

# SCXI™

## SCXI-1581 User Manual

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# Conventions

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The following conventions are used in this manual:

<>

Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, AO <3..0>.

»

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.



This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When this symbol is marked on the product, refer to the *Read Me First: Safety and Radio-Frequency Interference* document, shipped with the product, for precautions to take.



When symbol is marked on a product it denotes a warning advising you to take precautions to avoid electrical shock.



When symbol is marked on a product it denotes a component that may be hot. Touching this component may result in bodily injury.

**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.

*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

Text in this font 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, and code excerpts.

**monospace bold**

Bold text in this font denotes the messages and responses that the computer automatically prints to the screen. This font also emphasizes lines of code that are different from the other examples.

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# About the SCXI-1581

The SCXI-1581 module provides 32 channels of 100  $\mu$ A current excitation. You can use the SCXI-1581 in any application that requires 100  $\mu$ A fixed current excitation. For example you can use the SCXI-1581 to provide excitation to resistive transducers such as RTDs and thermistors. This enables other input devices such as the SCXI-1102/B/C to measure the output of the transducers.

## What You Need to Get Started

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To set up and use the SCXI-1581, you need the following items:

- Hardware
  - SCXI-1581 module
  - One of the following terminal blocks:
    - SCXI-1300<sup>1</sup>—front-mount terminal block with screw terminal connectivity.
    - SCXI-1310—custom kit for custom connectivity.
    - BNC-2095—rack-mount terminal block for BNC connectivity.
    - TBX-96—DIN EN mount terminal block with screw terminal connectivity.
  - SCXI or PXI/SCXI combo chassis
  - E/M Series DAQ device
  - Computer
  - Cabling, cable adapter, and sensors as required for your application

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<sup>1</sup> When connected to an SCXI-1581, you cannot measure the onboard temperature sensor.



- ❑ Software
  - NI-DAQ 7.0 or later
  - Application software, such as LabVIEW, LabWindows™/CVI™, Measurement Studio, or other programming environments
- ❑ Documentation
  - *Read Me First: Safety and Radio-Frequency Interference*
  - *DAQ Getting Started Guide*
  - *SCXI Quick Start Guide*
  - *SCXI-1581 User Manual*
  - Documentation for your hardware
  - Documentation for your software
- ❑ Tools
  - Wire cutter
  - Wire stripper
  - Flathead screwdriver
  - Phillips screwdriver

## National Instruments Documentation

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The SCXI-1581 User Manual is one piece of the documentation set for data acquisition (DAQ) systems. You could have any of several types of manuals depending on the hardware and software in the system. Use the manuals you have as follows:

- The *SCXI Quick Start Guide*—This document contains a quick overview for setting up an SCXI chassis, installing SCXI modules and terminal blocks, and attaching sensors. It also describes setting up the SCXI system in MAX.
- SCXI or PXI/SCXI chassis manual—Read this manual for maintenance information on the chassis and for installation instructions.
- The *DAQ Getting Started Guide*—This document has information on installing NI-DAQ and the E/M Series DAQ device. Install these before you install the SCXI module.
- The SCXI hardware user manuals—Read these manuals for detailed information about signal connections and module configuration. They

also explain, in greater detail, how the module works and contain application hints.

- Accessory installation guides or manuals—Read the terminal block and cable assembly installation guides. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making the connections.
- The E/M Series DAQ device documentation—This documentation has detailed information about the DAQ device that plugs into or is connected to the computer. Use this documentation for hardware installation and configuration instructions, specification information about the DAQ device, and application hints.
- Software documentation—You may have both application software and NI-DAQ software documentation. National Instruments (NI) application software includes LabVIEW, LabWindows/CVI, and Measurement Studio. After you set up the hardware system, use either your application software documentation or the NI-DAQ documentation to help you write your application. If you have a large, complex system, it is worthwhile to look through the software documentation before you configure the hardware.
- One or more of the following help files for software information:
  - **Start»Programs»National Instruments»NI-DAQ»NI-DAQmx Help**
  - **Start»Programs»National Instruments»NI-DAQ»Traditional NI-DAQ User Manual**
  - **Start»Programs»National Instruments»NI-DAQ»Traditional NI-DAQ Function Reference Help**

You can download NI documents from [ni.com/manuals](http://ni.com/manuals). To download the latest version of NI-DAQ, click **Download Software** at [ni.com](http://ni.com).

## Installing Application Software, NI-DAQ, and the E/M Series DAQ Device

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Refer to the *DAQ Getting Started Guide* packaged with the NI-DAQ software to install your application software, NI-DAQ driver software, and the DAQ device to which you will connect the SCXI-1581. NI-DAQ 7.0 or later is required to configure and program the SCXI-1581 module. If you do not have NI-DAQ 7.0 or later, you can either contact an NI sales representative to request it on a CD or download the latest NI-DAQ version from [ni.com](http://ni.com).



**Note** Refer to the *Read Me First: Safety and Radio-Frequency Interference* document before removing equipment covers or connecting or disconnecting any signal wires.

## Installing the SCXI-1581 Module into the SCXI Chassis

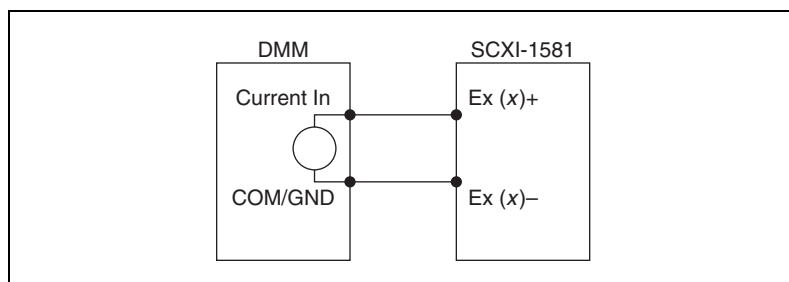
Refer to the *SCXI Quick Start Guide* to install your SCXI-1581 module.

## Verifying the SCXI-1581 Installation

The SCXI-1581 has no software configurable settings in MAX for use with either NI-DAQmx or Traditional NI-DAQ (Legacy).

To verify the functionality of the SCXI-1581 complete the following steps while referring to Figure 1-1:

1. Connect a high-precision DMM to each Ex (x)+ and Ex (x)- channel, configured in current measurement mode.
2. Verify that the output is 100  $\mu$ A and is within the specifications listed in Appendix A, *Specifications*.
3. If any channel is not within specifications, ensure that the SCXI chassis is functioning properly.
4. If the module is still not within specifications, contact NI for further technical assistance. NI contact information is listed in the *Technical Support Information* document.



**Figure 1-1.** SCXI-1581 to DMM Connections

## Configuring the SCXI System Software

Refer to the *SCXI Quick Start Guide* and the user manuals of the modules in your application to configure and verify them in software.

# Calibrating the SCXI-1581

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The SCXI-1581 is within the specifications described in Appendix A, *Specifications*, when it is shipped. You can verify that the SCXI-1581 is within the specification using a DMM of appropriate accuracy for your application. If a current source on the SCXI-1581 drifts out of specification over time, a subcomponent has likely failed. If the SCXI-1581 fails to operate according to the published specifications, send it back to NI for repair or replacement. For information about contacting NI, refer to the *Technical Support Information* document.

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## Connecting Signals

This chapter discusses signal connections to using the SCXI-1581 module.

### Pin Assignments

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The pin assignments for the SCXI-1581 front signal connector are shown in Table 2-1.



**Note** Do *not* make any connections to RSVD pins.

**Table 2-1.** Front Signal Pin Assignments

Front Connector Diagram	Pin Number	Column A	Column B	Column C
<div style="text-align: center;">                     Column                      A   B   C                 </div>	32	NC	EX0-	EX0+
	31	NC	EX1-	EX1+
	30	NC	EX2-	EX2+
	29	NC	EX3-	EX3+
	28	RSVD	EX4-	EX4+
	27	RSVD	EX5-	EX5+
	26	RSVD	EX6-	EX6+
	25	RSVD	EX7-	EX7+
	24	NC	EX8-	EX8+
	23	NC	EX9-	EX9+
	22	NC	EX10-	EX10+
	21	NC	EX11-	EX11+
	20	RSVD	EX12-	EX12+
	19	RSVD	EX13-	EX13+
	18	NC	EX14-	EX14+
	17	NC	EX15-	EX15+
	16	NC	EX16-	EX16+
	15	NC	EX17-	EX17+
	14	NC	EX18-	EX18+
	13	NC	EX19-	EX19+
	12	NC	EX20-	EX20+
	11	NC	EX21-	EX21+
	10	NC	EX22-	EX22+
	9	NC	EX23-	EX23+
	8	NC	EX24-	EX24+
	7	NC	EX25-	EX25+
	6	NC	EX26-	EX26+
	5	NC	EX27-	EX27+
4	NC	EX28-	EX28+	
3	NC	EX29-	EX29+	
NC means no connection	2	CGND	EX30-	EX30+
RSVD means reserved	1	RSVD	EX31-	EX31+

**Table 2-2.** Signal Descriptions

Pin	Signal Name	Description
A1, A19, A20, A25–28	RSVD	Reserved—this pin is reserved. Do <i>not</i> connect any signal to this pin.
A2	CGND	Chassis Ground—connects to the SCXI chassis.
B1–32	EX<0..31>-	Negative Excitation—connects to the channel ground reference. This is the return path for the corresponding EX+ channel.
C1–32	EX<0..31>+	Positive excitation—connects to the positive current output of the channel.

