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DAQ

SCB-68 68-Pin Shielded Connector Block User Manual

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Compliance

FFCC/Canada Radio Frequency Interference Compliance

Determining FCC Class

The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations). Depending on where it is operated, this product could be subject to restrictions in the FCC rules. (In Canada, the Department of Communications (DOC), of Industry Canada, regulates wireless interference in much the same way.)

Digital electronics emit weak signals during normal operation that can affect radio, television, or other wireless products. By examining the product you purchased, you can determine the FCC Class and therefore which of the two FCC/DOC Warnings apply in the following sections. (Some products may not be labeled at all for FCC; if so, the reader should then assume these are Class A devices.)

FCC Class A products only display a simple warning statement of one paragraph in length regarding interference and undesired operation. Most of our products are FCC Class A. The FCC rules have restrictions regarding the locations where FCC Class A products can be operated.

FCC Class B products display either a FCC ID code, starting with the letters **EXN**, or the FCC Class B compliance mark that appears as shown here on the right.



Consult the FCC Web site at `http://www.fcc.gov` for more information.

FCC/DOC Warnings

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual and the CE Marking Declaration of Conformity*, may cause interference to radio and television reception. Classification requirements are the same for the Federal Communications Commission (FCC) and the Canadian Department of Communications (DOC).

Changes or modifications not expressly approved by National Instruments could void the user's authority to operate the equipment under the FCC Rules.

Class A

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Canadian Department of Communications

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

Class B

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Canadian Department of Communications

This Class B digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe B respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

Compliance to EU Directives

Readers in the European Union (EU) must refer to the Manufacturer's Declaration of Conformity (DoC) for information* pertaining to the CE Marking compliance scheme. The Manufacturer includes a DoC for most every hardware product except for those bought for OEMs, if also available from an original manufacturer that also markets in the EU, or where compliance is not required as for electrically benign apparatus or cables.

To obtain the DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This Web site lists the DoCs by product family. Select the appropriate product family, followed by your product, and a link to the DoC appears in Adobe Acrobat format. Click the Acrobat icon to download or read the DoC.

* The CE Marking Declaration of Conformity will contain important supplementary information and instructions for the user or installer.

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About This Manual

This manual describes the SCB-68 and explains how to use the connector block with National Instruments data acquisition (DAQ) devices.

Conventions

The following conventions appear in this manual:

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

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

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

 — This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When this symbol is marked on the device, refer to the *Safety Information* of Chapter 1, *Introduction*, for precautions to take.

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

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

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

NI Documentation

For more information about using the SCB-68 with DAQ devices, refer to the following resources:

- DAQ device user manuals, at `ni.com/manuals`
- NI Developer Zone, at `ni.com/zone`

1 Introduction

The SCB-68 is a shielded I/O connector block with 68 screw terminals for easy signal connection to a National Instruments 68- or 100-pin DAQ device. The SCB-68 features a general breadboard area for custom circuitry and sockets for interchanging electrical components. These sockets or component pads allow RC filtering, 4 to 20 mA current sensing, open thermocouple detection, and voltage attenuation. The open component pads allow signal conditioning to be easily added to the analog input (AI) signals and to the DAC0OUT, DAC1OUT, and PFI0/TRIG1 signals of a 68-pin or 100-pin DAQ device.

What You Need to Get Started

To set up and use the SCB-68, you need the following items:

- ❑ SCB-68 68-pin shielded connector block
- ❑ One of the devices listed in Table 1-1
- ❑ One of the device-compatible cables listed in Table 1-1
- ❑ The device user manual or user guide, which you can access at `ni.com/manuals`
- ❑ Phillips number 1 and number 2 screwdrivers
- ❑ 0.125 in. flathead screwdriver
- ❑ Long-nose pliers
- ❑ Wire cutters
- ❑ Wire insulation strippers
- ❑ Quick reference label for the DAQ device you are using

- ❑ The following items, if you are adding components (optional):
  - Soldering iron and solder
  - Resistors
  - Capacitors

Quick Reference Label

A quick reference label for E Series devices is included in this kit. Quick reference labels for some other devices ship with the DAQ device itself. These labels show the switch configurations and define the screw terminal pinouts for compatible DAQ devices. You can put the label on the inside of the SCB-68 cover for easy reference if you are using one of these devices.

Refer to Appendix B, *Quick Reference Labels*, for the switch configurations and screw terminal pinouts that are included on each quick reference label.

Table 1-1 shows cabling options and features for DAQ devices that are compatible with the SCB-68. Figure 1-1 shows where to apply the quick reference label to the inside cover of the SCB-68.

Table 1-1. Device-Specific Hardware Configuration

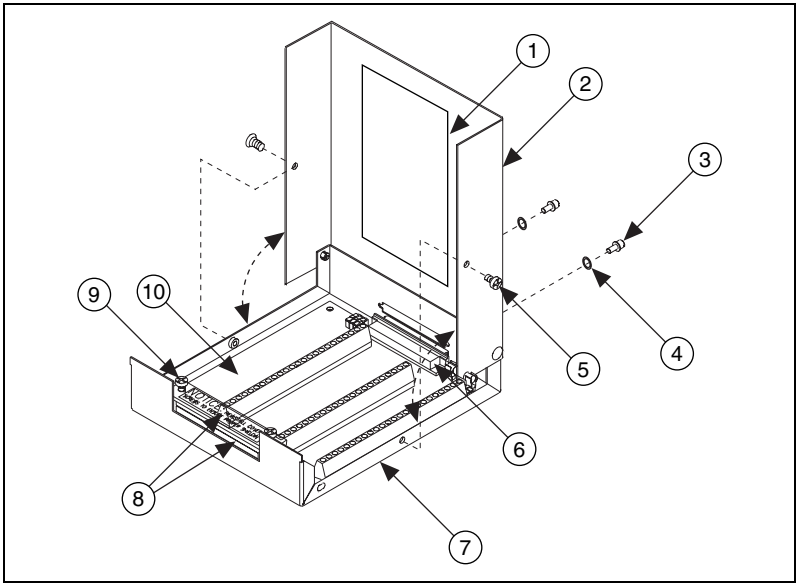
Device	Cable Assembly	Features
E Series Devices		
68-Pin Devices (except DAQCards)	SH68-68-EP, SH68-68-R1-EP, R6868	Direct feedthrough only Thermocouple measurements Open thermocouple detection Current input Filtering Voltage dividers AC coupling
100-Pin Devices	SH1006868	Direct feedthrough only Thermocouple measurements Open thermocouple detection Current input Filtering Voltage dividers AC coupling

Table 1-1. Device-Specific Hardware Configuration (Continued)

Device	Cable Assembly	Features
NI 6024E for PCMCIA (DAQCard-6024E), NI 6036E for PCMCIA (DAQCard-6036E), NI 6062E for PCMCIA (DAQCard-6062E)	SCH68-68-EP, RC68-68	Direct feedthrough only Thermocouple measurements Open thermocouple detection Current input Filtering Voltage dividers AC coupling
NI 6012E for PCMCIA (DAQCard-AI-16XE-50), NI 6041E for PCMCIA (DAQCard-AI-16E-4)	PSHR68-68, PR68-68F	Direct feedthrough only Thermocouple measurements Open thermocouple detection Current input Filtering Voltage dividers AC coupling
Analog Output (AO) Devices		
NI 670*X* for PCI/PXI/CompactPCI	SH68-68-D1 R6868	Direct feedthrough only RC filtering
NI 671*X*/673*X* for PCI/PXI/CompactPCI	SH68-68-EP SH68-68-R1-EP R6868	Direct feedthrough only RC filtering
NI 6715 for PCMCIA (DAQCard-6715)	SHC68-68-EP RC6868	Direct feedthrough only RC filtering
Digital I/O (DIO) Devices		
NI 6533 for ISA/PCI/PXI/CompactPCI	SH68-68-D1 R6868	Direct feedthrough only
NI 6533 for PCMCIA (DAQCard-6533),	PSHR68-68-D1, PR6868F	Direct feedthrough only
NI 6534 for PCI/PXI/CompactPCI	SH68-68-D1 R6868	Direct feedthrough only
Real-Time (RT) Devices		
NI 7030/6030E for PCI/PXI/CompactPCI, NI 7030/6040E for PCI/PXI/CompactPCI	SH68-68-EP SH68-68R1-EP, R6868	Direct feedthrough only Thermocouple measurements Open thermocouple detection Current input Filtering Voltage dividers AC coupling
NI 7030/6533 for PCI/PXI/CompactPCI	SH68-68-D1 R6868	Direct feedthrough only

Table 1-1. Device-Specific Hardware Configuration (Continued)

Device	Cable Assembly	Features
S Series Devices		
NI 6110/6111 for PCI	SH68-68-EP SH68-68R1-EP, R6868	Direct feedthrough only
NI 6115/6120 for PCI/PXI/CompactPCI	SH68-68-EP SH68-68R1-EP, R6868	Direct feedthrough only
Timing I/O (TIO) Devices		
NI 6601/6602 for PCI/PXI/CompactPCI	SH68-68-D1, R6868	Direct feedthrough only
Other Devices		
NI 250*X* for PXI/CompactPCI	SH68-68	Direct feedthrough only
NI 4350 for PCMCIA (DAQCard-4350), NI 4350 for USB	SH68-68	Not recommended for use with the SCB-68 To maximize the available features, NI recommends using this DAQ device with the CB-68T, TBX-68, or TBX-68T terminal blocks.
NI 4351 for PCI/PXI/CompactPCI	SH68-68	Not recommended for use with the SCB-68 To maximize the available features, NI recommends using this DAQ device with the CB-68T, TBX-68, or TBX-68T terminal blocks.
NI 445*X* for PCI	SHC50-68	Direct feedthrough only
NI 455*X* for PCI	SHC50-68	Direct feedthrough only
NI 5411 for PCI/PXI/CompactPCI	SHC50-68	Direct feedthrough only
NI 5431 for PCI/PXI/CompactPCI	SHC50-68	Direct feedthrough only



1	Quick Reference Label	4	Lock Washers	8	Strain-Relief Bars
2	Cover	5	Shielding Screws	9	Strain-Relief Screws
3	68-Pin Connector Screws	6	68-Pin I/O Connector	10	Circuit Card Assembly
		7	Base		

Figure 1-1. SCB-68 Parts Locator Diagram

Installing Cables

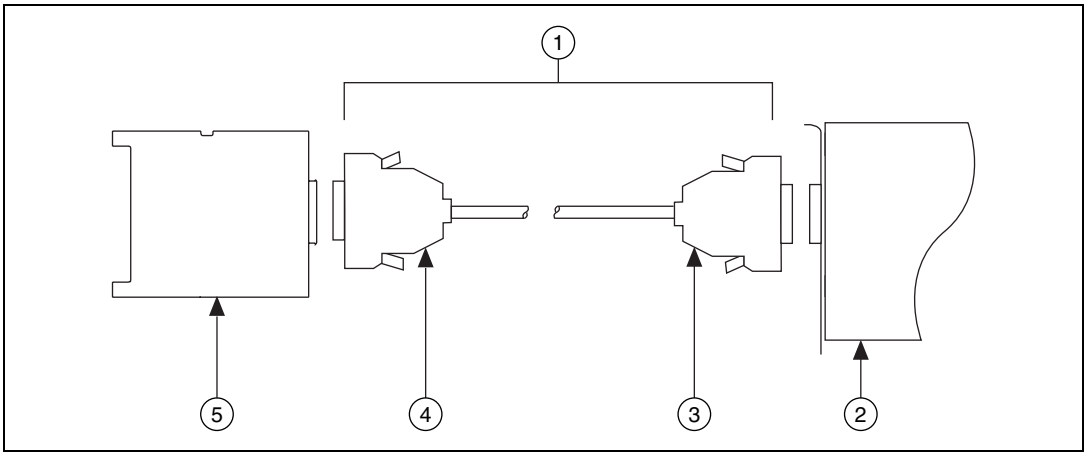
The following sections describe how to cable one or more SCB-68 connector blocks to a DAQ device using 68-pin or 100-pin cables.

Note For the I/O connector pinout of the DAQ device, refer to the device user manual at `ni.com/manuals` or to the quick reference label provided with the DAQ device.

Using 68-Pin Cables

Table 1-1 lists the 68-pin cable assemblies that can connect the SCB-68 to a 68-pin DAQ device. Each end of these 68-pin cables has a 68-pin I/O connector that you can connect to the SCB-68 and to the 68-pin DAQ device. In this configuration, the I/O connector pinout on the DAQ device determines the I/O connector pinout on the SCB-68.

Figure 1-2 shows how to use a 68-pin cable to connect the SCB-68 to a 68-pin DAQ device.

