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SCC Series Carrier and Components User Manual

Signal Conditioning Components for E Series Data Acquisition Devices

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Part Number 321331A-01

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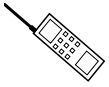
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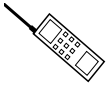
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This manual describes the electrical and mechanical aspects of the SC-2345 shielded carrier and the SCC Series components, and contains information concerning their operation, installation, and configuration.

The SC-2345 shielded carrier is supplied with one of the following power components:

- SCC-PWR01
- SCC-PWR02 and PS01 power supply
- SCC-PWR03

The SCC Series components include the following:

- SCC-A10 voltage attenuator (buffered)
- SCC-CI20 current input (buffered)
- SCC-TC thermocouple input
- SCC-FT01 feed through

Organization of This Manual

The *SCC Series Carrier and Components User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the SC-2345 shielded carrier and the SCC Series components, lists what you need to get started, and explains how to unpack your SC-2345 shielded carrier and SCC Series components.
- Chapter 2, *SCC-PWR Power Components*, describes the SCC-PWR power component options, how to select the correct SCC-PWR for your application, and important safety information.
- Chapter 3, *Connecting and Installing Your SCCs*, explains how to connect the SC-2345 shielded carrier to your E Series device, the configuration of your E Series device, the installation of the SCC Series components into the SC-2345 shielded carrier, the SCC

Series component signal installation, and the SC-2345 shielded carrier signal installation.

- Chapter 4, *SCCs*, describes signal conditioning components for the SC-2345.
- Appendix A, *Specifications*, lists the specifications of the SC-2345, power series components, and SCCs.
- Appendix B, *SCC Feature Reference Table*, provides a concise overview of the features of each SCC.
- Appendix C, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products.
- The *Glossary* contains an alphabetical list and description of the terms used in this manual, including acronyms, abbreviations, metric prefixes, mnemonics, and symbols.
- The *Index* alphabetically lists topics covered in this manual, including the page where you can find the topic.

Conventions Used in This Manual

The following conventions are used in this manual:

<>	Angle brackets containing numbers separated by an ellipsis represent a range of values associated with a bit or signal name (for example, DIO<3..0>).
	This icon to the left of bold italicized text denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.
	This icon to the left of bold italicized text denotes a note, which alerts you to important information.
bold italic	Bold italic text denotes a note, caution, or warning.
italic	Italic text denotes emphasis, a cross reference, or an introduction to a key concept.
SCC	SCC refers to an SCC Series signal conditioning component unless otherwise noted.

SCC-PWR	SCC-PWR refers to an SCC-PWR power component unless otherwise noted.
SCC-TC	SCC-TC refers to both the SCC-TC01 and the SCC-TC02 unless otherwise noted.

The *Glossary* lists abbreviations, acronyms, metric prefixes, mnemonics, symbols, and terms.

Related Documentation

Your E Series documentation contains information you may find helpful.

Customer Communication

National Instruments wants to receive your comments on our products and manuals. We are interested in the applications you develop with our products, and we want to help if you have problems with them. To make it easy for you to contact us, this manual contains comment and configuration forms for you to complete. These forms are in Appendix C, *Customer Communication*, at the end of this manual.

Chapter 1

Introduction

This chapter describes the SC-2345 shielded carrier and the SCC Series components, lists what you need to get started, and explains how to unpack your SC-2345 shielded carrier and SCC Series components.

About the SC-2345 and SCCs

The SC-2345 is a shielded carrier that connects I/O signals to 68-pin E Series devices. Combined with the SCC Series components, the SC-2345 offers easy-to-use signal conditioning options on a per channel basis. The SC-2345 provides 42 screw terminal connections to the E Series device digital signals. When used with the 68-pin E Series cable, the SC-2345 provides rugged, low-noise signal termination.

SCCs are signal conditioning components you use with a shielded carrier that connects to your 68-pin E Series device. You can use this combination of National Instruments devices for per-channel signal conditioning.

The SCCs provide voltage attenuation, current input, and thermocouple input to your E Series device. A feed through SCC allows direct connection to the analog input or analog output signals. You can customize this feed through SCC to meet your specific signal conditioning needs by adding your circuit design inside the feed through component.

What You Need to Get Started

To set up and use the SC-2345 and the SCCs, you need the following items:

- ❑ SC-2345 with one of the following
  - – SCC-PWR01
  - – SCC-PWR02 and the PS01 National Instruments supplied power supply
  - – SCC-PWR03 and a 7 to 42 VDC power supply
- ❑ One or more of the following SCCs:
  - – SCC-A10
  - – SCC-CI20
  - – SCC-TC
  - – SCC-FT01
- ❑ *SCC Series Carrier and Components User Manual*
- ❑ SC-2345 Quick Reference Label
- ❑ 68-pin E Series device and cable
- ❑ Flathead screwdriver (supplied)
- ❑ Phillips-head No. 1 and No. 2 screwdrivers
- ❑ Wire insulation strippers

Unpacking

Your shielded carrier is shipped in a cardboard box. The SCCs are shipped in antistatic packaging to prevent electrostatic damage to the components. Electrostatic discharge can damage several components on these products. To avoid such damage when you handle the products, take the following precautions:

- Ground yourself by using a grounding strap or by touching a grounded object.
- Touch the antistatic package to a metal part of your computer chassis before removing the components from the packaging.

- Remove the components from the packaging and inspect the components for any sign of damage. Notify National Instruments if the components appear damaged in any way. *Do not* install a damaged component into your system.
- *Never* touch the exposed pins of connectors.

SCC-PWR Power Components

Chapter 2

This chapter describes the SCC-PWR power component options, how to select the correct SCC-PWR for your application, and important safety information.

The SCC-PWR power components are a required part of the SC-2345 system. Your SC-2345 has one of three SCC-PWR power components installed in power socket J21, unless it is unnecessary for your application. The power component options are: SCC-PWR01, SCC-PWR02, and SCC-PWR03.

Each power component supplies digital power (+5 V) and analog power (±15 V) to each SCC in the SC-2345. LEDs on the SC-2345 indicate whether +5 V, +15 V, or –15 V is applied. Use Table 2-1 to determine the SCC-PWR power component that best suits your needs.

Table 2-1. Power Component Usage

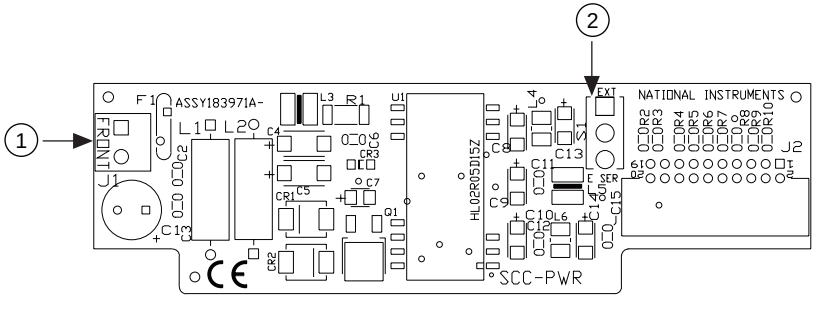
Power Component	Power Source	Usage Suggestions
SCC-PWR01	5 V from E Series device	Total P_A consumption ≤ 1.5 W *and* total of all SCC components power consumption within the limits of your E Series device
	5 V from external supply	Total P_A consumption ≤ 2 W *and* total of all SCC components power consumption exceeds the limits of your E Series device
P_A = analog power		

Table 2-1. Power Component Usage (Continued)

Power Component	Power Source	Usage Suggestions
SCC-PWR02	AC (5 V and ±15 V supplied by included PS01 DC adapter)	SCC-PWR01 is insufficient *or* SCC-PWR03 is insufficient
SCC-PWR03	7 to 42 V from external supply	Total P_A consumption ≤ 2 W *and* external supply is 7 to 42 V
P_A = analog power		

To change your SC-2345 SCC-PWR power component, unplug the existing SCC-PWR power component and plug in the new SCC-PWR power component.

Detailed specifications for all SCC-PWRs are in Appendix A, *Specifications*. Figure 2-1 shows the SCC-PWR component parts locator diagram.



1 J1 2 Switch S1

Figure 2-1. SCC-PWR Parts Locator Diagram

Safety Information

The following cautions contain important safety information concerning hazardous voltages and terminal blocks.

Caution: ***DO NOT OPERATE THE DEVICE IN AN EXPLOSIVE ATMOSPHERE OR WHERE THERE MAY BE FLAMMABLE GASES OR FUMES.***

KEEP AWAY FROM LIVE CIRCUITS. Do not remove equipment covers or shields unless you are trained to do so. If signal wires are connected to the device, hazardous voltages may exist even when the equipment is turned off. To avoid a shock hazard, do not perform procedures involving cover or shield removal unless you are qualified to do so and disconnect all field power prior to removing covers or shields.

Equipment described in this document must be used in an Installation Category II environment per IEC 664. This category requires local level supply mains-connected installation.

Do not operate this equipment in a manner that contradicts the information specified in this document. Misuse of this equipment could result in a shock hazard

Connections, including power signals to ground and vice versa, that exceed any of the maximum signal ratings on the device can create a shock or fire hazard or can damage any or all of the boards connected to the host computer and the device. National Instruments is NOT LIABLE FOR ANY DAMAGES OR INJURIES resulting from incorrect signal connections.

Connect the signal wires to the screw terminals by fully inserting the stripped end of the wire into the terminals. Tighten the terminals to a torque of 5 to 7 in./lb.

Clean devices and terminal blocks by brushing off light dust with a soft nonmetallic brush. Remove other contaminants with deionized water and a stiff nonmetallic brush. The unit must be completely dry and free from contaminants before returning to service.

The chassis ground terminal on your SC-2345 and the EMI gasket attached to the strain-relief of the SC-2345 are for grounding high-impedance sources such as a floating source (1 mA maximum). Do not use these terminals as safety earth grounds.

High voltages are voltages greater than or equal to 30 V_{rms} and 42.4 V_{peak}, or 60 VDC in normal conditions and are deemed to be a shock hazard.

SCC-PWR01

The SCC-PWR01 converts +5 V to ±15 V, which is the analog power supply used by the SCCs. Set switch S1 on the SCC-PWR01 to select the source of the +5 V as either *external* or from the *E Series* device. If you select E Series, the SCC-PWR01 uses +5 V from your E Series device. If you select *external*, you must connect a +5 V supply to the screw terminals of J1 on the SCC. Each screw terminal is labeled +5V or GND and should be wired accordingly. See Table 2-2 for usage information for your type of E Series device.

Table 2-2. SCC-PWR01 Power Usage Guide

Power Source or Device	Power Available or Required	Supported Configurations
AT/PCI E Series	2.4 W available	Up to 12 low-power SCCs *or* [P_A required ≤ 1.5 W *and* P_D required ≤ 2.4 W – (P_A / 62%)]
DAQCard E Series	1.14 W available	Up to 6 low-power SCCs *or* [P_A required ≤ 0.72 W *and* P_D required ≤ 1.14 W – (P_A / 62%)]

P_A = total analog power
P_D = total digital power
When P_A exceeds the above limits, you must use SCC-PWR02

NOTE: The efficiency of the +5 V to analog power converter used on the SCC-PWR01 is 62%. The power available is based on the +5 V fuse rating of the E Series device.

Table 2-2. SCC-PWR01 Power Usage Guide (Continued)

Power Source or Device	Power Available or Required	Supported Configurations
DAQPad E Series	1.25 W	Up to 6 low-power SCCs *or* [P_A required ≤ 0.77 W *and* P_D required ≤ 1.16 W – (P_A x 1.6)]
External +5 V	Power required = (P_A / 62%) + P_D	Up to 16 low-power SCCs *or* total P_A required ≤ 2 W

P_A = total analog power
P_D = total digital power
When P_A exceeds the above limits, you must use SCC-PWR02

NOTE: The efficiency of the +5 V to analog power converter used on the SCC-PWR01 is 62%. The power available is based on the +5 V fuse rating of the E Series device.

SCC-PWR02

The SCC-PWR02 is a two-part system containing a desktop power supply (PS01) and a filtering component (SCC-PWR02). The PS01 is a 15 W switching supply powered by 90 to 264 VAC. Plug the six-position connector of the PS01 into connector J25 of the SC-2345. See Figure 3-2 for the location of connector J25. The SCC-PWR02 filtering component filters and passes on +5 V and ±15 V. The SCC-PWR02 provides sufficient power for most SC-2345 configurations. Please refer to Appendix A, *Specifications*, for details.

