SCC-SG Series Strain-Gauge Modules

The SCC-SG Series strain-gauge input modules (SCC-SG*XX*) allow you to take quarter-, half-, and full-bridge configuration strain measurements. Use them as follows:

- SCC-SG01 for 120 Ω quarter-bridge configurations.
- SCC-SG02 for 350 Ω quarter-bridge configurations.
- SCC-SG03 for half-bridge configurations.
- SCC-SG04 for full-bridge configurations.
- SCC-SG24 for at least 350 Ω full-bridge configurations.

Each module consists of two strain-gauge input channels, offset-nulling circuitry for each channel, and an excitation circuit. Each input channel includes an instrumentation amplifier with differential inputs and a fixed gain of 100.

The SCC-SG11 is a shunt calibration module. It contains two pairs of switches and resistors that you connect across strain-gauge elements where you want to perform shunt calibration.

Contents

NATIONAL INSTRUMENTS™

Strain Gauges

Strain-gauge configurations are arranged as Wheatstone bridges. The gauge is the collection of all of the active elements of the Wheatstone bridge. There are three supported types of strain-gauge configurations: quarter-, half-, and full-bridge. The number of active element legs in the Wheatstone bridge determines the kind of bridge configuration. Refer to Table 1 to see how many active elements are in each configuration.

Table 1. Strain-Gauge Configurations

Configuration	Number of Active Elements
Quarter-bridge	1
Half-bridge	2
Full-bridge	4

Each of these three configurations is subdivided into multiple configuration types. The orientation of the active elements and the kind of strain measured determines the configuration type. NI supports seven configuration types in software. However, with custom software scaling you can use all Wheatstone bridge configuration types with any NI hardware product that supports the gauge configuration type.

The supported strain-gauge configuration types measure axial strain, bending strain, or both. You can use similar configuration types to measure torsional strain; however, NI software scaling does not support these configuration types. It is possible to use NI products to measure torsional strain, but to properly scale these configuration types you must create a custom scale in Measurement & Automation Explorer (MAX) or perform scaling in your software application.

This document discusses all of the mechanical, electrical, and scaling considerations of each strain-gauge configuration type supported by NI.

Conventions

The following conventions are used in this guide:

<>	Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, ai<0..7>.
»	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 in 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.
DAQ device	Data acquisition (DAQ) device refers to all entry-level basic and full-featured E Series multifunction DAQ devices.
SC-2345	SC-2345 refers to both the SC-2345 connector block and the SC-2345 with configurable connectors.
SCC	SCC refers to any SCC Series signal conditioning module.
SCC-SG0*X*	SCC-SG0*X* refers to SCC-SG Series strain-gauge input modules SG01, SG02, SG03, and SG04.
SCC-SG*XX*	SCC-SG*XX* refers to any SCC-SG series strain-gauge module.

What You Need to Get Started

To set up and use the SCC-SG*XX*, you need the following items:

❑ SC-2345 with one of the following:
  – SCC-PWR01
  – SCC-PWR02 and the PS01 power supply
  – SCC-PWR03 (requires a 7 to 42 VDC power supply, not included)

❑ One or more SCC-SG*XX*

❑ *SCC-SG Series Strain-Gauge Modules User Guide*

❑ *SC-2345 User Manual*

❑ *Read Me First: Safety and Radio-Frequency Interference*

❑ SC-2345 Quick Reference Label

❑ 68-pin Basic or E Series DAQ device, documentation, and 68-pin cable

❑ 1/8 in. flathead screwdriver

❑ Numbers 1 and 2 Phillips screwdrivers

❑ Wire insulation strippers

❑ NI-DAQ (current version) for Windows 2000/NT/XP/Me

Note Software scaling of measurements is not supported on the Mac OS. Refer to the *Converting Voltage Measurements to Units of Strain* section for more information.

Unpacking the Module

SCC modules are shipped in antistatic envelopes to prevent electrostatic damage (ESD) to the modules. ESD can damage several components on these products.

Caution *Never* touch the exposed pins of connectors.

To avoid damage from ESD when you handle the module, take the following precautions:

• Ground yourself by using a grounding strap or by touching a grounded object.

• Touch the antistatic envelope to a metal part of the computer chassis before removing the module from the envelope.

Remove the module from the envelope 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.

Store the module in the antistatic envelope when it is not in use.

Installing the Module

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

This section explains how to install the SCC-SG*XX* in the SC-2345 carrier.

Note The SCC-SG0*X* and SCC-SG24 act as single-stage modules only.

Plug the SCC-SG0*X* or the SCC-SG24 into any SC-2345 socket J(*X*+1), where *X* is 0 to 7, and wire the bridge configuration signals to the module. The socket you choose determines which E Series DAQ device channels receive the SCC-SG0*X* or SCC-SG24 signals, as explained in the *Connecting Strain-Gauge Input Signals* section.

If you are using an SCC-SG11 for shunt calibration, plug it into any digital input/output (DIO) socket J(*X*+9), where *X* is 0 to 7. This is not a dual-stage configuration. You must connect the SCC-SG11 to the bridge configuration using additional wires. Refer to the *Shunt Calibration Using the SCC-SG11* section.

Connecting Strain-Gauge Input Signals

The SCC-SG*XX* has a fixed screw-terminal receptacle and a removable screw-terminal block, as shown in Figure 1.

Note The SCC-SG11 has a four-terminal screw-terminal receptacle. Refer to the *Shunt Calibration Using the SCC-SG11* for more information about using the SCC-SG11.
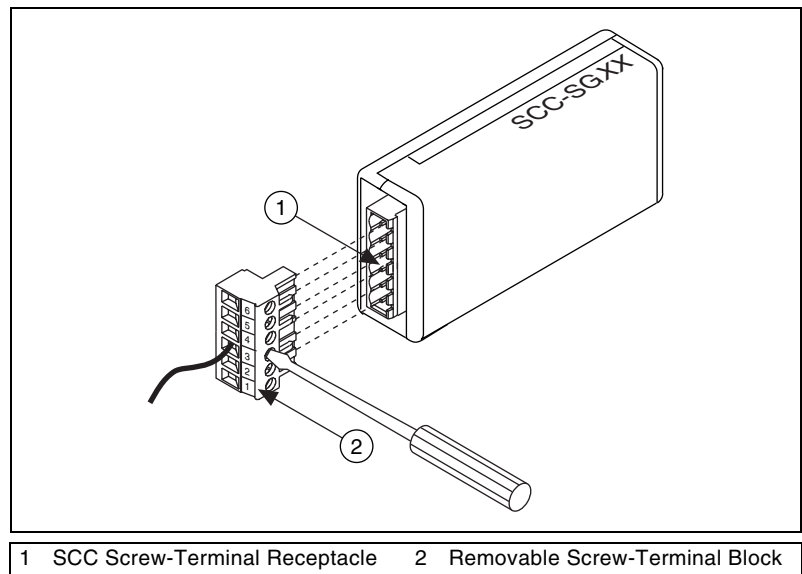

| 1 | SCC Screw-Terminal Receptacle | 2 | Removable Screw-Terminal Block |

Figure 1. SCC-SG*XX* Two-Part Screw-Terminal System

After you install the SCC-SG*XX*, complete the following steps to connect the signal lines to the module:

1. Remove power from the signal lines.
2. Strip 7 mm (0.25 in.) of insulation from the ends of the signal wires.
3. Insert the wires into the screw terminals.
4. Tighten the screws to 0.5 to 0.6 N · m (4.4 to 5.3 lb-in.) of torque with a flathead screwdriver.

Each screw terminal on the SCC-SG0*X* and SCC-SG24 is labeled by pin number <1..6>. The input stage of the SCC-SG0*X* and SCC-SG24 provides two differential analog input channels for measuring strain. The input pins to the SCC-SG0*X* and SCC-SG24 differ for each module. Pin 4 is a single-ended channel routed to E Series DAQ device channel *X*+8, and pin 6 is a single-ended channel routed to E Series DAQ device channel *X*. The value of *X* is 0 to 7 depending on the socket where you plug in the SCC-SG0*X* and SCC-SG24, J(*X*+1) or J(*X*+9).

Panelettes

If you have an SCC carrier with configurable connectors, you can install connectivity and interface panelettes to customize the SCC system. Panelettes simplify signal connection to the SCC modules and eliminate the need to rewire signals to the screw terminals when you change the signal source.

The most common panelettes used with the SCC-SG0X and SCC-SG24 strain applications are the 9-pin D-Subminiature (DSUB), MIL-Spec, and LEMO (B-Series).

SCC-SG0*X* and SCC-SG24

The various bridge configurations discussed in the *Strain Gauges* section require different SCC modules. The following sections discuss the bridge configuration types supported by each module, and provide connection and electrical diagrams for the different bridge configurations.

Variable Definitions

In the following figures, the variables are defined as:

ε is the measured strain (+ε is tensile strain and –ε is compressive strain).

ν is the Poisson's ratio, defined as the negative ratio of transverse strain to axial (longitudinal) strain.

V_{CH} is the measured voltage of the signal.

V_{EX} is the excitation voltage.

SCC-SG01/02 Quarter-Bridge Connection

In a quarter-bridge configuration, you use only one active strain-gauge element. The following section describes how to connect a quarter-bridge strain-gauge configuration type I.

Note NI software supports two quarter-bridge configuration types. However, to measure the quarter-bridge configuration type II you must use the SCC-SG03. Refer to the *SCC-SG03 Half-Bridge Connection* section for more information.

The SCC-SG01 module label displays the icon shown in Figure 2 and the SCC-SG02 module label displays the icon shown in Figure 3. These icon labels also represent the bridge configurations of the modules. On the SCC-SG*XX* module labels the boxed resistors represent external active strain-gauge elements.
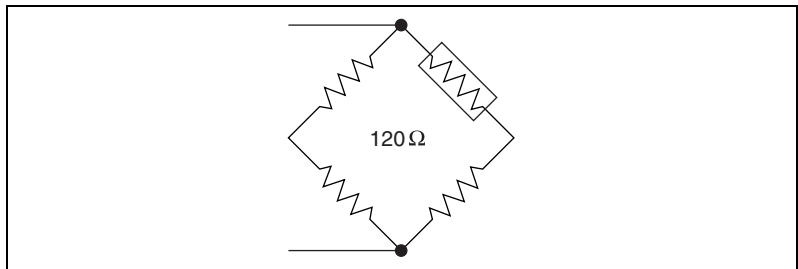
Figure 2. SCC-SG01 Icon

Figure 3. SCC-SG02 Icon

Quarter-Bridge Type I

This section provides information for the quarter-bridge strain-gauge configuration type I. The quarter-bridge type I measures either axial or bending strain.

Figure 4 shows a general quarter-bridge type I circuit diagram.

Figure 4. Quarter-Bridge Type I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are half-bridge completion resistors.
- R_3 is the socketed quarter-bridge completion resistor (dummy resistor).
- R_4 is the active element measuring tensile strain ($+\varepsilon$).