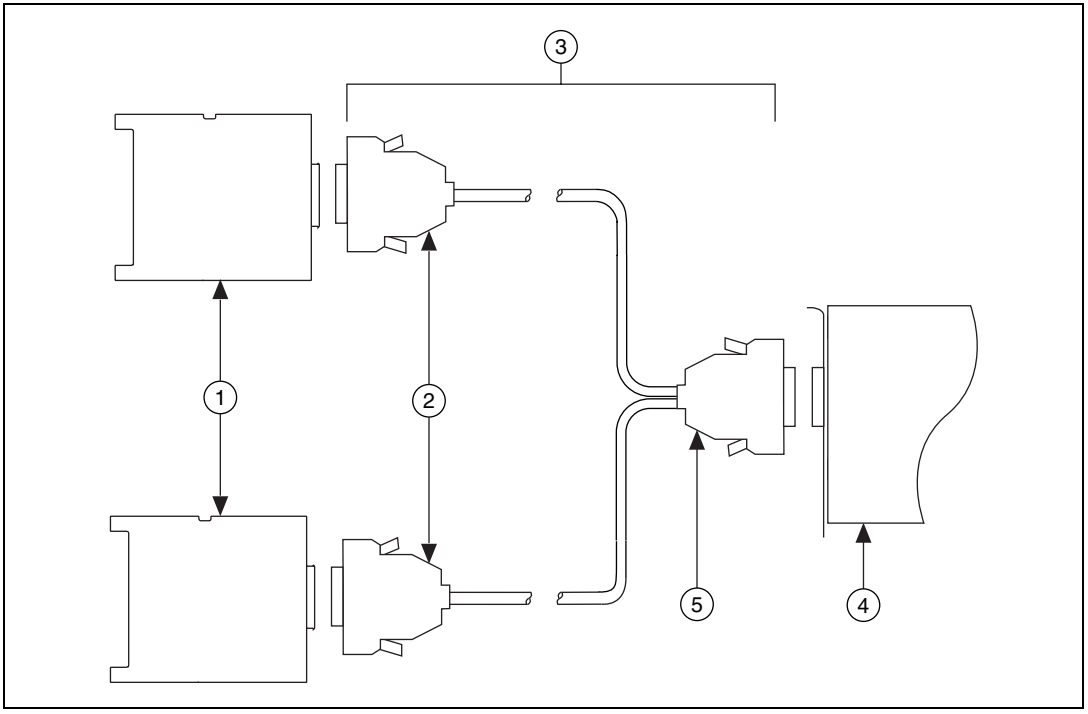


1 68-Pin Cable Assembly
2 68-Pin DAQ Device
3 68-Pin I/O Connector
4 68-Pin I/O Connector
5 SCB-68 Connector Block

Figure 1-2. Connecting a 68-Pin DAQ Device to an SCB-68

Using 100-Pin Cables

You can use the SH1006868 cable assembly to connect two SCB-68 connector blocks to a 100-pin DAQ device. The SH1006868 is Y-shaped, with a 100-pin male connector on one end and two 68-pin female connectors on the opposite end. The DAQ device connects to the 100-pin cable connector, and an SCB-68 can connect to each 68-pin cable connector. Figure 1-3 shows how use the SH1006868 to cable a 100-pin DAQ device to two SCB-68 devices.



1 SCB-68 Connector Blocks
2 68-Pin I/O Connectors
3 SH1006868 Cable Assembly
4 100-Pin DAQ Device
5 100-Pin I/O Connector

Figure 1-3. Connecting a 100-Pin DAQ Device to Two SCB-68 Connector Blocks

When you attach two SCB-68 devices to the SH1006868 cable, one of the SCB-68 connector blocks has a full 68-pin I/O connector pinout, and the other SCB-68 connector block has an extended AI or extended digital pinout. Each 68-pin end of the SH1006868 cable has a label that indicates which I/O connector pinout is associated with that 68-pin I/O connector.

Figure 1-4 shows the pin assignments for the I/O connector on a 68-pin E Series device. This connector is available when you use the SH68-68-EP or R6868 cable assemblies with an E Series DAQ device. It is also one of two 68-pin connectors available when you use the SH1006868 cable assembly with a 100-pin E Series DAQ device.

ACH8	34	68	ACH0
ACH1	33	67	AIGND
AIGND	32	66	ACH9
ACH10	31	65	ACH2
ACH3	30	64	AIGND
AIGND	29	63	ACH11
ACH4	28	62	AISENSE
AIGND	27	61	ACH12
ACH13	26	60	ACH5
ACH6	25	59	AIGND
AIGND	24	58	ACH14
ACH15	23	57	ACH7
DAC0OUT[1]	22	56	AIGND
DAC1OUT[1]	21	55	AOGND[2]
EXTREF[3]	20	54	AOGND[2]
DIO4	19	53	DGND
DGND	18	52	DIO0
DIO1	17	51	DIO5
DIO6	16	50	DGND
DGND	15	49	DIO2
+5V	14	48	DIO7
DGND	13	47	DIO3
DGND	12	46	SCANCLK
PFI0/TRIG1	11	45	EXTSTROBE*
PFI1/TRIG2	10	44	DGND
DGND	9	43	PFI2/CONVERT*
+5V	8	42	PFI3/GPCTR1_SOURCE
DGND	7	41	PFI4/GPCTR1_GATE
PFI5/UPDATE*	6	40	GPCTR1_OUT
PFI6/WFTRIG	5	39	DGND
DGND	4	38	PFI7/STARTSCAN
PFI9/GPCTR0_GATE	3	37	PFI8/GPCTR0_SOURCE
GPCTR0_OUT	2	36	DGND
FREQ_OUT	1	35	DGND

[1] No connect on the DAQCard-AI-16E-4, DAQCard-AI-16XE-50, NI PCI-6023E, NI PCI-6032E, NI PCI-6033E, and NI PCI-6034E

[2] No connect on the DAQCard-AI-16E-4 and DAQCard-AI-16XE-50

[3] No connect on the DAQCard-AI-16E-4, DAQCard-AI-16XE-50, DAQCard-6024E, NI PCI-6023E, NI PCI-6024E, NI PXI-6030E, NI PXI-6031E, NI PCI-6032E, NI PCI-6033E, NI PCI-6034E, NI PCI-6035E, NI PCI-6036E, PCI-MIO-16XE-10, and PCI-MIO-16XE-50

Figure 1-4. SCB-68 E Series I/O Connector Pinout (Full)

Figure 1-5 shows the pin assignments for the extended AI connector. This pinout shows the other 68-pin connector when you use the SH1006868 cable assembly with an NI 6031E, NI 6033E, or NI 6071E.

ACH24	34	68	ACH16
ACH17	33	67	ACH25
ACH18	32	66	ACH26
ACH27	31	65	ACH19
ACH20	30	64	ACH28
ACH21	29	63	ACH29
ACH30	28	62	ACH22
ACH23	27	61	ACH31
ACH32	26	60	ACH40
ACH41	25	59	ACH33
ACH34	24	58	ACH42
ACH35	23	57	ACH43
AIGND	22	56	AISENSE2
ACH44	21	55	ACH36
ACH37	20	54	ACH45
ACH38	19	53	ACH46
ACH47	18	52	ACH39
ACH48	17	51	ACH56
ACH49	16	50	ACH57
ACH58	15	49	ACH50
ACH51	14	48	ACH59
ACH52	13	47	ACH60
ACH61	12	46	ACH53
ACH54	11	45	ACH62
ACH55	10	44	ACH63
NC	9	43	NC
NC	8	42	NC
NC	7	41	NC
NC	6	40	NC
NC	5	39	NC
NC	4	38	NC
NC	3	37	NC
NC	2	36	NC
NC	1	35	NC

NC = No Connect

Figure 1-5. SCB-68 E Series I/O Connector Pinout (Extended AI)

Figure 1-6 shows the pin assignments for the extended digital connector. This pinout shows the other 68-pin connector when you use the SH1006868 cable assembly with an NI 6025E or the NI 6021E (AT-MIO-16DE-10) for ISA.

GND	34	68	PC7
PC6	33	67	GND
PC5	32	66	GND
GND	31	65	PC4
PC3	30	64	GND
PC2	29	63	GND
GND	28	62	PC1
PC0	27	61	GND
PB7	26	60	GND
GND	25	59	PB6
PB5	24	58	GND
PB4	23	57	GND
GND	22	56	PB3
GND	21	55	PB2
PB1	20	54	GND
PB0	19	53	GND
GND	18	52	PA7
PA6	17	51	GND
PA5	16	50	GND
GND	15	49	PA4
PA3	14	48	GND
PA2	13	47	GND
GND	12	46	PA1
PA0	11	45	GND
+5V	10	44	GND
NC	9	43	NC
NC	8	42	NC
NC	7	41	NC
NC	6	40	NC
NC	5	39	NC
NC	4	38	NC
NC	3	37	NC
NC	2	36	NC
NC	1	35	NC

NC = No Connect

Figure 1-6. SCB-68 E Series I/O Connector Pinout (Extended Digital)

Configuring the SCB-68

For instructions about using Measurement & Automation Explorer (MAX) to configure the SCB-68 as an accessory for a DAQ device, complete the following steps:

1. Navigate to MAX by selecting **Start»Programs»National Instruments»Measurement&Automation**.
2. Select **Help»Help Topics»NI-DAQ** in MAX.
3. Select **DAQ Devices»Configuring DAQ Devices»Configuring DAQ Devices»Accessory** in the *Measurement & Automation Explorer Help for MAX*.

Safety Information

The following section contains important safety information that you *must* follow when installing and using the SCB-68.

Do *not* operate the SCB-68 in a manner not specified in this document. Misuse of the SCB-68 can result in a hazard. You can compromise the safety protection built into the SCB-68 if the device is damaged in any way. If the SCB-68 is damaged, return it to NI for repair.

Do *not* substitute parts or modify the SCB-68 except as described in this document. Use the SCB-68 only with the chassis, modules, accessories, and cables specified in the installation instructions. You *must* have all covers and filler panels installed during operation of the SCB-68.

Do *not* operate the SCB-68 in an explosive atmosphere or where there may be flammable gases or fumes. Operate the SCB-68 only at or below the pollution degree stated in Appendix A, *Specifications*.

Pollution is foreign matter in a solid, liquid, or gaseous state that can reduce dielectric strength or surface resistivity. The following is a description of pollution degrees:

- Pollution Degree 1 means no pollution or only dry, nonconductive pollution occurs. The pollution has no influence.
- Pollution Degree 2 means that only nonconductive pollution occurs in most cases. Occasionally, however, a temporary conductivity caused by condensation must be expected.

- Pollution Degree 3 means that conductive pollution occurs, or dry, nonconductive pollution occurs that becomes conductive due to condensation.

Clean the SCB-68 with a soft nonmetallic brush. Make sure that the SCB-68 is completely dry and free from contaminants before returning it to service.

You *must* insulate signal connections for the maximum voltage for which the SCB-68 is rated. Do *not* exceed the maximum ratings for the SCB-68. Remove power from signal lines before connecting them to or disconnecting them from the SCB-68.

Operate the SCB-68 only at or below the installation category stated in Appendix A, *Specifications*.

The following is a description of installation categories:

- Installation Category I is for measurements performed on circuits not directly connected to MAINS[1]. This category is a signal level such as voltages on a printed wire board (PWB) on the secondary of an isolation transformer.

  Examples of Installation Category I are measurements on circuits not derived from MAINS and specially protected (internal) MAINS-derived circuits.

- Installation Category II is for measurements performed on circuits directly connected to the low-voltage installation. This category refers to local-level distribution such as that provided by a standard wall outlet.

  Examples of Installation Category II are measurements on household appliances, portable tools, and similar equipment.

- Installation Category III is for measurements performed in the building installation. This category is a distribution level referring to hardwired equipment that does not rely on standard building insulation.