SCC-PWR03

The SCC-PWR03 converts an external voltage, of 7 to 42 VDC, to +5 V and ±15 V and requires an external DC power source. Attach your voltage source to the screw terminals of J1. Each screw terminal is labeled 7-42 V or GND and should be wired accordingly. You can power the SCC-PWR03 with any 7 to 42 VDC source such as a standard 12 V car battery.

The usage criteria for the SCC-PWR03 follows:

- The external power required is (total P_A required / 46.5%) + (total P_D / 75%)
- Supported configurations are as follows:
  - Up to 16 low-power SCCs, or
  - Total P_A required ≤ 2 W

☞ **Note:** ***On the SCC-PWR03, efficiency of the +5 V step-down converter is 75% and the efficiency of the +5 V to analog power converter is 62%.***

Connecting and Installing Your SCCs

Chapter 3

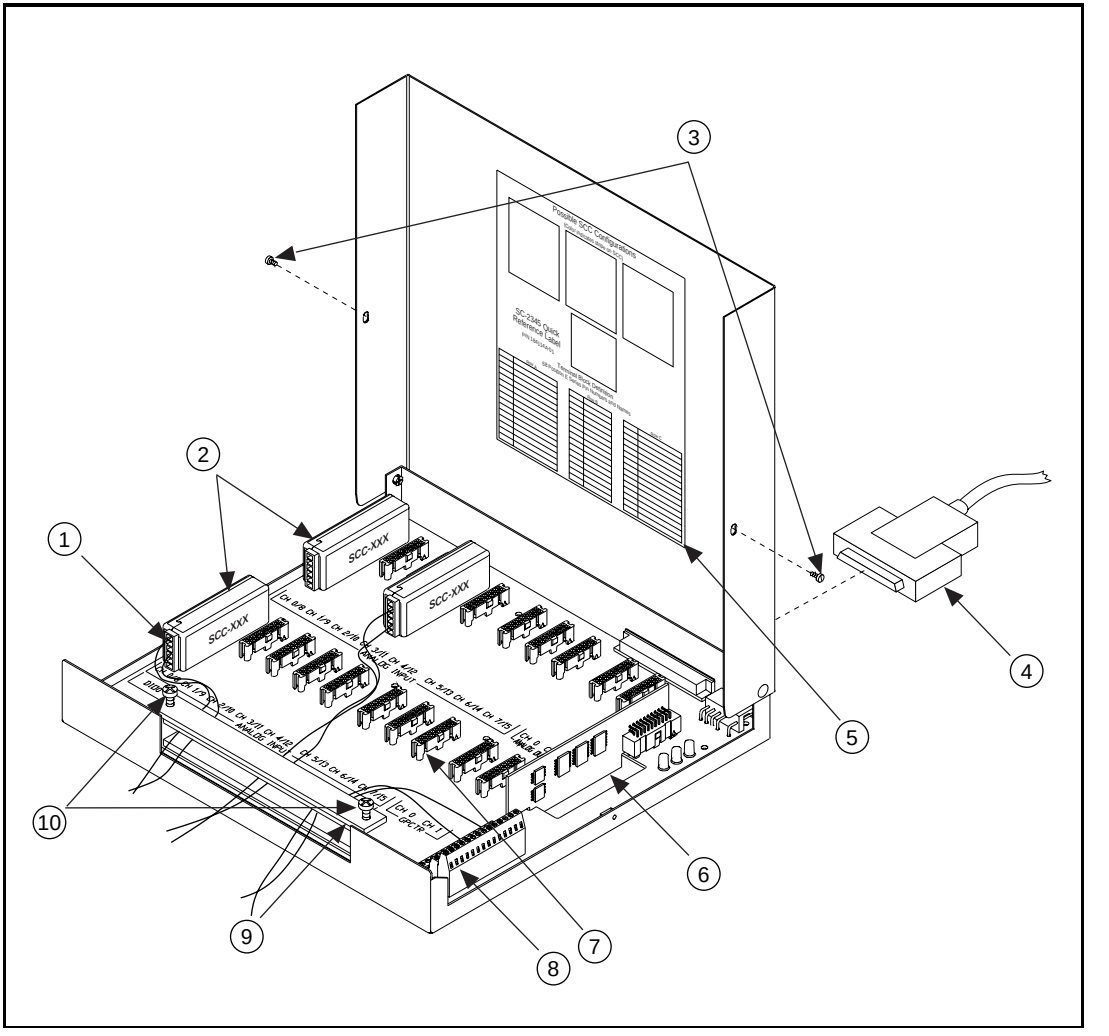
This chapter explains how to connect the SC-2345 shielded carrier to your E Series device, the configuration of your E Series device, the installation of the SCC Series components into the SC-2345 shielded carrier, the SCC Series component signal installation, and the SC-2345 shielded carrier signal installation.

Configuring Your E Series Device and Installing SCCs

Refer to Figure 3-1 as you perform the following to configure your E Series device and install your SCCs:

1. Configure your E Series device in nonreferenced single-ended (NRSE) analog input mode.
2. Connect the 68-pin cable to the SC-2345.
3. Remove the cover screws on either side of the top cover with a No. 1 Phillips-head screwdriver. Open the top cover.
4. Loosen the strain-relief screws with a No. 2 Phillips-head screwdriver and slide the signal wires through the strain-relief opening. If you are connecting multiple signals, you may need to remove the top strain-relief bar.
5. Plug SCCs into the appropriate SCC sockets. Refer to the *SC-2345 Configurations* section for proper SCC installation into the SC-2345.
6. Connect your signal wires to the SCC screw terminals and screw terminal block by stripping off 0.25 in. of insulation, inserting the wires into the screw terminals, and tightening the screws. For proper signal connection, refer to individual SCC Signal Connections sections in Chapter 4, *SCCs*.
7. Reinstall the strain-relief bar, if necessary, and tighten the strain-relief screws.
8. Close the top cover.
9. Reinsert the grounding screws to ensure proper shielding.

In high-vibration applications, you can insert a thin layer of foam between the SC-2345 top cover and the SCCs to prevent the SCCs from vibrating loose.



1	Screw Terminals	4	68-Pin Cable	7	SCC Socket	9	Top Strain-Relief Bar
2	SCCs	5	Quick Reference Label	8	Screw Terminal Block	10	Strain-Relief Screws
3	Cover Screws	6	SCC-PWR*xx*				

Figure 3-1. SC-2345 Module Assembly Parts Locator Diagram

The SC-2345 Quick Reference Label illustrates the possible configurations of the SCCs and defines the location of each signal on the terminal blocks. The numbers on the label correspond to the pin numbers on the 68-pin E Series connector. You can apply the self-adhesive Quick Reference Label to the inside cover of the SC-2345 as shown in Figure 3-1 or in another location that is convenient for your application.

SC-2345 Configurations

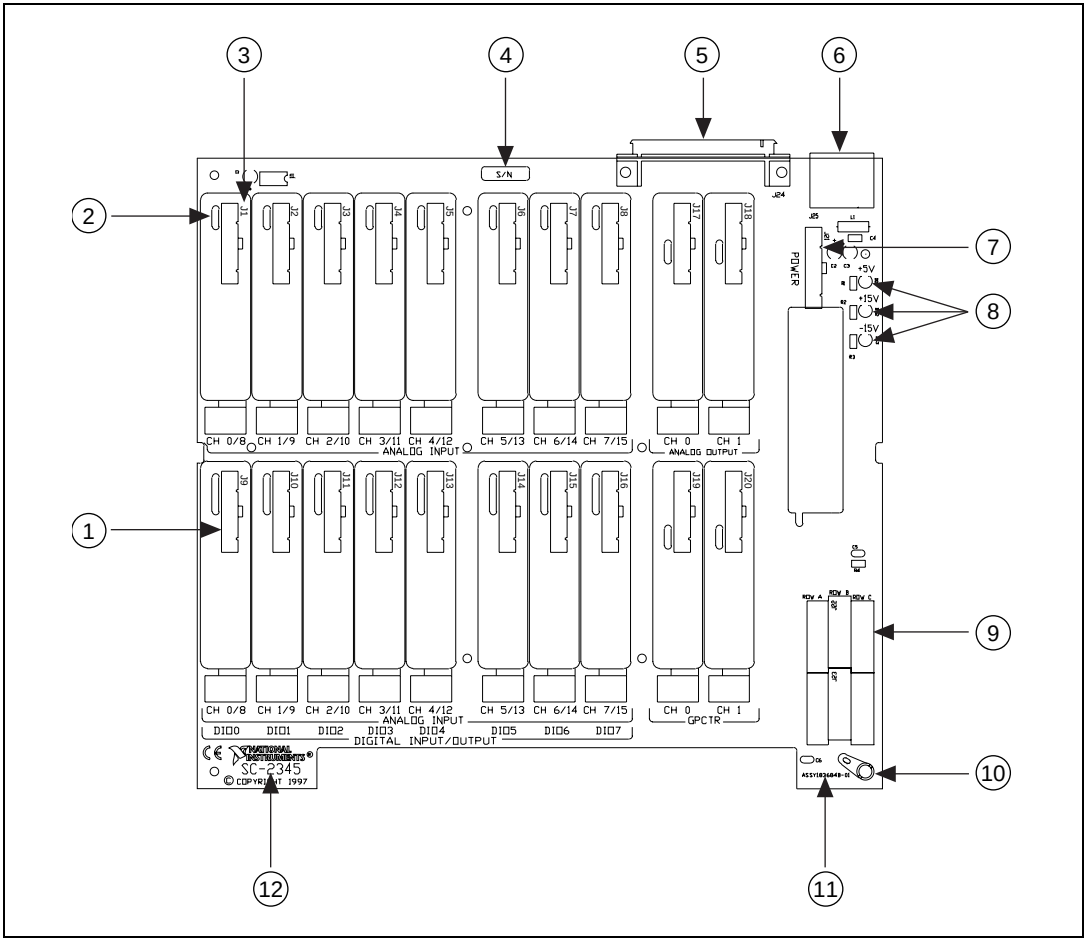
SCCs connect to the SC-2345 internal sockets to provide custom signal conditioning options for analog input, analog output, digital input/output (DIO), and general purpose counter/timers (GPCTR).

Sockets J1 through J8 and J9 through J16 provide analog input signal conditioning or connectivity. You can condition analog inputs on the SC-2345 in either single-stage or dual-stage configurations. In single-stage conditioning you use only one analog input SCC in each analog input signal path. When you use single-stage conditioning the analog input SCCs use sockets J1 through J8.

In dual-stage conditioning, each signal path uses two cascaded SCCs. The output of the first-stage (sockets J9 through J16) routes to the input of the second-stage (sockets J1 through J8) on the SC-2345 carrier. When using dual-stage conditioning of analog inputs, you wire your input signal to first-stage SCC (sockets J9 through J18). An example of dual-stage conditioning is a voltage attenuator SCC followed by a low-pass filter SCC. Cascading options will be useful as a wider variety of signal conditioning modules, such as different types of low-pass filters, become available.

You can use sockets J9 through J16 to access or condition the eight digital I/O lines of the E Series DAQ device.

Sockets J17 and J18 provide access to the analog output channels while J19 and J20 provide access to the GPCTR signals. See Figure 3-2 for SCC socket locations.



1	SCC Socket	5	J24	9	Screw Terminal Block
2	SCC Key Slot	6	J25	10	Grounding Terminal Lug
3	SCC Socket Reference Designator	7	J21	11	Assembly Number
4	Serial Number	8	Power LEDs	12	Product Name

Figure 3-2. SC-2345 Board Parts Locator Diagram

SCC Installation

The SCCs and sockets are keyed for proper orientation and are color-coded for easy connections. All SCCs have a color stripe across the top that indicates its function classification. The SCCs fit easily into the correct sockets when properly oriented. Never force an SCC into a

socket. Align the keyed, color-coded component to the appropriate socket on the SC-2345 and snap them together.

You can use all analog input SCCs in single-stage analog input configurations. You can use most analog input SCCs in dual-stage configurations by cascading your SCCs. Refer to Appendix B, *SCC Feature Reference Table*, to determine correct configurations of each SCC.

Figure 3-3 illustrates the possible configurations of the SCCs on the SC-2345, and shows the color code identification information. The figure shows a portion of the SC-2345 Quick Reference Label.

