# SCXI™

## SCXI-1581 User Manual

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**Worldwide Technical Support and Product Information**

`ni.com`

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# Conventions

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, DIO<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.

**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. This font 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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# Installing and Configuring the SCXI-1581

This chapter provides information for the SCXI-1581 module installation, configuration, and removal.

## About the SCXI-1581

The SCXI-1581 module provides 32 channels of 100 µA current excitation. You can use the SCXI-1581 in any application that requires 100 µA fixed current excitation. The SCXI-1581 is configured using Measurement & Automation Explorer (MAX).

## What You Need to Get Started

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

- ❑ SCXI-1581 and documentation
- ❑ SCXI chassis and documentation
- ❑ E Series data acquisition (DAQ) device and documentation
- ❑ One of the following terminal blocks and documentation
  - SCXI-1300[1]
  - SCXI-1310
  - BNC-2095
  - TBX-96
- ❑ *Read Me First: Safety and Radio-Frequency Interference*
- ❑ Wire cutter

[1] When connected to an SCXI-1581, you cannot measure the onboard temperature sensor.

- ❑ Wire stripper
- ❑ Flathead screwdriver
- ❑ Phillips screwdriver

# Installing the Software

Follow these instructions to install the SCXI-1581 software:

1. Install your application development environment (ADE) if you have not already done so. National Instruments ADEs have release notes containing software installation instructions.
2. Install NI-DAQ, which came with the E Series DAQ device. NI-DAQ version 6.9.1 or higher is required to configure the SCXI-1581 module. If you do not have NI-DAQ version 6.9.1 or higher, download the latest NI-DAQ version at no cost from the National Instruments Web site, `ni.com/download`, or you can contact a National Instruments sales representative to request it on a CD.

# Installing the SCXI-1581

The following section describes how to install the SCXI-1581 for use with SCXI chassis and E Series DAQ devices.

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

## Unpacking

The SCXI-1581 module is shipped in an antistatic package to prevent electrostatic damage to the module. Electrostatic discharge can damage several components in the module. To avoid such damage in handling the module, take the following precautions:

- Ground yourself using a grounding strap or by holding a grounded object.
- Touch the antistatic package to a metal part of the plugged-in computer chassis before removing the module from the package.

⚠ **Caution** *Never* touch the exposed pins of connectors.

Remove the module from the package and inspect the module for loose components or any sign of damage. Notify NI if the module appears damaged in any way. Do *not* install a damaged module into the SCXI chassis.

Store the SCXI-1581 module in the antistatic package when not in use.

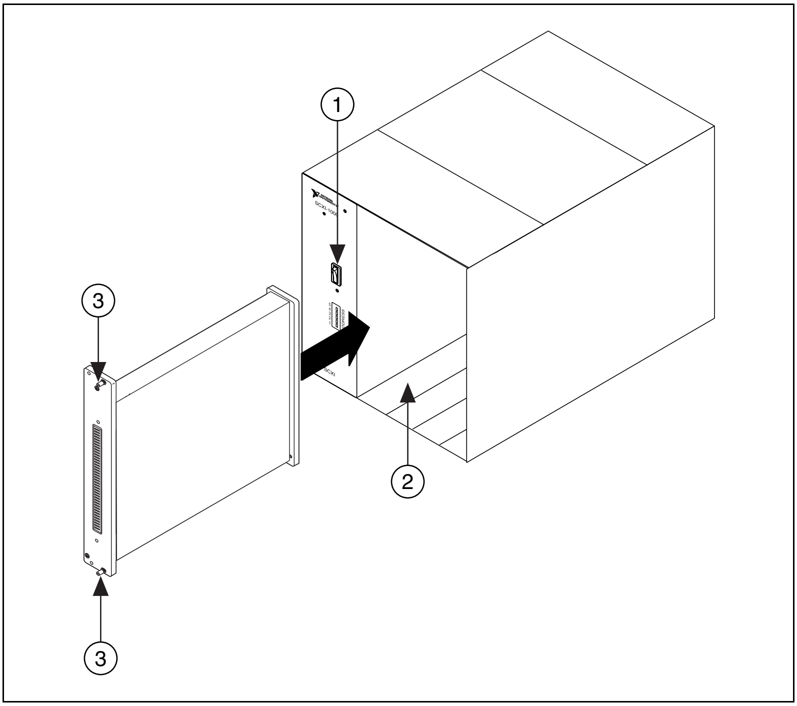
## Installing the SCXI-1581 Module into the SCXI Chassis

You need the following items to complete the installation:

- SCXI-1581
- SCXI chassis or PXI combination chassis
- 1/4 in. flathead screwdriver

To install the SCXI-1581 module into the SCXI chassis, complete the following steps while referring to Figure 1-1:

1. Power off the computer that contains the E Series DAQ device, or disconnect it from the SCXI chassis.
2. Power off the SCXI chassis. Do *not* insert the SCXI-1581 module into a chassis that is powered on.
3. Insert the SCXI-1581 into an open slot in the SCXI chassis. Refer to the *SCXI Quick Start Guide* for information on the correct order to install modules. Gently guide the module into the slot guides and push it toward the back of the chassis until the front face of the module is flush with the front of the chassis.
4. Insert any other SCXI modules into the remaining slots in the same manner as described in step 3.
5. Secure each SCXI module to the SCXI chassis using both thumbscrews.




| | | | |
|---|---|---|---|
| 1 | SCXI Chassis Power Switch | 3 | SCXI Module Thumbscrews |
| 2 | SCXI Chassis Slots | | |

**Figure 1-1.** Installing the SCXI-1581 Module

To complete the SCXI-1581 installation, follow the steps in the appropriate sections that follow.

## Connecting the SCXI-1581 to an E Series DAQ Device for Multiplexed Scanning in an SCXI Chassis

In this configuration, you can multiplex the input channels of the analog-input SCXI modules into a single channel of the E Series DAQ device. You need the following items for this installation:

- SCXI chassis with the SCXI module(s) installed
- SCXI cable assembly, which consists of a cable adapter and a cable
- An installed E Series DAQ device
- 1/4 in. flathead screwdriver

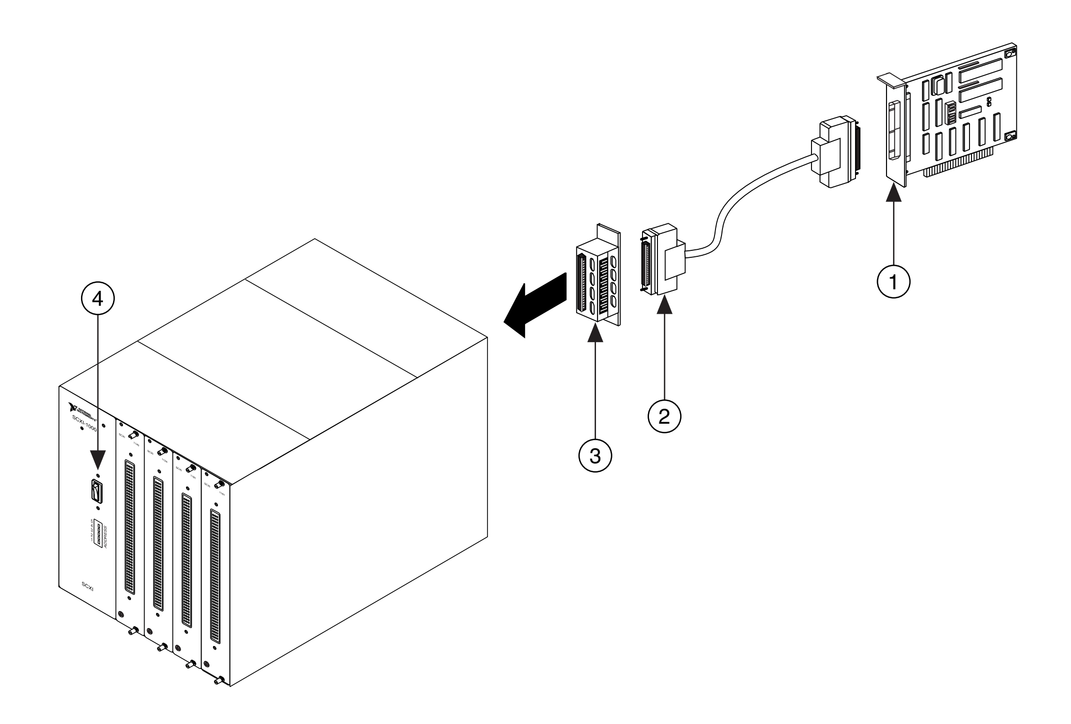
Consult the SCXI chassis documentation, other SCXI module documentation, and E Series DAQ device documentation for additional instructions and cautions. You should have already installed the SCXI-1581 module and any other SCXI modules in the chassis according to their installation instructions.