  Examples of Installation Category III include measurements on distribution circuits and circuit breakers. Other examples of Installation Category III are wiring including cables, bus-bars, junction boxes, switches, socket outlets in the building/fixed

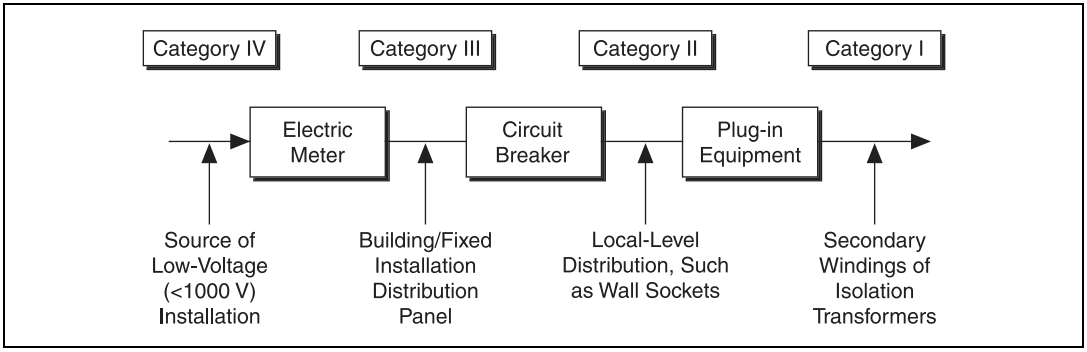
[1] MAINS is defined as the electricity supply system to which the equipment concerned is designed to be connected either for powering the equipment or for measurement purposes.

installation, and equipment for industrial use, such as stationary motors with a permanent connection to the building/fixed installation.

- Installation Category IV is for measurements performed at the source of the low-voltage (<1,000 V) installation.

  Examples of Installation Category IV are electric meters, and measurements on primary overcurrent protection devices and ripple-control units.

Below is a diagram of a sample installation.



2

Parts Locator and Wiring Guide

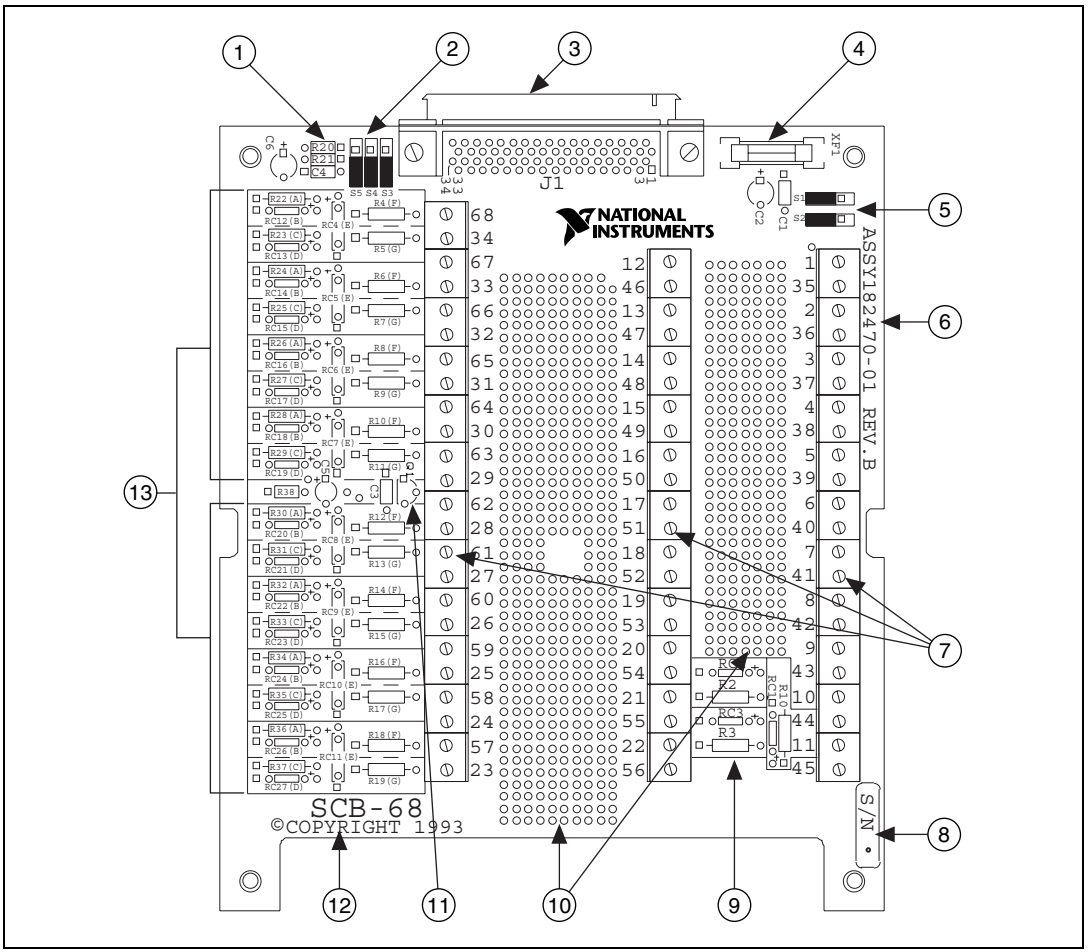
This chapter explains how to connect signals to the SCB-68.

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

Cautions 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 SCB-68, dangerous voltages may exist even when the equipment is powered off. To avoid dangerous electrical shock, do not perform procedures involving cover or shield removal unless you are qualified to do so. Before you remove the cover, disconnect the AC power or any live circuits from the SCB-68.

The chassis GND terminals are for grounding high-impedance sources such as floating sources (1 mA maximum). Do *not* use these terminals as safety earth grounds.

Do *not* connect high voltages to the SCB-68 even with an attenuator circuit. *Never* connect voltages ≥42 V_{rms}. NI is *not* liable for any damage or injuries resulting from improper use or connection.



1	Pads R20 and R21	8	Serial Number
2	Switches S3, S4, and S5	9	RC Filters and Attenuators for DAC0, DAC1, and TRIG1
3	68-Pin I/O Connector	10	Breadboard Area
4	Fuse (0.8 A)	11	Temperature Sensor
5	Switches S1 and S2	12	Product Name
6	Assembly Number and Revision Letter	13	Pads for AI Conditioning
7	Screw Terminals		

Figure 2-1. SCB-68 Printed Circuit Diagram

To connect signals to the SCB-68, complete the following steps while referring to Figure 1-1, *SCB-68 Parts Locator Diagram*, and to Figure 2-1.

1. Disconnect the 68-pin cable from the SCB-68, if it is connected.
2. Remove the shielding screws on either side of the top cover with a Phillips-head number 1 screwdriver. You can now open the box.
3. Configure the switches and other options relative to the types of signals you are using.
4. Loosen the strain-relief screws with a Phillips-head number 2 screwdriver. Slide the signal wires through the front panel strain-relief opening. You can also remove the top strain-relief bar if you are connecting many signals. Add insulation or padding if necessary.
5. Connect the wires to the screw terminals by stripping off 0.25 in. of the insulation, inserting the wires into the green terminals, and tightening the screws.
6. Reinstall the strain-relief bar (if you removed it) and tighten the strain-relief screws.
7. Close the top cover.
8. Reinsert the shielding screws to ensure proper shielding.

You can now connect the SCB-68 to the 68-pin I/O connector.

Switch Configuration

The SCB-68 has five switches that must be properly configured to use the SCB-68 with the DAQ device. Table 2-1 illustrates the available switch configurations and the affected signals for each switch setting. Refer to Table 2-1 to determine the switch setting that applies to your application, and then refer to the following sections for more information on specific types of signals.

Table 2-1. Switch Configurations and Affected Signals

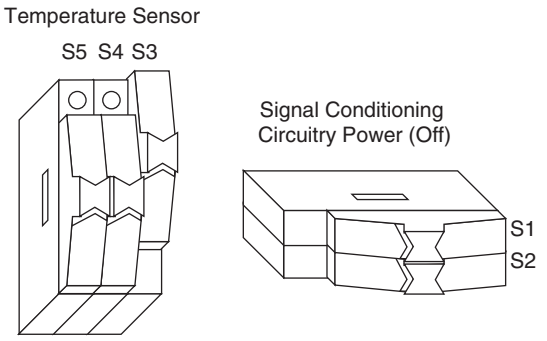
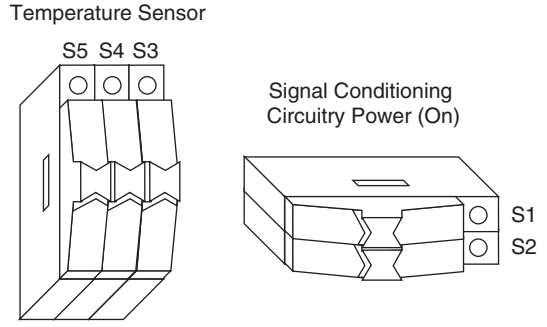
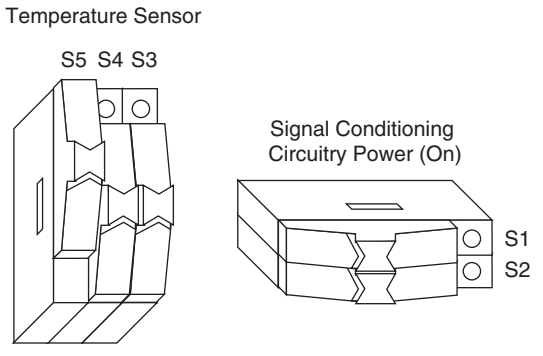
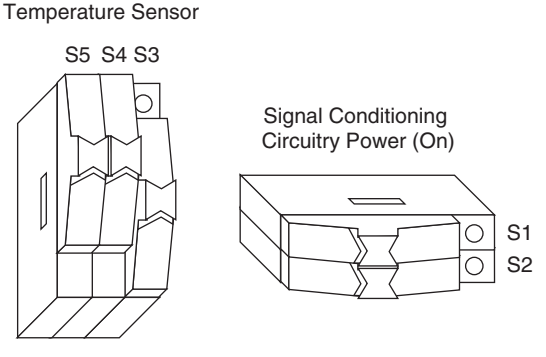
Switch Setting	Applicable Signals
 Direct feedthrough, with temperature sensor disabled and accessory power disabled	Analog input, analog output, digital I/O, and timing I/O
 Temperature sensor disabled, and accessory power enabled[2] **Note:** This configuration is the factory-default configuration.	Analog input and analog output[1]

Table 2-1. Switch Configurations and Affected Signals (Continued)

Switch Setting	Applicable Signals
 Single-ended temperature sensor, with accessory power enabled[2]	Single-ended analog input[3]
 Differential temperature sensor, with accessory power enabled[2]	Differential analog input

[1] When accessory power is enabled, I/O pin 8 is fused and is intended to be connected to +5V. This setting is not recommended for use with the NI 653*X*, NI 670*X*, or NI 660*X*. Refer to the device user manual at `ni.com/manuals` to determine if the device supplies +5 V to I/O pin 8.
[2] Only applies to the signal conditioning circuitry.
[3] Except NI 61*XX* devices. Refer to the device user manual at `ni.com/manuals` to determine if the device supports single-ended inputs.

3

Connecting Signals

This chapter describes the types of signal sources that you use when configuring the channels and making signal connections to the SCB-68, describes input modes, and discusses noise considerations to help you acquire accurate signals.

Connecting Analog Input Signals

The following sections describe how to connect signal sources for single-ended or differential (DIFF) input mode. On most devices, you can software-configure the DAQ device channels for two types of single-ended connections—nonreferenced single-ended (NRSE) input mode and referenced single-ended (RSE) mode. RSE input mode is used for floating signal sources. In this case, the DAQ device provides the reference ground point for the external signal. NRSE input mode is used for ground-referenced signal sources. In this case, the external signal supplies its own reference ground point, and the DAQ device should not supply one.

Note Some devices might only support one of the possible input modes.

Input Modes

You can configure the DAQ device for one of three input modes—NRSE, RSE, or DIFF. The following sections discuss the use of single-ended and differential measurements and considerations for measuring both floating and ground-referenced signal sources. On devices that support both single-ended and DIFF input modes, using DIFF input mode commits two channels, ACH<*i*> and ACH<*i*+8>, to each signal. Figure 3-1 summarizes the recommended input modes for both types of signal sources.