The rear signal connector, shown in Table 2-3, is used for analog signal connectivity and communication between the SCXI-1581 and the E/M Series DAQ device. Grounding signals AIGND and OUTREF provide reference signals needed in the various analog input referencing modes on the E/M Series DAQ device. In multiplexed mode, the CH0 signal pair is used for sending analog signals from other modules to the connected E/M Series DAQ device. If the module is directly connected to the E/M Series DAQ device, the other analog channels of the E/M Series DAQ device are available for general-purpose analog input because they are not connected to the SCXI-1581 in multiplexed mode.

The communication signals between the E/M Series DAQ device and the SCXI system are SERDATIN, SERDATOUT, DAQD\*/A, SLOT0SEL\*, SERCLK, and SCANCLK. The digital ground, DIGGND on pins 24 and 33, provides a separate ground reference for the communication signals. SERDATIN, SERDATOUT, DAQD\*/A, SLOT0SEL\*, and SERCLK are the communication lines for programming the SCXI-1581. The SCANCLK and SYNC signals are the signals necessary for multiplexed mode scanning. If the E/M Series DAQ device is connected to the SCXI-1581, these digital lines are unavailable for general-purpose digital I/O.

**Table 2-3.** Rear Signal Pin Assignments

Rear Connector Diagram		Signal Name	Pin Number	Pin Number	Signal Name
		AI GND	1	2	AI GND
		CH 0 +	3	4	CH 0 –
		—	5	6	—
1	2	—	7	8	—
3	4	—	9	10	—
5	6	—	11	12	—
7	8	—	13	14	—
9	10	—	15	16	—
11	12	—	17	18	—
13	14	—	19	20	—
15	16	—	21	22	—
17	18	OUT REF	23	24	DIG GND
19	20	—	25	26	SER DAT OUT
21	22	—	27	28	—
23	24	—	29	30	—
25	26	SER DAT IN	31	32	—
27	28	DAQ D*/A	33	34	—
29	30	SLOT 0 SEL*	35	36	AI HOLD COMP, AI HOLD
31	32	—	37	38	—
33	34	—	39	40	—
35	36	DIG GND	41	42	—
37	38	—	43	44	—
39	40	—	45	46	SYNC
41	42	—	47	48	—
43	44	SER CLK	49	50	—
45	46	—			
47	48	—			
49	50	—			



The communication signals between the DAQ device and the SCXI system are listed in Table 2-4. If the DAQ device is connected to the SCXI-1581, these digital lines are unavailable for general-purpose digital I/O.

**Table 2-4.** SCXI-1581 Communication Signals

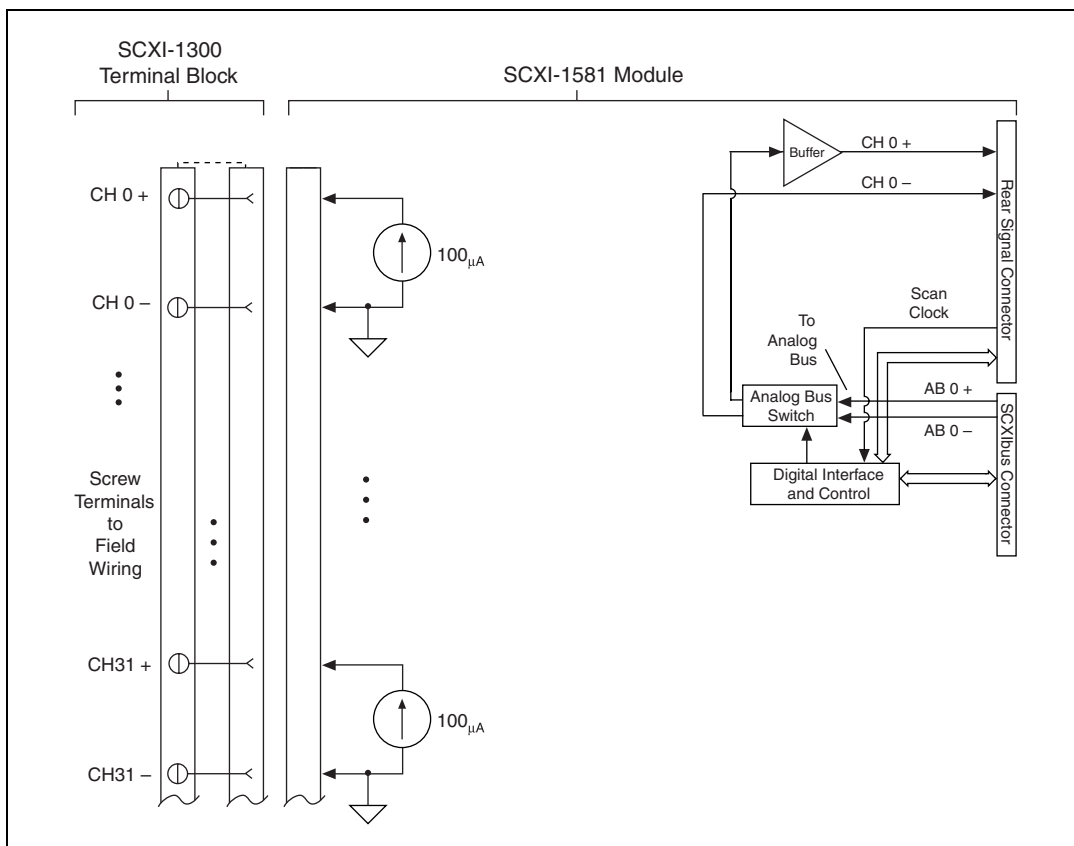
Pin	SCXI Signal Name	NI-DAQmx Device Signal Name	Traditional NI-DAQ (Legacy) Device Signal Name	Direction	Description
24, 33	DIG GND	D GND	DGND	—	Digital ground—these pins supply the reference for E/M Series DAQ device digital signals and are connected to the module digital ground.
25	SER DAT IN	P0.0	DIO0	Input	Serial data in—this signal taps into the SCXIBus MOSI line to send serial input data to a module or Slot 0.
26	SER DAT OUT	P0.4	DIO4	Output	Serial data out—this signal taps into the SCXIBus MISO line to accept serial output data from a module.
27	DAQ D*/A	P0.1	DIO1	Input	Board data/address line—this signal taps into the SCXIBus D*/A line to indicate to the module whether the incoming serial stream is data or address information.
29	SLOT 0 SEL*	P0.2	DIO2	Input	Slot 0 select—this signal taps into the SCXIBus INTR* line to indicate whether the information on MOSI is being sent to a module or Slot 0.

**Table 2-4.** SCXI-1581 Communication Signals (Continued)

<b>Pin</b>	<b>SCXI Signal Name</b>	<b>NI-DAQmx Device Signal Name</b>	<b>Traditional NI-DAQ (Legacy) Device Signal Name</b>	<b>Direction</b>	<b>Description</b>
36	SCAN CLK	AI HOLD COMP, AI HOLD	SCANCLK	Input	Scan clock—a rising edge indicates to the scanned SCXI module that the E/M Series DAQ device has taken a sample and causes the module to advance channels.
37	SER CLK	EXT STROBE*	EXTSTROBE*	Input	Serial clock—this signal taps into the SCXIbus SPICLK line to clock the data on the MOSI and MISO lines.

# Theory of Operation

This chapter provides a brief overview and a detailed discussion of the circuit features of the SCXI-1581 module. Refer to Figure 3-1 while reading this section.



**Figure 3-1.** Block Diagram of SCXI-1581

## Scanning Other SCXI Modules Through the SCXI-1581

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When connected as the cabled module in an SCXI chassis, the SCXI-1581 can route the multiplexed signals from other SCXI modules to the E/M Series DAQ device. The SCXI-1581 routes multiplexed signals from other SCXI modules to the E/M Series DAQ device even though the SCXI-1581 does not have any analog-input channels. Refer to the user manuals for your other SCXI modules for details about scanning those modules in multiplexed mode.

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# Using the SCXI-1581

This chapter makes suggestions for developing your application.

## Operation of the Current Sources

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The current sources on the SCXI-1581 continuously provide 32 channels of 100  $\mu$ A current excitation. These current sources are on whenever the SCXI chassis is powered-on. The current sources on the SCXI-1581 are designed to be accurate to within  $\pm 0.05\%$  of the specified value with a temperature drift of no more than  $\pm 5$  ppm/ $^{\circ}$ C. The high accuracy and stability of these current sources makes them especially well suited to measuring resistance to a high degree of accuracy.