In the chassis, you must select an analog-input module with simultaneous sampling capability as the cabled module, to which the SCXI cable assembly will connect. This includes the SCXI-1520, SCXI-1530/1531, and SCXI-1140. Refer to the *SCXI Quick Start Guide* for information on the correct order to install modules. If you cable to a module without simultaneous sampling capability, you will get an error message each time you run your application.

**Note** The SCXI-1581 is *not* an analog-input module.

To connect the chassis to an E Series DAQ device for multiplexed operation, complete the following steps while referring to Figure 1-2:

1. Power off the SCXI chassis.
2. Power off the computer that contains the E Series DAQ device.
3. Insert the cable adapter into the back of the SCXI chassis aligned with the module that you intend to connect to the E Series DAQ device. Refer to the installation guide for the cable assembly for more information.
4. Connect the cable to the back of the cable adapter, ensuring that the cable fits securely.
5. Connect the other end of the cable to the E Series DAQ device you are using to control the SCXI system.
6. Check the cable installation, making sure the connectors and cable adapter are securely fastened at both ends.
7. Power on the SCXI chassis.
8. Power on the computer.




| | | | |
|---|---|---|---|
| 1 | E Series DAQ Device | 3 | Cable Adapter |
| 2 | SH68-68 Cable | 4 | SCXI Chassis Power Switch |

**Figure 1-2.** Connecting an SCXI Chassis to an E Series DAQ Device

If you have already installed the appropriate software, refer to the *Configuring and Self-Testing* section to configure the SCXI-1581 module(s) for multiplexed mode operation.

## Connecting the SCXI-1581 to an E Series DAQ Device for Multiplexed Scanning in a PXI Combination Chassis

In this configuration, you can multiplex the input channels of the SCXI analog-input modules into a single channel of the E Series DAQ device in the combination PXI chassis. You need the following items for this installation:

- PXI combination chassis (PXI-1010 or PXI-1011) with the SCXI module(s) installed
- PXI Multifunction E Series DAQ device installed in the right-most PXI slot

Consult the PXI chassis documentation, other SCXI module documentation, and E Series DAQ device documentation for additional instructions and cautions. You should have already installed your software, the SCXI-1581 module, and any other SCXI modules in the chassis according to their installation instructions. To use the SCXI-1581 module in multiplexed mode with an E Series DAQ device in a PXI combination chassis, complete the following steps:

1. No cables are required between the SCXI-1581 and the E Series DAQ device if the PXI E Series DAQ device is installed in the right-most PXI slot. You can configure this device to control the SCXI system using an internal bus that connects the PXI chassis to the SCXI chassis. If the E Series DAQ device for controlling the SCXI system is not installed in the right-most slot of the PXI combination chassis, assemble the system as described in the *Connecting the SCXI-1581 to an E Series DAQ Device for Multiplexed Scanning in an SCXI Chassis* section.
2. Power on the SCXI portion of the PXI combination chassis.

You should have already installed the appropriate software. Refer to the *Configuring and Self-Testing* section to configure the SCXI-1581 for multiplexed mode operation.

# Configuring and Self-Testing

You can configure an SCXI system under **Traditional NI-DAQ Devices** or **NI-DAQmx Devices**.

## Configuring SCXI Using Traditional NI-DAQ

Use MAX to configure and test the SCXI-1581. If you need help during the configuration process, open the *Measurement & Automation Help* by selecting **Help Topics** from the **Help** menu. Complete the following steps to configure the SCXI system.

1. Double-click the **Measurement & Automation Explorer** icon on the desktop. If you are adding a new module to an already configured chassis, go to the *Manually Adding and Configuring Modules in Traditional NI-DAQ* section.
2. Add a new chassis to the configured devices and interfaces by right-clicking **Devices and Interfaces** and selecting **Create New**.
3. Select the appropriate chassis from the list box under **Traditional NI-DAQ Device** and click **Finish**.

4. Configure the chassis.
   a. Select a **Chassis ID**. This is an integer value you choose to uniquely identify the chassis for programming and scanning. The default Chassis ID starts at 1 and increments as the numbers are used.
   b. Select the **Chassis Address**. This is needed to address the chassis in a multichassis SCXI system. Unless you are using multiple chassis with the same E Series DAQ device, select a Chassis Address of zero, which is the factory-default setting of all SCXI chassis. A chassis address of zero is indicated by setting all of the chassis address DIP switches to the *OFF* position. If you are using multiple chassis or one or more of the chassis address DIP switches is not in the *OFF* position, refer to the *SCXI Chassis User Manual* for more information.
   c. If you are using a PXI-1010 or PXI-1011 chassis, select the **Controlling SCXI with internal bus** checkbox if you are communicating directly with the SCXI portion of the chassis without external cabling.
   d. Click **Next**.
5. You can now choose to automatically detect which modules are installed in the chassis or you can manually add them. Click **Next** if you selected **Yes** and **Finish** if you selected **No**. If you selected **No**, go to the *Manually Adding and Configuring Modules in Traditional NI-DAQ* section.
6. If you selected auto-detection, select the communication path and click **Next**.
7. Select the cabled module by clicking the module in the list box and clicking **Finish**.

You have completed configuring the SCXI-1581 using Traditional NI-DAQ.

## Manually Adding and Configuring Modules in Traditional NI-DAQ

If you did not auto-detect the SCXI modules, you must manually add and configure each of the modules. Complete the following steps to manually add modules.

1. Click the **+** next to **Devices and Interfaces**, **Traditional NI-DAQ Devices**, and the chassis you want to configure.
2. Add a module in an empty module number. If a module number is not empty, right-click the module number you want to change and select **Delete**.
3. Right-click the slot you want to configure and select **Insert**.
4. In the list box, select a module you want to add and click **Next**.
5. Select the E Series DAQ device to which this specific module connects if it is a cabled module. Otherwise, select **None** and click **Next**. If you select a device, select the **This device will control the chassis** checkbox if you want the device as the communicating device.
6. Continue following the onscreen instructions to complete the configuration. When you have clicked **Finish**, the module configuration is complete.
7. Repeat steps 2 through 6 until you have added all the modules.

The SCXI chassis and SCXI module(s) should now be configured properly. If you need to change the module configuration, right-click the module you want to change and select **Properties**. If you need to change the actual module, repeat steps 2 through 6. If the configuration is complete, test the system as described in the *Verifying and Self-Testing the Configuration* section to ensure the SCXI system is communicating properly with the E Series DAQ device.

## Verifying and Self-Testing the Configuration

To test the successful configuration of the system, complete the following steps after opening MAX:

1. Verify that the chassis power is on and is correctly connected to an E Series DAQ device.
2. Display the list of devices and interfaces by clicking the **+** next to the **Devices and Interfaces** icon.
3. From the list that appears under Traditional NI-DAQ Devices, locate the chassis you want to test. Right-click the chassis and click **Test**.
4. If the communication test is successful, a message **`The Chassis has been Verified`** appears. Click **OK**.

The SCXI system should now operate properly with your ADE software. If the test did not complete successfully, refer to the *Troubleshooting the Self-Test Verification* section for troubleshooting steps.

## Configuring SCXI Using NI-DAQmx

Use MAX to configure and test the SCXI-1581. If you need help during the configuration process, open the *Measurement & Automation Help* by selecting **Help Topics** from the **Help** menu. Complete the following steps to configure the SCXI system.

1. Double-click the **Measurement & Automation Explorer** icon on the desktop.
2. Click the **+** next to the **Devices and Interfaces** icon. If you are adding modules to an already configured chassis, go to the *Manually Adding and Configuring Modules in NI-DAQmx* section.
3. Add a new chassis to the configured devices and interfaces by holding down the right mouse button on **NI-DAQmx Devices** and selecting **Create New DAQmx Device**.
4. Select **NI-DAQmx SCXI Chassis**.
5. Select the appropriate chassis from the pull-down menu.
6. Configure the chassis.
   a. Select the **Chassis Communicator** that is connected to the SCXI chassis. This setting is dimmed if there is only one E Series DAQ device.
   b. Select the **Communicating SCXI Module Slot**.
   c. Select the **Chassis Address**. Make sure the setting matches the chassis address on the SCXI chassis.
7. You can now choose to automatically detect which modules are installed in the chassis, or you can manually add them by selecting or clearing the **Auto-Detect Modules** checkbox.
8. Left-click **Save** and go to step 1 in the *Manually Adding and Configuring Modules in NI-DAQmx* section to complete configuration.