Figure 5 shows how to set up two quarter-bridge type I configurations with the SCC-SG01/02.

| R$_4$ Strain-Gauge Active Element | R$_{NULL}$ Nulling Resistor |
| R$_3$ Quarter-Bridge Completion Resistor | |
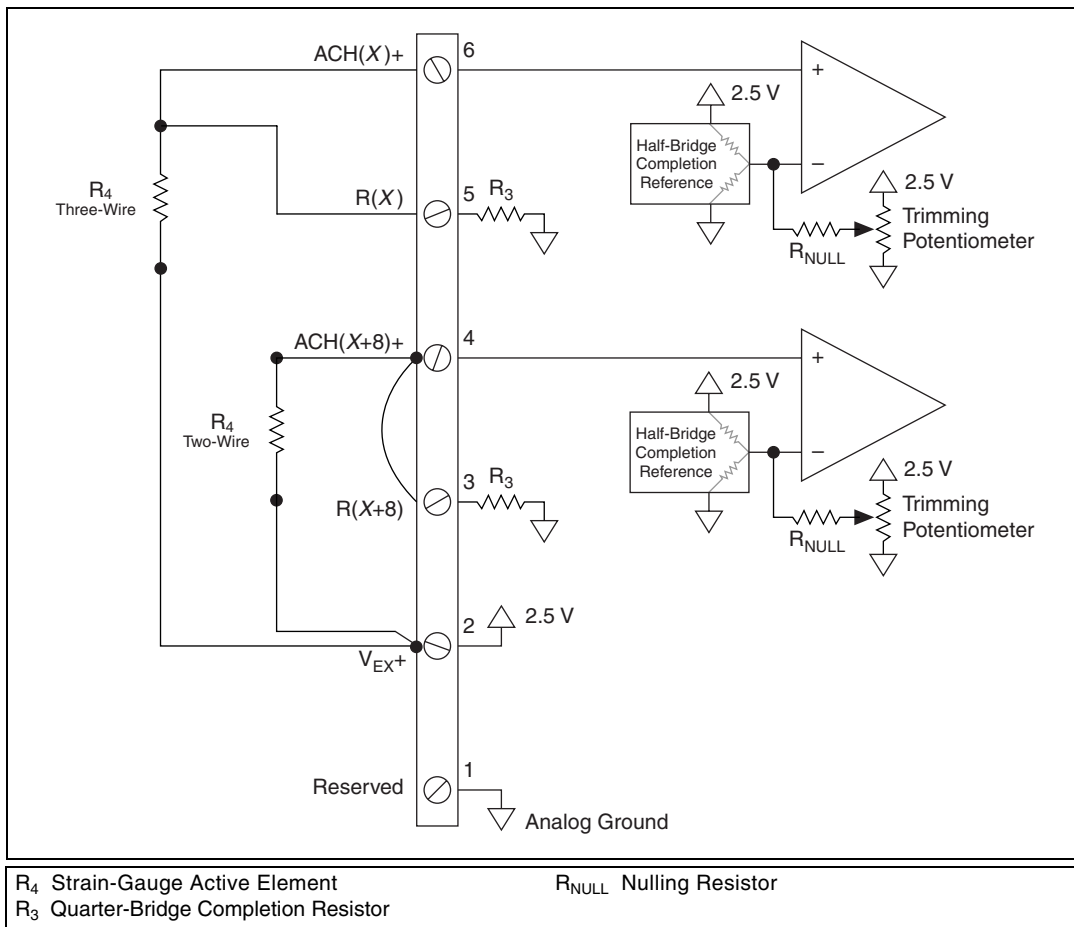
Figure 5. SCC-SG01/02 Quarter-Bridge Configuration Connection (Two Channels)

Connect the two-wire strain-gauge element leads to ACH(X) and V$_{EX}$+. For a three-wire strain-gauge, connect the two-wire lead to ACH(X)+ and R(X), then connect the single lead to V$_{EX}$+. Figure 5 shows two quarter-bridge configurations using ACH(X) and ACH(X+8) with a three-wire strain-gauge connected to ACH(X) and a two-wire strain-gauge connected to ACH(X+8). If you are using a two-wire strain-gauge, short the ACH(X) or ACH(X+8) screw terminal with the corresponding reference screw terminal, R(X) and R(X+8).

The dummy resistor must be equal in value to the nominal resistance of the active strain-gauge element. The SCC-SG01 contains one 120 Ω quarter-bridge completion resistor per channel. The SCC-SG02 contains one 350 Ω quarter-bridge completion resistor per channel. One socketed quarter-bridge completion resistor is internally connected between R(X) and analog ground. The other is between R(X+8) and analog ground. These

resistors are socketed for easy replacement. Refer to the *Replacing Resistors* section for more information.

SCC-SG03 Half-Bridge Connection

In a half-bridge configuration, you use two active strain-gauge elements. A half-bridge completion reference inside the SCC-SG03 completes the bridge configuration. There are two half-bridge configuration types supported by NI software, and one quarter-bridge configuration type that requires half-bridge completion. The following sections describe how to connect half-bridge strain-gauge configuration types I and II and quarter-bridge strain-gauge configuration type II.

The SCC-SG03 module label displays the icon shown in Figure 6. This icon label also represents the module bridge configuration.
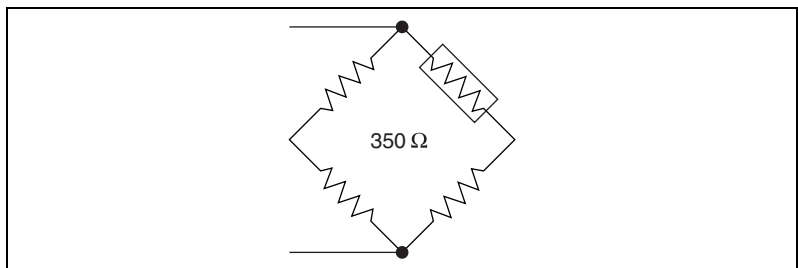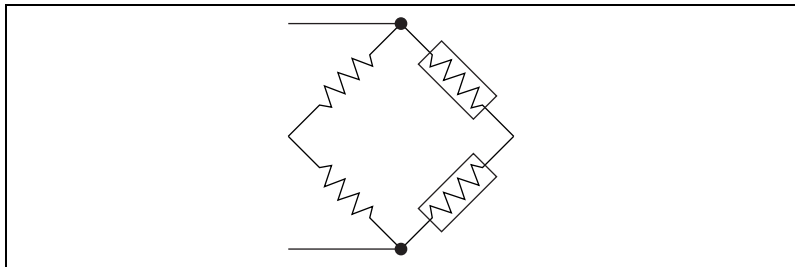

Figure 6. SCC-SG03 Icon

Half-Bridge Type I

This section provides information for the half-bridge strain-gauge configuration type I. The half-bridge type I measures either axial or bending strain.

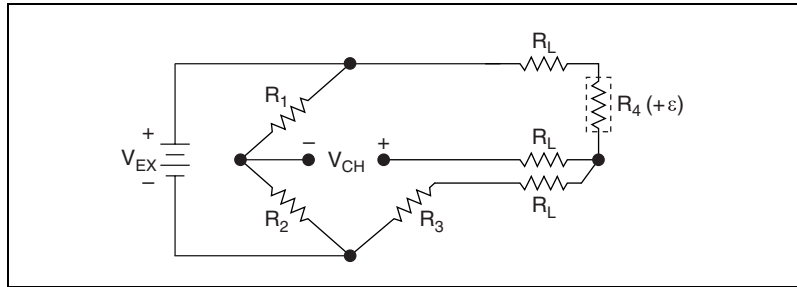Figure 7 shows a general half-bridge type I circuit diagram.
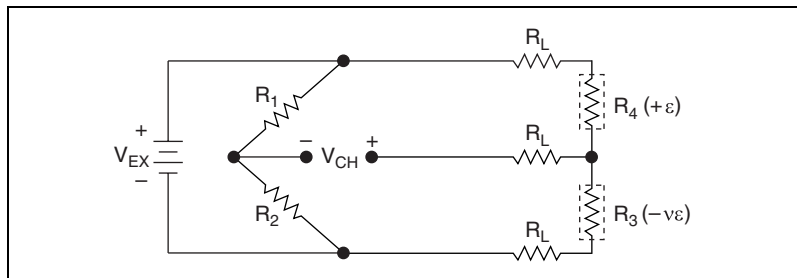
Figure 7. Half-Bridge Type I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are half-bridge completion resistors.
- R_3 is the active element measuring compression from Poisson effect ($-\nu\varepsilon$).
- R_4 is the active element measuring tensile strain ($+\varepsilon$).

Figure 10 shows how to set up two half-bridge type I configurations with the SCC-SG03.

Half-Bridge Type II

This section provides information for the half-bridge strain-gauge configuration type II. The half-bridge type II only measures bending strain.

Figure 8 shows a general half-bridge type II circuit diagram.

Figure 8. Half-Bridge Type II Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are half-bridge completion resistors.
- R_3 is the active element measuring compressive strain ($-\varepsilon$).
- R_4 is the active element measuring tensile strain ($+\varepsilon$).

Figure 10 shows how to set up two half-bridge type II configurations with the SCC-SG03.

Quarter-Bridge Type II

This section provides information for the quarter-bridge strain-gauge configuration type II. The quarter-bridge type II measures either axial or bending strain.

✎ **Note** The quarter-bridge temperature-compensating element (dummy gauge) adds an additional strain-gauge element to the quarter-bridge type II that is not present in the quarter-bridge type I. You must use the half-bridge completion on the SCC-SG03 for the quarter-bridge type II to function properly.

Figure 9 shows a general quarter-bridge type II circuit diagram.
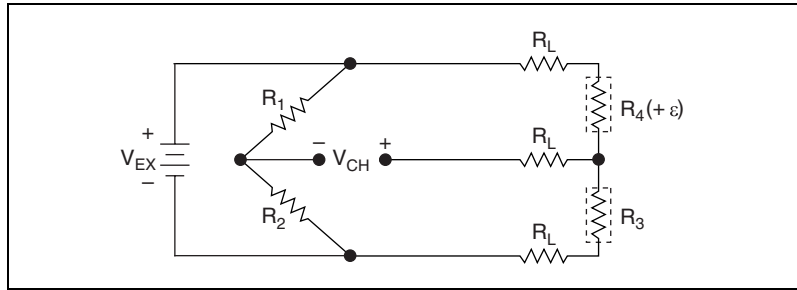
Figure 9. Quarter-Bridge Type II Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are a half-bridge completion resistors.

- R_3 is the quarter-bridge temperature-compensating element (dummy gauge).

- R_4 is the active element measuring tensile strain (+ε).

Figure 10 shows how to set up two quarter-bridge type II configurations with the SCC-SG03. You connect a quarter-bridge type II to the SCC-SG03 the same way you connect a half-bridge configuration to the SCC-SG03.
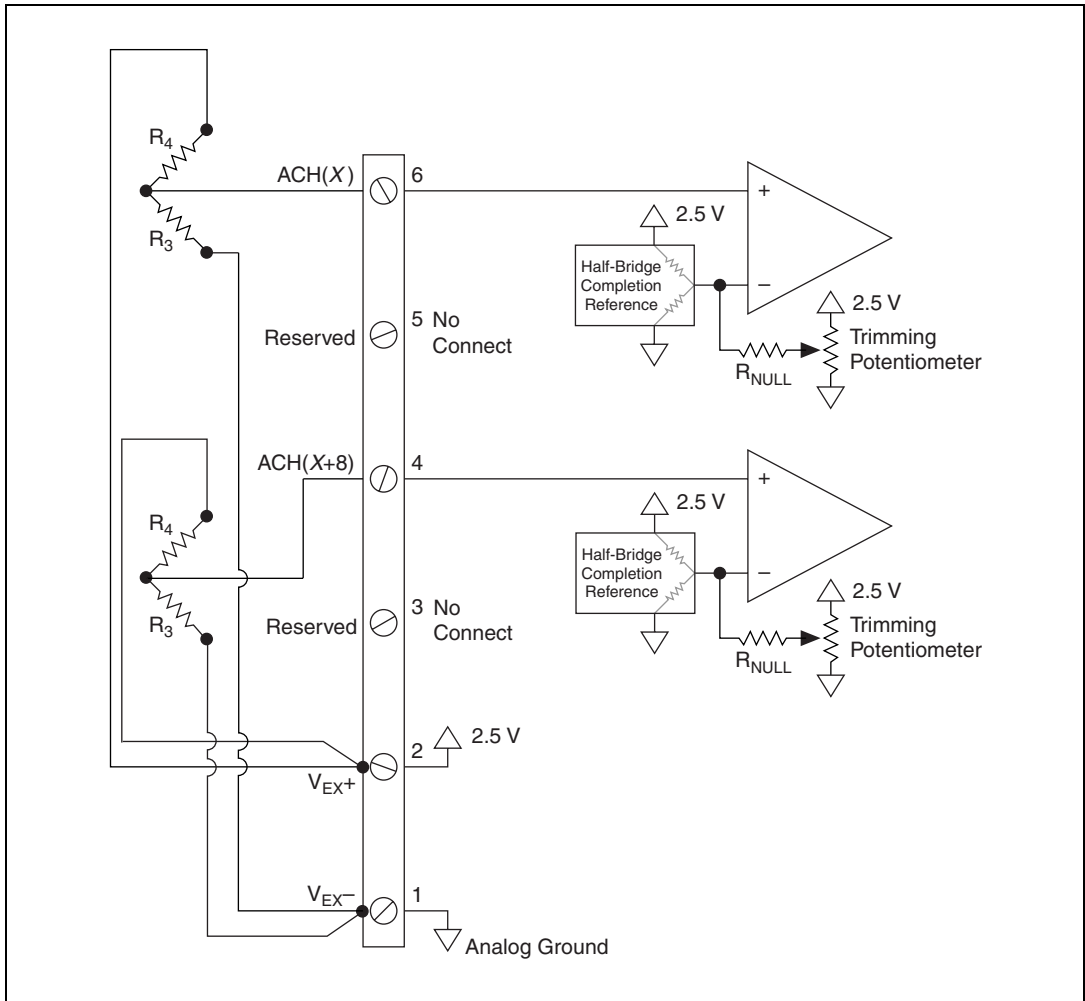
Figure 10. SCC-SG03 Half-Bridge Configuration Connection (Two Channels)

Use three lead wires to connect the strain gauges to screw terminals $V_{EX}+$, $V_{EX}-$, and ACH(X)+. The pair of wires connected to $V_{EX}+$ and $V_{EX}-$ provide excitation voltage to the strain gauge. The other wire, connected to ACH(X)+, senses the output voltage of the strain gauge with respect to the internal half-bridge completion reference. Figure 10 shows two half-bridge configurations using ACH(X) and ACH(X+8).

