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**NI-9939**

# NI 9217 Calibration Procedure

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This document contains information about calibrating the National Instruments 9217 module using NI-DAQmx. This calibration procedure is intended for metrology labs.

This document does not discuss programming techniques or compiler configuration. The NI-DAQmx driver contains online help files that have compiler-specific instructions and detailed function explanations. You can install these help files when you install NI-DAQmx on the calibration computer.

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# Conventions

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The following conventions appear in this manual:

» The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.



This icon denotes a note, which alerts you to important information.

**bold** Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names and hardware labels.

*italic* Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.

monospace Monospace text denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.

*monospace italic* Italic text in this font denotes text that is a placeholder for a word or value that you must supply.

## Software

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Install NI-DAQmx 8.5 or later on the calibration computer. NI-DAQmx includes high-level function calls to simplify the task of writing software to calibrate devices. You must have the proper device driver installed on the calibration system before calibrating the device.



**Note** NI recommends that you install the NI-DAQmx driver software before physically installing the NI 9217. NI-DAQmx, available at [ni.com/downloads](http://ni.com/downloads), configures and controls the NI 9217.

NI-DAQmx supports a number of programming languages, including LabVIEW, LabWindows™/CVI™, Microsoft Visual C++ 6.0, Microsoft Visual Basic 6.0, Microsoft .NET, and Borland C++.

You can access the NI-DAQmx header file, `NIDAQmx.h`, like any standard library. You can find examples of how to use the NI-DAQmx driver in the `Program Files\National Instruments\NI-DAQ\Examples` directory.

## Documentation

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You might find the following documentation helpful as you write the calibration procedure:

- *NI-DAQmx Help*—This help file contains general information about measurement concepts, key NI-DAQmx concepts, and common applications that apply to all programming environments. To access this help file, select **Start»All Programs»National Instruments»NI-DAQ»NI-DAQmx Help**.
- *NI-DAQmx C Reference Help*—This help file contains C reference and general information about measurement concepts. To access this help file, select **Start»All Programs»National Instruments»NI-DAQ»NI-DAQmx C Reference Help**.
- *DAQ Getting Started Guide* for NI-DAQ 8.0 or later—This guide describes how to install NI-DAQmx for Windows software and NI-DAQmx-supported DAQ devices, and how to confirm that your device is operating properly. To access this guide, select **Start»All Programs»National Instruments»NI-DAQ»DAQ Getting Started Guide**.



**Note** The documents above are installed with NI-DAQmx. You can also download the latest versions from the NI Web site at [ni.com/manuals](http://ni.com/manuals).

- *NI 9217 Operating Instructions and Specifications* — This document describes how to use the NI 9217 and includes specifications and terminal assignments for the NI 9217. The limits you use to verify the accuracy of this device are based on the specifications found in this document. You can download the latest version of this document from the NI Web site at [ni.com/manuals](http://ni.com/manuals).

## Calibration Interval

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The NI 9217 should be calibrated at a regular interval as defined by the measurement accuracy requirements of your application. National Instruments recommends that you routinely perform a complete calibration at least once every year. You can shorten this interval based on the accuracy demands of your application or requirements of your processes.

# Test Equipment

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National Instruments recommends that you use the following equipment for calibrating the NI 9217.

**Table 1.** Recommended Equipment

Equipment	Recommended Model	Requirements
DMM	NI 4070	If this instrument is unavailable, use a multiranging 6 1/2 digit DMM with an accuracy of at least 90 ppm.
Precision resistors	0 $\Omega$ , 100 $\Omega$ , 350 $\Omega$ *	You must use resistors that are <10 ppm/°C or better.
Chassis	NI cDAQ-9172	—
Connection accessory	NI 9939	—

\*These are approximate values. Use resistor values as close to 100  $\Omega$  and 350  $\Omega$  as possible. For the 0  $\Omega$  resistor, use a short piece of wire.

# Test Conditions

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Follow these guidelines to optimize the connections and the environment:

- Keep connections to the device as short as possible. Long cables and wires act as antennae, picking up extra noise that can affect measurements.
- Use shielded copper wire for all cable connections to the device. Use twisted-pair wire to eliminate noise and thermal offsets.
- Maintain an ambient temperature of  $25 \pm 10$  °C. The device temperature will be greater than the ambient temperature.
- Keep relative humidity below 80%.
- Allow a warm-up time of at least 10 minutes to ensure that the measurement circuitry is at a stable operating temperature.