## Manually Adding and Configuring Modules in NI-DAQmx

You must add and configure each of the modules in the **SCXI Chassis Configuration** window. If you are not in the **SCXI Chassis Configuration** window, right-click on the chassis in which the module is installed and select **Properties**. Complete the following steps to manually add modules.

1. Left-click the down arrow in the module column corresponding to the slot where the added module is located. If the appropriate module name does not appear on the list, refer to Appendix C, *Common Questions*.
2. Left-click the down arrow in the **Accessory** column to select the appropriate accessory on the module.
3. To change the cabled module, put the module in parallel mode, change the E Series DAQ device which connects to this module, or set up a multichassis daisy chain, left-click the **Details** button and click the **Cabling** tab.
4. When you have finished, click **OK**.
5. When you have completed configuring the module, click **OK**.

The SCXI chassis and SCXI module(s) should now be configured properly. If you need to change the module configuration, right-click the module you want to change and select **Properties**. If you need to change the actual module, go to the SCXI Chassis Configuration window and repeat steps 1 through 5. If the configuration is complete, test the system as described in the *Verifying and Self-Testing the Configuration* section to ensure the SCXI system is communicating properly with the E Series DAQ device.

## Verifying and Self-Testing the Configuration

To test the successful configuration of the system, complete the following steps after opening MAX:

1. Verify that the chassis power is on and is correctly connected to an E Series DAQ device.
2. Display the list of devices and interfaces by clicking the **+** next to the **Devices and Interfaces** icon.
3. From the list that appears under NI-DAQmx Devices, locate the chassis you want to test. Right-click the chassis and click **Test**.
4. If the communication test is successful, a message **`Chassis Verified`** appears. Click **OK**.

The SCXI system should now operate properly with your ADE software. If the test did not complete successfully, refer to the *Troubleshooting the Self-Test Verification* section for troubleshooting steps.

# Troubleshooting the Self-Test Verification

If the Self-Test Verification did not verify the chassis configuration, check the following items to successfully complete system configuration.

- If you get the message **`Unable to test chassis at this time`**, you have not designated at least one module as connected to an E Series DAQ device.
  1. Return to the *Manually Adding and Configuring Modules in NI-DAQmx* section.
  2. Change the configuration of the cabled module in the system from not being connected to connected to device ***x***.
- If you get the message **`Failed to find`**, followed by the module codes and the message **`Unable to communicate with chassis`**:
  1. Make sure the SCXI chassis is powered on.
  2. Make sure the cable between the SCXI chassis and E Series DAQ device is properly connected.
  3. Inspect the cable connectors for bent pins.
  4. Make sure you are using the correct NI cable assembly.
  5. Test the E Series DAQ device to verify it is working properly. Refer to the E Series DAQ device user manual for more information.
- If you get the message **`Failed to find`**, followed by module codes and the message **`Instead found: module with ID 0Xxx`**:
  1. Return to the *Manually Adding and Configuring Modules in NI-DAQmx* section and make sure the correct module is in the specified slot.
  2. Delete the incorrect module as described in the *Removing the SCXI-1581 from Measurement & Automation Explorer* section.
  3. Add the correct module as described in the *Manually Adding and Configuring Modules in NI-DAQmx* section.

- If you get the message `Failed to find`, followed by a module code and the message `Slot x is empty`:
  1. Check to see if the configured module is installed in the specified slot. If not, install the module by referring to the *Installing the SCXI-1581 Module into the SCXI Chassis* section.
  2. If the module is installed in the correct slot, power off the chassis.
  3. Remove the module as specified in the *Removing the SCXI-1581 from an SCXI Chassis* section.
  4. Verify that no connector pins are bent on the rear signal connector.
  5. Reinstall the module as described in the *Installing the SCXI-1581 Module into the SCXI Chassis* section, ensuring the module is fully inserted and properly aligned in the slot.
- After checking the preceding items, return to the *Verifying and Self-Testing the Configuration* section and retest the SCXI chassis.

If these measures do not successfully configure the SCXI system, refer to Appendix C, *Common Questions*, for more information.

# Removing the SCXI-1581

This section provides details for removing an SCXI-1581 module from an SCXI chassis and for removing the SCXI-1581 module from MAX.

## Removing the SCXI-1581 from Measurement & Automation Explorer

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

1. Display the list of installed devices and interfaces by clicking the **+** next to the **Devices and Interfaces** icon. If the SCXI-1581 is configured under **NI-DAQmx**, remove the module under **NI-DAQmx Devices**. If the SCXI-1581 is configured under **Traditional NI-DAQ**, remove the module under **Traditional NI-DAQ Devices**.
2. Locate the chassis in the list of installed devices. Display the list of modules in the chassis by clicking the **+** next to the **Chassis** icon.
3. Right-click the module or chassis you want to delete and click **Delete**.
4. You are presented with a confirmation window. Click **Yes** to continue deleting the module or chassis or **No** to cancel this action.

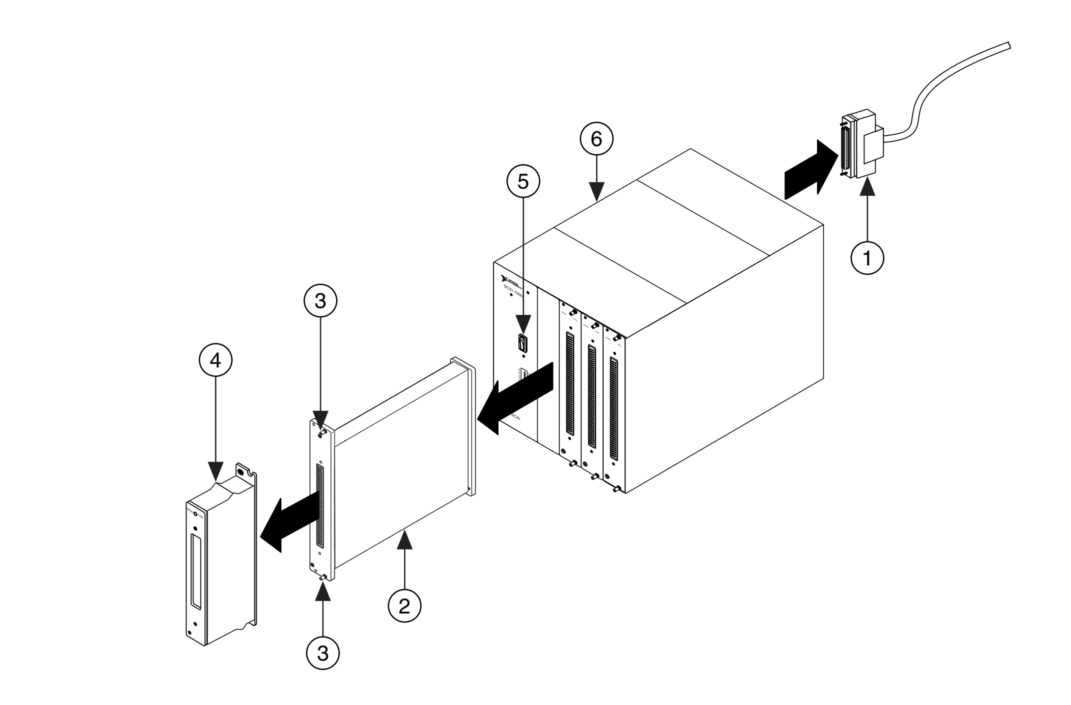
**Note** Deleting the SCXI chassis deletes all modules in the chassis. All configuration information for these modules is also lost.