SCC-SG04/24 Full-Bridge Connection

In a full-bridge configuration, you use four active strain-gauge elements in the bridge configuration with all of the elements external to the SCC module. There are three full-bridge configuration types supported by NI software. The following sections describe how to connect full-bridge configuration types I, II, and III.

The SCC-SG04/24 module labels display the icon shown in Figure 11. These icon labels also represent the bridge configuration of the modules.

✏️ **Note** By factory-default the nulling resistors are *not* installed in the SCC-SG24. Refer to the *Replacing Resistors* section for information on installing the nulling resistors.
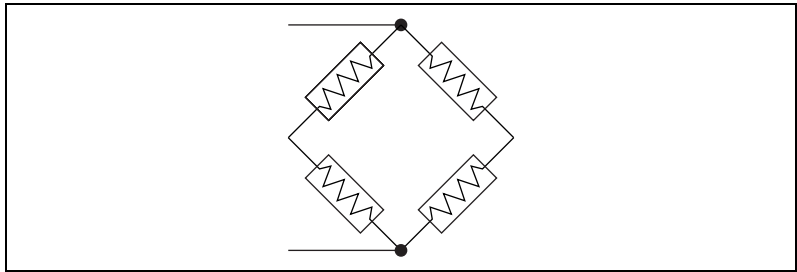
Figure 11. SCC-SG04/24 Icon

Full-Bridge Type I

This section provides information for the full-bridge strain-gauge configuration type I. The full-bridge type I only measures bending strain.

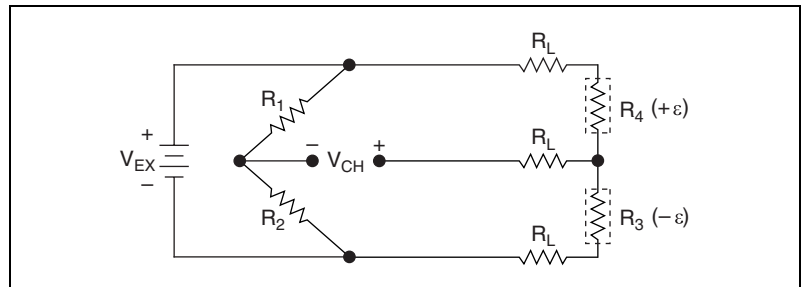Figure 12 shows a general full-bridge type I circuit diagram.
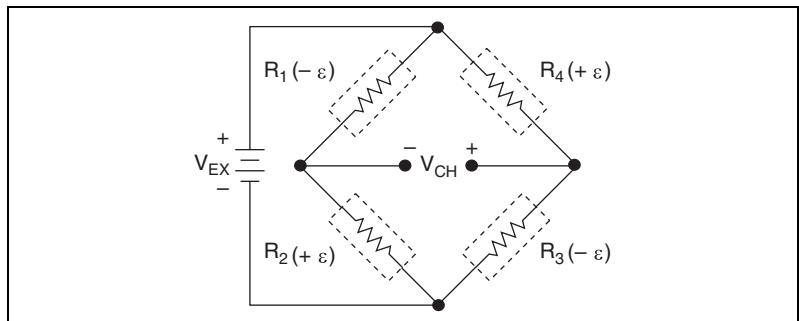
Figure 12. Full-Bridge Type I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 is an active element measuring compressive strain ($-\varepsilon$).
- R_2 is an active element measuring tensile strain ($+\varepsilon$).
- R_3 is an active element measuring compressive strain ($-\varepsilon$).
- R_4 is an active element measuring tensile strain ($+\varepsilon$).

Figure 15 shows how to set up two full-bridge type I configurations with the SCC-SG04/24.

Full-Bridge Type II

This section provides information for the full-bridge type II strain-gauge configuration. The full-bridge type II only measures bending strain.

Figure 13 shows a general full-bridge type II circuit diagram.
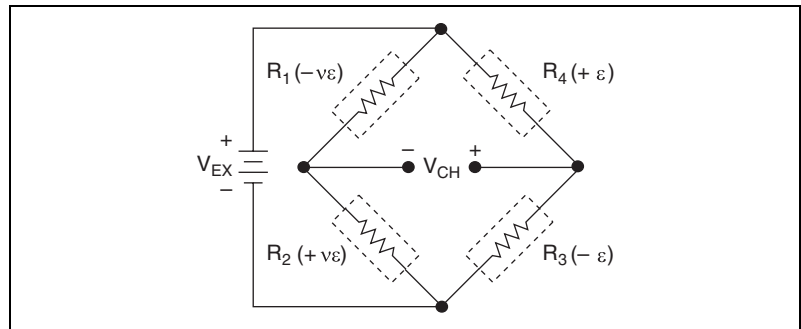
Figure 13. Full-Bridge Type II Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 is an active element measuring compressive Poisson effect ($-\nu\varepsilon$).
- R_2 is an active element measuring tensile Poisson effect ($+\nu\varepsilon$).
- R_3 is an active element measuring compressive strain ($-\varepsilon$).
- R_4 is an active element measuring tensile strain ($+\varepsilon$).

Figure 15 shows how to set up two full-bridge type II configurations with the SCC-SG04/24.

Full-Bridge Type III

This section provides information for the full-bridge strain-gauge configuration type III. The full-bridge type III only measures axial strain.

Figure 14 shows a general full-bridge type III circuit diagram.
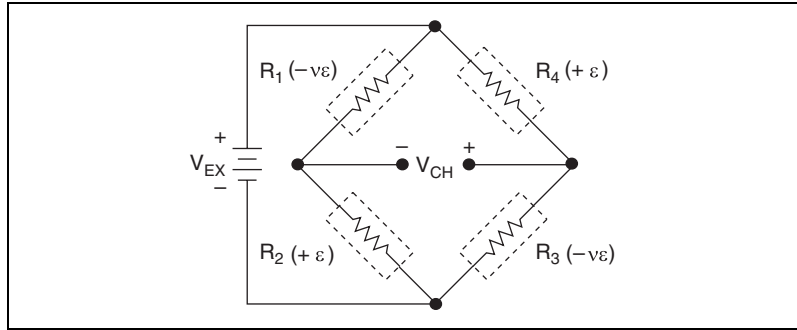
Figure 14. Full-Bridge Type III Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 is an active element measuring compressive Poisson effect ($-\nu\varepsilon$).
- R_2 is an active element measuring tensile strain ($+\varepsilon$).
- R_3 is an active element measuring compressive Poisson effect ($-\nu\varepsilon$).
- R_4 is an active element measuring the tensile strain ($+\varepsilon$).
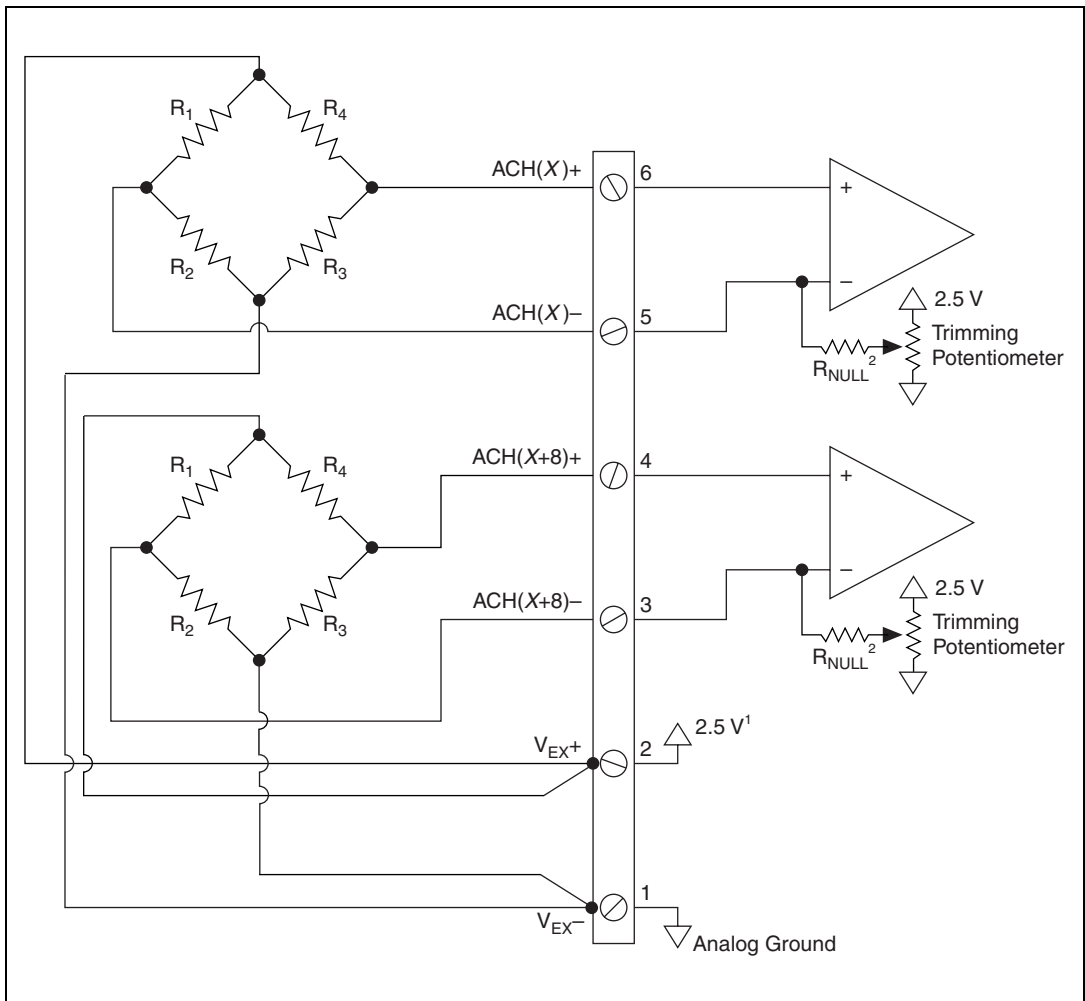
Figure 15 shows how to set up two full-bridge type III configurations with the SCC-SG04/24.

Figure 15. SCC-SG04/24 Full-Bridge Configuration Connection (Two Channels)

To connect a single full-bridge configuration to a channel, use four lead wires to connect the strain gauges to screw terminals $V_{EX}+$, $V_{EX}-$, ACH(X)+, and ACH(X)–. The two wires connected to $V_{EX}+$ and $V_{EX}-$ provide excitation voltage to the strain gauges. The other two wires, connected to ACH(X)+ and ACH(X)–, sense the output voltage of the strain gauges. Figure 15 shows two full-bridge configurations using ACH(X) and ACH(X+8).

Configuring the SCC System

Measurement & Automation (MAX) Explorer Configuration

Run MAX to configure the SCC system. Complete one of the following sets of steps depending on the version of NI-DAQ used in your application.