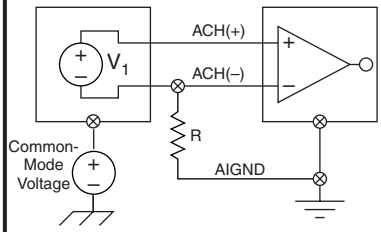
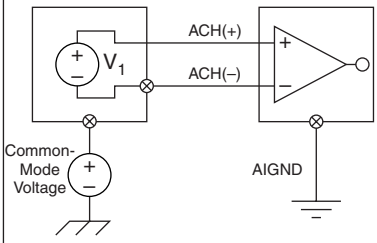
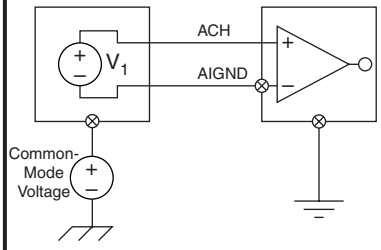
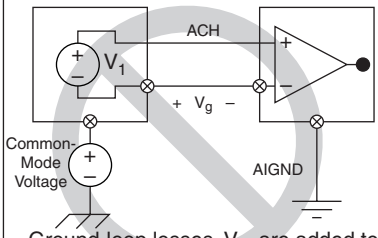
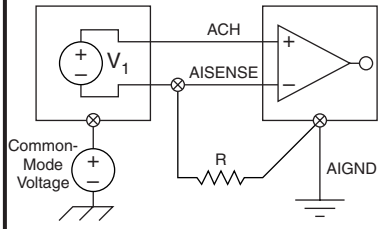
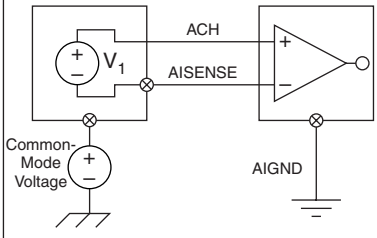
Input	Signal Source Type	
	Floating Signal Source (Not Connected to Building Ground)	**Grounded Signal Source**
	Examples: • Ungrounded thermocouples • Signal conditioning with Isolated outputs • Battery devices	Examples: • Plug-in instruments with nonisolated outputs
Differential (DIFF)	 Refer to the *Using Bias Resistors* section for information on bias resistors.	
Single-Ended — Ground Referenced (RSE)		NOT RECOMMENDED  Ground-loop losses, V_g, are added to measured signal.
Single-Ended — Nonreferenced (NRSE)	 Refer to the *Using Bias Resistors* section for information on bias resistors.	

Figure 3-1. Summary of AI Connections

Nonreferenced or Floating Signal Sources

A floating signal source is a signal source that is not connected in any way to the building ground system, but has an isolated ground-reference point. Instruments or devices with isolated outputs are considered floating signal sources, and they have high-impedance paths to ground. Some examples of floating signal sources are outputs for thermocouples, transformers, battery-powered devices, optical isolators, and isolation amplifiers. The ground reference of a floating source must be tied to the ground of the DAQ device to establish a local or onboard reference for the signal. Otherwise, the measured input signal varies as the source floats outside the common-mode input range.

Differential Inputs

When measuring differential floating sources, you must configure the device for DIFF input mode. To provide a return path for the instrumentation amplifier bias currents, differential floating sources must have a 10 to 100 kΩ resistor connected to AIGND on one input if they are DC coupled or on both inputs if sources are AC coupled. You can install bias resistors in positions B and D of the SCB-68, as shown in Figure 5-1, *Analog Input Channel Configuration Diagram for ACH<i> and ACH<i+8>*.

Single-Ended Inputs

When measuring single-ended floating signal sources, you must configure the DAQ device to supply a ground reference by configuring the DAQ device for RSE input mode. In this mode, the negative input of the instrumentation amplifier on the DAQ device is tied to the analog ground.

To use the SCB-68 with single-ended inputs, where ACH<*i*> and ACH<*i*+8> are used as two single-ended channels, configure the SCB-68 in its factory-default configuration. In the factory-default configuration, jumpers on the SCB-68 are in the two series positions, F and G, as shown in Figure 5-1, *Analog Input Channel Configuration Diagram for ACH<i> and ACH<i+8>*. In this configuration, you should connect all signal grounds to AIGND.

Note Some versions of the SCB-68 use hardwired 0 Ω resistors as the factory-default jumpers. In such cases, to move these jumpers to and from the factory-default positions, you must solder and desolder on the SCB-68 circuit card assembly. When soldering, refer to Appendix E, *Soldering and Desoldering on the SCB-68*.

Ground-Referenced Signal Sources

A grounded signal source is connected in some way to the building system ground; therefore, the signal source is already connected to a common ground point with respect to the DAQ device (assuming that the host computer is plugged into the same power system). Nonisolated outputs of instruments and devices that plug into the building power system fall into this category.

The difference in ground potential between two instruments connected to the same building power system is typically between 1 and 100 V, but the difference can be much greater if the power distribution circuits are improperly connected. If a grounded signal source is incorrectly measured, this difference may appear as a measurement error. The connection instructions for grounded signal sources are designed to eliminate this ground potential difference from the measured signal.

Differential Inputs

If the DAQ device is configured for DIFF input mode, where ACH<*i*> and ACH<*i*+8> are used as a single differential channel pair, ground-referenced signal sources connected to the SCB-68 need no special components. You can leave the inputs of the SCB-68 in the factory configuration with the jumpers in the two series positions, F and G. Refer to Figure 5-1, *Analog Input Channel Configuration Diagram for ACH<i> and ACH<i+8>*, for a diagram of this configuration.



Note Some versions of the SCB-68 use hardwired 0 Ω resistors as the factory-default jumpers. In such cases, to move these jumpers to and from the factory-default positions, you must solder and desolder on the SCB-68 circuit card assembly. When soldering, refer to Appendix E, *Soldering and Desoldering on the SCB-68*.

Single-Ended Inputs

When you measure ground-referenced single-ended signals, the external signal supplies its own reference ground point, and the DAQ device should not supply one. Therefore, you should configure the DAQ device for NRSE input mode. In this input mode, connect all the signal grounds to AISENSE pin, which connects to the negative input of the instrumentation amplifier on the DAQ device. RSE input mode is not recommended for grounded signal sources.

To leave the SCB-68 inputs in the factory configuration with jumpers in the series position (F or G, depending on the channel), do not use the open positions that connect the input to AIGND, A, and C (refer to Figure 5-1,

Analog Input Channel Configuration Diagram for ACH<i> and ACH<i+8>). Any signal conditioning circuitry requiring a ground reference should be built in the custom breadboard area using AISENSE as the ground reference instead of building the circuitry in the open component positions. Referencing the signal to AIGND can cause inaccurate measurements resulting from an incorrect ground reference.

Note Some versions of the SCB-68 use hardwired 0 Ω resistors as the factory-default jumpers. In such cases, to move these jumpers to and from the factory-default positions, you must solder and desolder on the SCB-68 circuit card assembly. When soldering, refer to Appendix E, *Soldering and Desoldering on the SCB-68*.

Differential Connection Considerations (DIFF Input Mode)

A differential connection is one in which the DAQ device AI signal has its own reference signal, or signal return path. These connections are available when the selected channel is configured in DIFF input mode. The input signal is tied to the positive input of the instrumentation amplifier, and its reference signal, or return, is tied to the negative input of the instrumentation amplifier. On DAQ devices that support both single-ended and DIFF input modes, using DIFF input mode commits two channels, ACH<*i*> and ACH<*i*+8>, to each signal.

You should use differential input connections for any channel that meets any of the following conditions:

- The input signal is low-level (less than 1 V).
- The leads connecting the signal to the DAQ device are longer than 10 ft (3 m).
- The input signal requires a separate ground-reference point or return signal.
- The signal leads travel through noisy environments.

Differential signal connections reduce noise pickup and increase common-mode noise rejection. Differential signal connections also allow input signals to float within the common-mode limits of the instrumentation amplifier.

Differential Connections for Ground-Referenced Signal Sources

Figure 3-2 shows how to connect a ground-referenced signal source to a channel on the DAQ device configured in DIFF input mode.

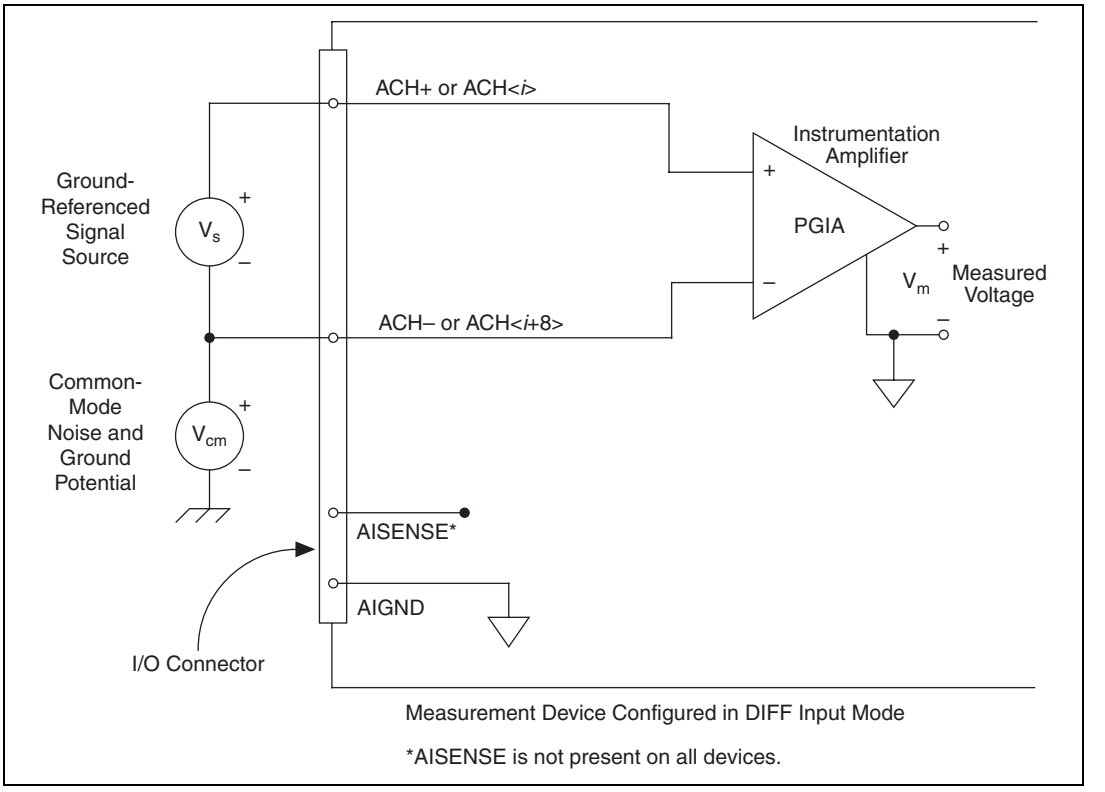


Figure 3-2. Differential Input Connections for Ground-Referenced Signals

With this connection type, the instrumentation amplifier rejects both the common-mode noise in the signal and the ground potential difference between the signal source and the DAQ device ground, shown as V_{cm} in Figure 3-2.

Differential Connections for Nonreferenced or Floating Signal Sources

Figure 3-3 shows how to connect a floating signal source to a channel on the DAQ device configured in DIFF input mode.

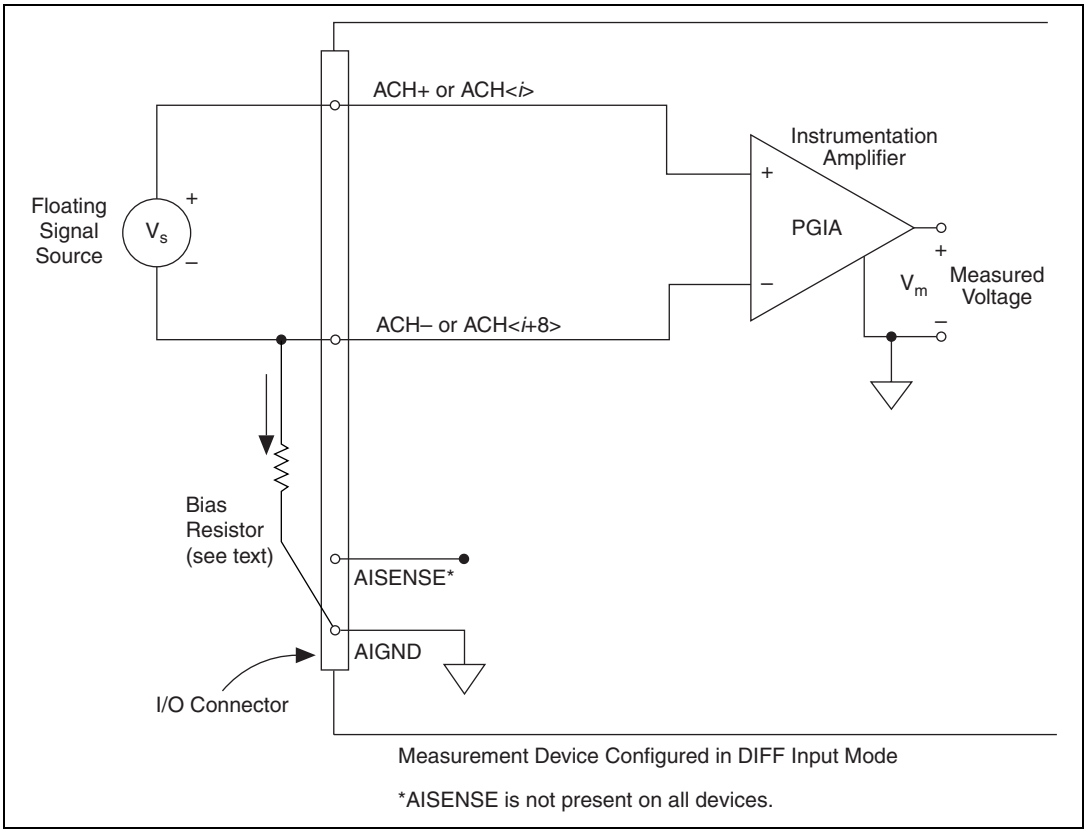


Figure 3-3. Differential Input Connections for Nonreferenced Signals

Using Bias Resistors

Figure 3-3 shows a bias resistor connected between ACH– or ACH<*i*+8>, and AIGND. This resistor provides a return path for the ±200 pA bias current. A value of 10 kΩ to 100 kΩ is usually sufficient. If you do not use the resistor and the source is truly floating, the source is not likely to remain within the common-mode signal range of the PGIA, and the PGIA saturates, causing erroneous readings. You must reference the source to the respective channel ground.