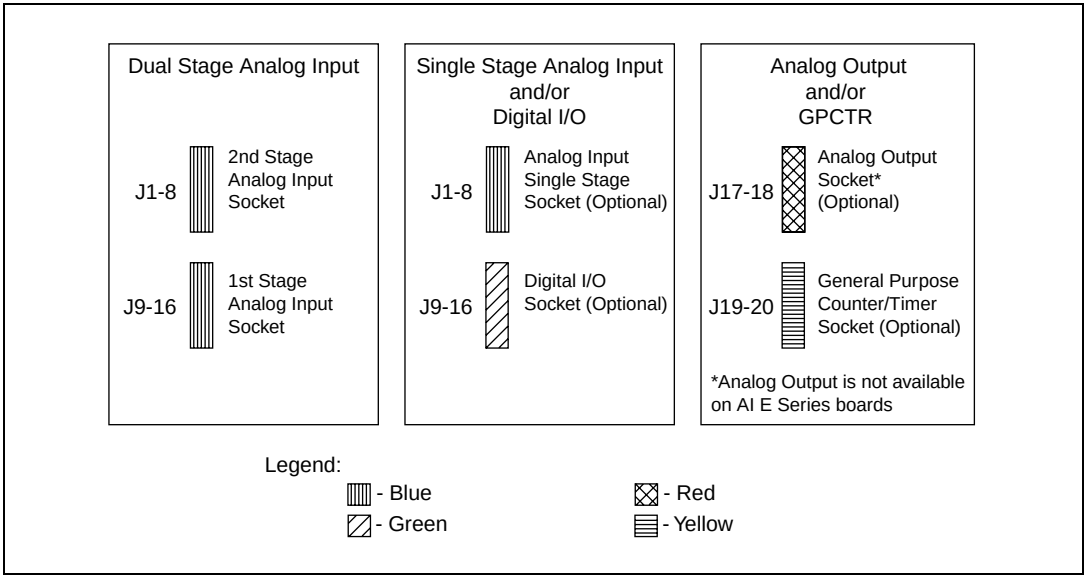


Figure 3-3. SCC Socket Configurations and Color Codes

You do not need to go through the SCCs to connect to the GPCTR and the DIO signals of the E Series device. GPCTR and DIO signals are accessible at the SC-2345 terminal block. See the *Terminal Block Signal Connections* section for details.

Analog Input SCCs

Each analog input SCC label has a blue stripe for easy identification. You can condition analog input signals in two ways: single-stage or dual-stage (cascading) conditioning.

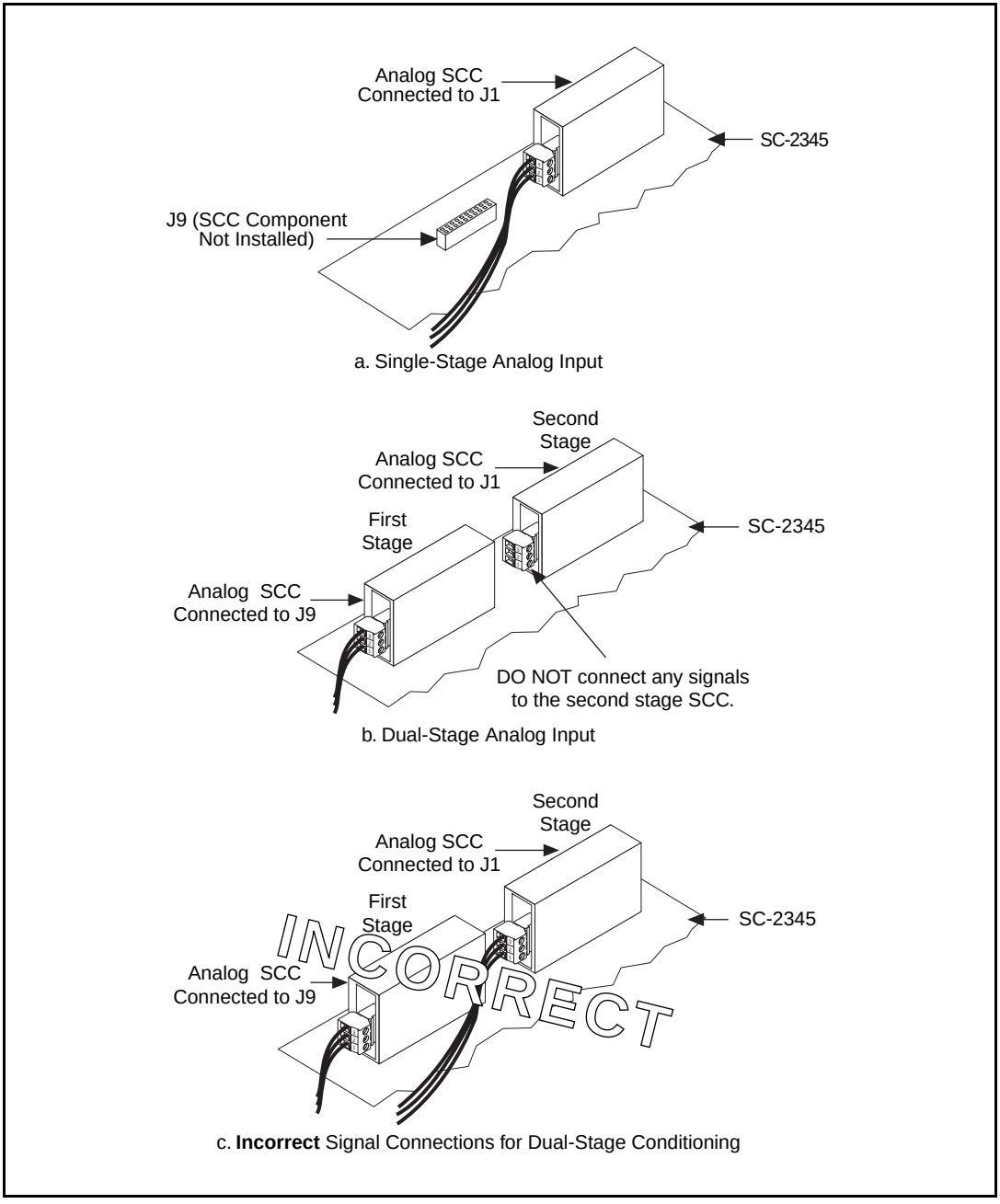


Figure 3-4. Single-Stage and Dual-Stage Analog Input SCC Configuration

For single-stage input conditioning plug your SCCs into sockets J1 to J8 and wire the SCC to your I/O signals, as illustrated in Figure 3-4a.

For dual-stage analog input conditioning, plug the first stage SCC into sockets J9 to J16 and plug the second stage SCC into sockets J1 to J8 as illustrated in Figure 3-4b. When using dual-stage analog input conditioning, wire the first-stage SCC to your I/O signals. For all SCCs listed in this manual, do not connect signals to the second-stage SCC. The SC-2345 connects the output signals of the first-stage SCC to the input signals of the second-stage SCC. Figure 3-4c shows the *incorrect* configuration of dual-stage analog input conditioning. Do *not* configure your SCCs this way.

Sockets J9 to J16 are available for DIO conditioning or control, as illustrated in Figure 3-5. If you installed both an analog input SCC and a DIO SCC into the SC-2345, you must wire each SCC separately.

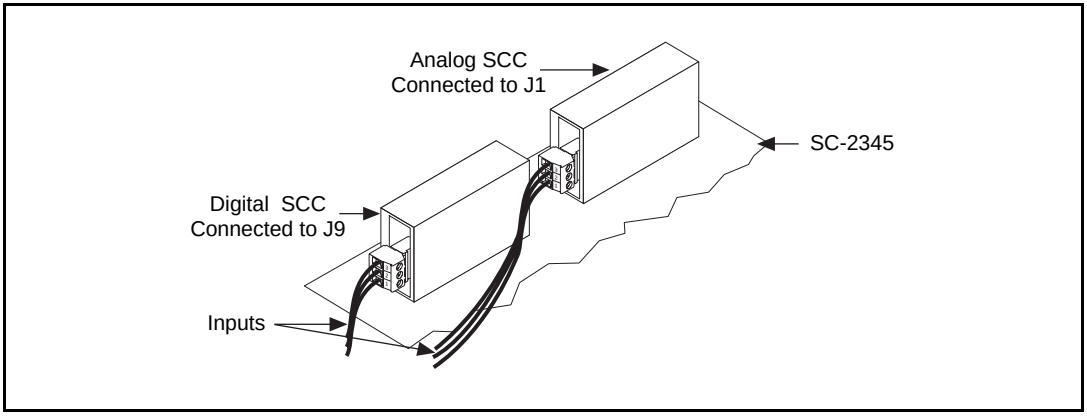


Figure 3-5. Single-Stage Analog Input and DIO SCC Configuration

DIO SCCs

Each DIO SCC label has a green stripe for easy identification. You can plug DIO SCCs into the SC-2345 using sockets J9 to J16.

Analog Output SCCs

Each analog output SCC label has a red stripe for easy identification. You can plug analog output SCCs into the SC-2345 using sockets J17 and J18. Each socket connects to both analog output channels of the E Series device although identified on the SC-2345 for either channel 0 or channel 1. These designations indicate the primary analog output

channel used by each socket. Analog output channel 0 is the primary channel for socket J17. Analog output channel 1 is the primary channel for socket J18.

GPCTR SCCs

Each GPCTR SCC label has yellow stripe for easy identification. You can plug GPCTR SCCs into the SC-2345 using sockets J19 and J20. Socket J19 connects to GPCTR channel 0. Socket J20 connects to GPCTR channel 1.

SCCs Signal Connections

After you install the SCCs, attach your signals to the screw terminals of the SCCs by passing the signal wires through the strain-relief bar. Each screw terminal of an SCC is labeled and should be wired accordingly. You can find individual details of signal descriptions and signal connections in Chapter 4, *SCCs*.

A metallized nylon knit electromagnetic interference (EMI) gasket is attached to the strain-relief bars of the SC-2345. If you use shielded cables for connecting your signals, this allows you to easily ground your shielded signal cables. Stripping the insulation away from the shield of your cables forms a chassis ground connection at the strain-relief.

Each SCC screw terminal is a two-part system, with a fixed receptacle and a removable screw terminal, as shown in Figure 3-6.

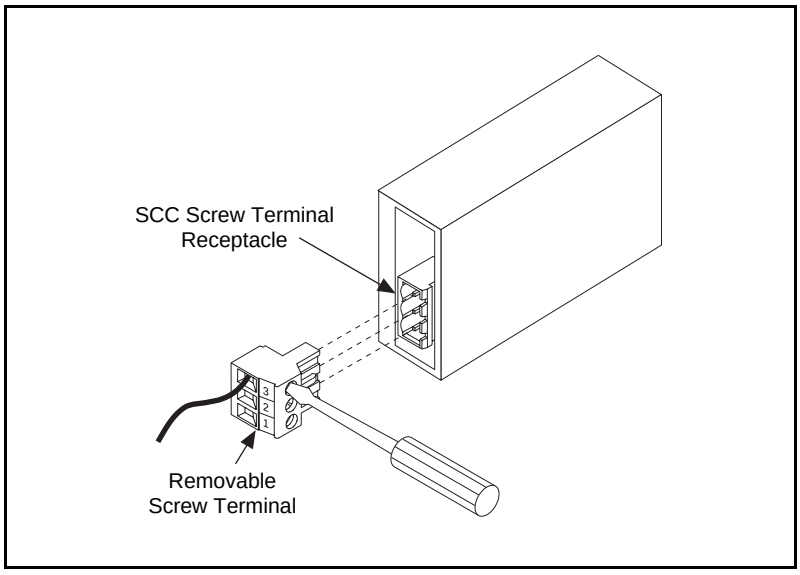


Figure 3-6. Two-Part Screw Terminal System

This two-part system simplifies the swapping of similar SCCs. For example, when using an SCC for filtering on an analog input channel, you can remove the screw terminal from the SCC and plug it into another filtering component with the same pin assignment and you do not need to rewire the screw terminal.

Depending on the component and its function, the two-part system has a different number of terminals and different size terminals. For safety, high-voltage input SCCs contain larger screw terminals and will not connect to a low-voltage input SCC screw terminal receptacles.

Terminal Block Signal Connections

The SC-2345 has a 42-position, triple-row screw terminal block, see Figure 3-1, for connection to the E Series digital signals. The terminal block provides connection to DIO <0..7>, +5 V, DGND, PFI <0..9>, GPCTR, AISENSE, FREQ_OUT, EXTSTROBE, and SCANCLK. The SC-2345 Quick Reference Label identifies the location of each signal on the terminal rows A to C. The terminal label numbers correspond to the pin number location of each signal on the 68-pin E Series connector. See your E Series device manual for more information about this connector.

Figure 3-7 shows the location of each signal on the terminal block.