NI-DAQmx

Complete the following steps to configure the SCC-SG module using NI-DAQmx:

1. Open **Measurement & Automation** Explorer.

2. Right-click **Devices and Interfaces** and select **Create New**.

3. Under **NI-DAQmx SCC Connector Block** select **SC-2345**. Click **Finish**.

4. In the **SCC Connector Block Configuration** window, configure the SCC system as follows:

    a. Specify the **SCC Carrier Type**. The location of the SCC sockets change depending on the SCC carrier type.

    b. Select the E Series **DAQ device** that is connected to the SC-2345.

    c. Type the **SCC Connector Block ID**. The default value is SCC1.

    d. In the J21 drop-down list next to Power, select the correct SC-2345 power configuration. Refer to the *SC-2345 User Manual* for information on power configurations.

    e. For each SCC module physically installed in the SC-2345, add a corresponding entry in the SC-2345 configuration window. To add the SCC, click the socket drop-down box and select the correct module. If the module name does not appear in the list, either the module is not allowed in that location or you do not have the current version of NI-DAQ. If you do not have the current version of NI-DAQ, download it from ni.com.

    f. Click **OK** after completing all SCC entries to complete the configuration process.

5. Close MAX.

Note Configuring the SCC system using MAX automatically sets the E Series DAQ device analog input mode to nonreferenced single-ended (NRSE).

Traditional NI-DAQ

Complete the following steps to configure the SCC-SG module using Traditional NI-DAQ:

1. Open **Measurement & Automation** Explorer.

2. Expand **Devices and Interfaces**.

3. Expand **Traditional NI-DAQ Devices**.

4. Right-click the E Series DAQ device connected to the SC-2345, and select **Properties**.

5. Select the **Accessory** tab.

6. Under **Accessory**, select **SC-2345**.

7. Click the **Configure** button. A new window appears listing the sockets (connector reference designators) of the SC-2345.

8. Select the SC-2345 socket where you installed an SCC.

9. Click **Add** and select the SCC you installed. If the module name does not appear in the list, either the module is not allowed in that location or you do not have the current version of NI-DAQ. If you do not have the current version of NI-DAQ, download it from ni.com.

10. If you make a selection mistake, select the socket and click **Remove**.

11. Repeat steps 8 and 9 for each newly installed SCC.

12. Click **OK** after completing all SCC entries.

13. Click **OK** to complete the configuration process and close MAX.

Note Configuring the SCC system using MAX automatically sets the E Series DAQ device analog input mode to nonreferenced single-ended (NRSE).

Virtual Channels, Physical Channels, and Tasks

After you have installed and configured your SCC-SG0*X* or SCC-SG24 you can use software tools within MAX to further configure the module and take measurements.

Creating an NI-DAQmx Task or Global Channel

To create an NI-DAQmx task or global channel, complete the following steps:

1. Open **Measurement & Automation** Explorer.

2. Right-click **Data Neighborhood** and select **Create New**.

3. Select **NI-DAQmx Task** or **NI-DAQmx Global Channel** and click **Next**.

4. Select **Analog Input** and then select **Strain**.

5. If you are creating a task, select the channels to add to the task. You can select blocks of channels by pressing the <Shift> key while making the selections or select individual channels by pressing the <Ctrl> key while making the selections. If you are creating a channel, you can select only one channel. Click **Next**.

6. Enter a name for the task or global channel and click **Finish**.

7. In the **Channel List** box, select the channel(s) you want to configure. You can select blocks of channels by pressing the <Shift> key while making the selections or select individual channels by pressing the <Ctrl> key while making the selections.

8. Enter the specific values for your application in the **Settings** tab. Context help information for each setting is provided on the right side of the screen. Refer to the module user manuals for more information on determining the correct values.

   Table 2 lists suggested values for parameters. Use default values for parameters not shown.

Table 2. Suggested Values for Strain-Gauge Channel

Module	Supported Strain Configurations	Gauge Resistance	V_{EX} Value
SCC-SG01	Quarter Bridge I	120 Ohms	2.5 V
SCC-SG02	Quarter Bridge I	350 Ohms	2.5 V
SCC-SG03	Quarter Bridge II, Half Bridge I, Half Bridge II	From strain-gauge specification	2.5 V
SCC-SG04	Full Bridge I, Full Bridge II, Full Bridge III	N/A (use default)	2.5 V
SCC-SG24	Full Bridge I, Full Bridge II, Full Bridge III	N/A (use default)	10 V
SCC-SG11	N/A (Shunt calibration module)	N/A	N/A

9. Click **Test** to test the channel. You can view the strain measurement in the window that appears.

You have completed configuring the NI-DAQmx task or global channel.

Note If you see a flat line in your test panel that does not respond to change in strain, you may need to null the strain-gauge offset. Refer to *Offset Nulling Adjustment* for more information.

Alternately, you can also create a **Custom Voltage with Excitation** task or channel using the following steps. Use this task or channel to take measurements from bridge-based sensors such as load cells and pressure sensors.

Table 3 lists suggested values for parameters. Use default values for parameters not shown.

Table 3. Suggested Values for Custom Voltage with Excitation Channel

Module	Input Range	Supported Bridge Types	Excitation Source	Excitation Value
SCC-SG01	±100 mV	Quarter Bridge	Internal	2.5 V
SCC-SG02	±100 mV	Quarter Bridge	Internal	2.5 V
SCC-SG03	±100 mV	Half Bridge	Internal	2.5 V
SCC-SG04	±100 mV	Full Bridge, None	Internal	2.5 V
SCC-SG24	±100 mV	Full Bridge, None	Internal	10 V
SCC-SG11	N/A	N/A (Shunt calibration module)	N/A	N/A

You have completed configuring the NI-DAQ task or global hannel.

Creating a Virtual Channel in Traditional NI-DAQ

To create a Traditional NI-DAQ virtual channel, complete the following steps:

1. Open **Measurement & Automation** Explorer.

2. Right-click **Data Neighborhood** and select **Create New**.

3. Select **Traditional NI-DAQ Virtual Channel** and click **Finish**.

4. Click **Next** to select **Analog Input** as the type of channel to configure.

5. Enter a channel name in the **Channel Name** box and click **Next**. You also can enter a channel description.

6. Select **Strain Gauge** as the sensor type.

7. Select the strain-gauge bridge configuration type from the drop-down box. Refer to the *Connecting Strain-Gauge Input Signals* and *Theory of Operation* sections to determine what configuration type you are using.

8. Enter the rest of the values as they apply to your setup and click **Next**.

9. On the next screen, specify information about the E Series DAQ device being used and the excitation voltage and click **Finish**.

10. To test the channel, click **Test**.

You have finished configuring the Traditional NI-DAQ virtual channel.

Theory of Operation

This section contains information about Wheatstone bridges and the different strain-gauge bridge configuration types.

Wheatstone Bridges

All strain-gauge configurations are based on the concept of a Wheatstone bridge. A Wheatstone bridge is a network of four resistive legs. One or more of these legs can be active sensing elements. Figure 16 shows a Wheatstone bridge circuit diagram.
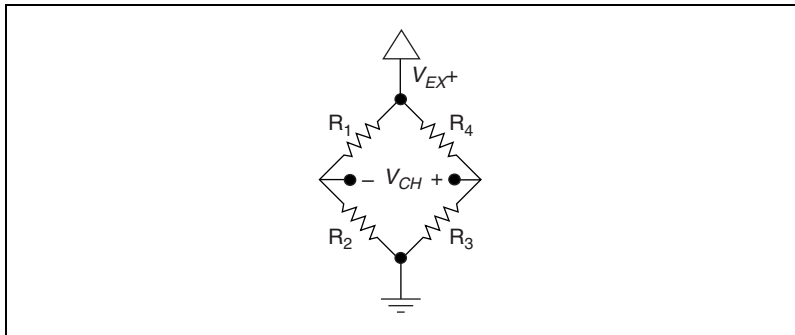
Figure 16. Basic Wheatstone Bridge Circuit Diagram

The Wheatstone bridge is the electrical equivalent of two parallel voltage divider circuits. R_1 and R_2 compose one voltage divider circuit, and R_4 and R_3 compose the second voltage divider circuit. The output of a Wheatstone bridge is measured between the middle nodes of the two voltage dividers (V_{CH}).

Physical phenomena, such as a change in strain applied to a specimen or a temperature shift, changes the resistance of the active sensing elements in the Wheatstone bridge. The Wheatstone bridge configuration is used to help measure the small variations in resistance that the sensing elements produce corresponding to a physical change in the specimen. For more information on strain-gauge Wheatstone bridge configurations, refer to the *Strain Gauges* section.

You use different Wheatstone bridge configurations for different tasks. The following sections provide information that should help you determine what bridge configuration type to use, how it works, and if it is the right configuration type for your task.

✎ **Note** Normally load, force, pressure, and torque sensors are arranged in full-bridge Wheatstone bridge configurations, similar to strain-gauge full-bridge configurations. If you are measuring load, force, pressure, or torque use the SCC-SG04/24.

Quarter-Bridge Type I

This section provides information for the quarter-bridge strain-gauge configuration type I. The quarter-bridge type I measures either axial or bending strain.
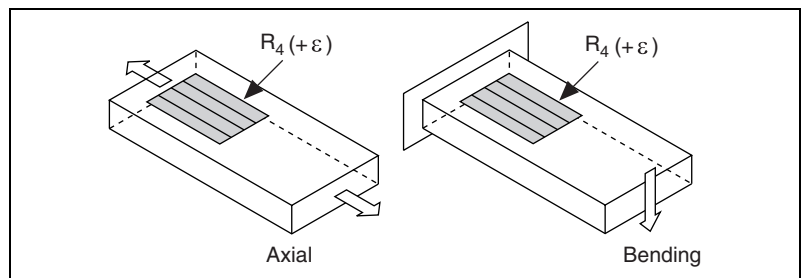
Figure 17. Quarter-Bridge Type I Measuring Axial and Bending Strain

A quarter-bridge type I has the following characteristics:

- A single active strain-gauge element is mounted in the principle direction of axial or bending strain.

- A passive quarter-bridge completion resistor (dummy resistor) is required in addition to half-bridge completion.

- Temperature variation in specimen decreases the accuracy of the measurements.

- Sensitivity at 1000 $\mu\varepsilon$ is ~ 0.5 mV_{OUT}/V_{EX} input.

- Used with the SCC-SG01/02.

Quarter-Bridge Type II

This section provides information for the quarter-bridge strain-gauge configuration type II. The quarter-bridge type II measures either axial or bending strain.
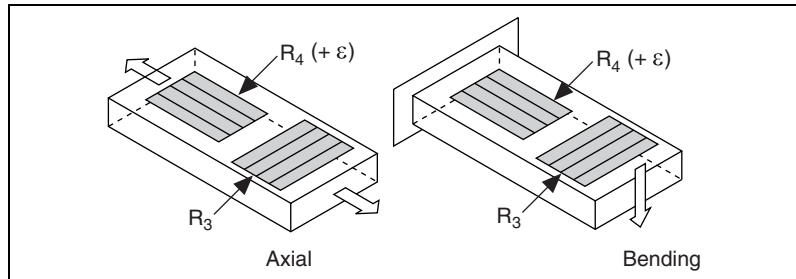
Figure 18. Quarter-Bridge Type II Measuring Axial and Bending Strain

A quarter-bridge type II has the following characteristics:

- One active strain-gauge element and one passive, temperature-sensing quarter-bridge element (dummy gauge). The active element is mounted in the direction of axial or bending strain. The dummy gauge is mounted in close thermal contact with the strain specimen, but not bonded to the specimen, and is usually mounted transversely (perpendicular) to the principle axis of strain.

- This configuration is often confused with the more commonly used half-bridge type I configuration, with the difference being that in the half-bridge type I configuration the R_3 element is active and bonded to the strain specimen to measure the effect of Poisson's ratio.

- Completion resistors provide half-bridge completion.

- Compensates for temperature.

- Sensitivity at 1000 $\mu\varepsilon$ is ~ 0.5 mV_{OUT}/V_{EX} input.

- Used with the SCC-SG03. Dummy gauge R_3 provides quarter-bridge completion.

Half-Bridge I

This section provides information for the half-bridge strain-gauge configuration type I. The half-bridge type I measures either axial or bending strain.

Figure 19. Half-Bridge Type I Measuring Axial and Bending Strain

A half-bridge type I has the following characteristics:

- Two active strain-gauge elements. One is mounted in the direction of axial strain, the other acts as a Poisson gauge and is mounted transversely (perpendicular) to the principal axis of strain.

- Completion resistors provide half-bridge completion.

- Sensitive to both axial and bending strain.

- Compensates for temperature.