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 an SCXI Chassis

Consult the documentation for an SCXI chassis or PXI/SCXI combination chassis and accessories for additional instructions and cautions. To remove the SCXI-1581 module from an SCXI chassis, complete the following steps while referring to Figure 1-3:

1. Power off the SCXI chassis. Do *not* remove the SCXI-1581 module from a chassis that is powered on.
2. If the SCXI-1581 is the cabled module, disconnect the cable running from the SCXI-1581 to the E Series DAQ device.
3. Remove any terminal block that connects to the SCXI-1581.
4. Rotate the thumbscrews that secure the SCXI-1581 to the chassis counter-clockwise until they are loose, but do not completely remove the thumbscrews.
5. Remove the SCXI-1581 by pulling steadily on both thumbscrews until the module slides completely out.




| | | | |
|---|---|---|---|
| 1 | Cable | 4 | Terminal Block |
| 2 | SCXI-1581 | 5 | SCXI Chassis Power Switch |
| 3 | SCXI Module Thumbscrews | 6 | SCXI Chassis |

**Figure 1-3.** Removing the SCXI-1581

## Removing the SCXI-1581 from Measurement & Automation Explorer

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

1. Display the list of installed devices and interfaces by expanding **Devices and Interfaces**.
    a. If the module is installed in a Traditional NI-DAQ chassis, click the **+** next to the **Traditional NI-DAQ Devices** icon.
    b. If the module is installed in a NI-DAQmx chassis, click the **+** next to the **NI-DAQmx Devices** icon.
2. Locate the chassis in the list of installed devices. Display the list of modules in the chassis by clicking the **+** next to the **Chassis** icon.

3. Right-click the module or chassis you want to delete and click **Delete**.

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

4. You are presented with a confirmation window. Click **Yes** to continue deleting the module or chassis or **No** to cancel this action.

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

**Note** If the SCXI chassis and/or SCXI module(s) are installed in both a Traditional NI-DAQ and NI-DAQmx configuration, you must remove each configuration separately.

# 2

# Using the SCXI-1581

This chapter discusses operation of the current sources, signal connections, and scanning related to using the SCXI-1581 module.

## Operation of the Current Sources

The current sources on the SCXI-1581 continuously provide 32 channels of 100 µA 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 ±0.05% of the specified value with a temperature drift of no more than ±5 ppm/°C. The high accuracy and stability of these current sources makes them especially well suited to measuring resistance to a high degree of accuracy.

## Signal Connections

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

**Note** The positive terminals are listed in Column C and the negative terminals are listed in Column B. The pins labeled RSVD are reserved. Do *not* make any connections to these pins. Refer to Appendix B, *Measuring Temperature with Resistive Transducers*, for information about connecting resistive transducers to the SCXI-1581.

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

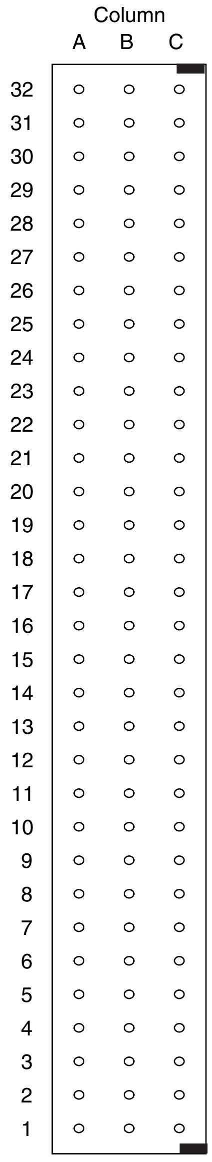
| Front Connector Diagram | Pin Number | Column A | Column B | Column C |
|---|---|---|---|---|
|  | 32 | NC | EX0– | EX0+ |
| | 31 | NC | EX1– | EX1+ |
| | 30 | NC | EX2– | EX2+ |
| | 29 | NC | EX3– | EX3+ |
| | 28 | RSVD | EX4– | EX4+ |
| | 27 | RSVD | EX5– | EX5+ |
| | 26 | RSVD | EX6– | EX6+ |
| | 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+ |
| — means no physical pin | 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 *not* connect any signal to this pin. |
| A2 | CGND | Chassis Ground—connects to the SCXI chassis. |
| B1–32 | EX<0..31>– | Multiplexed Temperature Sensor—connects the temperature sensor to the output multiplexer. |
| C1–32 | EX<0..31>+ | Direct Temperature Sensor—connects the temperature sensor to the CH1+ signal when the terminal block is configured for direct temperature connection. |

The rear signal connector, shown in Figure 2-1, is used for analog signal connectivity and communication between the SCXI-1581 and the E Series DAQ device. Grounding signals AIGND and OUTREF provide reference signals needed in the various analog input referencing modes on the E Series DAQ device. In multiplexed mode, the CH0 signal pair is used for sending analog signals from other modules to the connected E Series DAQ device. If the module is directly connected to the E Series DAQ device, the other analog channels of the E 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 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 Series DAQ device is connected to the SCXI-1581, these digital lines are unavailable for general-purpose digital I/O.

| Signal | Pin | Pin | Signal |
|---|---|---|---|
| AIGND | 1 | 2 | AIGND |
| MCH0+ | 3 | 4 | MCH0– |
| | 5 | 6 | |
| | 7 | 8 | |
| | 9 | 10 | |
| | 11 | 12 | |
| | 13 | 14 | |
| | 15 | 16 | |
| | 17 | 18 | |
| OUTREF | 19 | 20 | |
| | 21 | 22 | |
| | 23 | 24 | DIGGND |
| SERDATIN | 25 | 26 | SERDATOUT |
| DAQD*/A | 27 | 28 | |
| SLOT0SEL* | 29 | 30 | |
| | 31 | 32 | |
| DIGGND | 33 | 34 | |
| | 35 | 36 | SCANCLK |
| SERCLK | 37 | 38 | |
| | 39 | 40 | |
| | 41 | 42 | |
| | 43 | 44 | |
| | 45 | 46 | SYNC |
| | 47 | 48 | |
| | 49 | 50 | |

**Figure 2-1.** Rear Signal Connector Pin Assignments

# Scanning Other SCXI Modules Through the SCXI-1581

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 Series DAQ device. The SCXI-1581 routes multiplexed signals from other SCXI modules to the E Series DAQ device even though the SCXI-1581 does not have any analog-input channels.

## Theory of Multiplexed Hardware Operation

When you configure a module for multiplexed operation, the routing of analog-input signals to the E Series DAQ device depends on the module in the SCXI system to which the E Series DAQ device is cabled. There are several possible scenarios for routing signals from the multiplexed modules to the E Series DAQ device.

If the module you are scanning is not directly cabled to the E Series DAQ device, the module sends its signals through the SCXIbus to the cabled module. The cabled module, whose routing is controlled by the SCXI chassis, routes the SCXIbus signals to the E Series DAQ device through the CH0 pins on its rear signal connector shown in Figure 2-1. Because the SCXI-1581 does not have any input channels to scan, multiplexed scanning is the only scanning mode that is possible when the SCXI-1581 is the cabled module.

If the module you are scanning is directly cabled to the E Series DAQ device, the module routes its input signals through the CH0 pins on its rear signal connector.

The power of SCXI multiplexed scanning is its ability to route many input channels to a single channel on the E Series DAQ device. The number of channels you can scan in multiplexed mode is limited to 512 channels per chassis.

Immediately prior to a multiplexed scanning operation, the SCXI chassis is programmed with a module scan list that controls which module sends its output to the SCXIbus during a scan. Depending on which module you are scanning, you can give the list of channels in a random order or you are required to give the list in sequential order.

Refer to the appropriate user manual for information regarding the procedure for scanning specific SCXI analog-input modules.

# A

# 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 µA

Accuracy ............................................... ±0.05%

Temperature drift .................................. ±5 ppm/°C

Output voltage compliance .................... 10 V

Maximum resistive load......................... 100 kΩ

Overvoltage protection........................... ±40 VDC

Installation Category .............................. 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

Dimensions ............................................3.0 by 17.2 by 20.3 cm
(1.2 by 6.9 by 8.0 in.)

## Safety

The SCXI-1581 meets the requirements of the following standards for safety and electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 3111-1, UL 61010B-1
- CAN/CSA C22.2 No. 1010.1

**Note** For UL and other safety certifications, refer to the product label or to `ni.com`.

## 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, you *must* 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, click **Declarations of Conformity** at `ni.com/hardref.nsf/`.

# B

# Measuring Temperature with Resistive Transducers

This appendix discusses RTDs and thermistors and describes how to connect 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 Ω at 0 °C.

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

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

Because an RTD is a passive resistive device, you must pass a current through it to produce a measurable voltage. This current causes the RTD to heat internally, which appears as an error. Self-heating is typically specified as the amount of power that raises the RTD temperature by 1 °C, given in units of mW/°C. You can minimize self-heating by using the smallest possible excitation current. The amount of self-heating also depends heavily on the medium into which you immerse the RTD. An RTD can self-heat up to 100 times higher in still air than in moving water.

