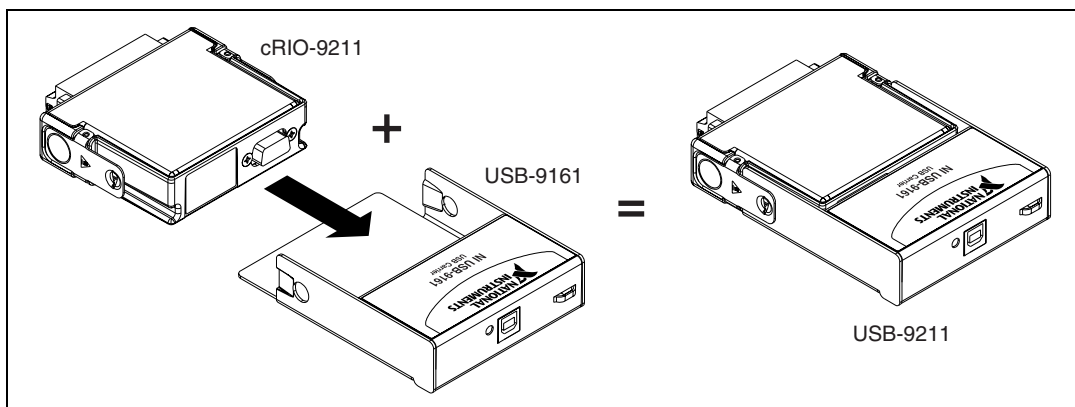


Figure 1. USB-9211 Components

Software support is provided by NI-DAQmx Base. For more information about NI-DAQmx Base, refer to the *NI-DAQmx Base Getting Started Guide*.

Safety Guidelines

Operate the USB-9211 only as described in these operating instructions.



Note Although the cRIO-9211 module may have more stringent certification standards than the USB-9211, when used with the USB-9161 carrier, the combined system may be limited. Refer to the [Specifications](#) section for more details.



Hot Surface This icon denotes that the component may be hot. Touching this component may result in bodily injury.



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.

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 $42.4 V_{\text{peak}}$ 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.

Installing the cRIO-9211 in the USB-9161 Carrier

The cRIO-9211 module and USB-9161 carrier are packaged separately. Refer to Figure 2, while completing the following assembly steps:

1. Make sure that no signals are connected to the CompactRIO module.
2. Align the I/O module with the carrier, as shown in Figure 2.

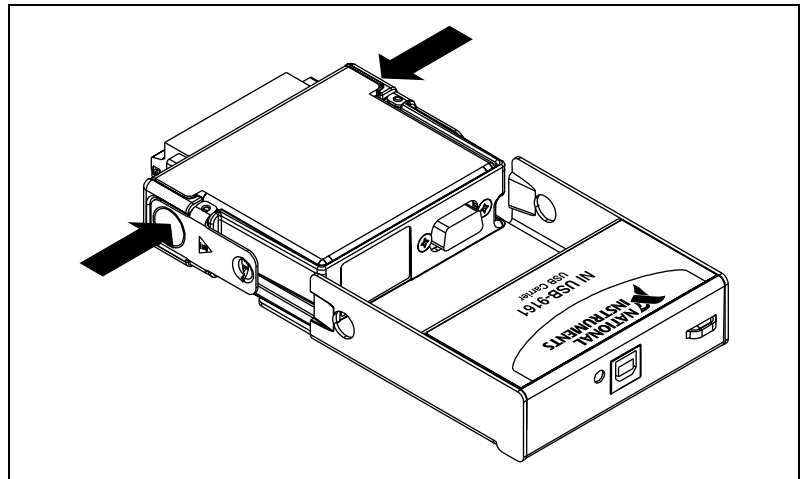


Figure 2. Module Installation

3. Squeeze the latches and insert the CompactRIO module into the carrier.
4. Press firmly on the connector side of the CompactRIO module until the latches lock the module into place, as shown in Figure 3.