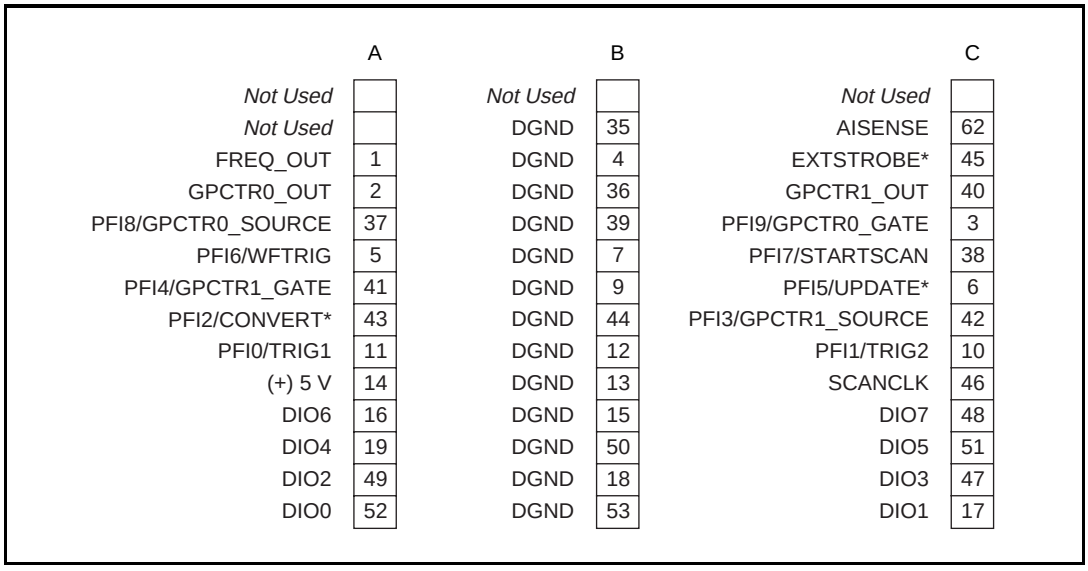


Figure 3-7. SC-2345 Terminal Block I/O Connector Pin Assignments

SCCs

Chapter 4

This chapter describes signal conditioning components for the SC-2345.

The SCC Series components include the following:

- SCC-A10 voltage attenuator (buffered)
- SCC-CI20 current input (buffered)
- SCC-TC01 and SCC-TC02 thermocouple input
- SCC-FT01 feed through

See Appendix B, *SCC Feature Reference Table*, to calculate power requirements for your SCCs.

SCC-A10 Voltage Attenuator Component (Buffered)

The SCC-A10 voltage attenuator accepts up to two voltage sources at a maximum of 100 V, attenuates each source by a factor of 10, and provides a differential measurement of the source. The input signals are buffered by a differential instrumentation amplifier that allows for maximum scan rates by the E Series device. The SCC-A10 contains circuitry capable of protecting E Series devices for input signals up to 250 V_{rms}.

A blue label stripe identifies the SCC-A10 as an analog input component. Figure 4-1 shows the icon that represents the SCC-A10.

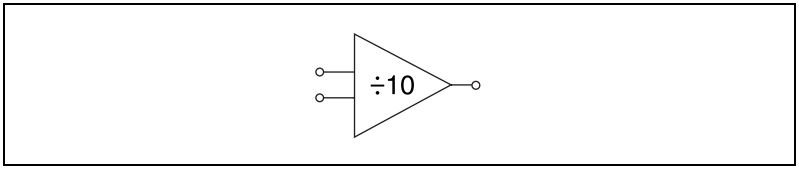


Figure 4-1. SCC-A10 Icon

You can plug the SCC-A10 into any analog input socket on the SC-2345, although the component cannot function as the second-stage of a dual-stage configuration.

Signal Connections

The SCC-A10 provides two differential analog input channels that are capable of measuring signals of up to 100 V. Pins 1 and 2 form a differential channel that is routed to E Series device channel *x*+8, where *x*+8 is channel 8 through 15 depending on the socket where you plug the SCC-A10. Pins 3 and 4 form the second differential channel that is routed to E Series device channel *x*, where *x* is channel 0 through 7 depending on the socket where you plug the SCC-A10.

Your signal source can be floating or ground-referenced. Floating signal sources do not require bias resistors to ground with the SCC-A10. The SCC-A10 design does not require high-impedance bias resistors for floating sources. Figure 4-2 shows the SCC-A10 signal connections.

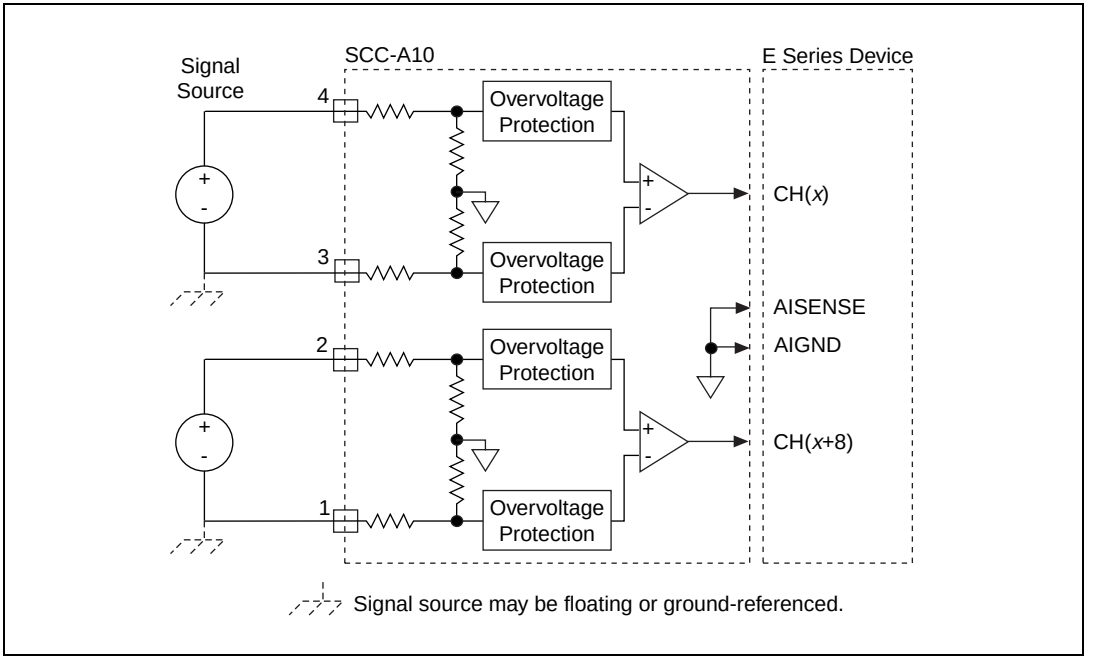


Figure 4-2. SCC-A10 Signal Connections

Measurement Scaling Considerations

In your software environment, the voltage reading you obtain from the E Series DAQ device may not account for the voltage scaling effect of the SCC-A10. If it does not, the voltage measurements from the E Series DAQ device is one-tenth of the voltage applied at the SCC-A10 input. In this case, you must multiply the voltage reading obtained from the E Series DAQ device by ten to obtain the correct input voltage.

SCC-CI20 Current Input Component (Buffered)

The SCC-CI20 accepts up to two current sources at a maximum of 20 mA. The SCC-CI20 converts the current to voltage using a precision 249 Ω resistor and provides a differential measurement of the source. The voltage is measured by the E Series device as a 0 to +5 V input signal. The input signals are buffered by a differential instrumentation amplifier that allows for maximum scan rates by the E Series device.

A blue label stripe identifies the SCC-CI20 as an analog input component. Figure 4-3 shows the icon that represents the SCC-CI20. You can plug the SCC-CI20 into any analog input socket.

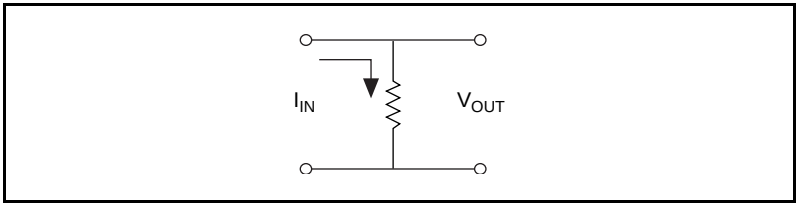


Figure 4-3. SCC-CI20 Icon

Signal Connections

The SCC-CI20 provides two differential analog input channels for 0 to 20 mA signals. Pins 1 and 2 form a differential channel that is routed to E Series device channel *x*+8, where *x+8* is channel 8 through 15 depending on the socket where you plug the SCC-CI20. Pins 3 and 4 form the second differential channel that is routed to E Series channel *x*, where *x* is channel 0 through 7 depending on the socket where you plug the SCC-CI20. Figure 4-4 shows the SCC-CI20 signal connections.

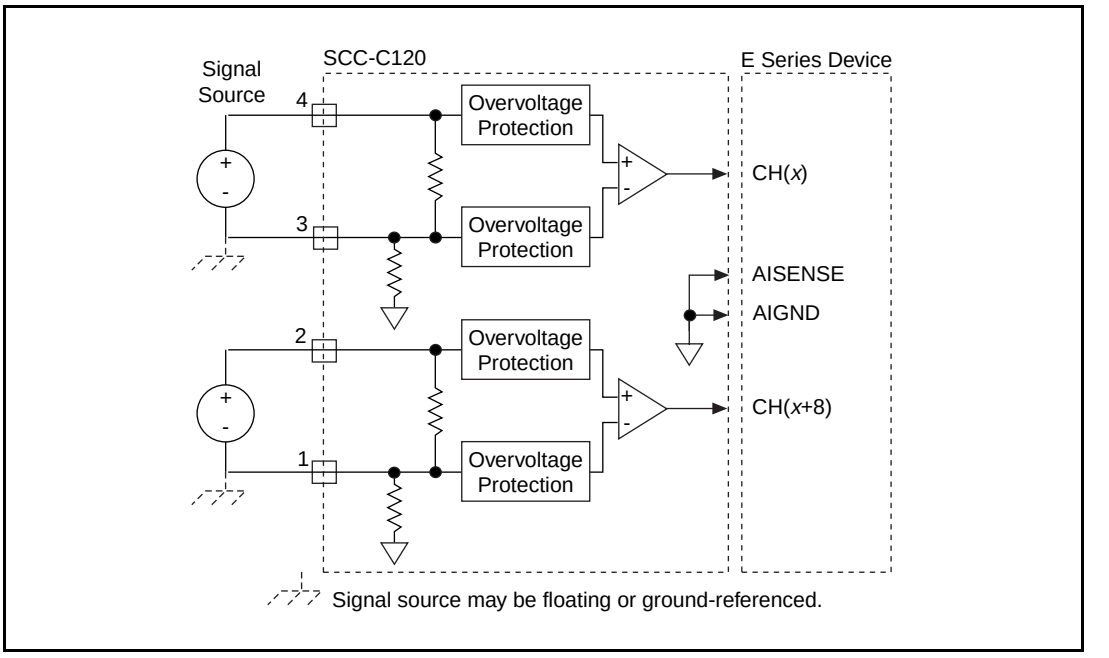


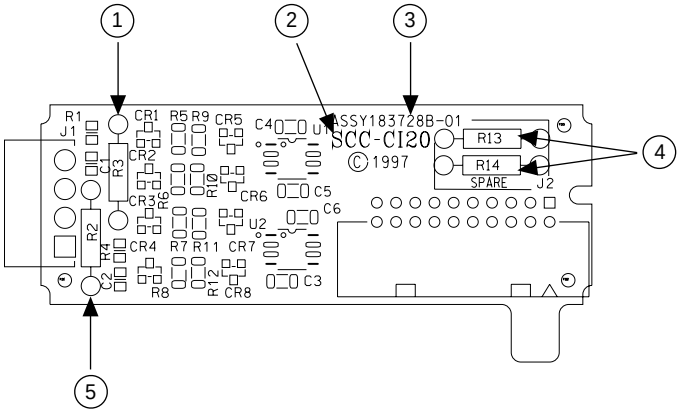
Figure 4-4. SCC-CI20 Signal Connection

Input Resistor Replacement

Your signal source can be floating or ground-referenced. Floating signal sources do not require bias resistors to ground with the SCC-CI20. The SCC-CI20 has high-impedance bias resistors typically required for floating sources. The input resistors are not protected from destruction caused by incorrect connections. Spare 249 Ω resistors are available inside the SCC-CI20. To open the SCC-CI20:

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.

The spare resistors are located, as illustrated in Figure 4-5. R2 and R3 are socketed for quick and easy replacement. Replace R2 and R3 with the spares when needed.