## Connecting Resistive Devices to the SCXI-1581

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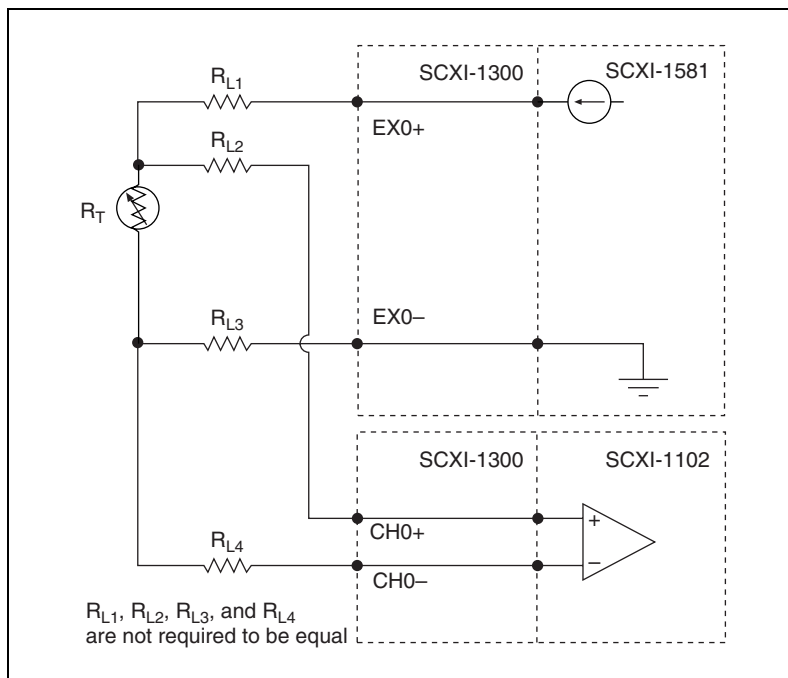
You can connect resistive devices to the SCXI signal conditioning system in a 4-, 2-, or 3-wire configuration. The SCXI-1102/B/C modules are 32-channel analog-input modules that are ideally suited for measuring DC or slowly varying voltages. Figures 4-1 through 4-5 illustrate various ways to connect sensors for current excitation and voltage measurements using the SCXI-1581 and the SCXI-1102B/C modules.

Refer to the appropriate ADE and SCXI documentation for information concerning setting appropriate voltage gains for the analog inputs.

You can use the SCXI-1300 terminal block to make signal connections to the SCXI-1581 and SCXI-1102 modules. When using the SCXI-1300 terminal block, terminals EX<0..31>+ and EX<0..31>- map to terminals CH<0..31>+ and CH<0..31>- respectively on the SCXI-1300 terminal block.

## 4-Wire Configuration

The 4-wire configuration, also referred to as a Kelvin connection, is shown in Figure 4-1. The 4-wire configuration uses one pair of wires to deliver the excitation current to the resistive sensor and uses a separate pair of wires to sense the voltage across the resistive sensor. Because of the high input impedance of the differential amplifier, negligible current flows through the sense wires. This results in a very small lead-resistance voltage drop error. The main disadvantage of the 4-wire connection is the greater number of field wires required.



**Figure 4-1.** 4-Wire Resistive Sensor Connected in a 4-Wire Configuration

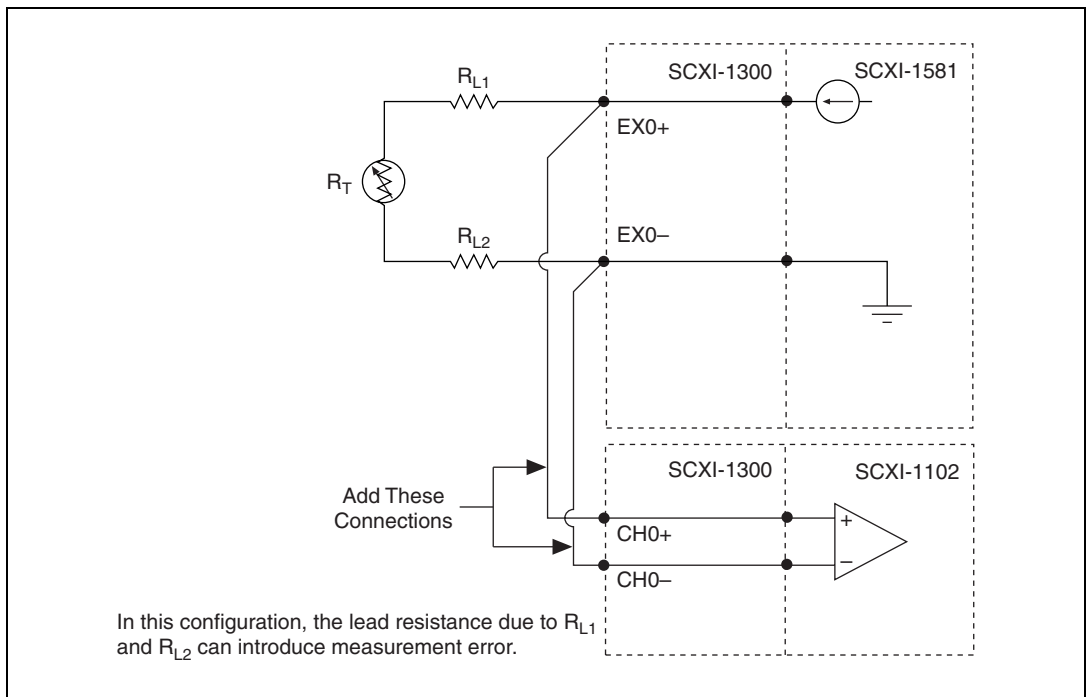
## 2-Wire Configuration

The basic 2-wire configuration is shown in Figure 4-2. In this configuration an error voltage ( $V_E$ ) is introduced into the measurement equal to the excitation current ( $I_{EX}$ ) times the sum of the two lead resistances,  $R_{L1}$  and  $R_{L2}$ . If we assume equal lead resistances,  $R_{L1} = R_{L2} = R_L$ , the magnitude of the error voltage is:

$$V_E = 2R_L I_{EX}$$

This is the most commonly used configuration for connecting thermistors to a signal conditioning system because the large sensitivity of thermistors usually results in the introduction of a negligible error by the lead resistances.

RTDs typically have a much smaller sensitivity and nominal resistance than thermistors, therefore a 2-wire configuration usually results in the introduction of larger errors by the lead resistance.



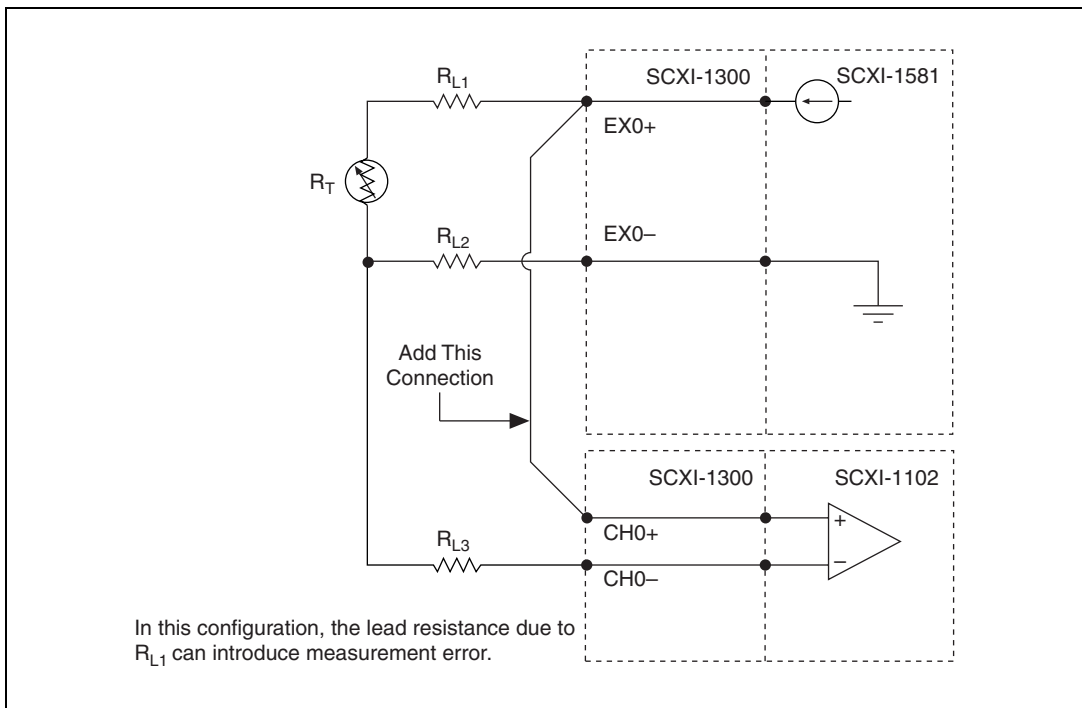
**Figure 4-2.** 2-Wire Resistive Sensor Connected in a 2-Wire Configuration

### 3-Wire Resistive Sensor Connected in a 2-Wire Configuration

If you are using a 3-wire resistive sensor, you can reduce the error voltage by one-half over the 2-wire measurement by connecting the device as shown in Figure 4-3. In this configuration, very little current flows through  $R_{L3}$  and therefore  $R_{L1}$  is the only lead resistance that introduces an error into the measurement. The resulting measurement error is:

$$VE = R_{L1}I_{EX}$$

An advantage of this configuration is that it only requires a single jumper wire from the SCXI-1581 EX0+ terminal to the SCXI-1102B/C CH0+ terminal.