- Compensates for the aggregate effect on the principle strain measurement due to the Poisson's ratio of the specimen material.

- Sensitivity at 1000 $\mu\varepsilon$ is ~ 0.65 mV_{OUT}/V_{EX} input.

- Used with the SCC-SG03.

Half-Bridge II

This section provides information for the half-bridge strain-gauge configuration type II. The half-bridge type II only measures bending strain.


Figure 20. Half-Bridge Type II Rejecting Axial and Measuring Bending Strain

A half-bridge type II configuration has the following characteristics:

- Two active strain-gauge elements. One is mounted in the direction of bending strain on one side of the strain specimen (top), the other is mounted in the direction of bending strain on the opposite side (bottom).

- Completion resistors provide half-bridge completion.

- Sensitive to bending strain.

- Rejects axial strain.

- Compensates for temperature.

- Sensitivity at 1000 $\mu\varepsilon$ is ~ 1 mV_{OUT}/V_{EX} input.

- Used with the SCC-SG03.

Full-Bridge Type I

This section provides information for the full-bridge strain-gauge configuration type I. The full-bridge type I only measures bending strain.
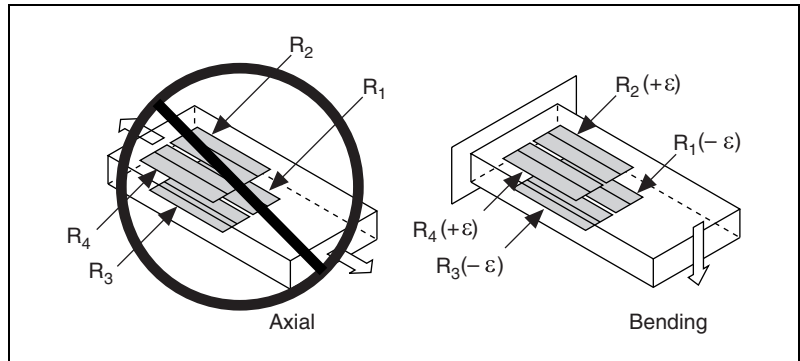

Figure 21. Full-Bridge Type I Rejecting Axial and Measuring Bending Strain

A full-bridge type I configuration has the following characteristics:

- Four active strain-gauge elements. Two are mounted in the direction of bending strain on one side of the strain specimen (top), the other two are mounted in the direction of bending strain on the opposite side (bottom).

- Highly sensitive to bending strain.

- Rejects axial strain.

- Compensates for temperature.

- Compensates for lead resistance.

- Sensitivity at 1000 $\mu\varepsilon$ is ~ 2.0 mV_{OUT}/V_{EX} input.

- Used with the SCC-SG04/24.

Full-Bridge Type II

This section provides information for the full-bridge type II strain-gauge configuration. The full-bridge type II only measures bending strain.
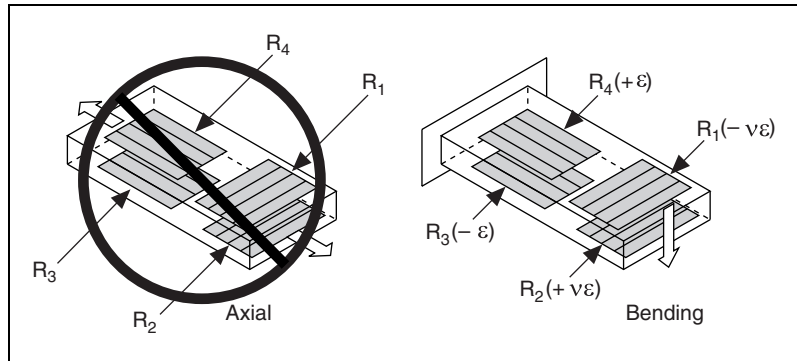
Figure 22. Full-Bridge Type II Rejecting Axial and Measuring Bending Strain

A full-bridge type II configuration has the following characteristics:

- Four active strain-gauge elements. Two are mounted in the direction of bending strain with one on one side of the strain specimen (top), the other on the opposite side (bottom). The other two act as Poisson gauges and are mounted transversely (perpendicular) to the principal axis of strain with one on one side of the strain specimen (top), the other on the opposite side (bottom).

- Rejects axial strain.

- Compensates for temperature.

- Compensates for the aggregate effect on the principle strain measurement due to the Poisson's ratio of the specimen material.

- Compensates for lead resistance.

- Sensitivity at 1000 $\mu\varepsilon$ is ~ 1.3 mV_{OUT}/V_{EX} input.

- Used with the SCC-SG04/24.

Full-Bridge Type III

This section provides information for the full-bridge strain-gauge configuration type III. The full-bridge type III only measures axial strain.

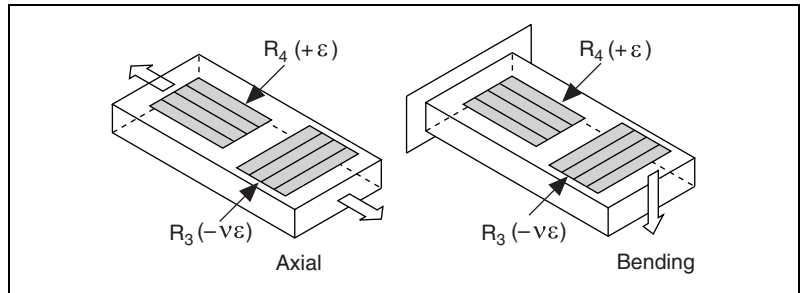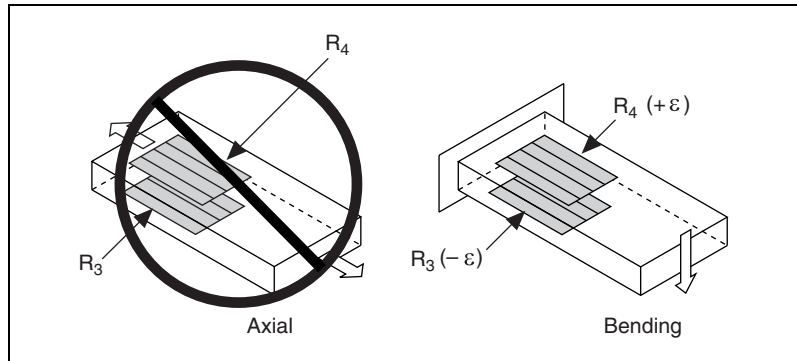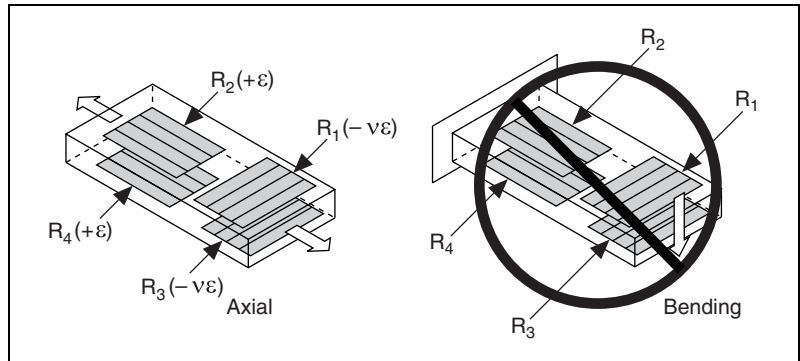**Figure 23.** Full-Bridge Type III Measuring Axial and Rejecting Bending Strain

A full-bridge type III configuration has the following characteristics:

- Four active strain-gauge elements. Two are mounted in the direction of axial strain with one on one side of the strain specimen (top), the other on the opposite side (bottom). The other two act as Poisson gauges and are mounted transversely (perpendicular) to the principal axis of strain with one on one side of the strain specimen (top), the other on the opposite side (bottom).

- Compensates for temperature.

- Rejects bending strain.

- Compensates for the aggregate effect on the principle strain measurement due to the Poisson's ratio of the specimen material.

- Compensates for lead resistance.

- Sensitivity at 1000 $\mu\varepsilon$ is ~ 1.3 mV_{OUT}/V_{EX} input.

- Used with the SCC-SG04/24.

Signal Conditioning

The SCC-SG*XX* modules all contain some form of signal conditioning. This signal conditioning can greatly increase the accuracy of your measurements. The following types of signal conditioning are provided by the SCC-SG*XX*:

- Filtering
- Amplification
- Excitation

- Bridge completion
- Offset nulling adjustment
- Shunt calibration

Refer to the *Filtering*, *Amplification*, *Excitation*, *Bridge Completion*, *Offset Nulling Adjustment*, and *Shunt Calibration Using the SCC-SG11* sections for more information about each type of signal conditioning.

Filtering

Each channel on the SCC-SG0*X* and SCC-SG24 has an output lowpass filter. The filter is a single-pole, buffered RC filter with a cutoff frequency of 1.6 kHz.

Amplification

Each channel on the SCC-SG0X and SCC-SG24 has an instrumentation amplifier with a gain of 100. This amplifier improves signal measurements by boosting strain measurements, typically approximately ±100 mV, to levels closer to the operating range of E Series DAQ devices, usually ±10 VDC.

Excitation

The SCC-SG0*X* and SCC-SG24 contain a single onboard voltage source for bridge configuration excitation. On the SCC-SG0*X,* the onboard-regulated +2.5 VDC excitation source supplies up to 42 mA, which is enough to drive two 120 Ω full-bridge configurations. The SCC-SG24 has an onboard-regulated +10 VDC excitation source that supplies up to 60 mA, which is enough to drive two 350 Ω full-bridge configurations. Optionally, you can connect an external excitation source of up to +15 VDC across the bridge configurations. If the external excitation source is *not* ground referenced, connect its negative terminal to $V_{EX}-$. If the external excitation source is ground referenced, and you connect the negative terminal to $V_{EX}-$, a ground loop could result that can damage the SCC-SG0*X* and SCC-SG24. External excitation *must not* exceed +15 VDC.

Bridge Completion

The SCC-SG01/02 come with quarter-bridge completion resistors that complete the bridge-configuration. The quarter-bridge completion resistors are socketed so that you can replace them. Refer to the *Replacing Resistors* section for more information on replacing resistors. Only replace them with resistors that match the value of the strain-gauge element actively measuring strain. By default the SCC-SG01/02 quarter-bridge completion resistor value is 120 Ω and 350 Ω, respectively.

Offset Nulling Adjustment

The SCC-SG0X and SCC-SG24 have circuitry for offset-nulling adjustment of bridge configuration circuits. The nulling circuitry uses the excitation voltage as a reference and operates with quarter-, half-, and full-bridge configurations. Each channel has its own nulling circuit with a trimming potentiometer to adjust the nulling voltage level. These potentiometers are accessible on the top of the SCC and are marked *X* for ACH(*X*) offset nulling and *X*+8 for ACH(*X*+8) offset nulling. The offset-nulling circuitry has the added advantage of nulling the offset voltages of the entire signal path including the bridge configuration, the SCC channel, and the E Series DAQ device analog-input channel.

✎ **Note** By factory-default the nulling resistors are *not* installed in the SCC-SG24. Refer to the *Replacing Resistors* section for information on installing the nulling resistors.

To null the voltage offset of the system including the bridge configuration, complete the following steps:

1. Configure and connect the bridge configuration to an SCC-SG0X or SCC-SG24 channel.

2. Create a strain-gauge virtual channel as described in the *Virtual Channels, Physical Channels, and Tasks* section.

3. Read the channel using a MAX test panel or in another continuous acquisition application.

4. If you see a flat line in your test panel, increase the channel input limits until you see a changing signal. Try ±50,000 με.

5. While monitoring the channel input voltage, rotate the appropriate trimming potentiometer wiper with a flathead screwdriver until you read 0.0 ε.

6. Next decrease the input range (use ±1000 με) and repeat step 5.

You have successfully nulled the system offset.

Nulling Range Adjustment

The nulling range of the offset-nulling adjustment circuitry for the SCC-SG0X and SCC-SG24 is referred to input (RTI)[1] and given in Table 4. The nulling range figures assume a 30 kΩ nulling resistor and an excitation voltage of +2.5 VDC for the SCC-SG0X and +10 VDC for the SCC-SG24.

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[1] Calculated relative to the input range of the module.