1	R3	3	Assembly Number	5	R2
2	Product Name	4	Spare Resistors		

Figure 4-5. SCC-CI20 Parts Locator Diagram

Measurement Conversion Considerations

Your software environment may only return voltage measurements from your E Series devices. In this case you must convert your voltage measurement to current measurement. To make this conversion use the following formula:

$$I = \frac{V}{0.249}$$

where I is milliamps and V is volts.

SCC-TC Thermocouple Input Components

The SCC-TC thermocouple input components, SCC-TC01 and SCC-TC02, accept input signals from B, E, J, K, N, R, S, and T type thermocouples. The thermocouple inputs are filtered and passed into a differential amplifier with a gain of 100. The output of the amplifier passes through a dual-pole 2 Hz filter and is buffered to allow maximum scan rates. The amplified thermocouple signal connects to an E Series device channel 0 through 8, depending on the SC-2345 socket where you plug the SCC-TC. Each SCC-TC contains thermistor circuitry powered by a 2.5 V reference for compensating cold-junction effects.

This thermistor output connects to any single-ended channel 8 through 15, depending on the socket where you plug the SCC-TC. Each SCC-TC can also detect open thermocouple circuits.

The SCC-TC01 contains a two-prong uncompensated thermocouple miniconnector that accepts any miniature or subminiature two-prong male thermocouple connector. The SCC-TC02 contains a three-position screw terminal connector that accepts 28 to 16 AWG thermocouple wires. This three-position screw terminal allows for a ground connection when using shielded thermocouples. Otherwise, the two components function identically.

The SCC-TC02, because of its screw terminal connections, can also function as a low-bandwidth, millivolt input component. Because of the gain of 100, the maximum input is ±100 mV. You can read this input voltage on any E Series device single-ended channel 0 through 7. Figure 4-6 shows the SCC-TC icon.

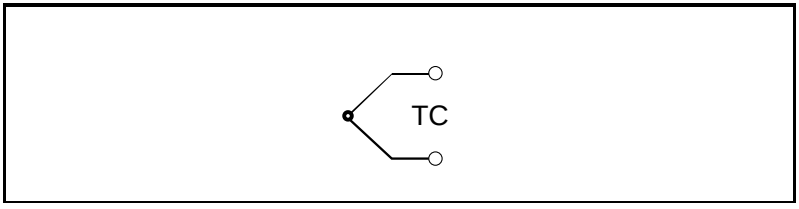


Figure 4-6. SCC-TC Icon

You can plug the SCC-TC thermocouple components into any single-stage analog input SCC socket.

Signal Connections

To use an SCC-TC01, plug your thermocouple miniconnector into the SCC and install the component into the SC-2345.

To use an SCC-TC02, attach your signal wires to the onboard screw terminals and install the SCC into the SC-2345. Each screw terminal component is labeled; connect the wires accordingly. The SCC-TC02 accepts up to three signals: TC+, TC-, GND. The GND terminal connects to AIGND on the E Series device and is available if you use a shielded thermocouple.

The SCC-TC has a 10 MΩ bias resistor connected from the negative thermocouple input to ground. This resistor allows your thermocouple

to be ground-referenced or floating without first having to add bias resistors.

The amplified thermocouple and the cold-junction sensor signals are measured by the E Series device channel *x* and channel *x*+8 respectively, where *x* is 0 through 7 and *x*+8 is 8 through 15 depending on the SC-2345 socket used. See Figure 4-7 for SCC-TC signal connections.

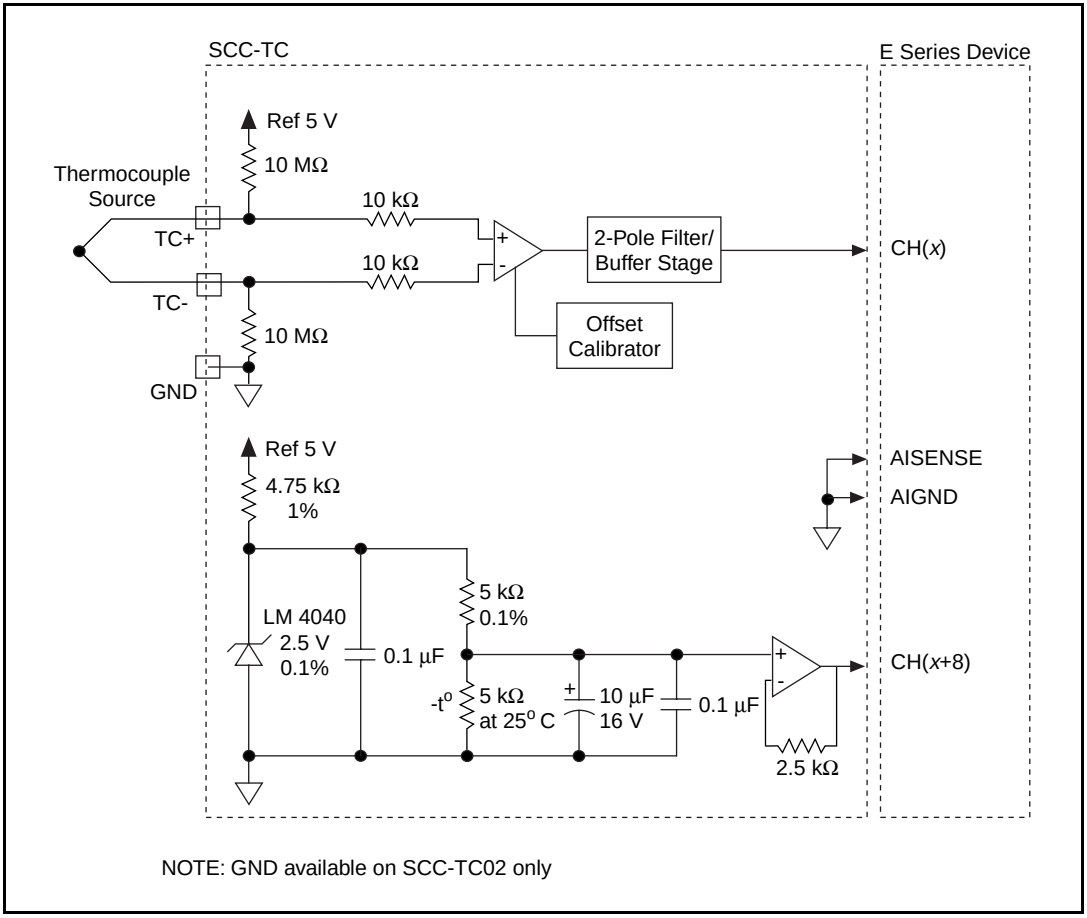


Figure 4-7. SCC-TC Signal Connection

Cold-Junction Sensor Output and Accuracy

The cold-junction sensor voltage output varies from 1.91 to 0.58 V over a 0° to 55 °C temperature range.

☞ **Note:** ***NI-DAQ includes thermistor conversion utilities that implement the equations listed below. Refer to your software documentation for more information on these utilities.***

You can use the following formulas to convert the cold-junction sensor voltage to cold-junction temperature:

$$T(°C) = T_K - 273.15$$

where T_K is the temperature in kelvin

$$T_K = \frac{1}{[a + b(\ln R_T) + c(\ln R_T)^3]}$$

$a = 1.295361 \times 10^{-3}$

$b = 2.343159 \times 10^{-4}$

$c = 1.018703 \times 10^{-7}$

R_T = resistance of the thermistor in ohms

$$R_T = 5,000\left(\frac{V_{TEMPOUT}}{2.5 - V_{TEMPOUT}}\right)$$

$V_{TEMPOUT}$ = output voltage of the cold-junction sensor

$$T(°F) = \frac{[T(°C)]9}{5} + 32$$

where T(°F) and T(°C) are the temperature readings in degrees Fahrenheit and Celsius, respectively.

☞ **Note:** ***$V_{TEMPOUT}$ varies from 1.91 V (at 0 °C) to 0.58 V (at 55 °C). For best resolution, use the maximum gain for this range on the analog input channel.***

For the cold-junction sensor measurement accuracy, refer to Appendix A, *Specifications*.

Open-Thermocouple Detection

The SCC-TC contains a 10 MΩ pull-up resistor that connects to +5 V to detect an open thermocouple. To determine if you have an open thermocouple, check whether the corresponding E Series channel is saturated. The pull-up and bias resistors saturate the channel by applying +2.5 V at the input of an open channel. This results in saturation to either the positive or negative rails of the E Series device (+9.99 V or –10 V).

Errors Due to Open-Thermocouple Detection Circuitry

The open-thermocouple detection circuitry can cause measurement errors. These errors are the results of common-mode voltage at the input of the SCC and current leakage into your signal leads. The 10 MΩ bias resistor in the SCC-TC causes this error to be negligible. With the 10 MΩ bias resistor connected to ground and the 10 MΩ pull-up resistor connected to +5 VDC, a current leakage of approximately 0.25 μA (5 V/20 MΩ) flows into the unbroken floating thermocouple. Long thermocouple leads result in larger voltage drops due to lead resistance.

For example, if you have a 24 AWG J-type thermocouple that is 20 ft long, a voltage drop of approximately 4.39 μV (0.878 Ω /double ft × 20 double ft × 0.25 μA) can develop in the thermocouple, which corresponds to an error of 0.09 °C.

With 10 MΩ pull-up and bias resistors, a common-mode voltage of +2.5 VDC develops if the thermocouple is floating. The common-mode rejection of the SCC-TC is sufficiently high, which results in the offset voltage being negligible in most applications.

If your application demands extremely high accuracy, you can eliminate these errors by calibrating your system. See the *Calibrating System Offsets* section in this chapter for more information.

Calibrating System Offsets

You can calibrate the SCC in-system using your E Series device. The following procedure requires a minimum 10 minute warm-up prior to calibration:

1. Select the desired channel and gain on the E Series device.
2. Short the inputs on the SCC screw terminals or miniplug.

3. While acquiring data on the selected channel, use a screwdriver to adjust the potentiometer protruding through the top of the SCC until you read 0 VDC.

This procedure calibrates the SCC-TC for minimum error at 0 °C. Alternatively, you can calibrate the SCC-TC for minimum errors at temperatures other than 0 °C using a thermocouple calibrator.

Calibrating Your System Using a Thermocouple Calibrator

To calibrate your system using a thermocouple calibrator, first make sure that the temperature of the thermocouple connections at both the SCC and the thermocouple calibrator are the same.

For best results, use thermocouple wire of the same length and type that you use in your thermocouple, as shown in Figure 4-8.

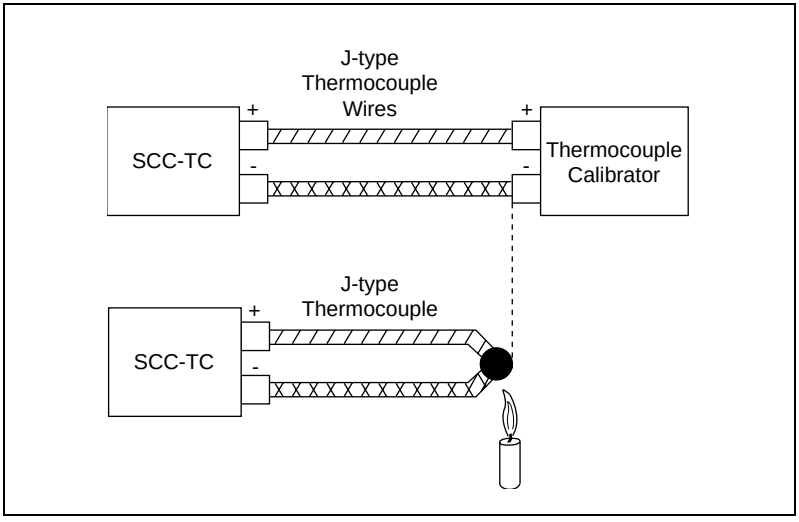


Figure 4-8. Thermocouple Calibration Configuration

Follow these steps to calibrate your system:

1. Connect the thermocouple wires from the thermocouple calibrator to the SCC.
2. Set the thermocouple calibrator to the required calibration temperature.

3. Measure the thermocouple temperature using the SCC.
4. Adjust the potentiometer on the top of the SCC so that the measured temperature is equal to the calibration temperature.