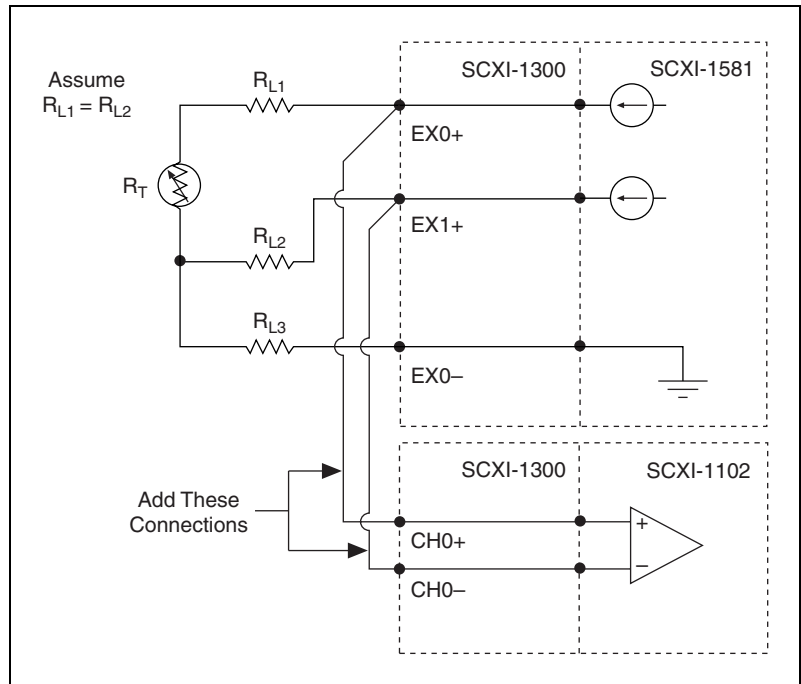


**Figure 4-3.** 3-Wire Resistive Sensor Connected in a 2-Wire Configuration



## Lead-Resistance Compensation Using a 3-Wire Resistive Sensor and Two Matched Current Sources

You can compensate for the errors introduced by lead-resistance voltage drops by using a 3-wire resistive sensor and two matched current sources connected as shown in Figure 4-4.



**Figure 4-4.** 3-Wire Configuration Using Matched Current Sources

In this configuration, the lead-resistance voltage drop across  $R_{L3}$  is converted into a common-mode voltage that is rejected by the differential amplifier. Also, the polarity of the lead-resistance voltage drops across  $R_{L1}$  and  $R_{L2}$  are series opposing, relative to the inputs of the differential amplifier, eliminating their effect on the voltage measured across  $R_T$ .

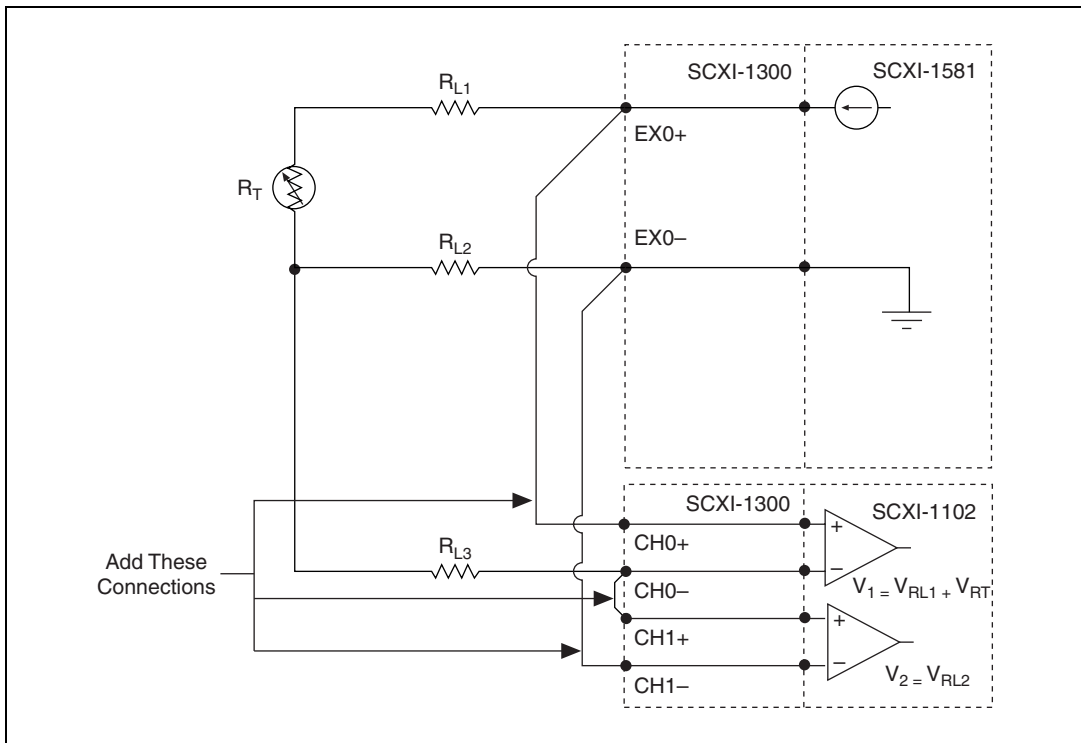


**Note**  $R_{L1}$  and  $R_{L2}$  are assumed to be equal.

The effectiveness of this method depends on the matching of the current sources. Each current source on the SCXI-1581 has an accuracy of  $\pm 0.05\%$ . This accuracy results in a worst-case matching of  $\pm 0.1\%$ . Refer to the [Measuring Temperature with Resistive Transducers](#) section for accuracy considerations of RTDs and thermistors.

## Lead-Resistance Compensation Using a 3-Wire Resistive Sensor and Two Differential Amplifiers

If the accuracy obtained by using a 3-wire device and matched current sources is not sufficient for your application, you can eliminate the error due to the mismatch of the current sources by using only one current source and two differential amplifiers. The 3-wire, 2-amplifier configuration is illustrated in Figure 4-5.



**Figure 4-5.** 3-Wire Configuration Using Two Differential Amplifiers

In this configuration, two separate measurements are taken; the first, labeled  $V_1$  in Figure 4-5, is the sum of the voltage drops across the lead resistance  $R_{L1}$  and the resistive device  $R_T$ . If the voltage drop across  $R_{L1}$  and  $R_T$  is denoted as  $V_{RL1}$  and  $V_{RT}$  respectively, the expression for  $V_1$  becomes:

$$V_1 = V_{RL1} + V_{RT}$$

The second measurement, labeled  $V_2$  in Figure 4-5, is equal to the voltage drop across the lead resistance  $R_{L2}$ , denoted as  $V_{RL2}$ ; therefore:

$$V_2 = V_{RL2}$$

If the lead resistances  $R_{L1}$  and  $R_{L2}$  are assumed equal, you can remove in software the error voltages due to the lead resistances by subtracting  $V_2$  from  $V_1$ . In most 3-wire device applications the lead wires are all the same length and made of the same material, therefore substantiating the assumption of equal lead resistances.

## Configuring Sensors in Software

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You can create a virtual channel to convert RTD voltages into temperature readings. To create an RTD virtual channel, refer to the *Creating an RTD Virtual Channel Using NI-DAQmx* section.

### Creating an RTD Virtual Channel Using NI-DAQmx

To create an RTD virtual channel using NI-DAQmx, complete the following steps:

1. Launch MAX.
2. Right-click **Data Neighborhood** and select **Create New**.
3. Select **NI-DAQmx Global Virtual Channel** and click **Next**.
4. Select **Analog Input»Temperature»RTD**.
5. Select the analog input device and channel to use, and click **Next**.
6. Enter a name for the virtual channel and click **Finish**.
7. In the configuration window that opens, set the following properties:
  - Signal input range—set the min and max to correspond to the measurement range of your application in terms of units that you select under **Scaled Units**.
  - RTD type—refer to Table 4-1 for a list of RTD types.
  - $R_0$ —the nominal resistance value of the RTD.
  - Configuration—how the RTD is connected.
  - $I_{ex}$  source—select **External** when connected to an SCXI-1581.
  - $I_{ex}$  value (A)—100  $\mu$  when connected to the SCXI-1581.

8. Click the device tab and set any device specific properties that are applicable for the measurement device.
9. To test the NI-DAQmx RTD virtual channel, click the **Test** button.

You have finished creating the NI-DAQmx virtual channel. You can access the channel by expanding **Data Neighborhood»NI-DAQmx Channels**.

For more information about incorporating the virtual channel into a task with the application, refer to the user manual of the analog input device to which the sensor connects.

## Creating a Thermistor Virtual Channel Using NI-DAQmx

To create an thermistor virtual channel using NI-DAQmx, complete the following steps:

1. Launch MAX.
2. Right-click **Data Neighborhood** and select **Create New**.
3. Select **NI-DAQmx Global Virtual Channel** and click **Next**.
4. Select **Analog Input»Temperature»I<sub>ex</sub> Thermistor**.
5. Select the analog input device and channel to which the sensor connects, and click **Next**.
6. Enter a name for the virtual channel and click **Finish**.
7. In the configuration window that opens, set the following properties:
  - Signal input range—set the min and max to correspond to the measurement range of your application in terms of units that you select under **Scaled Units**.
  - A, B, C—these scaling coefficients are obtained from the thermistor manufacturer, or calculated resistance-versus-temperature curves.
  - I<sub>ex</sub> source—select **External** when connected to an SCXI-1581
  - I<sub>ex</sub> value (A)—100  $\mu$  when connected to the SCXI-1581.
  - Configuration—the wire configuration of the sensor.
8. Click the device tab and set any device specific properties that are applicable for the measurement device.
9. To test the NI-DAQmx thermistor virtual channel, click the **Test** button.