Common-mode rejection might be improved by using another bias resistor between ACH+ or ACH<*i*>, and AIGND. This connection creates a slight measurement error caused by the voltage divider formed with the output impedance of the floating source, but it also gives a more balanced input for better common-mode rejection.

Single-Ended Connection Considerations

A single-ended connection is one in which the DAQ device AI signal is referenced to a ground that can be shared with other input signals. The input signal is tied to the positive input of the instrumentation amplifier, and the ground is tied to the negative input of the instrumentation amplifier.

You can use single-ended input connections for input signals that meet the following conditions:

- The input signal is high-level (greater than 1 V).
- The leads connecting the signal to the DAQ device are less than 10 ft (3 m).
- The input signal can share a common reference point with other signals.

DIFF input connections are recommended for greater signal integrity for any input signal that does not meet the preceding conditions.

In single-ended modes, more electrostatic and magnetic noise couples into the signal connections than in differential modes. The coupling is the result of differences in the signal path. Magnetic coupling is proportional to the area between the two signal conductors. Electrical coupling is a function of how much the electric field differs between the two conductors.

Single-Ended Connections for Floating Signal Sources (RSE Input Mode)

Figure 3-4 shows how to connect a floating signal source to a channel on the DAQ device configured for RSE input mode.

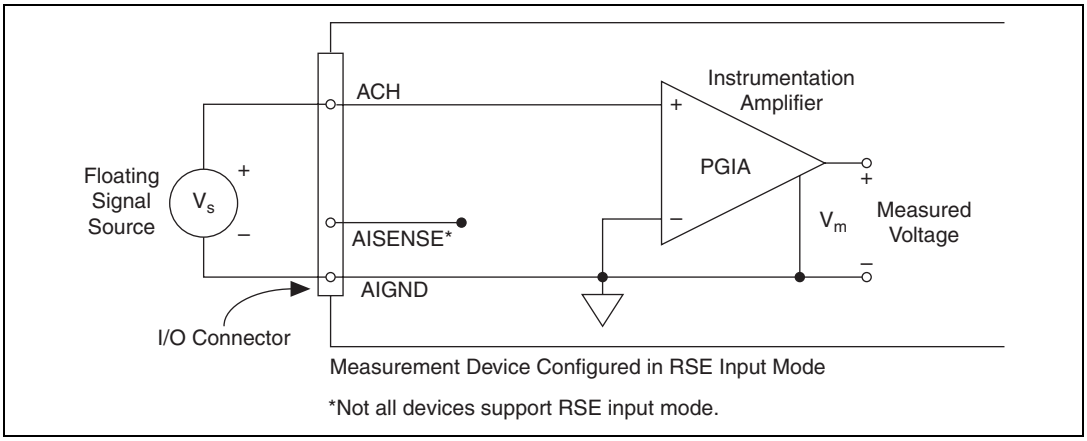


Figure 3-4. Single-Ended Input Connections for Nonreferenced or Floating Signals

Single-Ended Connections for Grounded Signal Sources (NRSE Input Mode)

To measure a grounded signal source with a single-ended configuration, configure the DAQ device in NRSE input mode. The signal is then connected to the positive input of the DAQ device instrumentation amplifier, and the signal local ground reference is connected to the negative input of the instrumentation amplifier. The ground point of the signal should, therefore, be connected to AISENSE. Any potential difference between the DAQ device ground and the signal ground appears as a common-mode signal at both the positive and negative inputs of the instrumentation amplifier, and this difference is rejected by the amplifier. If the input circuitry of a DAQ device were referenced to ground, in this situation (as in the RSE input mode), this difference in ground potentials would appear as an error in the measured voltage.

Figure 3-5 shows how to connect a grounded signal source to a channel on the DAQ device configured for NRSE input mode.

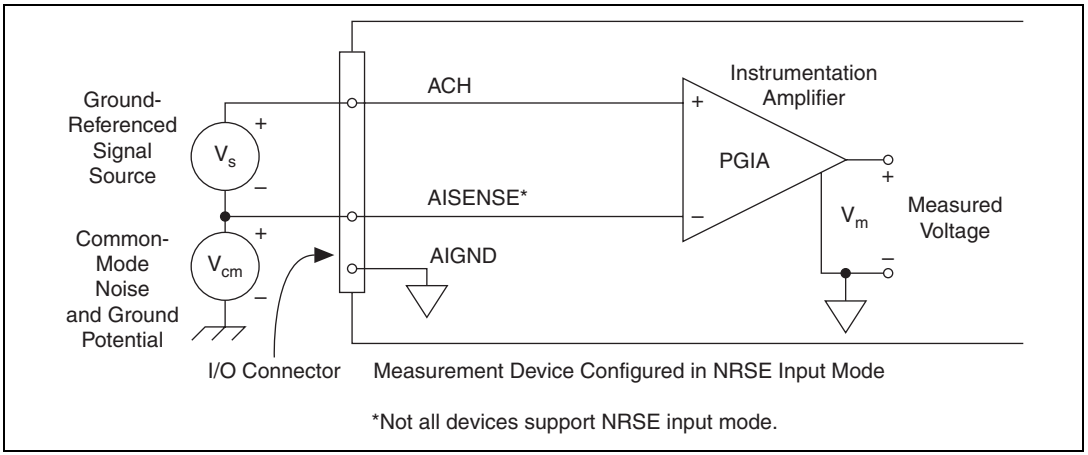


Figure 3-5. Single-Ended Input Connections for Ground-Referenced Signals

Connecting Analog Output Signals

When using the SCB-68 with a 68-pin or 100-pin DAQ device, the AO signals are DAC0OUT, DAC1OUT, EXTREF, and AOGND. DAC0OUT is the voltage output channel for AO channel 0. DAC1OUT is the voltage output channel for AO channel 1. EXTREF is the external reference input for both AO channels. AOGND is the ground reference signal for both AO channels and the external reference signal.

Note For more information, refer to the device user manual at `ni.com/manuals` for detailed signal connection information for AO signals.

Figure 3-6 shows how to make AO connections and the external reference connection to the SCB-68 and the DAQ device.

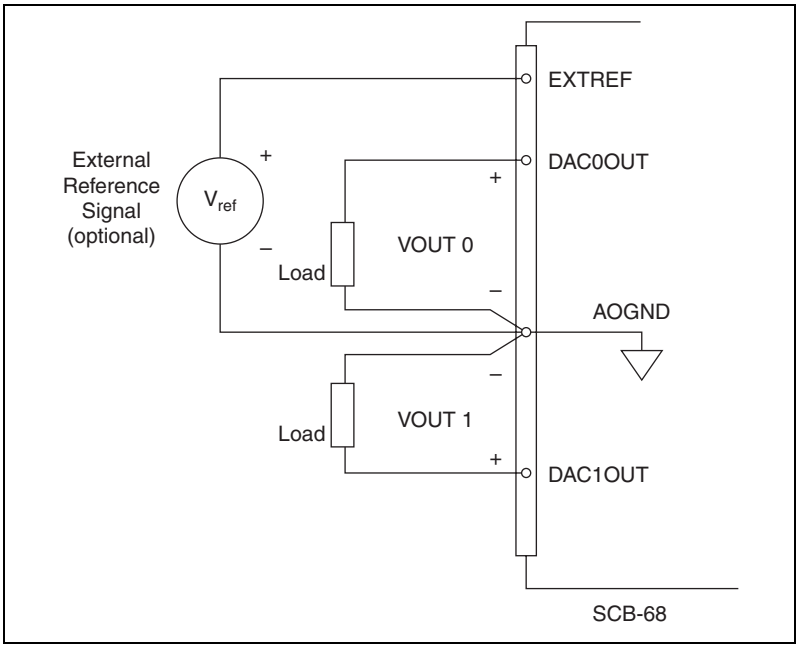


Figure 3-6. Connecting AO Signals

Connecting Digital Signals

When using the SCB-68 with a 68-pin or 100-pin DAQ device, the DIO signals are DIO<0..7> and DGND. DIO<0..7> are the eight single-ended DIO lines, and DGND is the ground reference. You can program all lines individually to be inputs or outputs.

Note For more information, refer to the device user manual at `ni.com/manuals` for detailed signal description and connection information.

Figure 3-7 illustrates several common DIO applications and signal connections. Digital input applications include receiving TTL signals and sensing external device states such as the state of the switch shown in Figure 3-7. Digital output applications include sending TTL signals and driving external devices such as the LED shown in Figure 3-7.

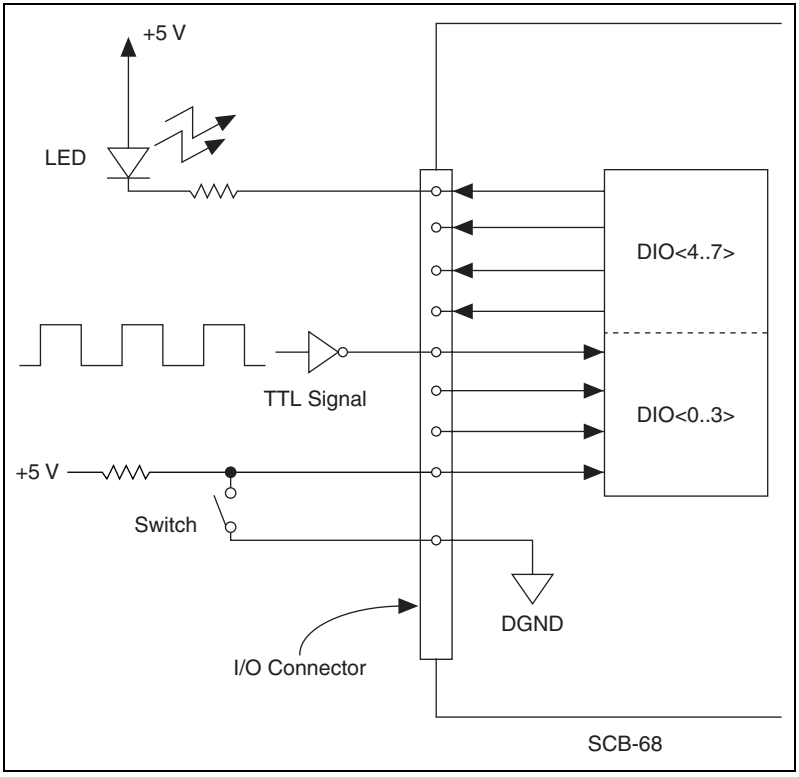


Figure 3-7. Digital I/O Connections

Connecting Timing Signals

If you are using a 68-pin or 100-pin DAQ device, all external control over device timing is routed through the programmable function input (PFI) lines <0..9>. These PFI lines are bidirectional; as outputs they are not programmable and reflect the state of many DAQ, waveform generation, and general-purpose timing signals. The remaining timing signals use five different dedicated outputs.

Note For more information, refer to the device user manual at `ni.com/manuals` for detailed signal description and connection information.

All digital timing connections are referenced to DGND. Figure 3-8 demonstrates how to connect two external timing signals to the PFI pins of a DAQ device.