Measurement Conversion Considerations

☞ **Note:** ***NI-DAQ includes thermistor conversion utilities that implement the conversions required in steps three and five below. Refer to your software documentation for more information on these utilities.***

Your software environment may only return voltage measurements from your E Series devices. In this case you must convert your voltage measurement to a temperature measurement. To make this conversion perform the following steps:

1. Measure the thermocouple voltage by performing the following:
   a. Read the thermocouple channel on the E Series DAQ device $V_{eseries}$ [CH(*x*)].
   b. Calculate the thermocouple voltage by using the following formula:

$$V_{tc} = \frac{V_{eseries}}{100}$$

   where V_{tc} is thermocouple voltage and $V_{eseries}$ is E Series device voltage. This step provides proper scaling for the thermocouple amplifier in the SCC-TC
2. Measure the reference-junction (cold-junction) temperature by performing the following:
   a. Read the thermistor voltage [CH (*x*+8)]
   b. Convert the thermistor voltage to cold-junction temperature using the formula provided in the *Cold-Junction Sensor Output and Accuracy* section.
3. Calculate the cold-junction compensation voltage by converting the cold-junction temperature you obtained in step 2 to a thermocouple voltage. Use the polynomial expressions that are applicable to your thermocouple type.

4. Apply the cold-junction compensation to the thermocouple reading by adding the cold-junction compensation voltage obtained in step 3 to V_{tc}.
5. Calculate the thermocouple temperature by converting the voltage result you obtained in step 4 to a temperature. Use the polynomial expressions that are valid for your thermocouple type. This gives you a linearized temperature measurement.

☞ **Note:** ***Polynomials come from the NIST Monograph 175.***

SCC-FT01 Feed Through Component

The SCC-FT01 is a feed through component that offers direct connection to analog input or analog output channels. You can modify the SCC-FT01 to create a custom signal conditioning component. The SCC-FT01 contains a breadboard area for custom conditioning and connection to both analog and digital signals on the E Series device. Figure 4-9 shows the SCC-FT01 icon.



Figure 4-9. SCC-FT01 Icon

You can plug the SCC-FT01, as shipped, into any analog input or analog output socket in the carrier. When used as a prototyping component, the SCC-FT01 plugs into any socket on the SC-2345 except the power socket.

⚠ **Caution:** ***If you plug the SCC-FT01 into any other type of SCC socket, you can damage the E Series device.***

To modify the SCC-FT01 to perform custom signal conditioning, see the *Customizing the SCC-FT01* section later in this chapter.

Signal Connections

After installing the SCC-FT01, attach your signal wires to the screw terminals of the SCC-FT01. Each screw terminal is labeled numerically and the label is identified with signal names. Connect the wires accordingly.

The SCC-FT01 accepts up to five signals: CH+, CH-, AIGND, AISENSE, and EXTREF. Table 4-1 shows the signals available if you plug the SCC-FT01 into analog input single-stage SCC socket J1 or analog output SCC socket J17.

Table 4-1. SCC-FT01 Signals

Screw Terminal Label	Analog Input Single-Stage SCC Socket J1	Analog Output SCC Socket J17
CH+	ACH0	DAC0 (DAC(A))
CH-	ACH8	AOGND0 (AOGND(A))
AIGND	AIGND	AIGND
AISENSE	AISENSE	DAC1 (DAC(B))
EXTREF	N/A	EXTREF

When you plug the SCC-FT01 into a single-stage analog input SCC socket, the following conditions are true:

- CH+ connects to the lower analog input channel number indicated (CH0 through CH7).
- CH- connects to the higher analog input channel number indicated. (CH8 through CH15).
- AIGND connects to analog input ground.
- AISENSE connects to AISENSE.
- EXTREF does not connect and should not be used.

Because the E Series device is configured in the NRSE analog input configuration, you must connect your source to single-ended channels on the SCC-FT01.

When you plug the SCC-FT01 into an analog output SCC socket, the following conditions are true:

- CH+ connects to the analog output channel number indicated.
- CH- connects to the analog output ground of the channel indicated.
- AIGND connects to analog input ground.

- AISENSE connects to the second analog output channel. Do *not* use this pin.
- EXTREF connects to EXTREF.

Customizing the SCC-FT01

You can customize the SCC-FT01 to connect to any of the analog input, analog output, DIO, or GPCTR signals of the E Series device. Once you customize your SCC-FT01, you can plug it into any SCC socket on the SC-2345 except the SCC power socket. The SCC-FT01 PWB contains 1 sq in. of prototyping breadboard area. This area accommodates as many as four 8-pin, dual- inline packages and other discrete components, such as resistors and capacitors.

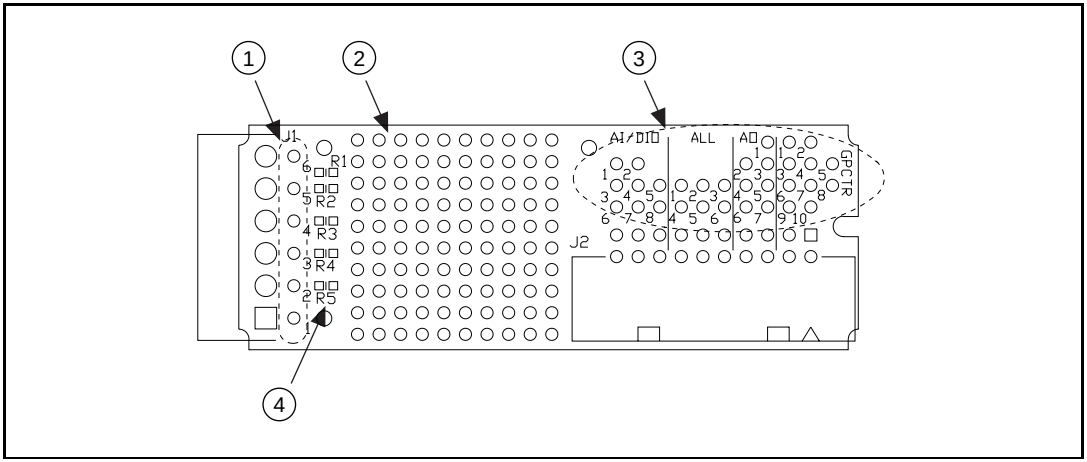
Place the SCC-FT01 prototyping component label, which is included in your kit, over the SCC-FT01 feed through component label on the SCC enclosure. This label does not contain signal names because you will be customizing the pin assignments of the screw terminals.

Circuit Design

You must disassemble the SCC-FT01 to install custom circuitry. To open the component:

1. Remove the screw from the back (wide unlabeled side).
2. Turn the front (wide label side) toward you.
3. Place the screw terminal receptacle on the left.
4. Slide the top cover to the right.
5. Lift off the cover.

You *must* remove resistors R1 through R5, shown in Figure 4-10, when you develop your circuitry.



1 I/O Pads 2 Prototyping Breadboard Area 3 Signal Connection Pads
4 R1 Through R5

Figure 4-10. SC-FT01 Parts Locator Diagram

The signal connection pads above connector J2 connect to different signals on the E Series device, depending on where you install the SCC-FT01 on the SC-2345. Table 4-2 shows the signals available for circuit design when you plug the SCC-FT01 into each type of SCC socket on the SC-2345. The pad numbers correspond to the number next to each pad on the SCC-FT01.

Table 4-2. Signals Available by SCC Socket Type

	Signal Name				
Pad Number	**AI/DIO**	**AO**	**ALL**	**GPCTR CH0**	**GPCTR CH1**
1	AISENSE	EXTREF	–15V	PFI8/ GPCTR0_SOURCE	PFI3/ GPCTR1_SOURCE
2	ACH+	DAC(B)	REF5V	PFI6/WFTRIG	EXTSTROBE*

† Available on final-stage analog input SCC sockets (J1 to J8) only
†† Available on DIO SCC sockets (J9 to J16) only
††† Not an AO signal name. Available on any analog input SCC socket J1 through J8

Table 4-2. Signals Available by SCC Socket Type (Continued)

	Signal Name				
Pad Number	**AI/DIO**	**AO**	**ALL**	**GPCTR CH0**	**GPCTR CH1**
3	AIGND	AOGND(B)	GND (+5V)	N/A	PFI1/TRIG2
4	PFI7/STARTSCAN† DIO(X) ††	AOGND(A)	+15V	FREQ_OUT	FREQ_OUT
5	ACH-	DAC(A) or ACH+ Cascaded REF†††	GND (15V and REF5V)	PFI5/UPDATE*	SCANCLK
6	ACH+ Cascaded†	PFI6/WFTRIG or ACH- Cascaded REF†††	+5V	DIO6	DIO7
7	ACH- Cascaded†	PFI5/UPDATE*	N/A	PFI0/TRIG1	PFI0/TRIG1
8	AISENSE Cascaded†	N/A	N/A	N/A	PFI7/STARTSCAN
9	N/A	N/A	N/A	PFI9/ GPCTR0_GATE	PFI4/ GPCTR1_GATE
10	N/A	N/A	N/A	GPCTR0_OUT	GPCTR1_OUT

† Available on final-stage analog input SCC sockets (J1 to J8) only
†† Available on DIO SCC sockets (J9 to J16) only
††† Not an AO signal name. Available on any analog input SCC socket J1 through J8

An SCC-FT01 signal connection label, which defines the pad numbers on the SCC-FT01 PWB, is attached to the cover of the SCC enclosure.

Whether you plug the SCC-FT01 into an SCC socket for analog input, analog output, DIO, or GPCTR conditioning, the pads listed under ALL in Table 4-2 are connected and can be used.

Wiring Considerations

The following sections contain signal wire considerations for the SCC-FT01 prototype circuit. The signal names in the following sections refer to the signals in Table 4-2.

☞ **Note:** ***When you plug the SCC-FT01 into the first-stage socket of dual-stage analog input SCC sockets on the SC-2345, you do not connect the outputs of your circuitry to the pads labeled*** *Cascaded****. Use pads labeled*** *Cascaded* ***only when you plug the SCC-FT01 into the second-stage (final-stage) socket to obtain your input signals through the SC-2345 from the first-stage socket. Refer to Figure 4-11a and Figure 4-11b***

Analog Input and Digital Input/Output

If you plug the SCC-FT01 into any analog input SCC socket J1 to J16 on the SC-2345, use the pads above connector J2 labeled AI/DIO for connections to the breadboard area. The signals available are slightly different when plugged into the first-stage analog input (also known as DIO) than when plugged into the second-stage analog input (also known as single-stage analog input). Use SCC sockets J9 to J16 for first-stage analog input. Use SCC sockets J1 to J8 for second-stage analog input.

PFI7/STARTSCAN, ACH+ Cascaded, ACH+ Cascaded REF, ACH- Cascaded, ACH- Cascaded REF, and AISENSE Cascaded signals are available for the second-stage analog input SCC sockets only. The DIO*x* signal is available for the first-stage analog input SCC sockets only. See Table 4-2 for pad definitions.

Remember, the E Series device is configured in the NRSE analog input configuration. This means you must design your prototype circuitry so that the output of the SCC-FT01 to the E Series device is single-ended referenced to AIGND.

Figure 4-11 illustrates example wiring for the SCC-FT01 prototyping component used in both single-stage analog input and dual-stage analog input configurations.

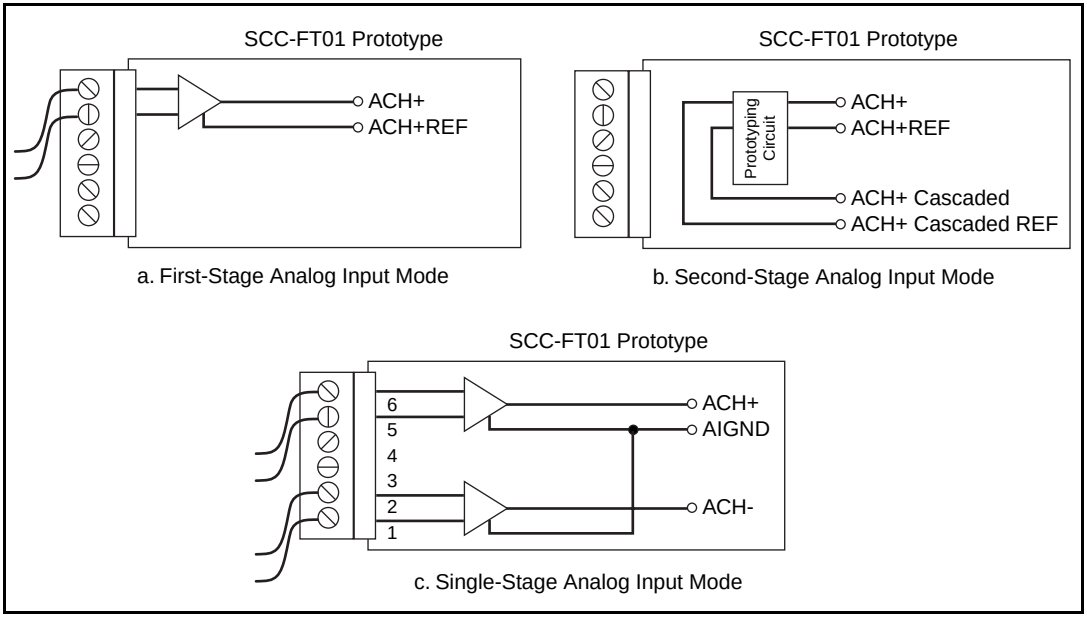


Figure 4-11. Analog Input Configurations

Analog Output

If you plug the SCC-FT01 into any analog output socket on the SC-2345, use the pads listed under AO in Table 4-2. DAC(A), AOGND(A), DAC(B), and AOGND(B) signals are determined by which SCC socket on the SC-2345 you use. For example, if you plug the SCC-FT01 into the analog output CH0 socket (J17), the DAC(A) and AOGND(A) pads connect to DAC0 and AOGND0, while the DAC(B) and AOGND(B) pads connect to DAC1 and AOGND1, respectively, on the E Series device.