Table 4. SCC-SG0*X* and SCC-SG24 Nulling Ranges

SCC Module	Active Strain-Gauge Element Value	Nulling Range
SCC-SG01	120 Ω	±2.5 mV
SCC-SG02/03/04	350 Ω	±6.6 mV
SCC-SG24	350 Ω	±29 mV

Note The nulling range of the SCC-SG0*X* and SCC-SG24 is dependent on the excitation voltage, active strain-gauge element value, and the value of the nulling resistor.

You can change the nulling range of the offset-nulling circuitry for each channel by replacing its nulling resistor with a nulling resistor of another value. The value of the nulling resistors on the SCC-SG0*X* and SCC-SG24 is 30 kΩ. These nulling resistors are socketed for easy replacement. Refer to the *Replacing Resistors* section for more information on replacing resistors.

To determine the nulling range, use the following formula while referring to Figures 28, 29, or 30:

$$V_{NULLING} = \pm \left| \frac{V_{EX}}{2} - \frac{V_{EX}R_3(R_{NULL} + R_4)}{R_{NULL}R_4 + R_3(R_{NULL} + R_4)} \right|$$

where

R_4 is the nominal active strain-gauge element resistance value.

R_3 is either the value of the quarter-bridge completion resistor or the nominal resistance of the second active strain-gauge element. Refer to Figure 28, 29, or 30 to locate the resistor in quarter-, half-, and full-bridge configurations.

R_{NULL} is the value of the nulling resistor.

V_{EX} is the excitation voltage.

For example, for a quarter-bridge configuration using the SCC-SG01

$R_4 = 120$ Ω

$R_3 = 120$ Ω

$R_{NULL} = 30$ kΩ

$V_{EX} = +2.5$ VDC,

then $V_{NULLING} = \pm 2.5$ mV.

Shunt Calibration Using the SCC-SG11

The SCC-SG11 shunt calibration module label displays the icon shown in Figure 24. This icon label also represents the shunt calibration configuration using the SCC-SG11 with the SCC-SG0*X* or SCC-SG24.
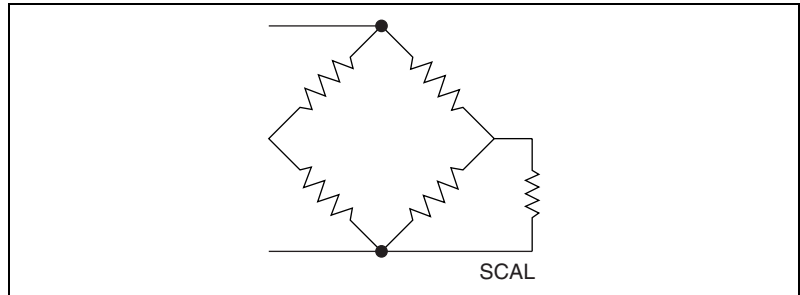
Figure 24. SCC-SG11 Icon

Connecting the SCC-SG11 Shunt Resistors

Install the SCC-SG11 according to the instructions in the *Installing the Module* section. Connect the shunt-calibration circuits as shown in Figure 25, 26, or 27, depending on the bridge configuration.
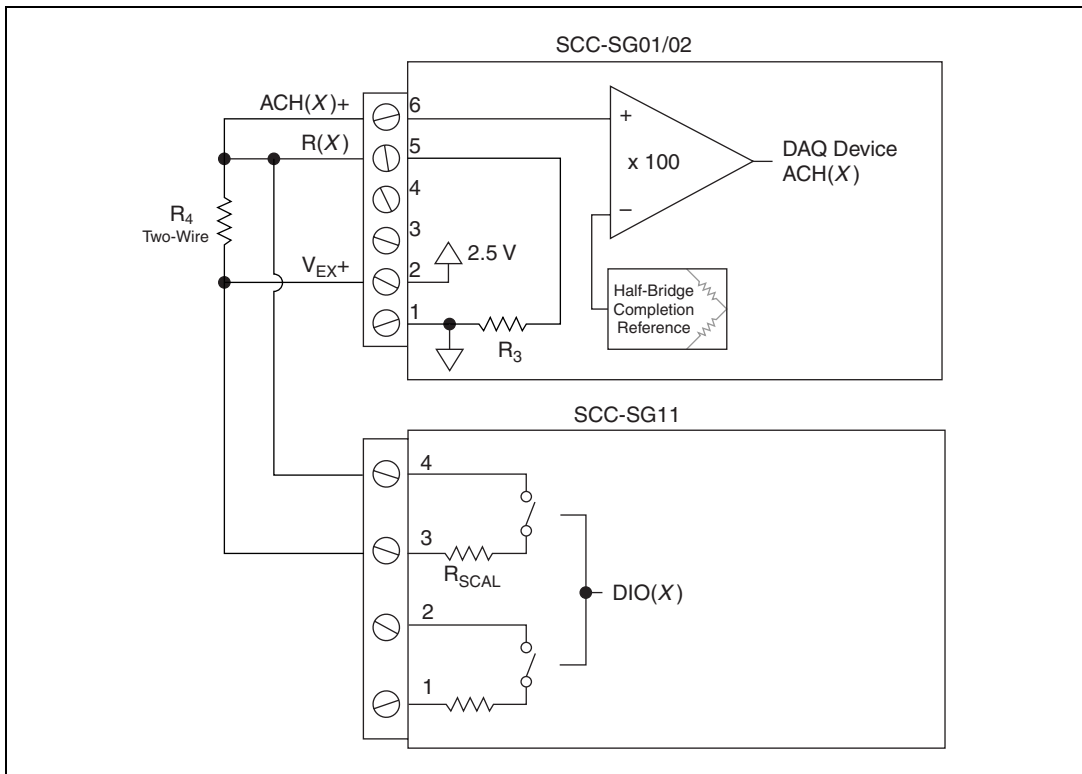
Figure 25. Quarter-Bridge Shunt Calibration Configuration Using SCC-SG11 and SCC-SG01/02 (One Channel) to Shunt R_4
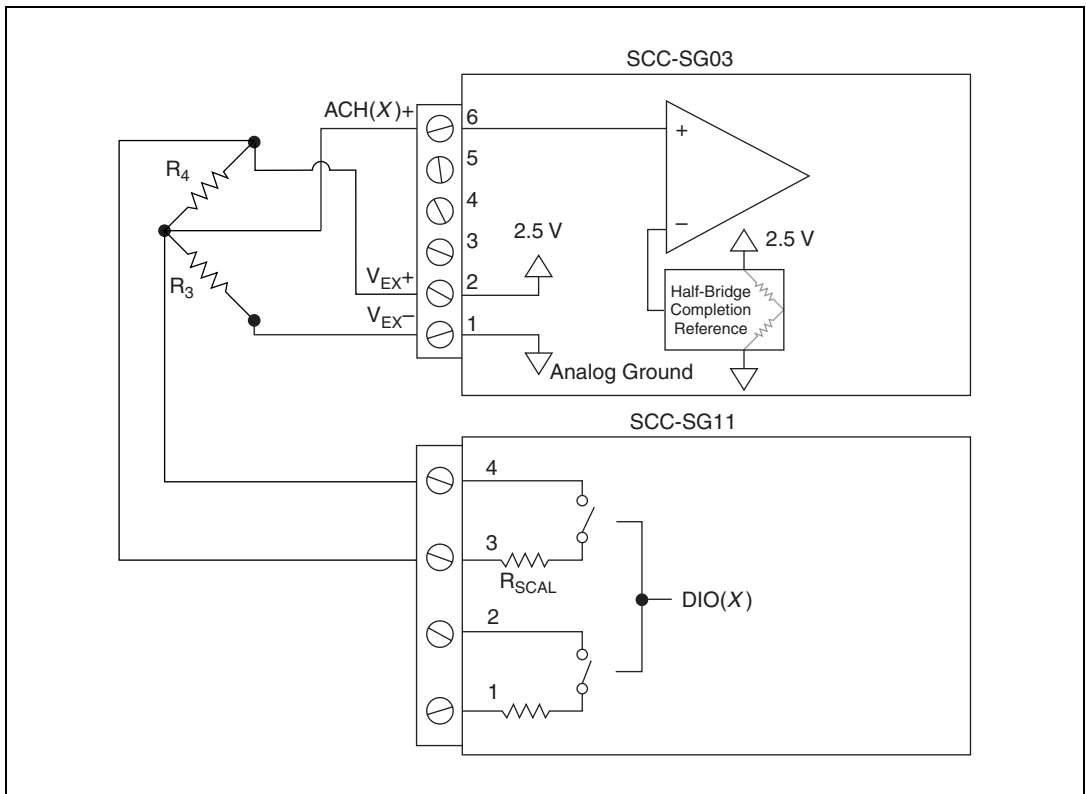
Figure 26. Half-Bridge Shunt Calibration Configuration Using SCC-SG11 and SCC-SG03 (One Channel) to Shunt R_4
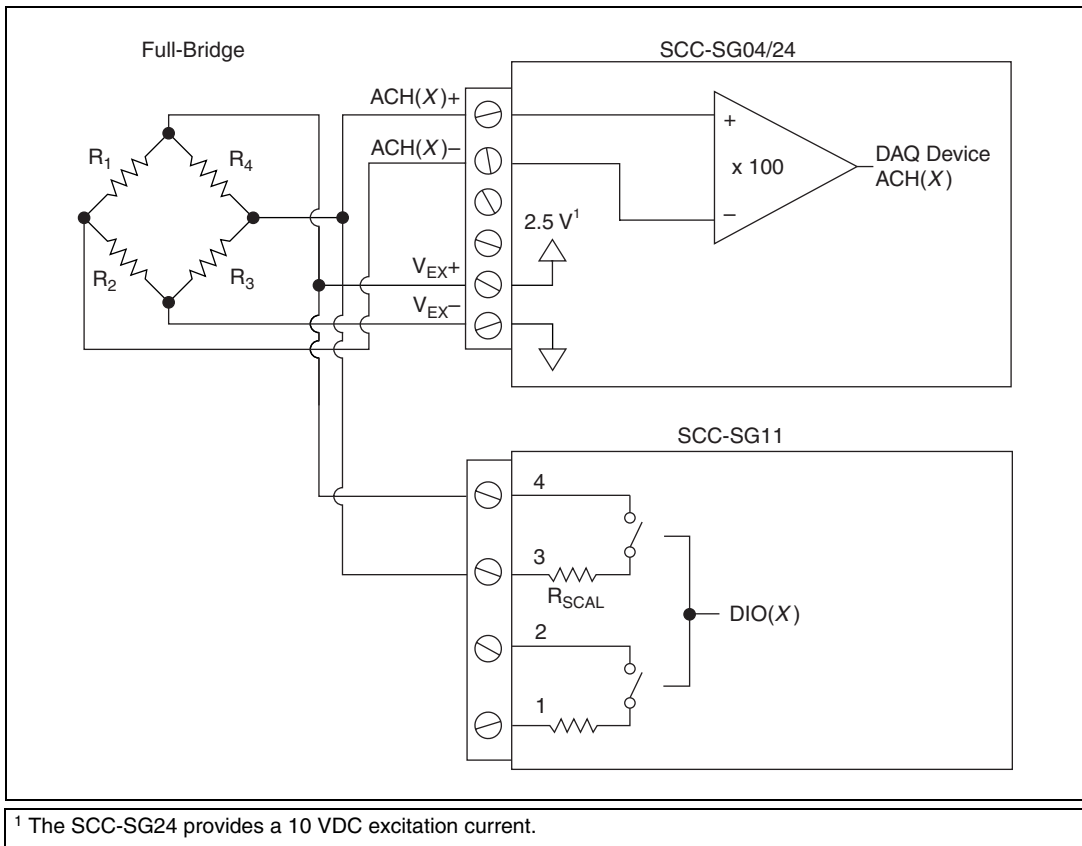
The SCC-SG24 provides a 10 VDC excitation current.

Figure 27. Full-Bridge Shunt Calibration Configuration Using SCC-SG11 and SCC-SG04/24 (One Channel) to Shunt R_4

Each screw terminal of the SCC-SG11 is labeled by pin number <1..4>. The SCC-SG11 contains two shunt-calibration circuits, each consisting of a precision 301 kΩ resistor and a relay contact. The circuits are independent of each other, but the relay contacts are controlled together by E Series DAQ device digital output channel DIO(X). The value of X is determined by the number of the SC-2345 socket, J(X+9), where you plug in the SCC-SG11.