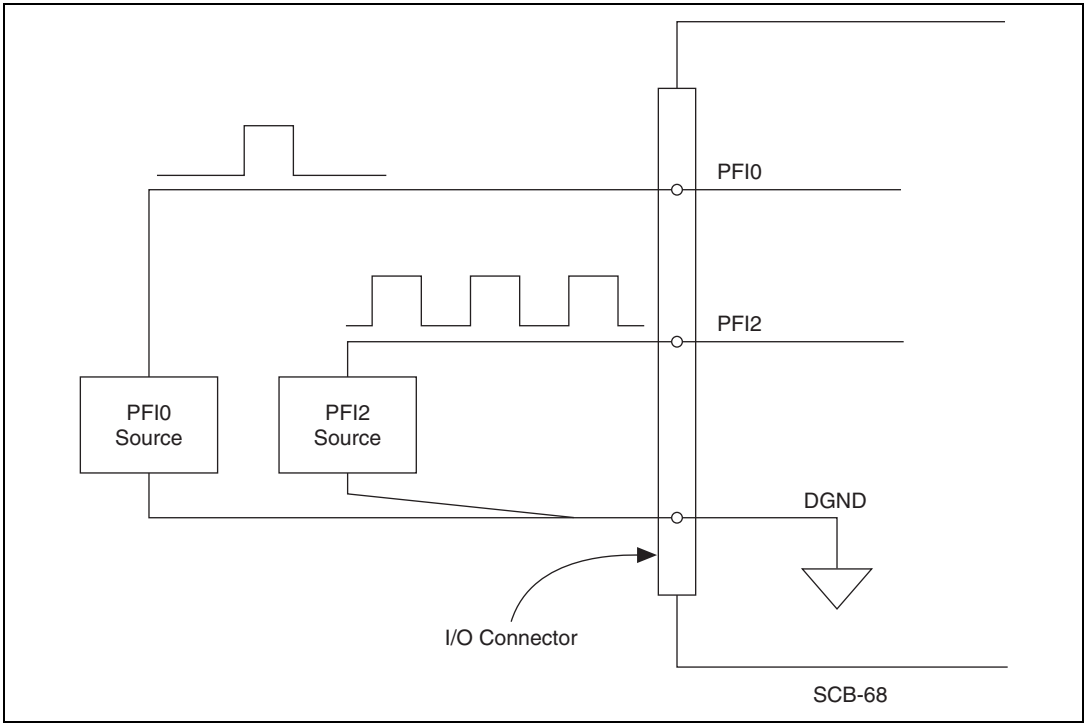


Figure 3-8. Timing I/O Connections

Noise Considerations

Environmental noise can seriously affect the measurement accuracy of your application if you do not take proper care when running signal wires between signal sources and the device. The following recommendations apply mainly to AI signal routing to the device, although they also apply to signal routing in general.

Minimize noise pickup and maximize measurement accuracy by taking the following precautions:

- Use differential AI connections to reject common-mode noise, if the DAQ device that you are using supports DIFF input mode.
- Use individually shielded, twisted-pair wires to connect AI signals to the device. With this type of wire, the signals attached to the

ACH+ and ACH– inputs are twisted together and then covered with a shield. You then connect this shield at only one point to the signal source ground. This kind of connection is required for signals traveling through areas with large magnetic fields or high electromagnetic interference.

- Route signals to the device carefully. Keep cabling away from noise sources. A common noise source in DAQ applications is the computer monitor. Separate the monitor from the analog signals as far as possible.

The following recommendations apply for all signal connections to the DAQ device:

- Separate DAQ device signal lines from high-current or high-voltage lines. These lines can induce currents in or voltages on the DAQ device signal lines if they run in parallel paths at a close distance. To reduce the magnetic coupling between lines, separate them by a reasonable distance if they run in parallel, or run the lines at right angles to each other.
- Do not run signal lines through conduits that also contain power lines.
- Protect signal lines from magnetic fields caused by electric motors, welding equipment, breakers, or transformers by running them through special metal conduits.

For information about minimizing noise in your application, refer to the NI Developer Zone tutorial, *Field Wiring and Noise Considerations for Analog Signals*, located at `ni.com/zone`.

4

Using Thermocouples

This chapter describes how to take thermocouple measurements using the SCB-68. A thermocouple is created when two dissimilar metals touch, and the contact produces a small voltage that changes as a function of temperature. By measuring the voltage of a thermocouple, you can determine temperature using a nonlinear equation that is unique to each thermocouple type. Thermocouple types are designated by capital letters that indicate their composition according to the American National Standards Institute (ANSI) conventions. To determine the type of thermocouple that you are using, refer to Table 4-1. For more information on the theory of operation of thermocouples, refer to the NI Developer Zone tutorial, *Measuring Temperature with Thermocouples*, at `ni.com/zone`.

Table 4-1. Thermocouple Coloring

Thermocouple Type	Positive Color	Negative Color	Thermocouple Cover Color	Extended Grade Cover Color
B	Gray	Red	—	Gray
C	White/Red Trace	Red	—	White/Red Trace
E	Purple	Red	Brown	Purple
J	White	Red	Brown	Black
K	Yellow	Red	Brown	Yellow
N	Orange	Red	Brown	Orange
R	Black	Red	—	Green
S	Black	Red	—	Green
U	Black	Red	—	Green
T	Blue	Red	Brown	Blue

The maximum voltage level thermocouples generate is typically only a few millivolts. Therefore, you should use a DAQ device with high gain for best resolution. You can measure thermocouples in either differential or single-ended configuration. The differential configuration has better noise immunity, but the single-ended configurations have twice as many inputs. The DAQ device must have a ground reference, because thermocouples are floating signal sources. Therefore, use bias resistors if the DAQ device is in DIFF input mode. For a single-ended configuration, use RSE input mode. For more information on field wiring considerations, refer to the NI Developer Zone tutorial, *Field Wiring and Noise Considerations for Analog Signals*, located at `ni.com/zone`.

Cold-junction compensation (CJC) with the SCB-68 is accurate only if the temperature sensor reading is close to the actual temperature of the screw terminals. When you read thermocouple measurements, keep the SCB-68 away from drafts or other temperature gradients, such as those caused by heaters, radiators, fans, and very warm equipment. To minimize temperature gradients, keep the cover of the SCB-68 closed and add custom insulation, such as foam tape, to the SCB-68.

Switch Settings and Temperature Sensor Configuration

To accommodate thermocouples with DAQ devices, the SCB-68 has a temperature sensor for CJC. To power the temperature sensor, set switches S1, S2, and S3 as shown in Figures 4-1 and 4-2. Notice that this configuration also powers on the signal conditioning accessory power. Signal conditioning accessories include temperature sensors and signal conditioning circuitry.

For single-ended operation, connect referenced single-ended analog channel 0 to the temperature sensor by switching S5 to the up position. The signal is referenced to AIGND. Set the switches as shown in Figure 4-1.

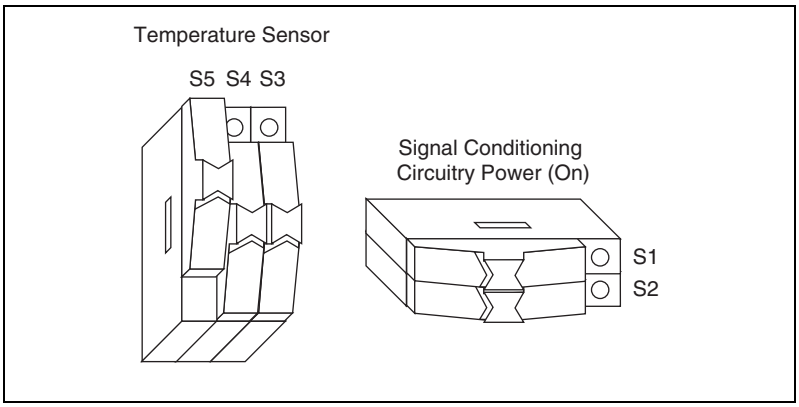


Figure 4-1. Single-Ended Switch Configuration

For differential operation, connect differential analog channel 0 to the temperature sensor by switching S5 and S4 to the up position, as shown in Figure 4-2.

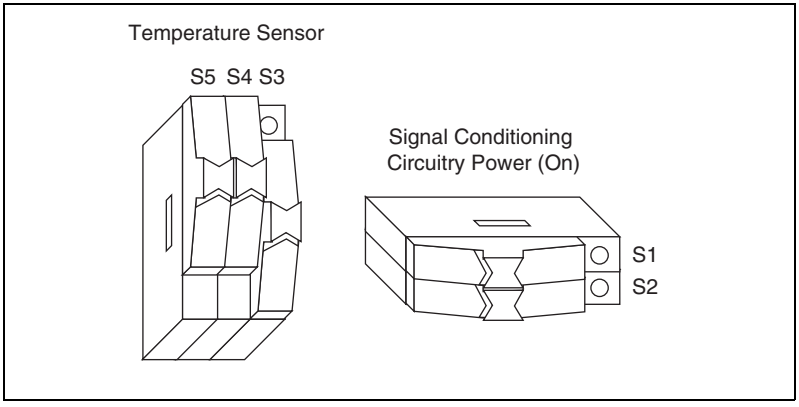


Figure 4-2. Differential Switch Configuration

Special Considerations

To connect a high-value resistor between the positive input and +5V, refer to the *Accuracy and Resolution Considerations* section of Chapter 5, *Adding Components for Special Functions*.

To reduce noise by connecting a lowpass filter to the analog inputs of the SCB-68, refer to the *Lowpass Filtering* section of Chapter 5, *Adding Components for Special Functions*.

5

Adding Components for Special Functions

This chapter describes how to condition signals by adding components to the open component locations of the SCB-68. To add components to these locations, the DAQ device must support switch configurations 2, 3, or 4 in Table 2-1, *Switch Configurations and Affected Signals*.

Caution Add components at your own risk.

The following signal conditioning applications are described in this chapter:

- Analog input
  - Open thermocouple detection
  - Lowpass filtering
  - Measuring 4–20 mA current
  - Voltage attenuation
- Analog output
  - Lowpass smoothing filter
  - Voltage attenuation
- Digital input
  - Lowpass digital filter
  - Voltage attenuation

In addition to the applications described in this chapter, many other types of signal conditioning can be built using the component pads and the general-purpose breadboard area of the SCB-68. Refer to Appendix E, *Soldering and Desoldering on the SCB-68*, for more information about adding components and for soldering and desoldering instructions.

After building one of the applications described in this chapter or your own custom circuitry, refer to the *Configuring the SCB-68* section of Chapter 1, *Introduction*, for instructions about how to configure the SCB-68 in MAX.

You can create virtual channels in MAX to map your voltage ranges to the type of transducer that you are using or to create a custom scale.

Channel Pad Configurations

When you use the SCB-68 with a 68-pin or 100-pin DAQ device, you can use the component pads on the SCB-68 to condition 16 AI channels, two AO channels, and PFI0/TRIG1.

Conditioning Analog Input Channels

Figure 5-1 illustrates the AI channel configuration. ACH<*i*> and ACH<*i*+8> can be used as either a differential channel pair or as two single-ended channels. Table 5-1 correlates the component labels of the SCB-68 to component locations A–G for differential channels 0–7. In the component names in Table 5-1, *R* denotes a resistor, and *C* denotes a capacitor. Component locations labeled RC*X* provide sockets for two components, a resistor and a capacitor, to be connected in parallel.

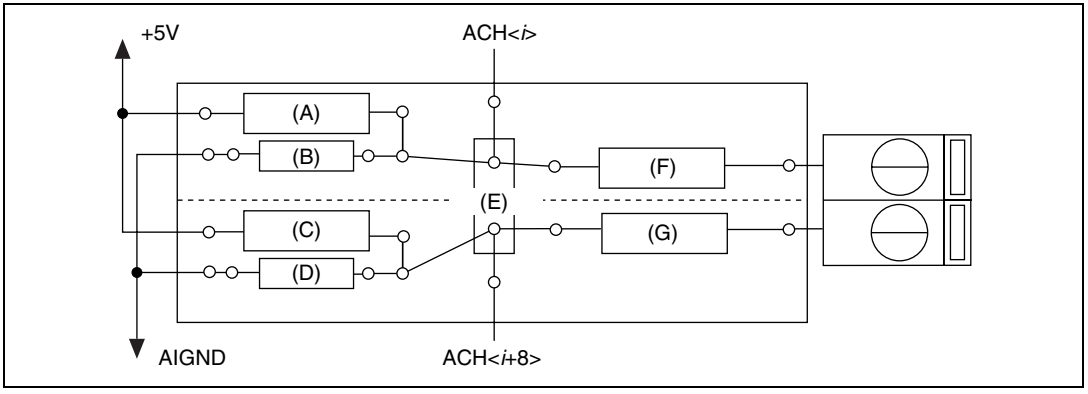


Figure 5-1. Analog Input Channel Configuration Diagram for ACH<*i*> and ACH<*i*+8>

Table 5-1. Component Location for Analog Input Channels in DIFF Input Mode

Channel	A	B	C	D	E	F	G
ACH0	R22	RC12	RC13	R23	RC4	R4	R5
ACH1	R24	RC14	RC15	R25	RC5	R6	R7
ACH2	R26	RC14	RC17	R27	RC6	R8	R9
ACH3	R28	RC18	RC19	R29	RC7	R10	R11

Table 5-1. Component Location for Analog Input Channels in DIFF Input Mode (Continued)

Channel	A	B	C	D	E	F	G
ACH4	R30	RC20	RC21	R31	RC8	R12	R13
ACH5	R32	RC22	RC23	R33	RC9	R14	R15
ACH6	R34	RC24	RC25	R35	RC10	R16	R17
ACH7	R36	RC26	RC27	R37	RC11	R18	R19

Conditioning Analog Output Channels

Figure 5-2 illustrates the generic AO channel pad configuration, and Table 5-2 describes the AO component locations and labels. Figure 5-3 shows the AO channel configuration for DAC0OUT.