GPCTR

If you plug the SCC-FT01 into any GPCTR socket on the SC-2345, use the pads listed under GPCTR CH0 and GPCTR CH1in Table 4-2. The signals available depend on which SCC socket on the SC-2345 you use. If you plug the SCC-FT01 into the GPCTR CH0 socket (J19), the pads under GPCTR CH0 connect to signals associated with GPCTR channel 0 and analog output of the E Series device. When the SCC-FT01 is plugged into the GPCTR CH1 socket (J20), the pads under GPCTR CH1 connect to signals associated with GPCTR channel 1and analog input of the E Series device.

Screw Terminal Connection

The pads next to connector J1 connect to each pin of the screw terminal connector. Use these pads to connect your external signals to the circuitry you added in the breadboard area. The numbers next to each hole correspond to the numbers on the screw terminals. Space is available on the SCC-FT01 prototyping component label for custom signal names.

Appendix A

Specifications

This section lists the specifications of the SC-2345, power series components, and SCCs. These ratings are typical at 25° C unless otherwise stated.

SC-2345

Analog

I/O connections.....16, 20-pin connectors for analog input
2, 20-pin connectors for analog output
1, 20-pin connector for external power

Number of input channels.....16 SE

Number of output channels.....2

Stability

Onboard calibration reference

Level.....5.000 V ±2.5 mV

Temperature coefficient.....±5 ppm/°C max

Long-term stability.....±15 ppm/$\sqrt{1,000\ h}$

Load regulation

Sourcing $0 < I_{OUT} < 10$ mA...100 µV/mA

Sinking $-10 < I_{OUT} < 0$ mA...400 µV/mA

Power Requirement

+15 VDC.....2 mA (0.03 W)[1]

Digital

I/O connections	8, 20-pin connectors for DIO (shared with analog input), 42-position, triple-row terminal block

Physical

Dimensions	24.1 D by 26.2 W by 3.937 H cm (9.5 D by 10.3 W by 1.55 H in.)
I/O connectors	1, 68-pin male SCSI connector 1, 6-pin male connector

Environment

Operating temperature	0° to 70° C
Storage temperature	–55° to 125° C
Relative humidity	5% to 90% noncondensing

SCC-Power Series Components

SCC-PWR01

Input

DC input voltage.....+5 VDC ±5% (from an external power source)
or
+5 VDC from an E Series DAQ device

DC input power .....750 mW without SCC

Output

	Nominal Voltage		
	+5 VDC	**+15 VDC**	**–15 VDC**
Voltage Range	+4.4 to +5.25 VDC	+14.20 to +15.25 VDC	–14.20 to –15.25 VDC
Max power available, Power source:			
AT/PCI E Series device	1.75 W (390 mA)[a]	0.75 W (50 mA)[a]	0.75 W (50 mA)[a]
DAQCard/ DAQPad E Series device	0.5 W (100 mA)[b]	0.36 W (24 mA)[b]	0.36 W (24 mA)[b]
External power	Dependent on source	1 W (67 mA)	1 W (67 mA)
Efficiency	100%	62%	62%

[a] The SCC-PWR01 should only be used with an SH6868 shielded cable that is ≤ 2 m long. This is due to increased cable impedance in longer cables. To guarantee 4.5 V at the SCC-PWR01 input, limit current draw from the E Series device to 540 mA max.
Combined max power = $[(P_A / 62\%) + P_D] \leq 2.4$ W

[b] Combined max power = $[(P_A / 62\%) + P_D] \leq 1.14$ W

P_A = total analog power
P_D = total digital power

	Nominal Voltage		
	+5 VDC	**+15 VDC**	**–15 VDC**
Line regulation	System dependent	±0.5% typ	±0.5% typ
Load regulation	System dependent	±0.1% typ	±0.1% typ
Ripple and noise Bandwidth = DC to 10 MHz	System dependent	15 mV_{rms} typ	20 mV_{rms} typ

[a] The SCC-PWR01 should only be used with an SH6868 shielded cable that is ≤ 2 m long. This is due to increased cable impedance in longer cables. To guarantee 4.5 V at the SCC-PWR01 input, limit current draw from the E Series device to 540 mA max.
Combined max power = $[(P_A / 62\%) + P_D] \leq 2.4$ W

[b] Combined max power = $[(P_A / 62\%) + P_D] \leq 1.14$ W

P_A = total analog power
P_D = total digital power

Physical

Screw terminal ..... 24 to 16 AWG

SCC-PWR02

Input

AC input voltage ..... 90 to 264 VAC

AC input frequency ..... 47 to 63 Hz

AC input current ..... 1.0 A max

In-rush current (at cold start)..... 30 A max

Output

	Output Voltage		
	+5 VDC	**+15 VDC**	**–15 VDC**
Voltage range	+4.64 to +5.25 VDC	+14.45 to +15.25 VDC	–14.45 to –15.25 VDC
Max power available	5 W (1.0 A)	4.5 W (0.3 A)	4.5 W (0.3 A)
Line regulation	±1%	±5%	±5%
Load regulation	±5%	±10%	±10%
Ripple and noise Bandwidth = DC to 10 MHz	20 mV_{rms} typ	20 mV_{rms} typ	20 mV_{rms} typ

Overall Performance

Max output .....14 W

Efficiency .....65% typ

Switching frequency .....50 kHz nominal

Other Features

Short circuit protection .....Yes

Overvoltage protection.....343 VAC

Dimensions of the external supply .....15.5 L by 8.5 W by 4.8 H cm (6.1 L by 3.3 W by 1.9H in.)

Environment for External Supply

Operating temperature .....0° to 40° C

Storage temperature .....–20° to 80° C

Relative humidity .....0% to 90% noncondensing

SCC-PWR03

Input

DC input voltage ..... 7 to 42 VDC

DC input current ..... 0.25 A min (dependent on SCCs installed)

Output

	Output Voltage		
	+5 V ±5%	**+15 VDC ±5%**	**–15 VDC ±5%**
Max power available	†	1 W (67 mA)	1 W (67 mA)
Efficiency	75%††	46%†††	46%†††
Line regulation	±1%	±5%	±5%
Load regulation	±5%	±10%	±10%
Ripple and noise Bandwidth = DC to 10 MHz	†	20 mV_{rms} typ	20 mV_{rms} typ

† depends on user supply
†† relative to input voltage
††† after +5 V efficiency

Physical

Screw terminal ..... 24 to 16 AWG

SCC-A10 Buffered Voltage Attenuator

Analog Input

Number of input channels .....2 DIFF

Input range.....±100 VDC
each input should remain within ±100 V of ground

Input impedance .....1 MΩ (powered on or off)

Overvoltage protection.....Up to 250 VDC/AC

Gain error .....±0.14% max[2]

Gain stability .....±0.006%/°C max[3]

Offset error (referred to input) .....±6.5 mV max[3]

Stability (referred to input) .....±80 µV/°C max[3]

Nonlinearity.....±0.004%

Common mode rejection ratio.....60 dB min at 60 Hz

Dynamic Response

Bandwidth (–3dB, amplitude ≤1 V) ....1 MHz

Output slew rate.....0.75 V/µs min

Power Requirement

Analog power .....100 mW max[3]
+15 V .....3.2 mA max
–15 V .....3.2 mA max

Digital power.....+5 V 0.0 mA

Physical

Dimensions	8.89 L by 2.92 H by 1.85 D cm (3.5 L by 1.15 H by 0.73 D in.)
I/O connectors	1, 20-pin right-angle male connector 1, 4-pin screw terminal system
Screw terminal	24 to 12 AWG

Environment

Operating temperature	0° to 50° C
Storage temperature	–55° to 125° C
Relative humidity	5% to 90% noncondensing

SCC-CI20 Buffered Current Input

Analog Input

Number of input channels .....2 DIFF

Input range.....0 to 20 mA

Input resistor

- Value.....249 Ω
- Tolerance 0.05%
- TCR .....10 ppm/° C
- Max power dissipation .....0.25 W

Absolute maximum input current.....32 mA

Absolute maximum voltage
on CH+ and CH- .....±15 V

Output range .....0 to +5 V

Output slew rate.....0.75 V/µs min

Gain error .....0.1% max[2]

Gain stability .....±0.006%/°C max[3]

Offset error .....±0.6 mV max[2]

Offset stability .....±21 µV/°C max[3]

Power Requirement

Analog power .....100 mW max

- (+15 V.....3.2 mA max[3])
- (–15 V.....3.2 mA max[3])

Digital power.....0.0 mW

- 5 V ..... 0.0 mA

Physical

Dimensions	8.89 L by 2.92 H by 1.85 D cm (3.50 L by 1.15 H by 0.73 D in.)
I/O connectors	1, 20-pin right-angle male connector 1, 4-pin screw terminal system
Screw terminal	28 to 16 AWG

Environment

Operating temperature	0° to 50° C
Storage temperature	–55° to 125° C
Relative humidity	5% to 90% noncondensing

SCC-TC01/02 Thermocouple

Analog Input

Number of thermocouple input channels.....1 DIFF

Input signals .....Thermocouples of types B, E, J, K, N, R, S, and T

Input signal range .....±100 mV

Max working voltage (signal + common mode) .....Each input should remain within ±12 V of chassis ground

Input damage level.....60 VAC/DC[4]

Input impedance .....10 MΩ powered on
10 kΩ powered off or overload

Bandwidth .....2 Hz

Amplifier Characteristics

Input bias current.....5 nA max[2]

Input offset current .....5 nA max[2]

Common-mode rejection ratio.....110 dB min[2]

Output range .....±10 V max[2]

Transfer Characteristics

Gain.....100

Gain error .....±0.08% max[2]

Gain stability .....±0.0005%/°C max[3]

Offset error .....±5 µV max (post calibration)[2]

Offset stability ..... ±0.6 µV/C max[3]

Nonlinearity ..... ±0.004% max[2]

Measurement Accuracy[5]

TC Type	Temperature Range (°C)	Maximum (±°C)	Typical (±°C)
B	400 to 600 600 to 1800	2.5 2	0.31 0.13
E	–200 to –100 –100 to 600 600 to 1000	2 1 1.5	1.76 1 0.6
J	–200 to –100 –100 to 500 500 to 1100	2 1 1.5	1.6 0.9 0.72
K	–200 to –100 –100 to 600 600 to 1200	2.5 1.25 2	1.25 0.67 0.45
N	–200 to –100 –100 to 1300	2.5 2	2 0.7
R	–50 to 0 0 to 100 100 to1600	3 2 1.75	1.24 0.82 0.4
S	–50 to 0 0 to 1400 1400 to 1600	3 2 2.5	1.3 1 1
T	–200 to –100 –100 to 400	2.5 1	2 0.9

Cold-Junction Sensor

Cold-junction sensor accuracy .....±0.4° max from 15° to 35° C, ±0.75° max from 0° to 15° C and 35° to 55° C

Output.....1.91 V (0° C) to 0.58 V (55° C)

☞ **Note:** ***The accuracy specification includes the combined effects of the temperature sensor accuracy and the temperature difference between the temperature sensor and any thermocouple connector. The temperature sensor accuracy includes component tolerances, temperature drifts, and self-heating effects. It does not include measurement device errors.***

Open Thermocouple Detection

Pull-up resistor .....10 MΩ

Bias resistor .....10 MΩ

Maximum field wire gauge .....28 to 16 AWG

Power Requirement

Analog power .....114 mW max
(+15 V.....3.5 mA max)
(–15 V.....3.5 mA max)

Digital power .....0.0 mW
(+5 V.....0.0 mA)

Physical

Dimensions .....8.89 L by 2.92 H x 1.85 D cm (3.50 L by 1.15 H by 0.73 D in.)