## 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 °C, divided by the resistance at 0 °C, divided by 100 °C:

$$\alpha(\Omega/\Omega/(°\mathrm{C})) = \frac{R_{100} - R_0}{R_0 \times 100\ °\mathrm{C}}$$

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 Ω platinum RTD with $\alpha = 0.003911$ has a resistance of 139.11 Ω at 100 °C.

Figure B-1 displays a typical resistance-temperature curve for a 100 Ω platinum RTD.

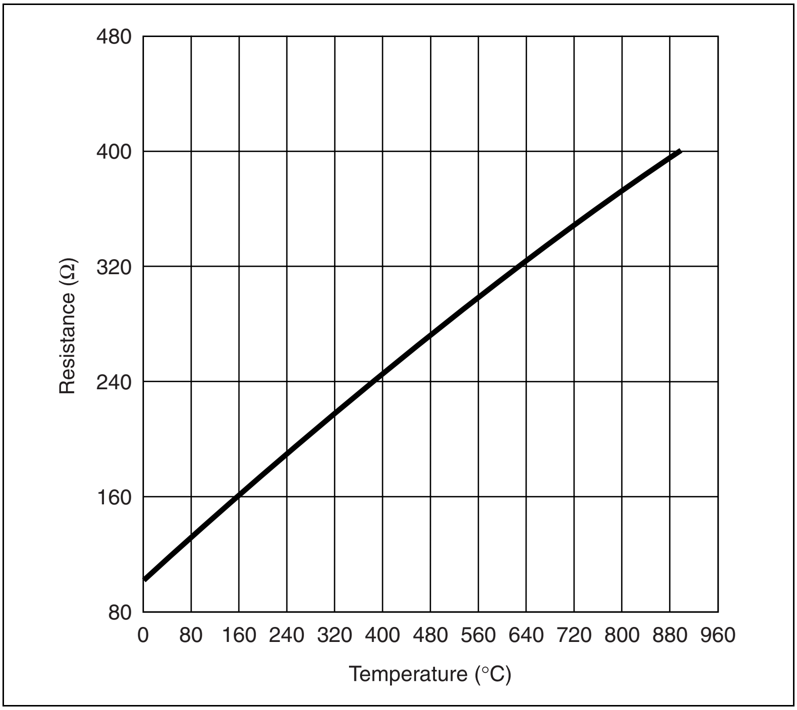



**Figure B-1.** Resistance-Temperature Curve for a 100 Ω Platinum RTD, α = 0.00385

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 B-1.

$T$ is the temperature in °C.

Most platinum RTD curves follow one of three standardized curves—the DIN 43760 standard, the U.S. Industrial or American standard, or the International Temperature Scale (ITS-90) used with wire-wound RTDs.

**Table B-1.** Callendar-Van Dusen Coefficients

| Standard | Temperature Coefficient $\alpha$ | A | B | C |
|---|---|---|---|---|
| DIN 43760 | 0.003850 | $3.9080 \times 10^{-3}$ | $-5.8019 \times 10^{-7}$ | $-4.2735 \times 10^{-12}$ |
| American | 0.003911 | $3.9692 \times 10^{-3}$ | $-5.8495 \times 10^{-7}$ | $-4.2325 \times 10^{-12}$ |
| ITS-90 | 0.003926 | $3.9848 \times 10^{-3}$ | $-5.870 \times 10^{-7}$ | $-4.0000 \times 10^{-12}$ |

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:

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

where

$V_0$ is the measured RTD voltage.

$I_{EX}$ is the excitation current.

You can create a virtual channel to convert RTD voltages into temperature readings. To create an RTD virtual channel, refer to either the *Creating an RTD Virtual Channel Using Traditional NI-DAQ* section or the *Creating an RTD Virtual Channel Using NI-DAQmx* section, depending on the version of NI-DAQ you are using.

## Creating an RTD Virtual Channel Using Traditional NI-DAQ

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

1. Launch MAX.
2. Right-click **Data Neighborhood** and select **Create New**.
3. Select **Traditional NI-DAQ Virtual Channel** and click **Finish**.
4. Select **Analog Input** from the drop-down listbox and click **Next**.

5. Enter a channel name and click **Next**. You also can enter a channel description.
6. Select the type of RTD you have from the drop-down listbox and click **Next**.
7. Select the appropriate temperature unit from the drop-down listbox and enter the measurement range. Click **Next**.
8. Enter the nominal resistance value of the RTD and click **Next**.
9. Select the E Series DAQ device to use, channel number, analog-input mode, and excitation current source and value. Click **Finish**.
10. To test the Traditional NI-DAQ RTD virtual channel, click the **Test** button.

You have finished creating the traditional NI-DAQ virtual channel. You can access the channel by expanding **Data Neighborhood»Traditional NI-DAQ Virtual Channels**.

## Creating an RTD Virtual Channel Using NI-DAQmx

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

1. Launch MAX.
2. Right-click **Data Neighborhood** and select **Create New**.
3. Select **NI-DAQmx Channel** and click **Next**.
4. Select **Analog Input»Temperature»RTD** and click **Next**.
5. Select the E Series DAQ device channel to use and click **Next**.
6. Enter a name for the virtual channel and click **Finish**.
7. In the configuration screen that appears, select the input range, RTD type, nominal resistance value, wire configuration, excitation source, and excitation value.
8. 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**.

**Note** You can use the LabVIEW VI **Convert RTD Reading** to convert RTD voltage measurements into temperature readings. This VI is located in the **Data Acquisition» Signal Conditioning** function subpalette.

# 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 B-2, the voltage drop across the lead resistances (labeled $R_L$) adds an error voltage to the measured voltage.

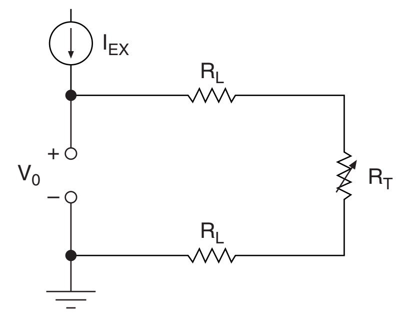



**Figure B-2.** 2-Wire RTD Measurement

For example, a lead resistance of 0.3 Ω in each wire adds a 0.6 Ω error to the resistance measurement. For a platinum RTD at 0 °C with α = 0.00385, the lead resistance equates to an error of approximately

$$\frac{0.6\ \mathrm{W}}{0.385\ \mathrm{W/°C}} = 1.6\ °\mathrm{C}$$

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

# 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 Ω thermistor has a sensitivity of –100 Ω/°C at room temperature. Higher resistance thermistors can exhibit temperature coefficients of –10 kΩ/°C or more. In comparison, a 100 Ω platinum RTD has a sensitivity of only 0.4 Ω/°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 B-3 shows the resistance-temperature curve for a 2,252 Ω thermistor. The curve of a 100 Ω RTD is also shown for comparison.

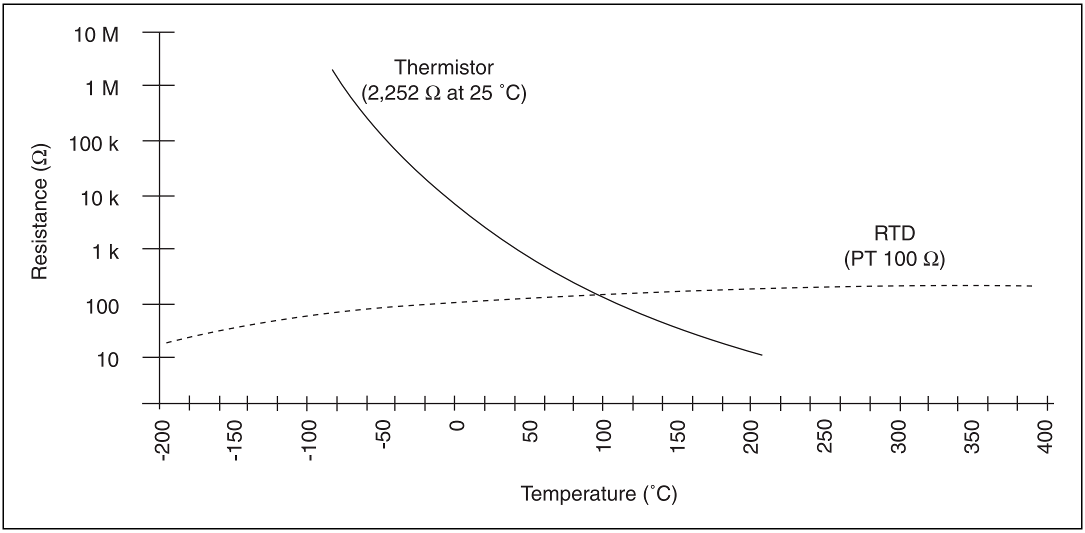



**Figure B-3.** Resistance-Temperature Curve for a 2,252 Ω Thermistor

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.