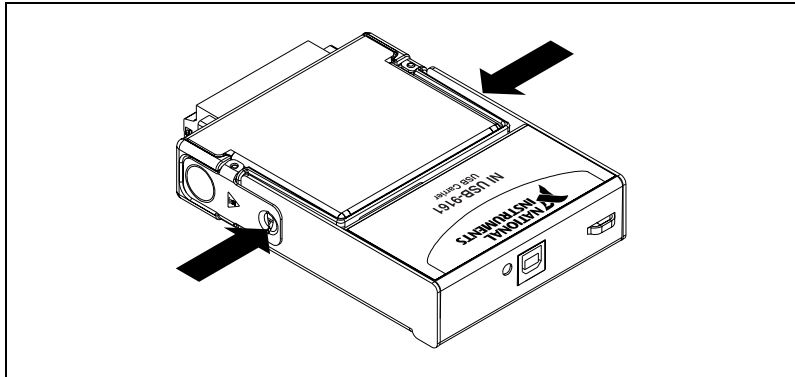


Figure 3. Locking Module into Place

5. Connect the USB cable to the assembled USB-9211.

Mounting the USB-9211 to a Panel

Threaded inserts are located in the USB-9211 for mounting it to a panel. Refer to Figure 4 for dimensions.

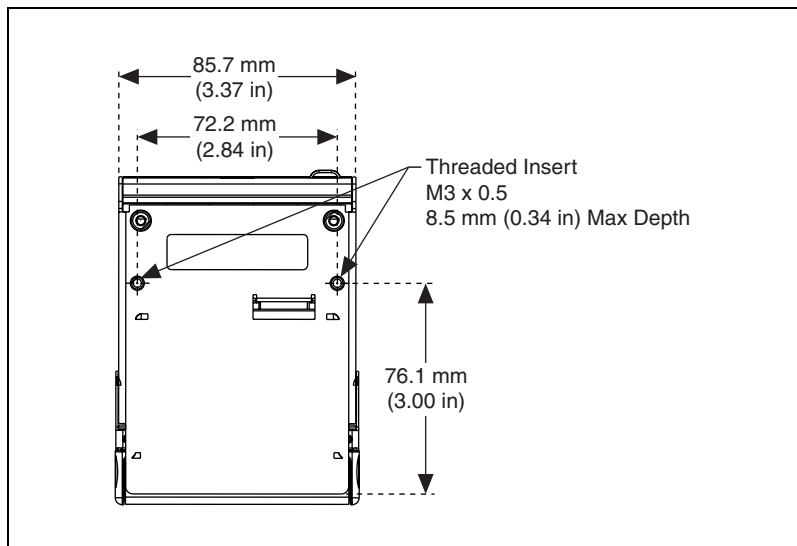


Figure 4. Module Dimensions

Software

Software support for the USB-9211 is provided by NI-DAQmx Base. NI-DAQmx Base is a subset of the NI-DAQmx API.

The NI-DAQmx Base CD contains example programs that you can use to get started programming with the USB-9211. Refer to the *NI-DAQmx Base 1.x Getting Started Guide* for more details.

Wiring the USB-9211

The USB-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 USB-9211 also has a common terminal, COM, that is internally connected to the isolated ground reference of the module.

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.

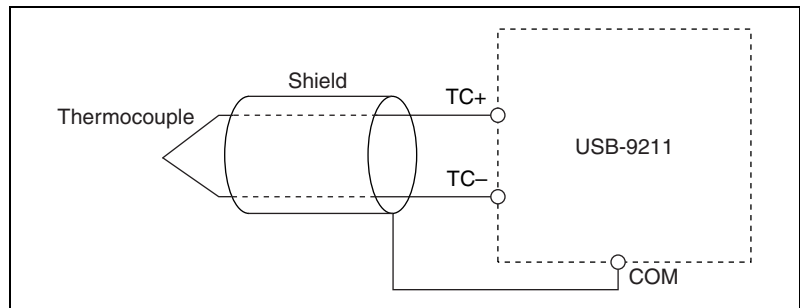
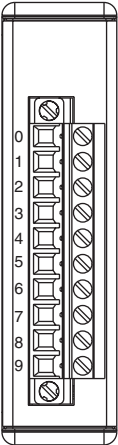