# Calibration Procedure

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This section provides instructions for verifying the performance of the NI 9217.

## Calibration Process Overview

The calibration process consists of the following steps:

1. *Initial Setup*—Configure the device in NI-DAQmx.
2. *Verification Procedure*—Verify the existing operation of the device. This step confirms whether the device is operating within its specified range and whether it needs adjustment.
3. *Adjustment*—If the device does not fall within the desired specifications, submit the device to NI for a factory calibration to adjust the calibration constants.
4. *Verification Procedure*— Perform another verification to ensure that the device operates within its specifications after adjustment.

The first two steps are explained in the following sections.

## Initial Setup

You must configure the device in Measurement & Automation Explorer (MAX) to communicate with NI-DAQmx.

Complete the following steps to configure a device in MAX:

1. Install the NI-DAQmx driver software.
2. Make sure that no power is connected to the module terminals. If the system is in a nonhazardous location, the chassis power can be on when you install the module.
3. Insert the module into an available slot in the cDAQ-9172 chassis.
4. Launch MAX.
5. Right-click the device name and select **Self-Test** to ensure that the device is working properly.



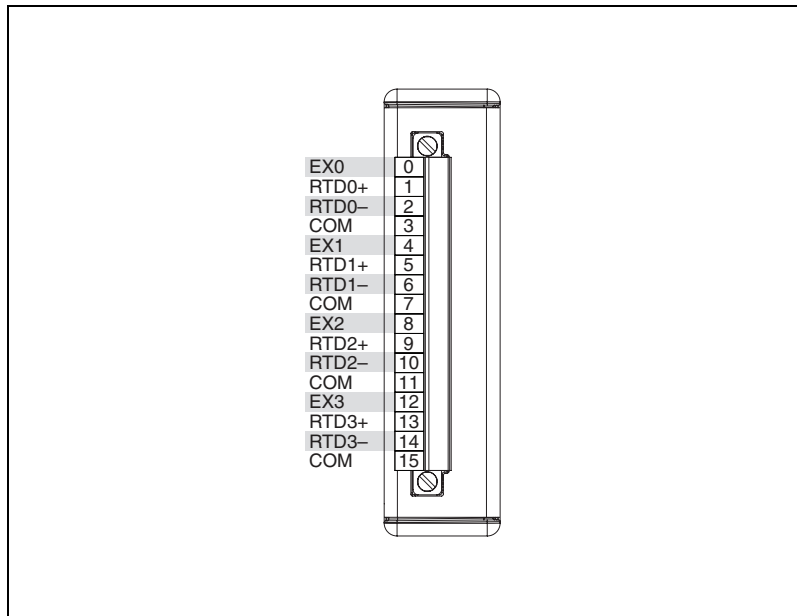
**Note** When a device is configured with MAX, it is assigned a device name. Each function call uses this device name to determine which DAQ device to calibrate. This document uses `dev1` to refer to the device name. In the following procedures, use the device name as it appears in MAX.

# Verification Procedure

Verification determines how well the device is meeting its specifications. By completing this procedure, you can see how the device has drifted over time, which helps you determine the appropriate calibration interval for your application. Table 2 in the *Test Limits* section shows all acceptable settings for the device type. Throughout the verification process, use Table 2 to determine if the device is operating within its specified range.

Complete the following steps to test the performance of the device:

1. Acquire a 4-wire resistance measurement of each resistor (0  $\Omega$ , 100  $\Omega$ , 350  $\Omega$ ) with a DMM. You must use the 4-wire resistance measurements to calculate the 1-Year Limits shown in Table 2. The Test Point Value in Table 2 refers to the 4-wire resistance measurement of each resistor with a DMM.
2. Connect a resistor from the previous step to the NI 9217. Connect EX0 and RTD0+ to one end of the resistor, and RTD0- and COM to the opposite end of the resistor. Refer to Figure 1 for the terminal assignments of the NI 9217.



**Figure 1.** NI 9217 Terminal Assignments

- If you use C function calls, create a task using `DAQmxCreateTask`, as shown in the following table. If you use LabVIEW, skip this step. The task is created in step 4 in LabVIEW.