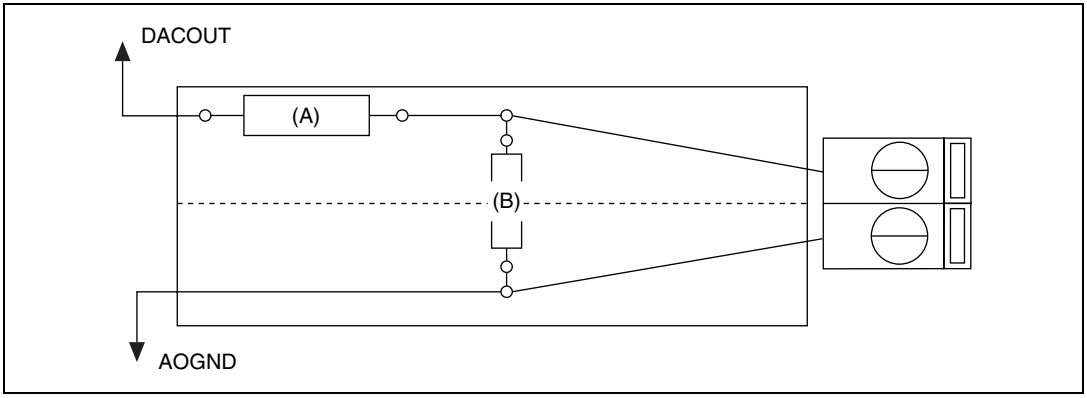


Figure 5-2. Analog Output Channel Configuration Diagram

Table 5-2. Component Location for Analog Output Channels in DIFF Input Mode

Channel	A	B
DAC0OUT	R3	RC3
DAC1OUT	R2	RC2

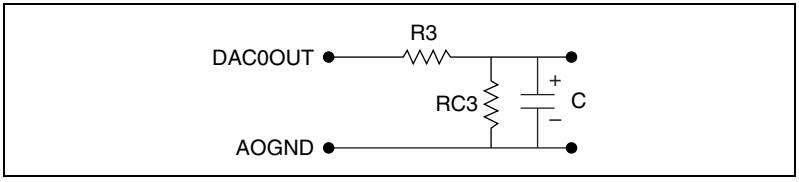


Figure 5-3. Analog Output Channel Configuration Diagram for DAC0OUT

Conditioning PFI0/TRIG1

Figure 5-4 illustrates the digital input channel configuration, and Figure 5-5 shows the digital input channel configuration for PFI0/TRIG1.

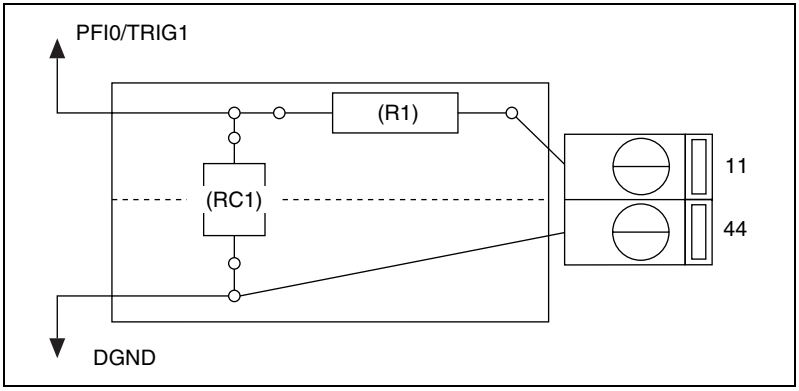


Figure 5-4. Digital Input Channel Configuration Diagram

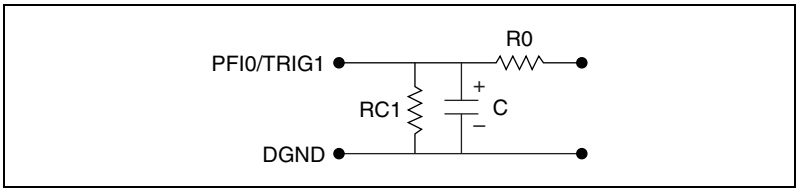


Figure 5-5. Digital Input Channel Configuration Diagram for PFI0/TRIG1

Accuracy and Resolution Considerations

When you measure voltage to subsequently measure current, take the following steps to maximize measurement accuracy:

1. Refer to the accuracy tables in Appendix A, *Specifications*, of the DAQ device user manual at `ni.com/manuals`.
2. Use Equation 5-1 to determine the code width, which is the smallest signal change that a system can detect.
3. Divide code width by the resistor value to determine the minimum current value you can measure.

$$Code\ Width = \frac{Range}{Gain \times 2^{Resolution}} \quad (5\text{-}1)$$

In Equation 5-1, *range* defines the values between and including the minimum and maximum voltages that the ADC can digitize. For example, the range is 20 when you measure a signal between –10 to 10 V. *Gain*, which is determined by the input limits of the application, is a value you apply to amplify or attenuate the signal.

Gain is expressed in decibels and is defined as:

$$Gain = 20\ \mathrm{Log}(f) \quad (5\text{-}2)$$

Resolution, or the smallest signal increment that can be detected by a measurement system, is either 12 or 16 bits, depending on the DAQ device.

Open Thermocouple Detection

As an option, you can build open thermocouple detection circuitry by connecting a high-value resistor between the positive input and +5V. A resistor of a few MΩ or more is sufficient, but a high-value resistor allows you to detect an open or defective thermocouple. If the thermocouple opens, the voltage measured across the input terminals rises to +5 V, a value much larger than any legitimate thermocouple voltage. You can create a bias current return path by using a 100 kΩ resistor between the negative input and AIGND.

Differential Open Thermocouple Detection

Use position A to connect a high-value resistor between the positive input and +5V. Leave the jumpers in place (positions F and G) for each channel used.

Single-Ended Open Thermocouple Detection

Use position A for one channel and C for the next channel when you connect a high-value resistor between the positive input and +5V. Leave the jumpers at positions F and G in place for each channel used.

Sources of Error

When making thermocouple measurements with the SCB-68, the possible sources of error are compensation, linearization, measurement, and thermocouple wire errors.

Compensation error can arise from two sources—inaccuracy of the temperature sensor and temperature differences between the temperature sensor and the screw terminals. The temperature sensor on the SCB-68 is specified to be accurate to ±1 °C. You can minimize temperature differences between the temperature sensor and the screw terminals by keeping the SCB-68 away from drafts, heaters, and warm equipment.

Thermocouple output voltages are nonlinear with respect to temperature. Conversion of the voltage output to temperature using either look-up tables or polynomial approximations introduces linearization error. The linearization error is dependent upon how closely the table or the polynomial approximates the true thermocouple output. For example, you can reduce the linearization error by using a higher degree polynomial.

Measurement error is the result of inaccuracies in the DAQ device. These inaccuracies include gain and offset. If the device is properly calibrated, the offset error should be zeroed out. The only remaining error is a gain error of ±0.08% of full range. If the input range is ±10 V and the gain is 500, gain error contributes 0.0008×20 mV, or 16 µV of error. If the Seebeck coefficient of a thermocouple is 32 µV/°C, this measurement error adds 0.5 °C of uncertainty to the measurement. For best results, you must use a well-calibrated DAQ device so that offsets can be ignored. You can eliminate offset error, however, by grounding one channel on the SCB-68 and measuring the voltage. You can then subtract this value, the offset of the DAQ device, in software from all other readings.

Thermocouple wire error is the result of inconsistencies in the thermocouple manufacturing process. These inconsistencies, or nonhomogeneities, are the result of defects or impurities in the thermocouple wire. The errors vary widely depending upon the thermocouple type and even the gauge of wire used, but an error of ±2 °C is typical. For more information on thermocouple wire errors and more specific data, consult the thermocouple manufacturer.

For best results, use the average of many readings (about 100 or so); typical absolute accuracies should then be about ±2 °C.

Lowpass Filtering

This section discusses lowpass filtering and how to add components for lowpass filtering.

Theory of Operation

Lowpass filters highly or completely attenuate signals with frequencies above the cut-off frequency, or high-frequency stopband signals, but lowpass filters do not attenuate signals with frequencies below the cut-off frequency, or low-frequency passband signals. Ideally, lowpass filters have a phase shift that is linear with respect to frequency. This linear phase shift delays signal components of all frequencies by a constant time, independent of frequency, thereby preserving the overall shape of the signal.

In practice, lowpass filters subject input signals to a mathematical transfer function that approximates the characteristics of an ideal filter. By analyzing the Bode Plot, or the plot that represents the transfer function, you can determine the filter characteristics.

Figures 5-6 and 5-7 show the Bode Plots for the ideal filter and the real filter, respectively, and indicate the attenuation of each transfer function.

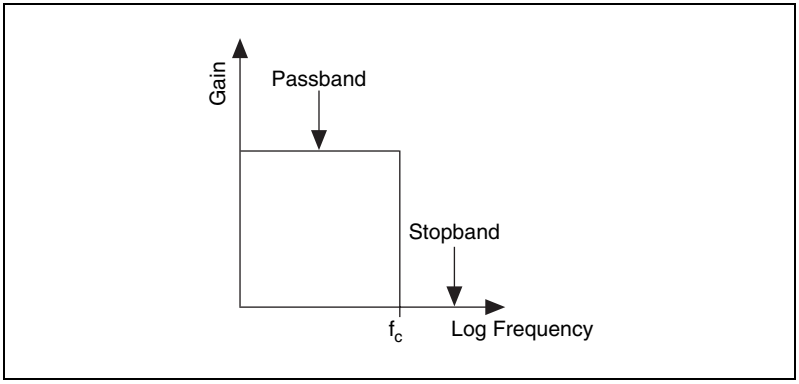


Figure 5-6. Transfer Function Attenuation for an Ideal Filter

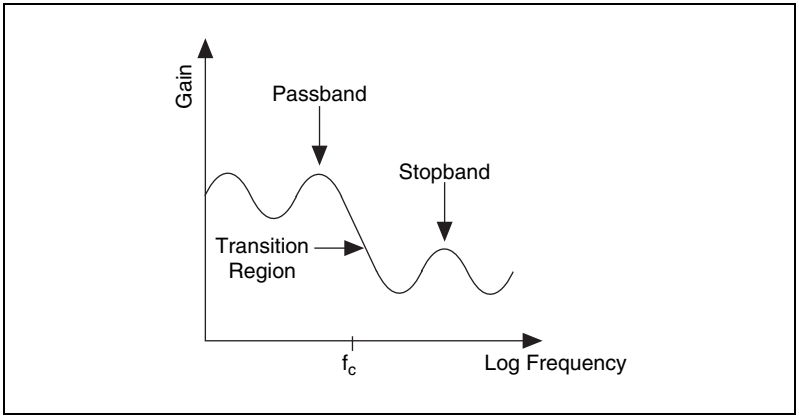


Figure 5-7. Transfer Function Attenuation for a Real Filter

The cut-off frequency, f_c, is defined as the frequency beyond which the gain drops 3 dB. Figure 5-6 shows how an ideal filter causes the gain to drop to zero for all frequencies greater than f_c. Thus, f_c does not pass through the filter to its output. Instead of having a gain of absolute zero for frequencies greater than f_c, the real filter has a transition region between the passband and the stopband, a ripple in the passband, and a stopband with a finite attenuation gain.

Real filters have some nonlinearity in their phase response, causing signals at higher frequencies to be delayed by longer times than signals at lower frequencies and resulting in an overall shape distortion of the signal. For example, when the square wave shown in Figure 5-8 enters a filter, an ideal filter smooths the edges of the input, whereas a real filter causes some

ringing in the signal as the higher frequency components of the signal are delayed.