You have finished creating the NI-DAQmx virtual channel. You can access the channel by expanding **Data Neighborhood»NI-DAQmx Channels**.

For more information about incorporating the virtual channel into a task with the application, refer to the user manual of the analog input device to which the sensor connects.

## Measuring Temperature with Resistive Transducers

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This section discusses RTDs and thermistors, and describes accuracy considerations when connecting resistive transducers to the signal conditioning system.

### RTDs

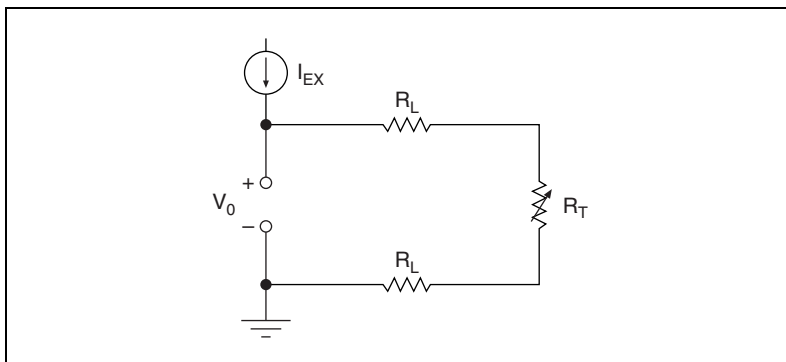
A resistive-temperature detector (RTD) is a temperature-sensing device whose resistance increases with temperature. An RTD consists of a wire coil or deposited film of pure metal. RTDs are made of different metals and have different resistances, but the most popular RTD is made of platinum and has a nominal resistance of 100  $\Omega$  at 0  $^{\circ}\text{C}$ .

RTDs are known for their excellent accuracy over a wide temperature range. Some RTDs have accuracies as high as 0.01  $\Omega$  (0.026  $^{\circ}\text{C}$ ) at 0  $^{\circ}\text{C}$ . RTDs are also extremely stable devices. Common industrial RTDs drift less than 0.1  $^{\circ}\text{C}/\text{year}$ , and some models are stable to within 0.0025  $^{\circ}\text{C}/\text{year}$ .

RTDs are sometimes difficult to measure because they have relatively low nominal resistance (commonly 100  $\Omega$ ) that changes only slightly with temperature (less than 0.4  $\Omega/^{\circ}\text{C}$ ). To accurately measure these small changes in resistance, you must use special configurations that minimize measured errors caused by lead-wire resistance.

### RTD Measurement Errors

Because the RTD is a resistive device, you must pass a current through the device and monitor the resulting voltage. However, any resistance in the lead wires that connect the measurement system to the RTD adds error to the readings. For example, consider a 2-wire RTD element connected to a measurement system that also supplies a constant current,  $I_{EX}$ , to excite the RTD. As shown in Figure 4-6, the voltage drop across the lead resistances (labeled  $R_L$ ) adds an error voltage to the measured voltage.



**Figure 4-6.** 2-Wire RTD Measurement

The maximum resistance of the thermistor is determined from the current excitation value and the maximum voltage range of the input device. When using the SCXI-1581 with an SCXI-1102/B/C, the maximum measurable resistance is 100 k $\Omega$ . Refer to Appendix A, *Specifications*, for the maximum ratings.

For example, a lead resistance of 0.3  $\Omega$  in each wire adds a 0.6  $\Omega$  error to the resistance measurement. For a platinum RTD at 0  $^{\circ}\text{C}$  with  $\alpha = 0.00385$ , the lead resistance equates to an error of approximately

$$\frac{0.6 \Omega}{0.385 \Omega/^{\circ}\text{C}} = 1.6 ^{\circ}\text{C}$$

The *Connecting Resistive Devices to the SCXI-1581* section describes different ways of connecting resistive devices to the SCXI system.

## The Relationship Between Resistance and Temperature in RTDs

Compared to other temperature-measurement devices, the output of an RTD is relatively linear with respect to temperature. The temperature coefficient, called alpha ( $\alpha$ ), differs between RTD curves. Although various manufacturers specify alpha differently, alpha is most commonly defined as the change in RTD resistance from 0 to 100  $^{\circ}\text{C}$ , divided by the resistance at 0  $^{\circ}\text{C}$ , divided by 100  $^{\circ}\text{C}$ :

$$\alpha(\Omega/\Omega/^{\circ}\text{C}) = \frac{R_{100} - R_0}{R_0 \times 100 ^{\circ}\text{C}}$$

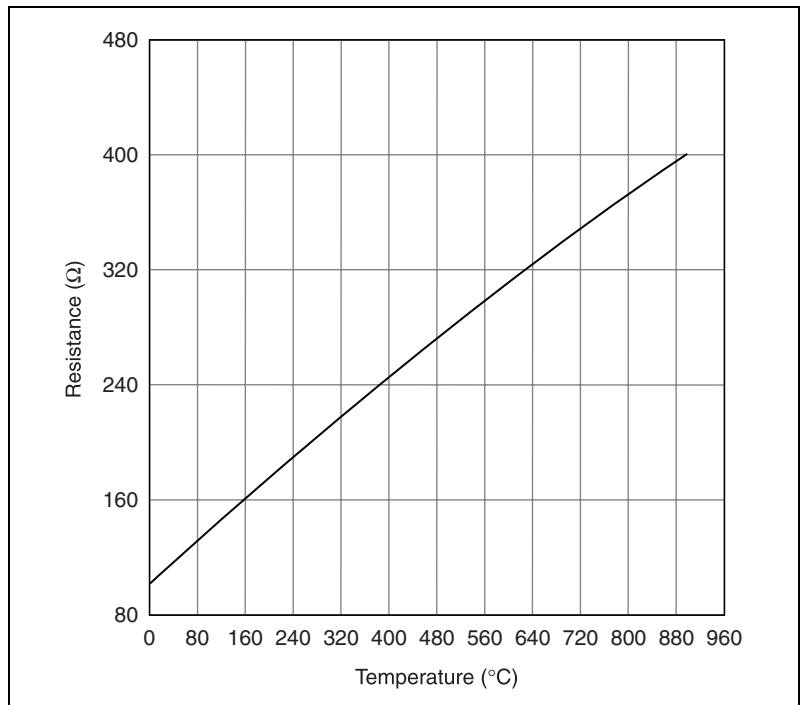
where

$R_{100}$  is the resistance of the RTD at 100 °C.

$R_0$  is the resistance of the RTD at 0 °C.

For example, a 100  $\Omega$  platinum RTD with  $\alpha = 0.003911$  has a resistance of 139.11  $\Omega$  at 100 °C.

Figure 4-7 displays a typical resistance-temperature curve for a 100  $\Omega$  platinum RTD.



**Figure 4-7.** Resistance-Temperature Curve for a 100  $\Omega$  Platinum RTD,  $\alpha = 0.00385$

Although the resistance-temperature curve is relatively linear, accurately converting measured resistance to temperature requires curve fitting. The following Callendar-Van Dusen equation is commonly used to approximate the RTD curve:

$$R_T = R_0[1 + AT + BT^2 + C(T - 100)^3]$$

where

$R_T$  is the resistance of the RTD at temperature  $T$ .

$R_0$  is the resistance of the RTD at 0 °C.

$A$ ,  $B$ , and  $C$  are the Callendar-Van Dusen coefficients shown in Table 4-1.

$T$  is the temperature in °C.

Table 4-1 lists the RTD types and their corresponding coefficients.

**Table 4-1.** Platinum RTD Types

Standard	Temperature Coefficient of Resistance (TCR, PPM)	Typical $R_0$	Callendar-Van Dusen Coefficient
IEC-751 DIN 43760 BS 1904 ASTM-E1137 EN-60751	3851	100 $\Omega$ 1000 $\Omega$	$A = 3.9083 \times 10^{-3}$ $B = -5.775 \times 10^{-7}$ $C = -4.183 \times 10^{-12}$
Low cost vendor compliant <sup>1</sup>	3750	1000 $\Omega$	$A = 3.81 \times 10^{-3}$ $B = -6.02 \times 10^{-7}$ $C = -6.0 \times 10^{-12}$
JISC 1604	3916	100 $\Omega$	$A = 3.9739 \times 10^{-3}$ $B = -5.870 \times 10^{-7}$ $C = -4.4 \times 10^{-12}$
US Industrial Standard D-100 American	3920	100 $\Omega$	$A = 3.9787 \times 10^{-3}$ $B = -5.8686 \times 10^{-7}$ $C = -4.167 \times 10^{-12}$
US Industrial Standard American	3911	100 $\Omega$	$A = 3.9692 \times 10^{-3}$ $B = -5.8495 \times 10^{-7}$ $C = -4.233 \times 10^{-12}$
ITS-90	3928	100 $\Omega$	$A = 3.9888 \times 10^{-3}$ $B = -5.915 \times 10^{-7}$ $C = -3.85 \times 10^{-12}$
<sup>1</sup> No standard. Check TCR.			