When DIO(X) is set to 1 on the E Series DAQ device, the shunt-calibration circuits are enabled and the LED indicator on the SCC-SG11 is lit. When DIO(X) is set to 0, the circuits are disabled and the LED indicator on the SCC-SG11 is off. At startup or reset, the circuits are disabled. When the circuits are enabled, the shunt-calibration resistor is connected to the SCC-SG11 screw terminals. This allows you to place a resistor in parallel with a strain-gauge element.

Using Shunt Calibration to Correct for Gain Error

1. Calculate the voltage change expected from the introduction of the shunt-calibration resistor using the following formula:

$$\Delta V_{EXPECTED} \ = \ \frac{R_3 V_{EX}(R_{SCAL} + R_4)}{R_4 R_{SCAL} + R_3(R_{SCAL} + R_4)} - \frac{V_{EX}}{2}$$

where

R_{SCAL} is the value of the shunt-calibration resistor.

R_4 is the nominal active strain-gauge element value.

R_3 is either the value of a completion resistor or a second active strain-gauge element nominal value.

V_{EX} is the excitation voltage.

For example, for a quarter-bridge configuration where

$R_4 = 120 \ \Omega$

$R_3 = 120 \ \Omega$

$R_{SCAL} = 301 \ k\Omega$

$V_{EX} = 2.5$ VDC

Offset Voltage $= 0$ VDC,

then $\Delta V_{EXPECTED} = 0.2491$ mV.

Note Before completing step 2, null the system offset voltage. Refer to the *Offset Nulling Adjustment* section for information on how to null the system offset voltage.

2. Enable the shunt-calibration circuit and measure the resulting voltage change ($\Delta V_{MEASURED}$). Use the following equation to calculate a correction factor that compensates for the DAQ system gain error.

$$\frac{\Delta V_{EXPECTED}}{\Delta V_{MEASURED}} \ = \ F_C$$

where

$\Delta V_{EXPECTED}$ is the expected change in voltage.

$\Delta V_{MEASURED}$ is the measured change in voltage.

F_C is the correction factor.

3. Multiply subsequent voltage measurements by the correction factor F_C to correct for any gain error present in the DAQ system.

Replacing Resistors

The SCC-SG*XX* all have socketed resistors so you can easily replace them. A typical 1/4 W size resistor should fit in the socket. Refer to the *Specifications* section for socket dimensions.

Replacing the Quarter-Bridge Completion Resistors

To replace a quarter-bridge completion resistor on the SCC-SG01/02, complete the following steps:

1. Remove the screw from the back (wide unlabeled side).

2. Turn the front (wide labeled side) toward you.

3. Place the screw-terminal receptacle to the left.

4. Slide the top cover to the right.

5. Lift off the cover.

6. Locate the completion resistor and replace it with a resistor that matches the value of the strain-gauge element actively measuring strain. Refer to Figure 28 to locate the completion resistor.
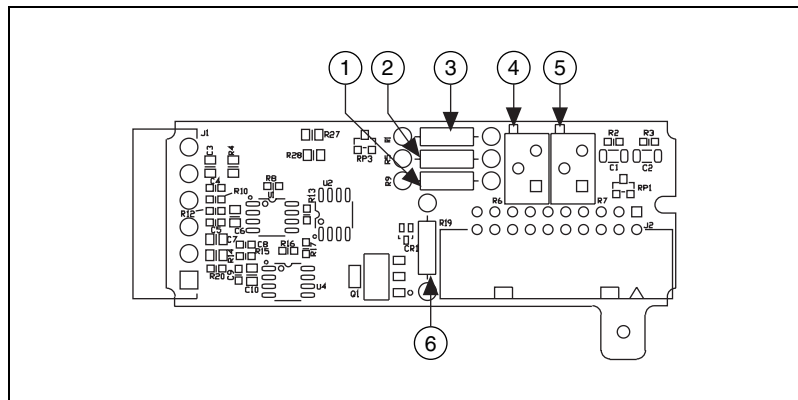
1 R9 Quarter-Bridge Completion Resistor for ACH(*X*)
   (SCC-SG01 and SCC-SG02 only)
2 R5 Nulling Resistor for ACH(*X*+8)
3 R1 Nulling Resistor for ACH(*X*)
4 R6 Offset Nulling Adjustment for ACH(*X*)
5 R7 Offset Nulling Adjustment for ACH(*X*+8)
6 R19 Quarter-Bridge Completion Resistor for ACH(*X*+8)
   (SCC-SG01 and SCC-SG02 only)

Figure 28. SCC-SG0*X* Parts Locator Diagram

Replacing the Nulling Resistors

To replace a nulling resistor on the SCC-SG0*X* or SCC-SG24, complete the following steps:

1. Remove the screw from the back (wide unlabeled side).

2. Turn the front (wide labeled side) toward you.

3. Place the screw-terminal receptacle to the left.

4. Slide the top cover to the right.

5. Lift off the cover.

6. Locate the nulling resistor and replace it. Refer to Figures 28 and 29 to locate the nulling resistors.

1   R5 Nulling Resistor for ACH(*X*+8)
2   R1 Nulling Resistor for ACH(*X*)
3   R39 Offset Nulling Adjustment for ACH(*X*)
4   R40 Offset Nulling Adjustment for ACH(*X*+8)
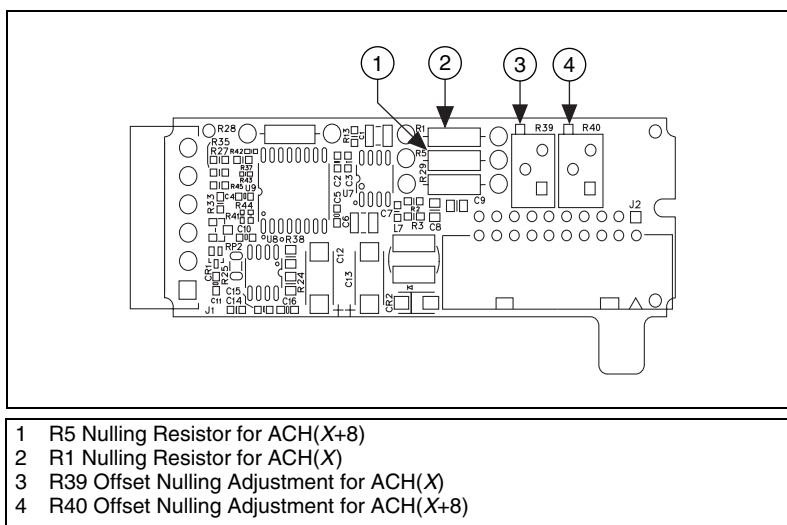
Figure 29. SCC-SG24 Parts Locator Diagram

✎ **Note** Replacing a nulling resistor can give you a larger nulling range, but makes the trimming potentiometers less sensitive when you adjust them.

Replacing the Shunt Resistors

The shunting resistors (R_{SCAL}) on the SCC-SG11 have a 301 kΩ ±1% value. To replace a shunting resistor on the SCC-SG11 complete the following steps:

1. Remove the screw from the back (wide unlabeled side).

2. Turn the front (wide labeled side) toward you.

3. Place the screw-terminal receptacle to the left.

4. Slide the top cover to the right.

5. Lift off the cover.

6. Locate the shunting resistor and replace it. Refer to Figure 30 to locate the shunting resistor on the SCC-SG11.

1	R1 Shunting Resistor Connected to Pins 3 and 4	2	R4 Shunting Resistor Connected to Pins 1 and 2
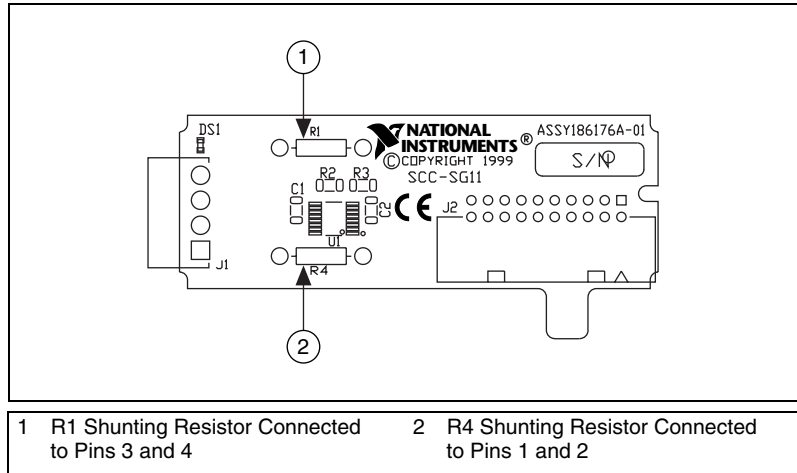
Figure 30. SCC-SG11 Parts Locator Diagram

Using the SCC-SG*XX*

This section provides information about how to ensure your readings are properly scaled and converted to the correct units.

Converting Voltage Measurements to Units of Strain

Once you have acquired the voltage signal V_{CH}, you can scale this voltage to the appropriate strain units in software. This is done automatically for you in traditional NI-DAQ using the strain virtual channel and in NI-DAQmx using a strain task or global channel. You also can scale the voltages manually in your application using the voltage to strain conversion equations provided in this document for each configuration type.

Finally, there are voltage to strain conversion functions included in LabVIEW, Traditional NI-DAQ, and NI-DAQmx. In LabVIEW, the conversion function VI is in the **Data Acquisition»Signal Conditioning** subpalette. For text-based programming ADEs, the prototypes for the NI-DAQ functions, Strain_Convert and Strain_Buf_Convert, are in the header file convert.h for C/C++, and convert.bas for Visual Basic. Refer to the *Traditional NI-DAQ User Manual* and the *LabVIEW Measurements Manual* for more information.

The names given to the strain-gauge types in this section directly correspond to bridge selections in MAX and the LabVIEW Convert Strain Gauge Reading VI.

If you have not configured the SCC-SG0*X* or SCC-SG24 as an accessory for the E Series DAQ device, as described in the *Offset Nulling Adjustment* section, or if you are using the Mac OS, you must divide voltage measurements by 100 before converting them to units of strain. This calculation accounts for the gain of 100 applied by each SCC-SG0*X* or SCC-SG24 channel.

If you have not configured the SCC-SG0*X* or SCC-SG24, or you are using the Mac OS, you *cannot* use virtual channels within the Data Neighborhood of MAX to convert voltage measurements into units of strain. To convert properly scaled voltage measurements to units of strain, complete the following steps:

1. Read the bridge configuration channel on the E Series DAQ device $V_{ESERIES}$ [ACH(*X*)].

2. Calculate the voltage by using the following formula:

$$V_{SG} = \frac{V_{ESERIES}}{100}$$

where

V_{SG} is the bridge configuration voltage.

$V_{ESERIES}$ is the E Series DAQ device voltage.

This calculation provides proper scaling for the amplifier in the SCC-SG0*X* and SCC-SG24.

Note The SCC-SG0*X* built-in excitation voltage is +2.5 VDC. The SCC-SG24 excitation voltage is +10 VDC.

Strain Equations

This section provides the equations used to convert voltage readings to units of strain and simulate the effect of a shunt resistor.

Note If you are not using NI software, or you are using the Mac OS, you can use these equations in your software application to properly scale your measurements.

Formulas and Variable Definitions

In the equations in this document, the following formulas and variable definitions are used:

ε_S is the simulated strain.

GF is the Gauge Factor, which should be specified by the gauge manufacturer.

R_g is the nominal gauge resistance, which should be specified by the gauge manufacturer.

R_L is the lead resistance. If lead lengths are long, R_L can significantly impact measurement accuracy.

✎ **Note** You can neglect the R_L of the wiring if shunt calibration is performed or if lead length is very short (~ <10 ft), depending on the wire gauge. For example 10 ft of 24-AWG copper wire has a lead resistance of 0.25 Ω.

R_s is the shunt calibration resistor value.