I/O .....one 20-pin right angle male connector, 3-pin screw terminal system

Screw terminal (SCC-TC02) .....28 to 16 AWG

Environment

Operating temperature..... 0° to 50° C

Storage temperature ..... –55° to 125° C

Relative humidity..... 5% to 90% noncondensing

SCC-FT01 Feed Through

Analog

Number of input channels .....1 DIFF or 2 SE (when plugged into an AI socket on the SC-2345)

Number of output channels .....1 (when plugged into an AO socket on the SC-2345)

Power Requirement

No power required

Physical

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

I/O connectors .....1, 20-pin right-angle male connector
1, 6-pin screw terminal system

Screw terminal.....28 to 16 AWG

---

1 These numbers exclude SCCs requirements

2 Temperature range is 23° C ±5° C

3 Temperature range is 0° C ±50° C

4 The SCC-TC01/02 is not designed for high voltage use. Voltages greater than ±40 V may be hazardous.

5 Total system measurement error for operating temperature within ±5 °C of calibration temperature. Includes PCI/AT-MIO-16XE-50 one year accuracy specification of 0.01% ±412 µV. SCC-TC01/02 accuracy specification of 0.08% ±5 µV, and reference junction measurement accuracy of 0.5 °C. Assumes averaging. Non-averaged, single-point reading will have an additional uncertainty(up to ±0.1 °C for J type thermocouple).

SCC Feature Reference Table

Appendix
B

This appendix provides a concise overview of the features of each SCC.

SCC Types	Features	SCC-A10	SCC-CI20	SCC-FT01	SCC-FT01 (Prototype Version)	SCC-TC
Analog input	Number of channels	2	2	2	2	1
	Input range	±100 V	0 to 20 mA	±10 V	±10 V	±100 mV (–200 C to 1800 C) dependent on thermocouple
	Differential measurement	Yes	Yes	No	User defined	Yes
	Buffered inputs	Yes	Yes	No	User defined	Yes
	Single-stage AI	Yes	Yes	Yes	User defined	Yes
	First-stage of dual-stage AI	Yes	Yes	Yes	User defined	No
	Second-stage of dual-stage AI	No	Yes	No	User defined	No
Analog output	Number of Channels	No	No	No	2	No
	Output range	No	No	No	±10 V	No
Digital I/O	Number of channels	No	No	No	User defined	No
GPCTR	Number of channels	No	No	No	User defined	No

SCC Types	Features	SCC-A10	SCC-CI20	SCC-FT01	SCC-FT01 (Prototype Version)	SCC-TC
Power	Analog power requirements	100 mW	100 mW	No	User defined	114 mW
	Digital power requirements	No	No	No	User defined	No
	Power category	Low	Low	Low	User defined	Low

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Appendix C

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve your technical problems and a form you can use to comment on the product documentation. When you contact us, we need the information on the Technical Support Form and the configuration form, if your manual contains one, about your system configuration to answer your questions as quickly as possible.

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Up to 14,400 baud, 8 data bits, 1 stop bit, no parity

United Kingdom: 01635 551422
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Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

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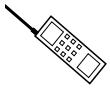
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Canada (Ontario)	905 785 0085	905 785 0086
Canada (Quebec)	514 694 8521	514 694 4399
Denmark	45 76 26 00	45 76 26 02
Finland	09 725 725 11	09 725 725 55
France	01 48 14 24 24	01 48 14 24 14
Germany	089 741 31 30	089 714 60 35
Hong Kong	2645 3186	2686 8505
Israel	03 5734815	03 5734816
Italy	02 413091	02 41309215
Japan	03 5472 2970	03 5472 2977
Korea	02 596 7456	02 596 7455
Mexico	5 520 2635	5 520 3282
Netherlands	0348 433466	0348 430673
Norway	32 84 84 00	32 84 86 00
Singapore	2265886	2265887
Spain	91 640 0085	91 640 0533
Sweden	08 730 49 70	08 730 43 70
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Name _____

Company _____

Address _____

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Fax (___)_____ Phone (___) _____

Computer brand _____ Model _____ Processor_____

Operating system (include version number) _____

Clock speed _____MHz RAM _____MB Display adapter _____

Mouse ___yes ___no Other adapters installed _____

Hard disk capacity _____MB Brand _____

Instruments used _____

_____

National Instruments hardware product model _____ Revision _____

Configuration _____

National Instruments software product _____ Version _____

Configuration _____

The problem is: _____

_____

_____

_____

_____

List any error messages: _____

_____

_____

The following steps reproduce the problem:_____

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SC-2345 and SCCs Hardware and Software Configuration Form

Record the settings and revisions of your hardware and software on the line to the right of each item. Complete a new copy of this form each time you revise your software or hardware configuration, and use this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

National Instruments Products

DAQ hardware _____

Interrupt level of hardware _____

DMA channels of hardware _____

Base I/O address of hardware _____

Programming choice _____

National Instruments software version _____

Other boards in system _____

Base I/O address of other boards _____

DMA channels of other boards _____

Interrupt level of other boards _____

Other Products

Computer make and model _____

Microprocessor _____

Clock frequency or speed _____

Type of video board installed _____

Operating system version _____

Operating system mode _____

Programming language _____

Programming language version _____

Other boards in system _____

Base I/O address of other boards _____

DMA channels of other boards _____

Interrupt level of other boards _____

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Fill in the form below with the name of the SCC you installed on each SC-2345 SCC socket.

J1 (ACH0/8)	SCC-_____
J2 (ACH1/9)	SCC-_____
J3 (ACH2/10)	SCC-_____
J4 (ACH3/11)	SCC-_____
J5 (ACH4/12)	SCC-_____
J6 (ACH5/13)	SCC-_____
J7 (ACH6/14)	SCC-_____
J8 (ACH7/15)	SCC-_____
J9 (ACH0/8 or DIO0)	SCC- _____
J10 (ACH1/9 or DIO1)	SCC- _____
J11 (ACH2/10 or DIO2)	SCC- _____
J12 (ACH3/11 or DIO3)	SCC- _____
J13 (ACH4/12 or DIO4)	SCC- _____
J14 (ACH5/13 or DIO5)	SCC- _____
J15 (ACH6/14 or DIO6)	SCC- _____
J16 (ACH7/15 or DIO7)	SCC- _____
J17 (DAC0)	SCC-_____
J18 (DAC1)	SCC-_____
J19 (GPCTR0)	SCC- _____
J20 (GPCTR1)	SCC- _____
J21 (POWER)	SCC- _____

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Title: *SCC Series Carrier and Components User Manual*

Edition Date: September 1997

Part Number: 321331A-01

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Please comment on the completeness, clarity, and organization of the manual.

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If you find errors in the manual, please record the page numbers and describe the errors.

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Prefix	Meaning	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}

Numbers/Symbols

%	percent
+	positive of, or plus
/	per
°	degree
Ω	ohm

A

A	amperes
ACH	analog input channel signal
AIGND	analog input ground signal
AISENSE	analog input sense signal

amplification	a type of signal conditioning that improves accuracy in the resulting digitized signal and reduces noise
AOGND	analog output ground signal
attenuate	to decrease the amplitude of a signal
AWG	American Wire Gauge

B

bandwidth	the range of frequencies present in a signal, or the range of frequencies to which a measuring device can respond
break-before-make	a type of switching contact that is completely disengaged from one terminal before it connects with another terminal

C

C	Celsius
cascading	the process of extending the counter range of a counter chip by connecting to the next counter
CH	channel
channel	pin or wire lead to which you apply or from which you read the analog or digital signal. Analog signals can be single-ended or differential. For digital signals, you group channels to form ports. Ports usually consist of either four or eight digital channels.
cold-junction compensation	a method of compensating for inaccuracies in thermocouple circuits
common-mode range	the input range over which a circuit can handle a common-mode signal
common-mode signal	the mathematical average voltage, relative to the computer's ground, of the signals from a differential input
common-mode voltage	any voltage present at the instrumentation amplifier inputs with respect to amplifier ground
counter/timer	a circuit that counts external pulses or clock pulses (timing)

D

DAC	digital-to-analog converter—an electronic device, often an integrated circuit, that converts a digital number into a corresponding analog voltage or current
dDAQ	data acquisition—(1) collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and inputting them to a computer for processing; (2) collecting and measuring the same kinds of electrical signals with A/D and/or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer
dB	decibel—the unit for expressing a logarithmic measure of the ratio of two signal levels: dB=20log10 V1/V2, for signals in volts
DC	direct current
device	a plug-in data acquisition board, card, or pad that can contain multiple channels and conversion devices. Plug-in boards, PCMCIA cards, and devices such as the DAQPad-1200, which connects to your computer parallel port, are all examples of DAQ devices. SCXI modules are distinct from devices, with the exception of the SCXI-1200, which is a hybrid.
DIFF	differential mode
DIO	digital input/output

E

EMI	electromagnetic interference
EXTREF	external reference signal
EXTSTROBE	external strobe signal

F

filtering	a type of signal conditioning that allows you to filter unwanted signals from the signal you are trying to measure

floating signal sources	signal sources with voltage signals that are not connected to an absolute reference or system ground. Also called nonreferenced signal sources. Some common example of floating signal sources are batteries, transformers, or thermocouples.
FREQ_OUT	frequency output signal

G

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
GPCTR0_GATE	general purpose counter timer 0 gate signal
GPCTR1_GATE	general purpose counter timer 1 gate signal
GPCTR0_OUT	general purpose counter timer 0 output signal
GPCTR1_OUT	general purpose counter timer 1 output signal
GPCTR0_SOURCE	general purpose counter timer 0 clock source signal
GPCTR1_SOURCE	general purpose counter timer 1 clock source signal

H

h	hour
hardware	the physical components of a computer system, such as the circuit boards, plug-in boards, chassis, enclosures, peripherals, cables, and so on
Hz	hertz—the number of scans read or updates written per second

I

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

input offset current	the difference in the input bias currents of the two inputs of an instrumentation amplifier
instrumentation amplifier	a circuit whose output voltage with respect to ground is proportional to the difference between the voltages at its two inputs
I/O	input/output—the transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces

K

K	Kelvin

L

LabVIEW	laboratory virtual instrument engineering workbench
LED	light-emitting diode

N

NC	normally closed, or not connected
NI-DAQ	NI driver software for DAQ hardware
NIST	National Institute of Standards and Technology
NMR	normal mode rejection
noise	an undesirable electrical signal—Noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to send or receive.
NRSE	nonreferenced single-ended mode—all measurements are made with respect to a common (NRSE) measurement system reference, but the voltage at this reference can vary with respect to the measurement system ground

P

pad	a hole in the PWB used by the customer for signal connection
peak to peak	a measure of signal amplitude; the difference between the highest and lowest excursions of the signal
PFI	Programmable Function Input
potentiometer	an electrical device the resistance of which can be manually adjusted; used for manual adjustment of electrical circuits and as a transducer for linear or rotary position
ppm	parts per million

R

referenced signal sources	signal sources with voltage signals that are referenced to a system ground, such as the earth or a building ground. Also called grounded signal sources.
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.
RTI	referred to input

S

s	seconds
scan	one or more analog or digital input samples. Typically, the number of input samples in a scan is equal to the number of channels in the input group. For example, one pulse from the scan clock produces one scan which acquires one new sample from every analog input channel in the group.
SCANCLK	scan clock signal

scan rate	the number of scans per second. For example, a scan rate of 10 Hz means sampling each channel 10 times per second.
SE	single-ended—a term used to describe an analog input that is measured with respect to a common ground
sensor	a device that responds to a physical stimulus (heat, light, sound, pressure, motion, flow, and so on), and produces a corresponding electrical signal
signal conditioning	the manipulation of signals to prepare them for digitizing
source impedance	a parameter of signal sources that reflects current-driving ability of voltage sources (lower is better) and the voltage-driving ability of current sources (higher is better)
STARTSCAN	start scan signal
system noise	a measure of the amount of noise seen by an analog circuit or an ADC when the analog inputs are grounded

T

thermistor	a semiconductor sensor that exhibits a repeatable change in electrical resistance as a function of temperature. Most thermistors exhibit a negative temperature coefficient.
thermocouple	a temperature sensor created by joining two dissimilar metals. The junction produces a small voltage as a function of the temperature.
TRIG	trigger signal

U

UPDATE	update signal

V

V	volts
V_{DC}	volts direct current

W

WFTRIG	waveform generation trigger signal

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