For temperatures above 0 °C, coefficient  $C$  equals 0, reducing this equation to a quadratic. If you pass a known current,  $I_{EX}$ , through the RTD and measure the output voltage developed across the RTD,  $V_0$ , you can solve for  $T$  as follows:

$$T = \frac{R_0 - \frac{V_0}{I_{EX}}}{-0.5 \left( R_0 A + \sqrt{R_0^2 A^2 - 4R_0 B \left( R_0 - \frac{V_0}{I_{EX}} \right)} \right)}$$

where

$V_0$  is the measured RTD voltage.

$I_{EX}$  is the excitation current.

## Thermistors

A thermistor is a piece of semiconductor made from metal oxides, pressed into a small bead, disk, wafer, or other shape, sintered at high temperatures, and finally coated with epoxy or glass. The resulting device exhibits an electrical resistance that varies with temperature.

There are two types of thermistors: negative temperature coefficient (NTC) thermistors, whose resistance decreases with increasing temperature, and positive temperature coefficient (PTC) thermistors, whose resistance increases with increasing temperature. NTC thermistors are more commonly used than PTC thermistors, especially for temperature measurement applications.

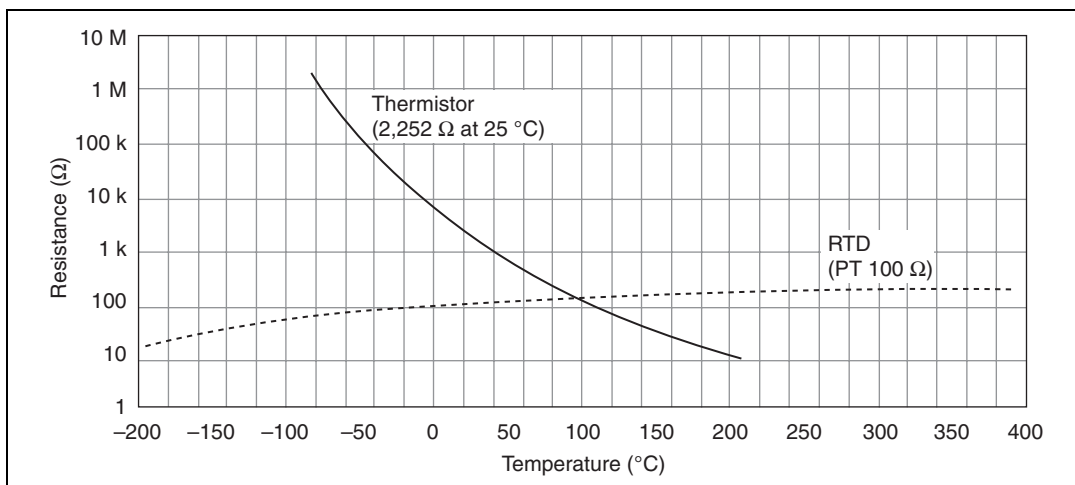
A main advantage of thermistors for temperature measurement is their extremely high sensitivity. For example, a 2,252  $\Omega$  thermistor has a sensitivity of  $-100 \Omega/^\circ\text{C}$  at room temperature. Higher resistance thermistors can exhibit temperature coefficients of  $-10 \text{ k}\Omega/^\circ\text{C}$  or more. In comparison, a 100  $\Omega$  platinum RTD has a sensitivity of only  $0.4 \Omega/^\circ\text{C}$ .

Also, the physically small size and low thermal mass of a thermistor bead allows a very fast response to temperature changes.

Another advantage of the thermistor is its relatively high resistance. Thermistors are available with base resistances (at 25 °C) ranging from hundreds to millions of ohms. This high resistance diminishes the effect of inherent resistances in the lead wires, which can cause significant errors with low resistance devices such as RTDs. For example, while RTD measurements typically require 3- or 4-wire connections to reduce errors

caused by lead-wire resistances, 2-wire connections to thermistors are usually adequate.

The major trade-off for the high resistance and sensitivity of the thermistor is its highly nonlinear output and relatively limited operating range. Depending on the type of thermistor, the upper range is typically limited to around 300 °C. Figure 4-8 shows the resistance-temperature curve for a 2,252  $\Omega$  thermistor. The curve of a 100  $\Omega$  RTD is also shown for comparison.

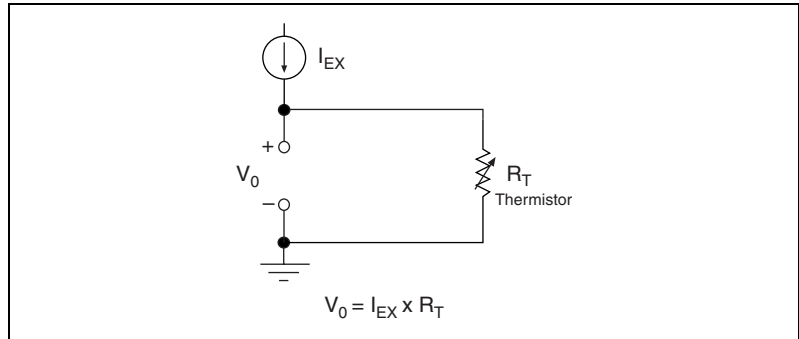


**Figure 4-8.** Resistance-Temperature Curve for a 2,252  $\Omega$  Thermistor

The thermistor has been used primarily for high-resolution measurements over limited temperature ranges. However, continuing improvements in thermistor stability, accuracy, and interchangeability have prompted increased use of thermistors in a variety of applications.

## Thermistor Measurement Circuits

This section details information about thermistor measurement circuits. The most common technique is to use a current-source, and measure the voltage developed across the thermistor. Figure 4-9 shows the measured voltage  $V_0$  equals  $I_{EX} \times R_T$ .



**Figure 4-9.** Thermistor Measurement with Constant Current Excitation

The level of the voltage output signal depends directly on the thermistor resistance and magnitude of the current excitation. Do *not* use a higher level of current excitation in order to produce a higher level output signal because the current causes the thermistor to heat internally, leading to temperature-measurement errors. This phenomena is called self-heating. When current passes through the thermistor, power dissipated by the thermistor equaling ( $I_{EX}^2 R_T$ ), heats the thermistor.

Thermistors, with their small size and high resistance, are particularly prone to these self-heating errors. Manufacturers typically specify this self-heating as a dissipation constant, which is the power required to heat the thermistor 1 °C from ambient temperature (mW/°C). The dissipation constant depends heavily on how easily heat is transferred away from the thermistor, so the dissipation constant can be specified for different media—in still air, water, or oil bath. Typical dissipation constants range anywhere from less than 0.5 mW/°C for still air to 10 mW/°C or higher for a thermistor immersed in water. A 2,252 Ω thermistor powered by a 100 μA excitation current dissipates:

$$I^2 R = 100 \mu\text{A}^2 \times 2,252 \Omega = 0.0225 \text{ mW}$$

If this thermistor has a dissipation constant of 10 mW/°C, the thermistor self-heats 0.00225 °C so the self-heating from the 100 μA source of the

SCXI-1581 is negligible for most applications. It is still important to carefully read self-heating specifications of the thermistors.

## Resistance/Temperature Characteristic of Thermistors

The resistance-temperature behavior of thermistors is highly dependent upon the manufacturing process. Therefore, thermistor curves are not standardized to the extent that thermocouple or RTD curves are standardized. Typically, thermistor manufacturers supply the resistance-versus-temperature curves or tables for their particular devices. You can, however, approximate the thermistor curve relatively accurately with the Steinhart-Hart equation:

$$T(^{\circ}\text{K}) = \frac{1}{a + b[\ln(R_T)] + c[\ln(R_T)]^3}$$

where

$T(^{\circ}\text{K})$  is the temperature in degrees Kelvin, equal to  $T(^{\circ}\text{C}) + 273.15$ .

$R_T$  is the resistance of the thermistor.

a, b, and c are coefficients obtained from the thermistor manufacturer or calculated from the resistance-versus-temperature curve.

# Specifications

This appendix lists the specifications for the SCXI-1581 modules. These specifications are typical at 25 °C unless otherwise noted.