U is the ratio of expected signal voltage to excitation voltage with the shunt calibration circuit engaged. Parameter *U* appears in the equations for simulated strain and is defined by the following equation:

$$U = \frac{-R_g}{4R_s + 2R_g}$$

V_r is the voltage ratio that is used in the voltage to strain conversion equations and is defined by the following equation:

$$V_r = \left(\frac{V_{CH}(\text{strained}) - V_{CH}(\text{unstrained})}{V_{EX}} \right)$$

Quarter-Bridge Type I

To convert voltage readings to strain units use the following equation:

$$strain \ (\varepsilon) = \frac{-4V_r}{GF(1 + 2V_r)} \times \left(1 + \frac{R_L}{Rg} \right)$$

To simulate the effect on strain of applying a shunt resistor across R₄, use the following equation:

$$\varepsilon_s = \frac{4U}{GF(1 + 4U)}$$

Quarter-Bridge Type II

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon)\ =\ \frac{-4V_r}{GF(1+2V_r)} \times \left(1 + \frac{R_L}{Rg}\right)$$

To simulate the effect on strain of applying a shunt resistor across R_4, use the following equation:

$$\varepsilon_s\ =\ \frac{4U}{GF(1+4U)}$$

Half-Bridge Type I

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon)\ =\ \frac{-4V_r}{GF[(1+v)-2V_r(v-1)]} \times \left(1 + \frac{R_L}{R_g}\right)$$

To simulate the effect on strain of applying a shunt resistor across R_4, use the following equation:

$$\varepsilon_s\ =\ \frac{4U}{GF[(1+v)-2U(v-1)]}$$

Half-Bridge Type II

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon)\ =\ \frac{-2V_r}{GF} \times \left(1 + \frac{R_L}{R_g}\right)$$

To simulate the effect on strain of applying a shunt resistor across R_4, use the following equation:

$$\varepsilon_s\ =\ \frac{2U}{GF}$$

Full-Bridge Type I

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon)\ =\ \frac{-V_r}{GF}$$

To simulate the effect on strain of applying a shunt resistor across R_4, use the following equation:

$$\varepsilon_s\ =\ \frac{U}{GF}$$

Full-Bridge Type II

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon)\ =\ \frac{-2V_r}{GF(1+v)}$$

To simulate the effect on strain of applying a shunt resistor across R_4, use the following equation:

$$\varepsilon_s\ =\ \frac{2U}{GF(1+v)}$$

Full-Bridge Type III

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon)\ =\ \frac{-2V_r}{GF[(v+1)-V_r(v-1)]}$$

To simulate the effect on strain of applying a shunt resistor across R_4, use the following equation:

$$\varepsilon_s\ =\ \frac{4U}{GF[(v+1)-U(v-1)]}$$

Specifications

These ratings are typical at 25 °C unless otherwise stated.

Note Due to functional and electrical differences between the SCC-SG0*X*, SCC-SG24, and SCC-SG11, module specific information is listed in separate sections followed by common information.

SCC-SG0*X* Strain-Gauge Input Modules

Strain-Gauge Bridge Configuration

SCC-SG01.. Quarter-bridge, 120 Ω

SCC-SG02.. Quarter-bridge, 350 Ω

SCC-SG03.. Half-bridge

SCC-SG04.. Full-bridge

Analog Input

Number of strain-gauge channels .... 2 differential

Input signal ranges .... ±100 mV (fixed gain of 100 on each channel)

Overvoltage protection........................... ±28 VDC powered on and powered off

Input impedance

Normal powered on .... 10 MΩ

Powered off or overload .... 10 kΩ

Bandwidth...................................... 1.6 kHz (single-pole RC filter)

Input noise..................................... 1 μV_{rms}

Transfer Characteristics

Gain.. 100

Gain error .... ±0.8% of reading max[1]

Gain-error temperature coefficient......... ±5 ppm/°C[2]

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[1] Temperature range is 23 °C ±5 °C.

[2] Temperature range is 0 to 50 °C.

Offset error ....±5 µV (post calibration)

Offset-error temperature coefficient.......±0.6 µV/°C[1]

Offset-nulling adjustment range ....±2.5 mV (RTI)

Nonlinearity ....10 ppm of full-scale range

Recommended warm-up time.................5 minutes

Amplifier Characteristics

Common-mode rejection ratio
(CMRR)..110 dB min

Output range ....±10 VDC max

Excitation

Number of channels................................1

Level ....+2.5 VDC, ±0.4%

Current drive..42 mA[2]

Drift ....13 mV/°C

Strain-Gauge Bridge Completions

Quarter-bridge ....One 120 Ω 1/4 W, 0.1%
tolerance, 10 ppm/°C
or
One 350 Ω 1/4 W, 0.1%
tolerance, 10 ppm/°C

Half-bridge...Two 10 kΩ, ±0.02% ratio
tolerance, ±2 ppm/°C tracking
temperature coefficient of
resistance resistors

Completion Accuracy

Half-bridge completion reference...........1.25 VDC, ±0.4%

---

[1] Temperature range is 0 to 50 °C.

[2] Excitation current drive assumes two full-bridge 120 Ω configurations.

Power Requirements

Analog power .... 143 mW max

    +15 VDC .... 4.75 mA max

    −15 VDC .... 4.75 mA max

Digital power .... 210 mW max

    +5 VDC .... 42 mA max

Operating voltage range

    +15 VDC .... ±10%

    −15 VDC .... ±10%

    +5 VDC .... ±5%

    REF5 VDC .... ±0.05%

SCC-SG24 Strain-Gauge Input Module

Analog Input

Number of strain-gauge channels .... 2 differential

Input signal ranges .... ±100 mV (fixed gain of 100 on each channel)

Strain-gauge bridge configuration .... Full-bridge

Overvoltage protection .... ±42 VDC powered on and powered off

Inputs protected .... <0,1>

Transfer Characteristics

Gain 100

Gain error .... ±0.20% of reading max

Offset error .... ±50 µV typ, 325 µV max before calibration[1]

Nonlinearity .... 200 ppm max of full-scale range

Bandwidth .... 1.6 kHz single-pole buffered RC filter

---

[1] By factory-default the nulling resistors are not installed in the SCC-SG24. Refer to the *Replacing Resistors* section for information on installing the nulling resistors. To nullify the offset error values with trimming potentiometers located on the module, refer to the *Offset Nulling Adjustment* section or negate the values in your software application.

Amplifier Characteristics

Common-mode rejection ratio
(CMRR) ....110 dB min

Output range ....±10 VDC max

Input impedance

    Common mode ....5 MΩ

    Differential ....20 MΩ

    Powered off or overload ....>60 kΩ

    Input bias current ....±10 nA max

    Input offset current ....±10 nA max

Dynamic

Input noise, 0.1 to 10 Hz.........................0.4 μV_{rms}, 2.5 μV pp

Input noise ....3 μV_{rms}, 25 μV pp

Stability

Recommended warm-up time.................5 minutes

Gain drift...10 ppm/°C max [1]

Offset-error temperature coefficient ....4 μV/°C max [1]

Null Compensation

Range ....±0.29% of excitation range,
        ±29 mV, or
        2,900 $\mu\varepsilon$ null compensation range

$$\varepsilon = \frac{\Delta V_{OUT}}{V_{EX} G_F} = 2,900\mu\varepsilon$$

where

    V_{OUT} is the output voltage range of 58 mV.

    V_{EX} is the excitation voltage of 10 VDC.

    G_F is 2.0.

---

[1] Temperature range is 0 to 50 °C.

Excitation

Number of channels 1

Level .... +10 VDC, ±0.05%

Current drive .... 60 mA[1]

Short circuit protection .... Yes

Temperature/drift .... 10 ppm/°C

Noise .... $0.5\ mV_{rms}$ typ

Power Requirements

Analog power .... 340 mW max

    +15 VDC .... 11.4 mA max

    −15 VDC .... 11.4 mA max

Digital power .... 930 mW max

    +5 VDC .... 186 mA max

Operating voltage range

    +15 VDC .... ±10%

    −15 VDC .... ±10%

    +5 VDC .... ±5%

SCC-SG11 Shunt Calibration Module

Digital I/O

Number of channels 1

Shunt Calibration

Number of channels 2

Resistor for each channel .... 301 kΩ ±1%, socketed

Resistor temperature coefficient .... ±100 ppm/°C

Max voltage across channel .... ±12 VDC

---

[1] Excitation current drive assumes two full-bridge 350 Ω configurations.

Power Requirements

Analog power ....0.1 mW max

    +15 VDC ....5 µA max

    –15 VDC.......................................5 µA max

Digital power ....25 µW

    +5 VDC ....5 µA max

Operating voltage range

    +15 VDC ....±10%

    –15 VDC.......................................±10%

    +5 VDC ....±5%

SCC-SGXX Strain-Gauge Input Modules

Maximum Working Voltage

Maximum working voltage refers to the signal voltage plus the common-mode voltage.

Channel-to-earth ....±12 VDC, Installation Category I

Module-to-module ....±12 VDC, Installation Category I

Channel-to-channel................................±12 VDC, Installation Category I

Physical

Dimensions ....8.89 by 2.92 by 1.85 cm
(3.50 by 1.15 by 0.73 in.)

Weight ....37 g

I/O connectors.......................................One 20-pin right-angle
male connector,
One 6-pin screw terminal

Screw terminal.......................................28 to 16 AWG

Resistor sockets

    Connecting lead size.......................0.023 to 0.026 in.

    Connecting lead length...................0.110 to 0.175 in.

    Lead spacing..................................0.500 in.

Environmental

Operating temperature .... 0 to 50 °C

Storage temperature .... –20 to 70 °C

Relative humidity .... 10 to 90% noncondensing

Maximum altitude .... 2,000 m

Pollution Degree (indoor use only) 2

Safety

This product 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 3111-1, UL 61010B-01
- CAN/CSA C22.2 No. 1010.1

Note For UL and other safety certifications, refer to the product label, or visit ni.com/hardref.nsf, 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, 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, visit `ni.com/hardref.nsf`, search by model number or product line, and click the appropriate link in the Certification column.

SCC-SG*XX* Module Pin Assignments

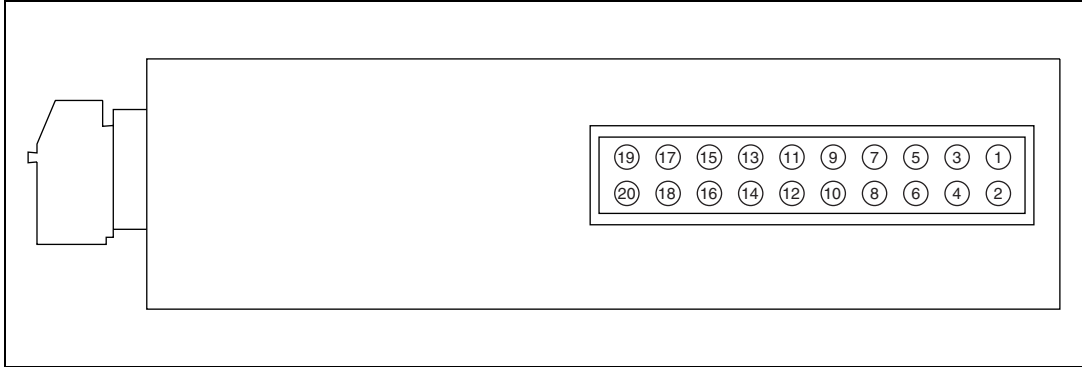Figure 31 shows the I/O connector pins on the bottom of the module.

Figure 31. SCC Module Bottom View

Table 5 lists the signal connection corresponding to each pin. ACH(*X*) and ACH(*X*+8) are the analog input signal channels of the E Series DAQ device. AIGND is the analog input ground signal and is the reference for ACH(*X*) and ACH(*X*+8). AGND is the reference for the ±15 V supplies and REF5V. AIGND and AGND connect to the SC-2345 at the SCC-PWR connector. GND is the reference for the +5 V supply.

Table 5. Pin Signal Connections for SCC-SG*XX*

Pin Number	SG*XX* Signal	SG11 Signal
1	DAQ device ACH(*X*)	—
2	—	—
3	—	—
4	DAQ device ACH(*X*+8)	—
5	—	—
6	DAQ device AIGND	—
7	—	DAQ device DIO(*X*)
8	—	—
9	+5 V	+5 V
10	GND	GND
11	AGND	AGND
12	REF5V	—
13	+15 V	+15 V
14	−15 V	−15 V
15	—	—
16	—	—
17	ACH(*X*)− (from first stage)	—
18	ACH(*X*+8)+ (from first stage)	—
19	ACH(*X*)+ (from first stage)	—
20	ACH(*X*+8)− (from first stage)	—

323098C-01   Sep03