## 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:

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

where

$T$(°K) is the temperature in degrees Kelvin, equal to $T$(°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.

## Creating a Thermistor Virtual Channel Using NI-DAQmx

To creat 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 Channel** and click **Next**.
4. Select **Analog Input»Temperature»**and either **Iex Thermistor** or **Vex Thermistor** and click **Next**.
5. Select the E Series DAQ device channel to use and click **Next**.
6. Enter a name for the virtual channel and click **Finish**.
7. In the configuration screen that appears, select the input range, $I_{EX}$ or $V_{EX}$ source, $I_{EX}$ or $V_{EX}$ value, wire configuration, and enter the values of *A*, *B*, and *C*. *A*, *B*, and *C* are coefficients obtained from the thermistor manufacturer or calculated from the resistance-versus-temperature curve. For $V_{EX}$ thermistors you must also enter the value of R1, the value of the dropping resistor in ohms.
8. 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**.

**Note** You can use the LabVIEW VI **Convert Thermistor Reading** to convert thermistor voltage measurements into temperature readings. This VI is located in the **Data Acquisition»Signal Conditioning** function subpalette.

## Thermistor Measurement Circuits

Because the thermistor is a resistive device, you must pass a current through the thermistor to produce a voltage that the data acquisition system can measure. The high resistance and high sensitivity of the thermistor simplify the necessary measurement circuitry and signal conditioning. Special 3- or 4-wire connections are not necessary. The most common technique is to use a constant-current source, and measure the voltage developed across the thermistor. As shown in Figure B-4, the measured voltage $V_0$ equals $R_T \times I_{EX}$.

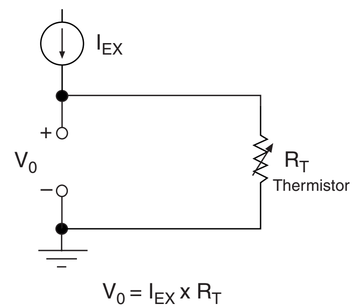



**Figure B-4.** Thermistor Measurement with Constant Current Excitation, $I_{EX}$

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 1 mA excitation current dissipates:

$$I^2R = 1\ \text{mA}^2 \times 2{,}252\ \Omega = 2.25\ \text{mW}$$

If this thermistor has a dissipation constant of 10 mW/°C, the thermistor self-heats 0.225 °C. Therefore, carefully read self-heating specifications of the thermistors and choose the excitation current accordingly. If the thermistors have a small dissipation constant, minimize the level of the excitation current to minimize self-heating errors.

# Connecting Resistive Devices to the SCXI-1581

You can connect resistive devices to the SCXI signal conditioning system in a 4-, 2-, or 3-wire configuration. The SCXI-1102B/C modules are 32-channel analog-input modules that are ideally suited for measuring DC or slowly varying voltages. Figures B-5 through B-9 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 B-5. 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.

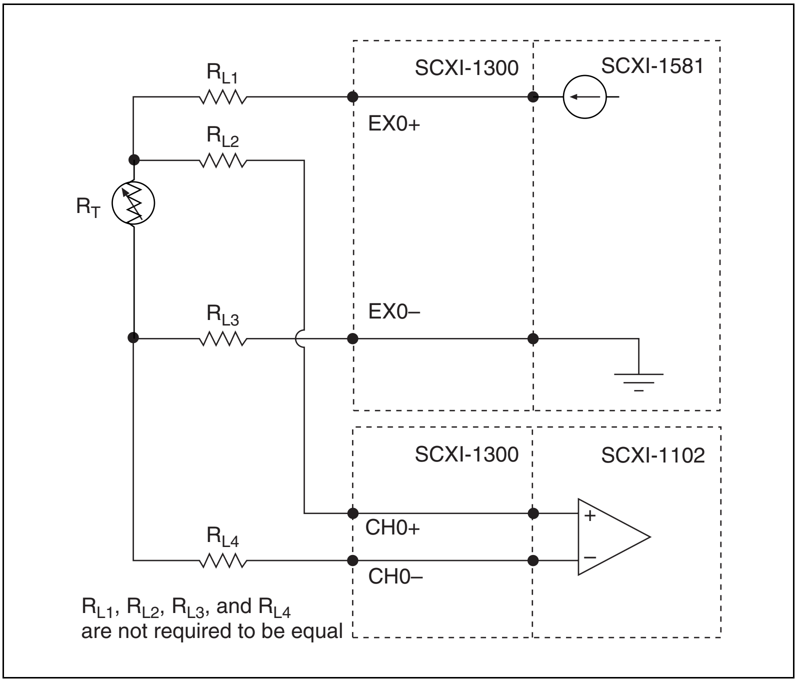



**Figure B-5.** 4-Wire Resistive Sensor Connected in a 4-Wire Configuration

## 2-Wire Configuration

The basic 2-wire configuration is shown in Figure B-6. 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 due to the negligible error introduced by the lead resistances.