LabVIEW Block Diagram	NI-DAQmx Function Call
<p style="text-align: center;">LabVIEW does not require this step.</p>	<p>Call <code>DAQmxCreateTask</code> with the following parameters:</p> <p><b>taskName:</b> <code>AIVerificationTask</code></p> <p><b>taskHandle:</b> <code>&amp;taskHandle</code></p>

- Create and configure an AI resistance channel using the DAQmx Create Virtual Channel VI, as shown in the following table. Use Table 2 to determine the minimum and maximum values for the device.

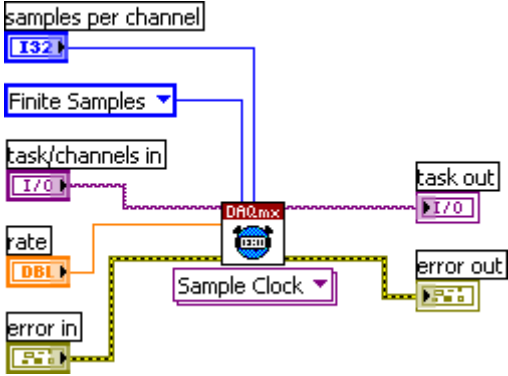


**Note** Throughout the procedure, refer to the NI-DAQmx function parameters for the LabVIEW input values. Refer to the block diagram images for the correct instance to use for polymorphic VIs.


LabVIEW Block Diagram	NI-DAQmx Function Call
	<p>Call <code>DAQmxCreateAIResistanceChan</code> with the following parameters:</p> <p><b>taskHandle:</b> <code>taskHandle</code></p> <p><b>physicalChannel:</b> <code>dev1/ai0</code></p> <p><b>nameToAssignToChannel:</b> <code>myResistanceChannel</code></p> <p><b>resistanceConfig:</b> <code>DAQmx_Val_4Wire</code></p> <p><b>minVal:</b> <code>0</code></p> <p><b>maxVal:</b> <code>400</code></p> <p><b>units:</b> <code>DAQmx_Val_Ohms</code></p> <p><b>customScaleName:</b> <code>NULL</code></p> <p><b>currentExcitSource:</b> <code>DAQmx_Val_Internal</code></p> <p><b>currentExcitValue:</b> <code>0.001</code></p>



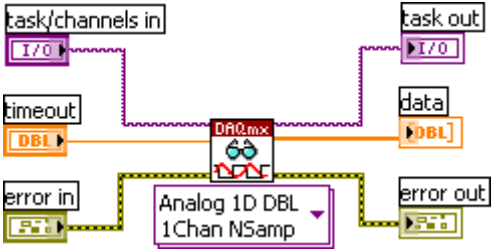
- Configure the timing properties for the resistance acquisition using the DAQmx Timing VI, as shown in the following table.

LabVIEW Block Diagram	NI-DAQmx Function Call
	<p>Call DAQmxCfgSampClkTiming with the following parameters:</p> <p><b>taskHandle:</b> taskHandle  <b>source:</b> NULL  <b>rate:</b> 1  <b>activeEdge:</b> DAQmx_Val_Rising  <b>sampleMode:</b> DAQmx_Val_FiniteSamps  <b>sampsPerChan:</b> 10</p>


- Start the acquisition using the DAQmx Start Task VI, as shown in the following table.

LabVIEW Block Diagram	NI-DAQmx Function Call
	<p>Call DAQmxStartTask with the following parameter:</p> <p><b>taskHandle:</b> taskHandle</p>

- Acquire 10 points of resistance data using the DAQmx Read VI, as shown in the following table.

LabVIEW Block Diagram	NI-DAQmx Function Call
 <p>The diagram shows a central DAQmx Read VI block. It has four inputs: 'task/channels in' (I/O), 'timeout' (DBL), 'error in' (Error), and 'Analog 1D DBL 1Chan NSamp' (a dropdown menu). It has three outputs: 'task out' (I/O), 'data' (DBL), and 'error out' (Error).</p>	<p>Call DAQmxReadAnalogF64 with the following parameters:</p> <p><b>taskHandle:</b> taskHandle  <b>numSampsPerChan:</b> -1  <b>timeout:</b> 30.0  <b>fillMode:</b> DAQmx_Val_GroupByChannel  <b>readArray:</b> data  <b>arraySizeInSamples:</b> 10  <b>sampsPerChanRead:</b> &amp;read  <b>reserved:</b> NULL</p>

- Average the resistance values that you acquired. Compare the resulting average to the Upper Limit and Lower Limit values in Table 2. If the result is between these values, the device passes the test.
- Clear the acquisition using the DAQmx Clear Task VI, as shown in the following table.