## Stability

Recommended warm-up time ..... 10 minutes

## Excitation

Channels ..... 32 single-ended outputs

Current output ..... 100  $\mu$ A

Accuracy .....  $\pm 0.05\%$

Temperature drift .....  $\pm 5$  ppm/ $^{\circ}$ C

Output voltage compliance ..... 10 V

Maximum resistive load ..... 100 k $\Omega$

Overvoltage protection .....  $\pm 40$  VDC

Measurement Category ..... CAT I

## Power Requirements From SCXI Backplane

V+ ..... 18.5 to 25 VDC, 75 mA

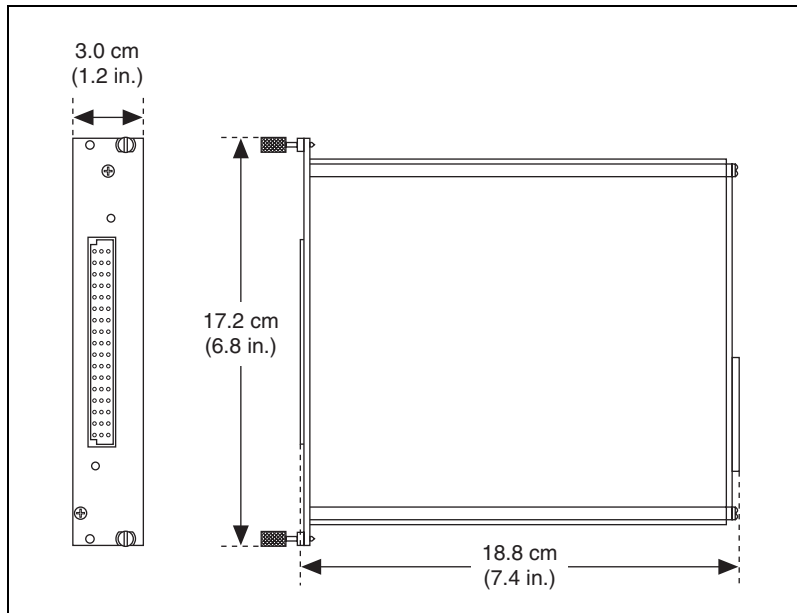
V- ..... -18.5 to -25 VDC, 23 mA

+5 V ..... +4.75 to 5.25 VDC, 20.2 mA

## Environmental

- Operating temperature .....0 to 50 °C
- Storage temperature .....-20 to 70 °C
- Humidity .....10 to 90% RH, noncondensing
- Maximum altitude.....2,000 meters
- Pollution Degree (indoor use only) .....2

## Physical



**Figure A-1. SCXI-1581 Dimensions**

- Weight .....731 gm (25.8 oz)

## Safety

The SCXI-1581 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 61010-1
- CAN/CSA-C22.2 No. 61010-1



**Note** For UL and other safety certifications, refer to the product label or visit [ni.com/certification](http://ni.com/certification), search by model number or product line, and click the appropriate link in the Certification column.

## Electromagnetic Compatibility

Emissions .....	EN 55011 Class A at 10 m FCC Part 15A above 1 GHz
Immunity .....	EN 61326:1997 + 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

The SCXI-1581 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](http://ni.com/certification), search by model number or product line, and click the appropriate link in the Certification column.

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# Removing the SCXI-1581

This appendix explains how to remove the SCXI-1581 from MAX and an SCXI chassis or PXI/SCXI combination chassis.

## Removing the SCXI-1581 from MAX

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To remove a module from MAX, complete the following steps after launching MAX:

1. Expand **Devices and Interfaces**.
2. Click the + next to **NI-DAQmx** and/or **Traditional NI-DAQ Devices** to expand the list of installed chassis.
3. Click the + next to the appropriate chassis to expand the list of installed modules.
4. Right-click the module or chassis you want to delete and click **Delete**.
5. A confirmation window opens. Click **Yes** to continue deleting the module or chassis or **No** to cancel this action.



**Note** Deleting the SCXI chassis deletes all modules in the chassis. All configuration information for these modules is also lost.

The SCXI chassis and/or SCXI module(s) should now be removed from the list of installed devices in MAX.

## Removing the SCXI-1581 from a Chassis

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Consult the documentation for the chassis and accessories for additional instructions and precautions. To remove the SCXI-1581 module from a chassis, complete the following steps while referring to Figure B-1:

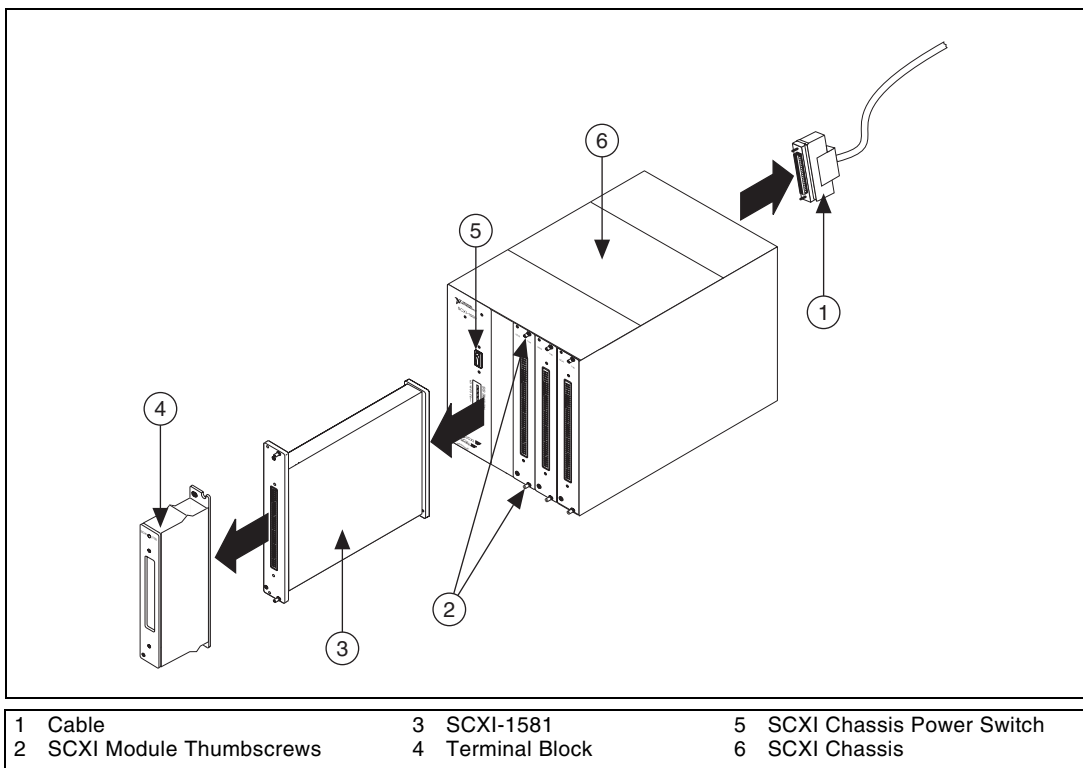


**Note** Figure B-1 shows an SCXI chassis, but the same steps are applicable to a PXI/SCXI combination chassis.



1. Power off the chassis. Do *not* remove the SCXI-1581 module from a chassis that is powered on.
2. If the SCXI-1581 is the module cabled to the E/M Series DAQ device, disconnect the cable.
3. Remove any terminal block that connects to the SCXI-1581.
4. Rotate the thumbscrews that secure the SCXI-1581 to the chassis counterclockwise until they are loose, but do not completely remove the thumbscrews.

Remove the SCXI-1581 by pulling steadily on both thumbscrews until the module slides completely out.



**Figure B-1.** Removing the SCXI-1581



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# Common Questions

This appendix lists common questions related to the use of the SCXI-1581.

**Which version of NI-DAQ works with the SCXI-1581, and how do I get the most current version of NI-DAQ?**

You must have NI-DAQ 7.0 or later. Visit the NI Web site at [ni.com](http://ni.com) and select **Download Software»Drivers and Updates»Search Drivers and Updates**. Enter the keyword NI-DAQ to find the latest version of NI-DAQ for your operating system.

**Can the SCXI-1581 be the *cabled* module when there are also multiplexed analog-input modules in the chassis?**

Yes, unless one or more of the multiplexed analog-input modules in the same chassis feature simultaneous sampling (such as the SCXI-1140, SCXI-1520, SCXI-1530, or SCXI-1531). In that case, you must cable to a simultaneous-sampling module.

**Can the SCXI-1581 current outputs be interactively controlled in MAX or programmatically controlled using NI-DAQ function calls, LabVIEW, or Measurement Studio?**

No. The current-output level is 100  $\mu$ A as long as the chassis is powered on. You cannot power off or adjust the current output using MAX, NI-DAQ function calls, or an ADE such as LabVIEW or Measurement Studio. If you require this functionality, consider using an SCXI-1124 module or NI 670X device instead.

**Can I create virtual channels for an SCXI-1581 current-output channel?**

No. As discussed above, you cannot programmatically control the current outputs.

**Can I connect  $N$  current-output channels in parallel to create a precision current source that provides  $N \times 100 \mu\text{A}$ ?**

Yes, you can connect the current output in parallel. When connecting the output in parallel, connect the appropriate EX+ terminals together and the corresponding EX- terminals together.

**Can I connect  $N$  current-output channels in series to achieve a higher terminal-voltage compliance limit?**

No. Each current source is ground referenced. Therefore, you cannot place multiple current-outputs in series.

**Are the SCXI-1581 current output channels isolated with respect to each other, the E/M Series DAQ device, or ground?**

No. The SCXI-1581 does not contain any isolation circuitry. All current outputs are referenced to chassis ground. If you require isolated current outputs, consider the SCXI-1124 module instead.

**Can I modify the SCXI-1581 circuitry to generate current at a level different than  $100 \mu\text{A}$ ?**

No. Do not attempt to modify any circuitry in the SCXI-1581.

**Are there any user-serviceable parts inside the SCXI-1581?**

No. There are no fuses, potentiometers, switches, socketed resistors, or jumpers inside the module. Disassembly of the module for any reason can void its warranty and nullify its accuracy specification.