Figure 5. Connecting a Thermocouple Input Signal to the USB-9211

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)

USB-9211 Circuitry

The USB-9211 channels share a common ground that is isolated from the chassis and the host computer. 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.

Effects of Source Impedance on Voltage Measurement Accuracy

The resistors shown in Figure 6 produce an input impedance at the terminals of the USB-9211.

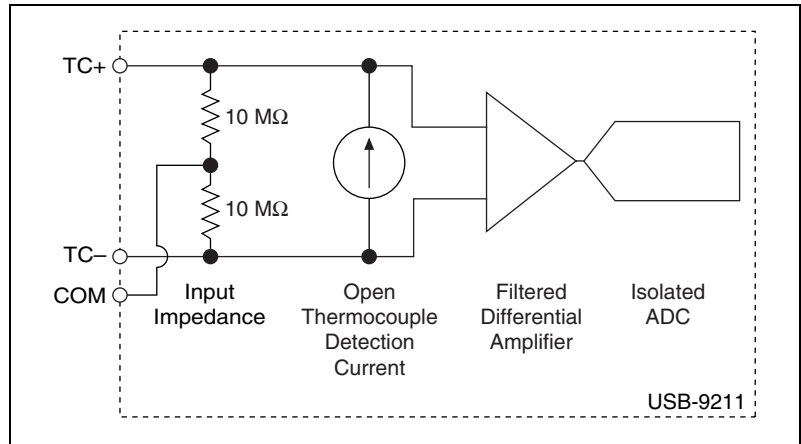


Figure 6. Input Circuitry for One Channel

If thermocouples are connected to the USB-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. For more information about errors resulting from source impedance, refer to the [Specifications](#) section.

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 USB-9211 has an internal autozero channel for measuring the offset error. If the ambient temperature of the USB-9211 is less than 15 °C or more than 35 °C, use this channel to read the offset error. You can configure the behavior of the autozero channel in the NI-DAQmx Base Task Configuration Utility.

Measurement Accuracy for the Different Types of Thermocouples

Figures 7, 8, 9, 10, and 11 show the typical and maximum errors for the different thermocouple types when used with the USB-9211 over the full temperature range. The figures also show the maximum error for the thermocouple types with the USB-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 USB-9211 terminals affect the cold-junction temperature accuracy. Refer to the [Cold-Junction Temperature Measurement Accuracy](#) section for more information about temperature gradients.