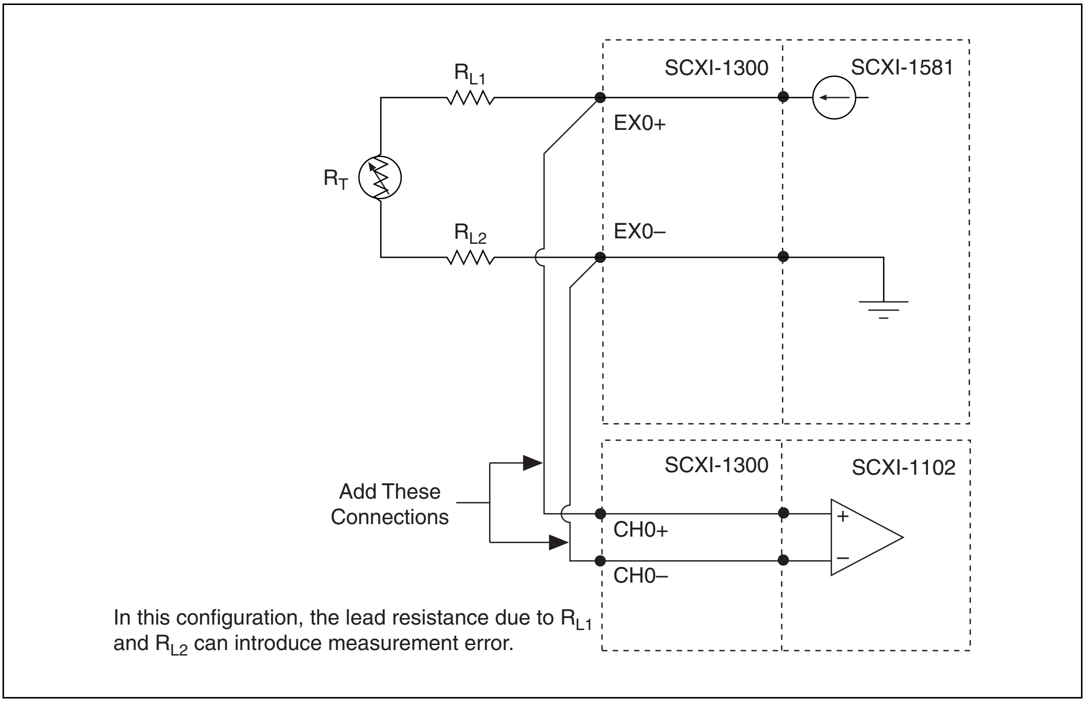



**Figure B-6.** 2-Wire Resistive Sensor Connected in a 2-Wire Configuration

# 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 B-7. 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.

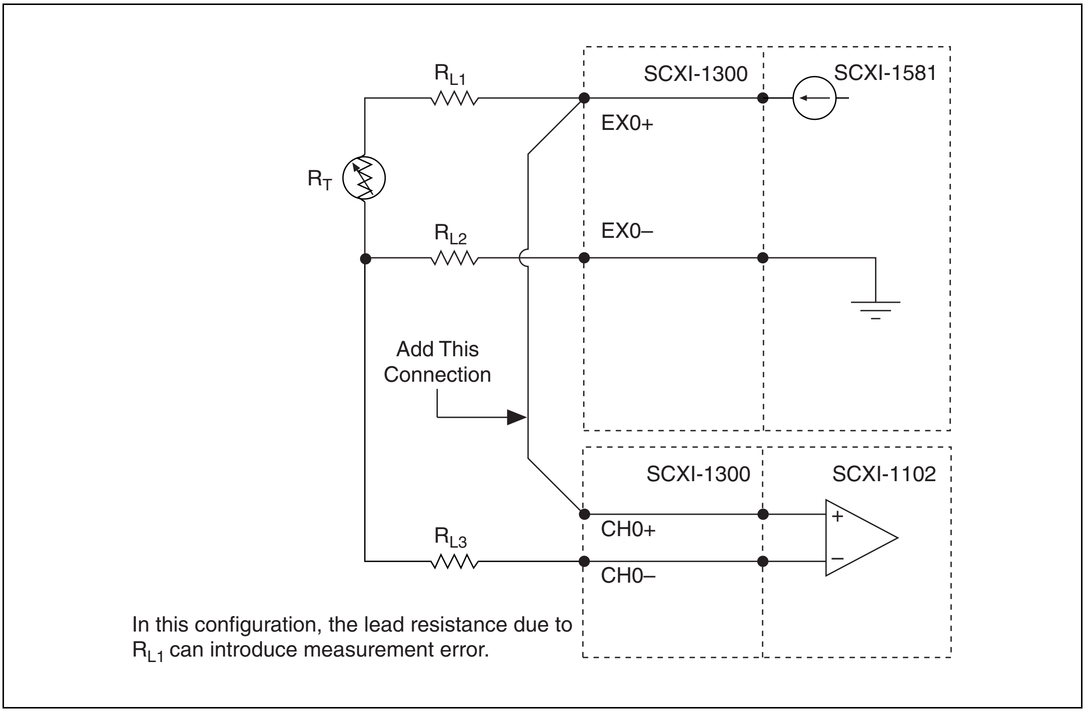



**Figure B-7.** 3-Wire Resistive Sensor Connected in a 2-Wire Configuration

## 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 B-8.

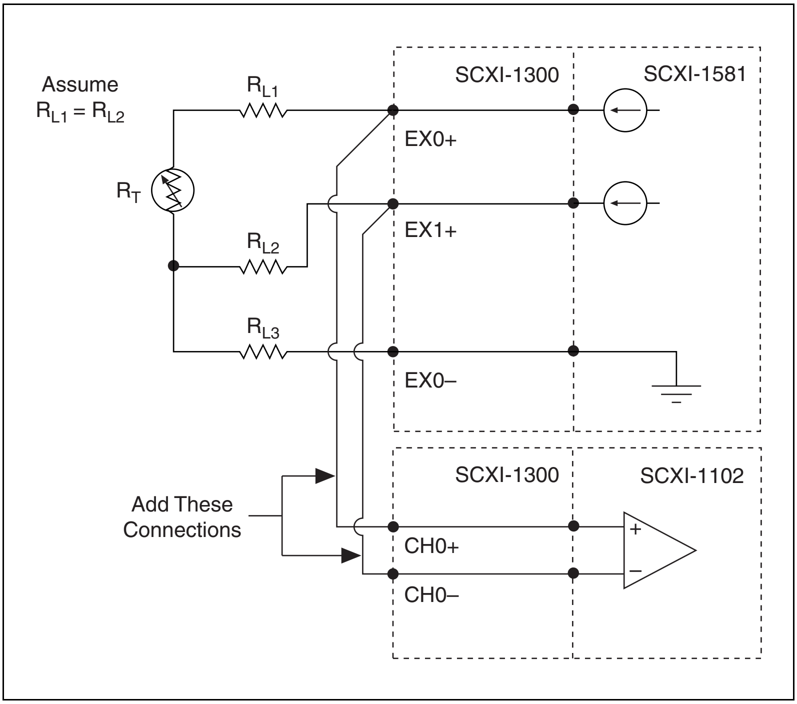



**Figure B-8.** 3-Wire Configuration Using Matched Current Sources

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 ±0.05%. This accuracy results in a worst-case matching of ±0.1%. As an example of the error introduced by this mismatch, consider a 3-wire resistive sensor with lead resistances of 10 Ω. The worst-case mismatch results in a total error voltage ($Ve_{RL}$) across the lead resistances equal to:

$$Ve_{RL} = \pm 2\delta R_L I_{EX}$$

where $\delta$ is the accuracy of the individual current sources, $R_L$ is the individual lead resistance and $I_{EX}$ is the value of the excitation current. In this example, the voltage equates to 1 µV. Converting this voltage into a resistance by dividing by $I_{EX}$ yields a resistance of 0.01 Ω. If this error is associated with the lead resistance of a 3-wire 100 Ω platinum RTD, the resulting temperature error, $Te_{RL}$, is:

$$Te_{RL} = Ve_{RL} / (0.385\ I_{EX}) = \pm 0.026\ °C$$

In contrast, if there is no lead-resistance compensation, a temperature error of 51.95 °C results.

## 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 B-9.

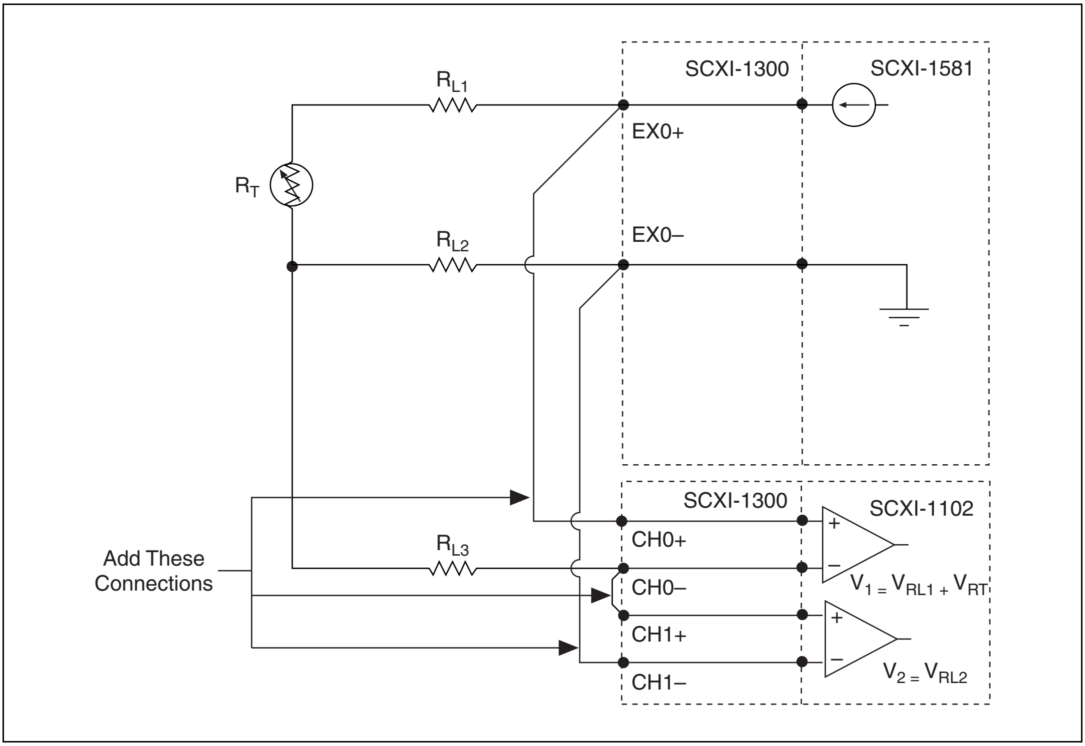



**Figure B-9.** 3-Wire Configuration Using Two Differential Amplifiers

In this configuration, two separate measurements are taken; the first, labeled $V_1$ in Figure B-9, 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 B-9, 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.

# C

# 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?**

NI recommends NI-DAQ 6.9.1 or later. With earlier versions of NI-DAQ, you cannot auto-detect or list the SCXI-1581 in the chassis as a configured module. However, even if the slot containing the SCXI-1581 is configured as *empty*, the current outputs are fully functional as long as the chassis is powered on.

Visit the National Instruments Web site and follow the link, **Download Software»Drivers and Updates»Search Drivers and Updates**, and enter the keyword `NI-DAQ` to find the latest version of NI-DAQ for your operating system.

**Can I use the SCXI-1581 with a version of NI-DAQ that works under the Macintosh Operating System (Mac OS)?**

At the time this manual was published, you cannot auto-detect or list the SCXI-1581 as a configured module using a version of NI-DAQ that works under Mac OS. However, even if the slot containing the SCXI-1581 is configured as *empty*, the current outputs are fully functional as long as the chassis is powered on.