LabVIEW Block Diagram	NI-DAQmx Function Call
 <p>The diagram shows a central DAQmx Clear Task VI block. It has two inputs: 'task in' (I/O) and 'error in' (Error). It has one output: 'error out' (Error).</p>	<p>Call DAQmxClearTask with the following parameter:</p> <p><b>taskHandle:</b> taskHandle</p>

- Repeat steps 2 through 9 for all resistance values and all channels.

# Test Limits

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Table 2 lists the specifications that the NI 9217 should meet if it has been one year between calibrations. The following definitions describe how to use the information from Table 2.

## Range

*Range* refers to the minimum or maximum resistance range of an input signal.

## Test Point

The *Test Point* is the resistance value that is input or output for verification purposes. This value is broken down into two columns—*Location* and *Value*. *Location* refers to where the test value fits within the test range. *Value* refers to the resistance value to be verified. *Max* refers to maximum value, *Min* refers to minimum value, and *Mid* refers to mid-scale.

## 1-Year Limits

The *1-Year Limits* column contains the *Upper Limits* and *Lower Limits* for the test point value, and an *Error* column to help calculate the limits. When the device is within its 1-year calibration interval, the test point value should fall between these upper and lower limit values.

**Table 2.** NI 9217 Verification Test Limits

Range ( $\Omega$ )		Test Point		1-Year Limits*		
Min	Max	Location	Value ( $\Omega$ ) <sup>†</sup>	Error	Lower Limit ( $\Omega$ ) <sup>‡</sup>	Upper Limit ( $\Omega$ ) <sup>‡</sup>
0	400	Max	$DMM_{350\Omega}$	$ DMM_{350\Omega} - 100\Omega  \times 175 \text{ ppm} + 16 \text{ m}\Omega$	$DMM_{350\Omega} - Error_{350\Omega}$	$DMM_{350\Omega} + Error_{350\Omega}$
0	400	Mid	$DMM_{100\Omega}$	$ DMM_{100\Omega} - 100\Omega  \times 175 \text{ ppm} + 16 \text{ m}\Omega$	$DMM_{100\Omega} - Error_{100\Omega}$	$DMM_{100\Omega} + Error_{100\Omega}$
0	400	Min	$DMM_{0\Omega}$	$ DMM_{0\Omega} - 100\Omega  \times 175 \text{ ppm} + 16 \text{ m}\Omega$	$DMM_{0\Omega} - Error_{0\Omega}$	$DMM_{0\Omega} + Error_{0\Omega}$

\* The 1-Year Limits are accurate assuming you have performed the verification procedure at an ambient temperature of  $25 \pm 10$  °C. Verification of the module against the 1-Year Limits guarantees operation within the range of  $-40$  to  $70$  °C as specified in the NI 9217 Operating Instructions and Specifications.

<sup>†</sup> You must read this value using a DMM with the accuracy requirements displayed in Table 1.

<sup>‡</sup> Use the  $25 \pm 10$  °C maximum gain error of 175 ppm and maximum offset error of 16 m $\Omega$  to calculate the lower and upper limits.

## Appendix

You can convert the resistance values into temperature values using the Callendar Van Dusen equations and common 100  $\Omega$  platinum RTD constants.

Temperatures below 0 °C:

$$R_T = R_0[1 + A \times T + B \times T^2 + C \times T^3 \times (T - 100 \text{ °C})]$$

Temperatures above 0 °C:

$$R_T = R_0(1 + A \times T + B \times T^2)$$

where  $T$  = temperature in degrees Celsius

$R_T$  = RTD resistance at temperature  $T$

$R_0$  = RTD nominal resistance at 0 °C. For the NI 9217,  $R_0$  is always equal to 100  $\Omega$ .

$$A = 3.9083 \times 10^{-3}$$

$$B = -5.775 \times 10^{-7}$$

$$C = -4.183 \times 10^{-12}$$

# Where to Go for Support

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The National Instruments Web site is your complete resource for technical support. At [ni.com/support](http://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](http://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:

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