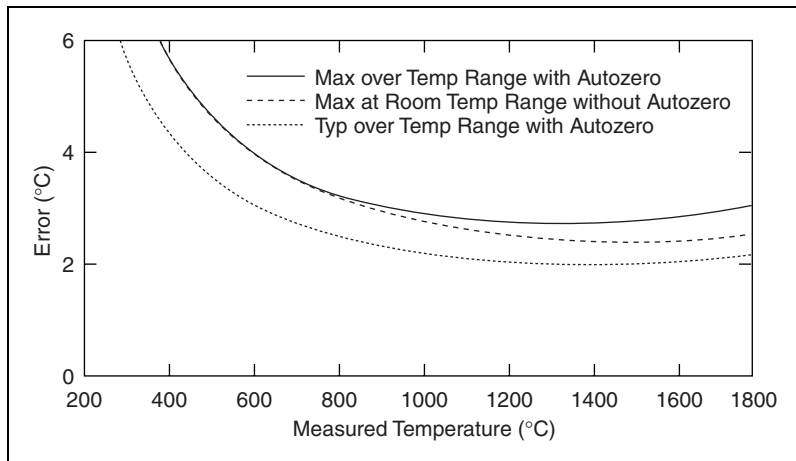


Figure 7. Type B Errors

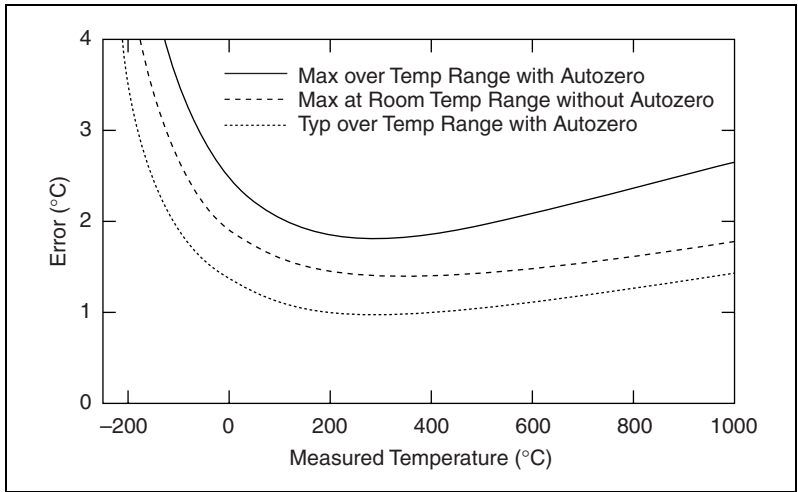


Figure 8. Type E and T Errors

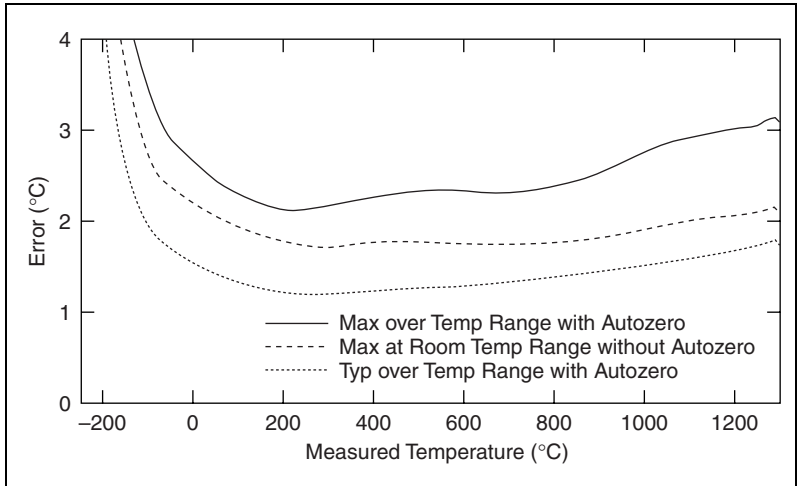


Figure 9. Type J and N Errors

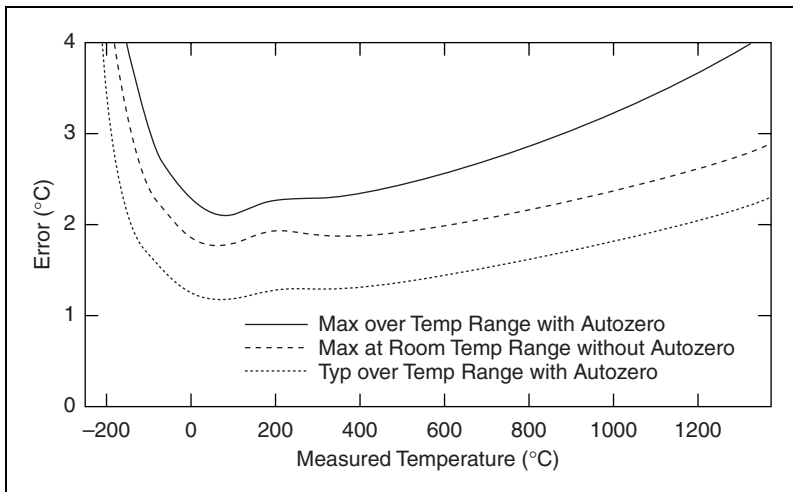


Figure 10. Type K Errors

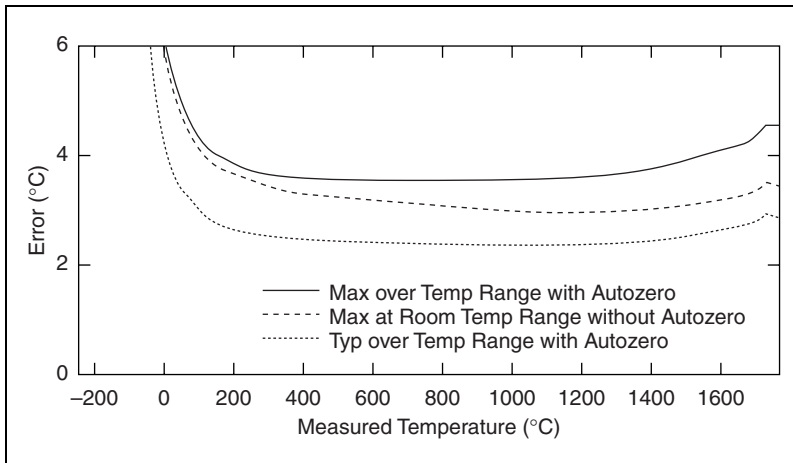


Figure 11. Type R and S Errors

Cold-Junction Temperature Measurement Accuracy

Heat from 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.

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, 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.

Specifications

The following specifications are typical at 25 °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 60 °C.....	0.6 °C (1.1 °F) typ, 1.3 °C (2.3 °F) max
Conversion time.....	70 ms per channel; 420 ms total for all channels including the autozero and cold-junction channels
Max sampling rate	12 S/s guaranteed
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 0 to 60 °C, 0.1% max at 0 to 60 °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

Power Requirements

Current consumption from USB.....	500 mA, max
Suspend mode.....	500 μA, max

Bus Interface

USB specification	USB 2.0 Full Speed
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Physical Characteristics

Dimensions	12.1 cm × 8.6 cm × 2.5 cm (4.75 in. × 3.37 in. × 0.99 in.)
Weight.....	Approx. 249 g (8.8 oz)
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.)

Safety

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

Standards

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

- IEC 61010-1, EN 61010-1
- UL 610610-1
- 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 model number or product line, and click the appropriate link in the Certification column.

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

Withstand2,300 V_{rms}, 1 minute max

Continuous250 V_{rms}, Installation Category II

Installation 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).

Hazardous Locations

The USB-9211 is not certified for use in hazardous locations.

Environmental

The USB-9211 device is intended for indoor use only.

Operating temperature

(IEC 60068-2-1 and IEC 60068-2-2).....0 to 60 °C

Storage temperature

(IEC 60068-2-1 and 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 (at 25°C ambient temperature)

Pollution Degree (IEC 60664).....2

Electromagnetic Compatibility

Emissions	EN 55011 Class A at 10 m FCC Part 15A above 1 GHz
Immunity	EN 61326-1:1997 + A2:2001, Table 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/certification, search by model number or product line, and click the appropriate link in the Certification column.

Calibration

You can obtain the calibration certificate for the USB-9211 at ni.com/calibration.

Calibration interval 1 year

Technical Support Resources

Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of ni.com.

Worldwide Support

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. You can access our branch office Web sites from the Worldwide Offices section of ni.com. Branch office Web sites provide up-to-date contact information, support phone numbers, email addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. For telephone support in the United States, dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

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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 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 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 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