**Is a register-level programming manual available for the SCXI-1581?**

No. Register-level programming is not required in order to make the SCXI-1581 fully functional. The SCXI-1581 is fully operational when powered on.

**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 µA 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 670*X* 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* × 100 µA?**

This is not recommended. The accuracy or stability of the resulting current-output value is unpredictable.

**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 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 µA?**

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 recalibrate the SCXI-1581 or return it to the factory for recalibration?

No. You cannot recalibrate the SCXI-1581 and it does not require factory recalibration. If a current source on the SCXI-1581 drifts out of specification over time, then a subcomponent has probably failed. If the SCXI-1581 fails to operate according to the published specifications, send it back to NI for repair or replacement.

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

Yes. E 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 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[1] |
|---|---|---|---|---|
| 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 |

[1] With respect to the E Series DAQ device.

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

No. The SCXI-1581 delivers 100 μA into any load from 0 Ω to 100 kΩ.

**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?**

First, disconnect all loads from the channel you are testing. Second, 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 kΩ) across the current output and use a voltmeter to measure the voltage drop across it. If the current output is working, you should measure $V = (100 \times 10^{-6}\ \text{A}) \times R$, where *R* is given in Ω.

**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?**

This is not recommended. The SCXI-1303 is optimized for temperature measurement using thermocouples. It will work with the SCXI-1581, but only if you remove all 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.

**Can I configure the SCXI-1581 in MAX for use in a chassis controlled by an SCXI-1200?**

Yes. However, remember that you cannot auto-detect modules in a chassis controlled by an SCXI-1200.

# Glossary

| Symbol | Prefix | Value |
|---|---|---|
| p | pico | $10^{-12}$ |
| n | nano | $10^{-9}$ |
| μ | micro | $10^{-6}$ |
| m | milli | $10^{-3}$ |
| k | kilo | $10^{3}$ |
| M | mega | $10^{6}$ |
| G | giga | $10^{9}$ |
| T | tera | $10^{12}$ |

## Numbers/Symbols

| | |
|---|---|
| % | percent |
| + | positive of, or plus |
| – | negative of, or minus |
| ± | plus or minus |
| < | less than |
| / | per |
| ° | degree |
| Ω | ohms |
| +5 V (signal) | +5 VDC source signal |

## A

| | |
|---|---|
| A | amperes |
| absolute accuracy | the maximum difference between the measured value from a data acquisition device and the true voltage applied to the input, typically specified as ± voltage |
| ADE | application development environment such as LabVIEW, LabWindows™/CVI™, Visual Basic, C, and C++ |
| AGND | analog ground signal |
| AI | analog input |
| AIGND | analog input ground signal |
| amp | amplifier |
| amplification | a type of signal conditioning that improves accuracy in the resulting digitized signal by increasing signal amplitude relative to noise |
| AOGND | analog output ground |
| AOGND/GUARD | analog output ground |
| AOUT | analog output signal |

## B

| | |
|---|---|
| bandwidth | the range of frequencies present in a signal, or the range of frequencies to which a measuring device can respond |
| bias current | the small input current flowing into or out of the input terminals of an amplifier |
| bipolar | a voltage range spanning both negative and positive voltages |
| 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 |
| CHSGND | chassis ground |
| CLK | clock input signal |
| CMV | *See* common-mode voltage. |
| common-mode noise | noise that appears on both inputs of a differential amplifier |
| 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 DIO and E Series MIO plug-in 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 |

| | |
|---|---|
| DIFF | differential input configuration |
| differential amplifier | an amplifier with two input terminals, neither of which are tied to a ground reference, whose voltage difference is amplified |
| differential input | the two-terminal input to a differential amplifier |
| DIN | Deutsche Industrie Norme (German Industrial Standard) |
| DIO | digital input/output |
| DoC | Declaration of Conformity |
| DOUT | digital output signal |
| drivers/driver software | software that controls a specific hardware device such as an E 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 |
| external trigger | a voltage pulse from an external source that causes a DAQ operation to begin |

## F

| | |
|---|---|
| FIFO | first-in first-out memory buffer |
| filtering | a type of signal conditioning that allows you to remove unwanted frequency components from the signal you are trying to measure |
| FSC | front signal connector |
| FSR | full-scale range |

## G

| | |
|---|---|
| G | gain |
| gain | the factor by which a signal is amplified, sometimes expressed in decibels |
| gain accuracy | a measure of deviation of the gain of an amplifier from the ideal gain |
| gain error | *See* gain accuracy. |

## H

| | |
|---|---|
| Hz | hertz—cycles per second of a periodic signal |

## I

| | |
|---|---|
| ID | identifier |
| in. | inch or inches |
| indirect scanning | the measurement that occurs when a signal passes on the SCXIbus from the scanned SCXI module to the cabled SCXI module |
| input bias current | the current that flows into the inputs of a circuit |
| input impedance | the measured resistance and capacitance between the input terminals of a circuit |
| instrumentation amplifier | a very accurate differential amplifier with a high input impedance |

## 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. |

## 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. |

## 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 |
| max | maximum |
| min | (1) minutes; (2) minimum |
| 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 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 |
| mux | multiplexer—a switching device with multiple inputs that sequentially connects each of its inputs to its single output, typically at high speeds, in order to measure several signals with a single analog-to-digital converter |

## N

| | |
|---|---|
| NC | not connected (signal) |
| NI-DAQ | the driver software needed in order to use National Instruments E Series DAQ devices and SCXI components |

| | |
|---|---|
| noise | an undesirable electrical signal—noise comes from external sources such as AC power lines, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, arc welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are measuring. |
| nonlinearity | for an amplifier, a measure of the maximum output deviation from an ideal linear response in units of percent relative to full scale. The ideal linear response is taken to be a straight line on a plot of measured output voltage to measured input voltage with the ends of the line connecting the extremes of the plot at the full-scale limits. |
| NRSE | nonreferenced single-ended mode—all measurements are made with respect to a common measurement system reference, but the voltage at this reference can vary with respect to the measurement system ground |

## O

| | |
|---|---|
| offset error | the output of a system with a zero-volt input |
| OUT | output signal |
| OUTPUT | output signal |
| 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 |
| overvoltage protection | maximum voltage that will not cause hardware damage |

## P

| | |
|---|---|
| parallel mode | a type of SCXI operating mode in which the module sends each of its output channels directly to a separate analog input channel of the E Series DAQ device connected to the module |
| port | (1) a digital port consisting of multiple I/O lines on a E Series DAQ device; (2) a serial or parallel interface connector on a PC |
| ppm | parts per million |
| PXI | PCI eXtensions for Instrumentation—an open specification that builds on the CompactPCI specification by adding instrumentation-specific features |

## R

| | |
|---|---|
| random scanning | the hardware capability to sequence through channels in a scan list in any order |
| $R_L$ | lead resistance |
| RMA | Return Material Authorization |
| rms | root mean square—the square root of the average value of the square of the instantaneous signal amplitude; a measure of signal amplitude |
| RSE | referenced single-ended mode—all measurements are made with respect to a common reference measurement system or a ground. Also called a grounded measurement system. |
| RSVD | reserved bit, pin, or signal |
| RTD | resistance-temperature detector |
| RTI | referred to input—calculates a specification relative to the input range |
| RTO | referred to output |

## S

| | |
|---|---|
| s | seconds |
| S | samples |
| S/s | samples per second—used to express the rate at which a E Series DAQ device samples an analog signal |
| 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. |
| scan rate | the number of scans a system takes during a given time period, usually expressed in scans per second |
| SCANCLK | scan clock signal used to increment to the next channel after each E 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 |
| settling time | the amount of time required for a voltage to reach its final value within specified accuracy limits |
| 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 |
| SYNC | synchronization pulse for scanning (only used with modules featuring simultaneous sample and hold) |

# T

| | |
|---|---|
| thermistor | a thermally sensitive resistor |
| TRIG0 | trigger 0 |
| transducer | a device capable of converting energy from one form to another |
| typ | typical |

# U

| | |
|---|---|
| UL | Underwriters Laboratory |
| unipolar | a voltage range that only spans positive voltages |

## 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 |
| $V_{rms}$ | volts, root mean square |

## W

| | |
|---|---|
| W | watts |
| working voltage | the highest voltage with respect to ground that should be applied to an input terminal during normal use, normally well under the breakdown voltage for safety margin. Includes both the signal and common-mode voltages. |

# Index

## Numerics



## B



## C



## D



## E



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## V