**Can I access the unused analog-input channels of the E/M Series DAQ device if it is directly cabled to the SCXI-1581 in a single-chassis system?**

Yes. E/M Series DAQ device channels 1 through 7 are available to measure unconditioned signals. Use an SCXI-1180 or the 50-pin breakout connector on the SCXI-1346 or SCXI-1349 cable adapter to route signals to these channels.

**Which digital lines are unavailable on the E/M Series DAQ device if I am cabled to an SCXI-1581 module?**

Table C-1 shows the digital lines that are used by the SCXI-1581 for communication and scanning. These lines are unavailable for general-purpose digital I/O if the SCXI-1581 is connected to the DAQ device.

**Table C-1.** SCXI-1581 Digital Signals

DAQ Signal Name	SCXI Signal Name	50-Pin Connector	68-Pin Connector	Direction <sup>1</sup>
DIO0	SERDATIN	25	52	Output
DIO4	SERDATOUT	26	19	Input
DIO1	DAQD*/A	27	17	Output
DIO2	SLOT0SEL*	29	49	Output
SCANCLK	SCANCLK	36	46	Output

<sup>1</sup> With respect to the E/M Series DAQ device.

**Does short-circuiting a current-output channel do any damage to the SCXI-1581?**

No. The SCXI-1581 delivers 100  $\mu$ A into any load from 0  $\Omega$  to 100 k $\Omega$ .

**Does open-circuiting a current-output channel damage the SCXI-1581? What is the open-circuit voltage level?**

No. An SCXI-1581 current-output channel is not damaged if no load is connected. The open-circuit voltage is 12.4 VDC.

**How can I tell if the SCXI-1581 is working?**

Disconnect all loads from the channel you are testing. Measure the current-output value using an ammeter. If the ammeter has a fuse, ensure that the fuse is not blown before performing the measurement.

Alternatively, place a known resistance  $R$  (<100 k $\Omega$ ) across the current output and use a voltmeter to measure the voltage drop across it. If the current output is functioning, you should measure

$$V = (100 \times 10^{-6} \text{ A}) \times R$$

where  $R$  is given in  $\Omega$ .

**How does the screw-terminal labeling on the SCXI-1300 relate to the front signal connector on the SCXI-1581? In other words, if I want to use current-output channel  $x$ , where do I connect wires in the SCXI-1300?**

CH  $x +$  corresponds to EX  $x +$ . Likewise, CH  $x -$  corresponds to EX  $x -$ . You cannot use any screw terminals in the SCXI-1300 other than CH  $x +$ , CH  $x -$ , and chassis ground.

**Can I use the BNC-2095 as an accessory for the SCXI-1581?**

Yes. However, you must set all the slide switches on the back of the BNC-2095 for no bias-resistor connections to ground and no pull-up resistor connections to +5 V. In other words, set all switches on the rear of the BNC-2095 to the *OFF* (down) position.

**When using an SCXI-1300 or BNC-2095 with the SCXI-1581, can I read the CJC sensor on these accessories?**

No.

**Can I use an SCXI-1303 terminal block as an accessory for the SCXI-1581?**

NI does not recommend this combination. The SCXI-1303 is optimized for temperature measurement using thermocouples. The SCXI-1303 works with the SCXI-1581, but only if you remove all of the resistor packs. Refer to the *SCXI-1303 32-Channel Isothermal Terminal Block Installation Guide* for more information. As with the SCXI-1300 and BNC-2095, you cannot measure the CJC sensor.

# Glossary

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Symbol	Prefix	Value
$\mu$	micro	$10^{-6}$
m	milli	$10^{-3}$
k	kilo	$10^3$
M	mega	$10^6$

## Numbers/Symbols

%	percent
+	positive of, or plus
-	negative of, or minus
$\pm$	plus or minus
<	less than
/	per
°	degree
$\Omega$	ohms
+5 V (signal)	+5 VDC source signal

## A

A	amperes
ADE	application development environment such as LabVIEW, LabWindows/CVI, Visual Basic, C, and C++
AI	analog input
AIGND	analog input ground signal

## **B**

bit one binary digit, either 0 or 1

## **C**

CE European emissions control standard

CGND chassis ground signal

CH channel

channel pin or wire lead to which you apply, or from which you read, an analog or digital signal. Analog signals can be single-ended or differential. For digital signals, channels (also known as lines) are grouped to form ports.

chassis the enclosure that houses, powers, and controls SCXI modules

CLK clock input signal

common-mode voltage voltage that appears on both inputs of a differential amplifier

current excitation a source that supplies the current needed by a sensor for its proper operation

## **D**

D/A digital-to-analog

D\*/A Data/Address

DAQ data acquisition—(1) collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and processing the measurement data using a computer; (2) collecting and measuring the same kinds of electrical signals with A/D and/or DIO devices plugged into a computer, and possibly generating control signals with D/A and/or DIO devices in the same computer

DAQ device a data acquisition device. Examples are E/M Series data acquisition devices.

DAQD\*/A the data acquisition device data/address line signal used to indicate whether the SERDATIN pulse train transmitted to the SCXI chassis contains data or address information

device	a plug-in data acquisition device, module, card, or pad that can contain multiple channels and conversion devices. SCXI modules are distinct from devices, with the exception of the SCXI-1200, which is a hybrid.
DGND	digital ground signal
differential amplifier	an amplifier with two input terminals, neither of which are tied to a ground reference, whose voltage difference is amplified
DIN	Deutsche Industrie Norme (German Industrial Standard)
DIO	digital input/output
DoC	Declaration of Conformity
drivers/driver software	software that controls a specific hardware device such as an E/M Series DAQ device

## E

EMC	electromagnetic compliance
EMI	electromagnetic interference
EX+	positive excitation channel
EX-	negative excitation channel
excitation	a voltage or current source used to energize a sensor or circuit
EXTCLK	external clock signal

## G

gain	the factor by which a signal is amplified, sometimes expressed in decibels
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## I

ID	identifier
in.	inch or inches
input impedance	the measured resistance and capacitance between the input terminals of a circuit

## J

jumper	a small rectangular device used to connect two adjacent posts on a circuit board. Jumpers are used on some SCXI modules and terminal blocks to either select certain parameters or enable/disable circuit functionality.
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## L

lead resistance	the small resistance of a lead wire. The resistance varies with the lead length and ambient temperature. If the lead wire carries excitation current, this varying resistance can cause measurement error.
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## M

m	meters
M	(1) Mega, the standard metric prefix for 1 million or $10^6$ , when used with units of measure such as volts and hertz; (2) mega, the prefix for 1,048,576, or $2^{20}$ , when used with B to quantify data or computer memory
MISO	master-in-slave-out signal
MOSI	master-out-slave-in signal
multiplex	to route one of many input signals to a single output
multiplexed mode	an SCXI operating mode in which analog input channels are multiplexed into one module output so that the cabled E/M Series DAQ device has access to the multiplexed output of the module as well as the outputs of all other multiplexed modules in the chassis

**N**

NC	not connected (signal)
NI-DAQ	the driver software needed in order to use National Instruments E/M Series DAQ devices and SCXI components
NI-DAQmx	The latest NI-DAQ driver with new VIs, functions, and development tools for controlling measurement devices.

**O**

output voltage compliance	the largest voltage that can be generated across the output of a current source without the current going out of specification
OUTREF	output reference signal

**P**

ppm	parts per million
PXI	PCI eXtensions for Instrumentation—an open specification that builds on the CompactPCI specification by adding instrumentation-specific features

**R**

$R_L$	lead resistance
RMA	Return Material Authorization
RSVD	reserved bit, pin, or signal
RTD	resistance-temperature detector

**S**

s	seconds
S	samples

scan	one or more analog samples taken at the same time, or nearly the same time. Typically, the number of input samples in a scan is equal to the number of channels in the input group. For example, one scan, acquires one new sample from every analog input channel in the group.
SCANCLK	scan clock signal used to increment to the next channel after each E/M Series DAQ device analog-to-digital conversion
SCXI	Signal Conditioning eXtensions for Instrumentation
SCXIBus	located in the rear of an SCXI chassis, the SCXIBus is the backplane that connects modules in the same chassis to each other
sensor	a type of transducer that converts a physical phenomenon into an electrical signal
SERCLK	serial clock signal used to synchronize digital data transfers over the SERDATIN and SERDATOUT lines
SERDATIN	serial data input signal
SERDATOUT	serial data output signal
signal conditioning	the manipulation of signals to prepare them for digitizing
Slot 0	refers to the power supply and control circuitry in the SCXI chassis
SLOT0SEL	slot 0 select signal
SPICLK	serial peripheral interface clock signal
<b>T</b>	
thermistor	a thermally sensitive resistor
Traditional NI-DAQ (Legacy)	An upgrade to the earlier version of NI-DAQ. Traditional NI-DAQ (Legacy) has the same VIs and functions and works the same way as NI-DAQ 6.9.x. You can use both Traditional NI-DAQ (Legacy) and NI-DAQmx on the same computer, which is not possible with NI-DAQ 6.9.x.
transducer	a device capable of converting energy from one form to another

**U**

UL Underwriters Laboratory

**V**

V volts

VAC volts, alternating current

VDC volts, direct current

VI virtual instrument—(1) a combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument; (2) a LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program

virtual channels channel names that can be defined outside the application and used without having to perform scaling operations

**W**

W watts

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