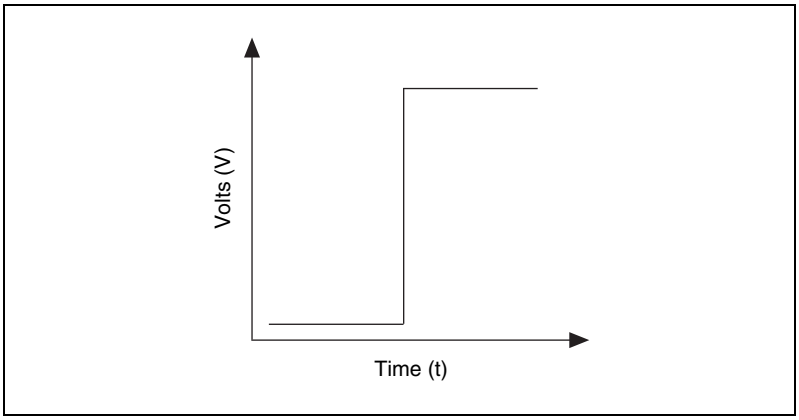


Figure 5-8. Square Wave Input Signal

Figures 5-9 and 5-10 show the difference in response to a square wave between an ideal and a real filter, respectively.

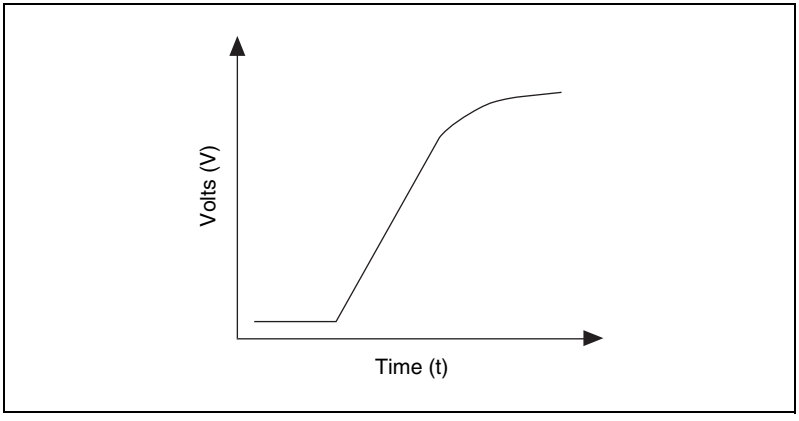


Figure 5-9. Response of an Ideal Filter to a Square Wave Input Signal

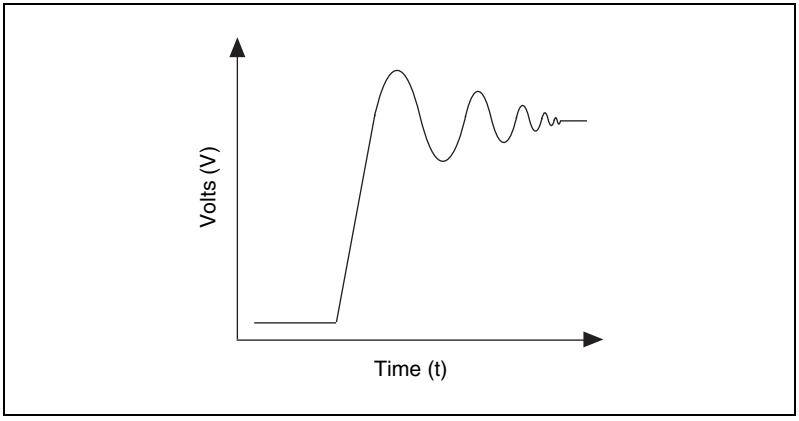


Figure 5-10. Response of a Real Filter to a Square Wave Input Signal

One-Pole Lowpass RC Filter

Figure 5-11 shows the transfer function of a simple series circuit consisting of a resistor (R) and capacitor (C) when the voltage across R is assumed to be the output voltage (V_m).

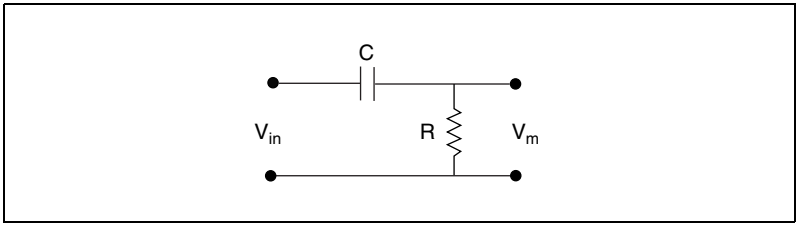


Figure 5-11. Transfer Function of a Simple Series Circuit

The transfer function is a mathematical representation of a one-pole lowpass filter, with a time constant of

$$\frac{1}{2\pi RC}$$

as follows:

$$T(s) = \frac{G}{1 + (2\pi RC)s} \tag{5-3}$$

Use Equation 5-3 to design a lowpass filter for a simple resistor and capacitor circuit, where the values of the resistor and capacitor alone determine f_c. In this equation, G is the DC gain and s represents the frequency domain.

Selecting Components

To determine the value of the components in the circuit, fix R (10 kΩ is reasonable) and isolate C from Equation 5-3 as follows:

$$C = \frac{1}{2\pi R f_c} \tag{5-4}$$

The cut-off frequency in Equation 5-4 is f_c.

For best results, choose a resistor that has the following characteristics:

- Low wattage of approximately 1/8 W
- Precision of at least 5%
- Temperature stability
- Tolerance of 5%
- AXL package (suggested)
- Carbon or metal film (suggested)

Choose a capacitor that has the following suggested characteristics:

- AXL or RDL package
- Tolerance of 20%
- Maximum voltage of at least 25 V

Adding Components

Using the circuit shown in Figure 5-11, you can use a two-component circuit to build a simple RC filter with analog input, analog output, or digital input. You can build a single-ended analog input RC filter with pads F and B for one channel and pads G and D for the next channel. You can build a differential analog input RC filter with pads F and E.

For TRIG1, you can use pads R1 and RC1. For AO, you can use R2 and RC2 for DAC1OUT, and you can use R3 and RC3 for DAC0OUT.

For any type of lowpass filter, use Equation 5-5 to determine the cut-off frequency (f_c).

$$fc = \frac{1}{2\pi RC} \quad (5\text{-}5)$$

Single-Ended Lowpass Filter

To build a single-ended lowpass filter, refer to Figure 5-12. Add the resistor to position B or D, depending on the AI channel you are using. Add the capacitor to position F or G, depending on the AI channel you are using.

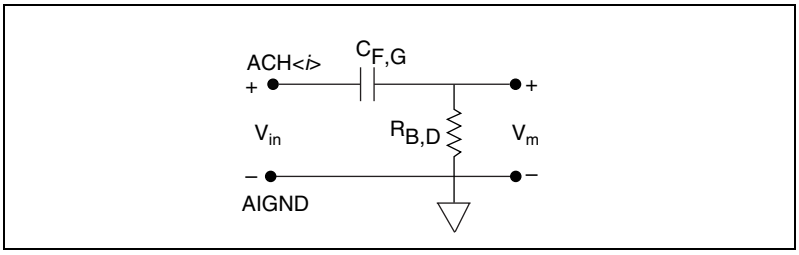


Figure 5-12. SCB-68 Circuit Diagram for a Single-Ended Lowpass Filter

Differential Lowpass Filter

To build a differential lowpass filter, refer to Figure 5-13. Add the resistor to position E and the capacitor to position F.

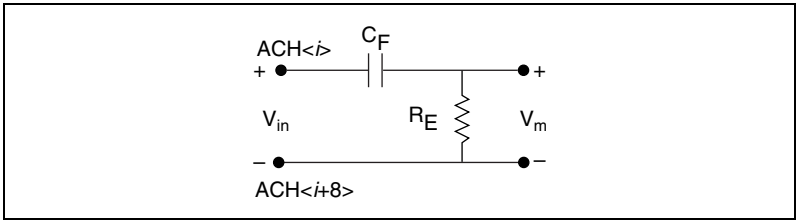


Figure 5-13. SCB-68 Circuit Diagram for a Differential Lowpass Filter

Analog Output and Digital Input Lowpass Filtering

For DAC0OUT, add the resistor to position RC3 and the capacitor to position R3. For DAC1OUT, add the resistor to position RC2 and the capacitor to position R2.

For TRIG1, add the resistor to position RC1 and the capacitor to position R1.

Lowpass Filtering Applications

Noise filtering and antialiasing are two applications that use lowpass filters.

Noise Filtering

You can use a lowpass filter to highly attenuate the noise frequency on a measured signal. For example, power lines commonly add a noise frequency of 60 Hz. Adding a filter with $f_c < 60$ Hz at the input of the measurement system causes the noise frequency to fall into the stopband.

Referring to Equation 5-4, fix the resistor value at 10 kΩ to calculate the capacitor value and choose a commercial capacitor value that satisfies the following relationship:

$$C > \frac{1}{2\pi(10,000)(60)} \tag{5-6}$$

Antialiasing Filtering

Aliasing causes high-frequency signal components to appear as a low-frequency signal, as Figure 5-14 shows.

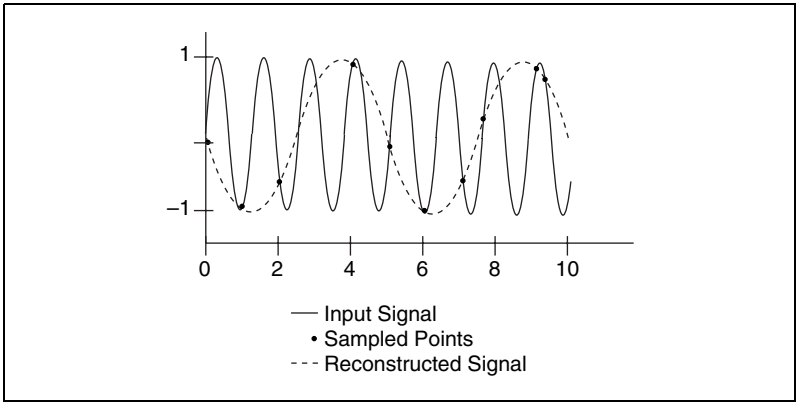


Figure 5-14. Aliasing of a High-Frequency Signal

The solid line depicts a high-frequency signal being sampled at the indicated points. When these points are connected to reconstruct the waveform, as shown by the dotted line, the signal appears to have a lower frequency. Any signal with a frequency greater than one-half of its sample rate is aliased and incorrectly analyzed as having a frequency below one-half the sample rate. This limiting frequency of one-half the sample rate is known as the *Nyquist frequency*.

To prevent aliasing, remove all signal components with frequencies greater than the Nyquist frequency from input signals before those signals are sampled. Once a data sample is aliased, it is impossible to accurately reconstruct the original signal.

To design a lowpass filter that attenuates signal components with a frequency higher than half of the Nyquist frequency, substitute the half Nyquist value for the f_c value in Equation 5-6.

The following devices provide antialiasing filters and do not need to have the filters implemented at the SCB-68 terminal block:

- NI PCI/PXI-61*XX* (not including the NI PCI-6110/6111)
- NI PCI-445*X*
- NI PCI-455*X*

Special Consideration for Analog Input Channels

Filtering increases the settling time of the instrumentation amplifier to the time constant of the filter used. Adding RC filters to scanning channels greatly reduces the practical scanning rate, since the instrumentation amplifier settling time can be increased to 10T or longer, where $T = (R)(C)$. You can use RC filters with single-ended or differential inputs.

Special Consideration for Analog Output Signals

Lowpass filters can smooth stairstep-like curves on AO signals. If the curves are not smoothed, the AO signals can be a hazard for some external circuitry connected to it. Figure 5-15 shows the output of a lowpass filter when a stairstep-like signal is the input.

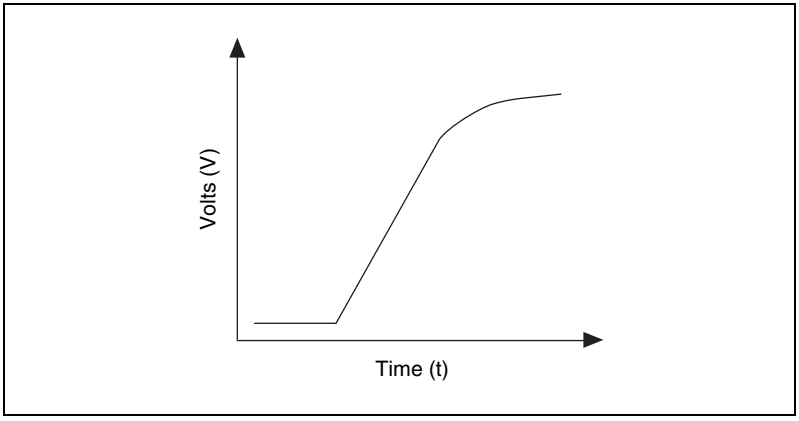


Figure 5-15. Lowpass Filtering of AO Signals

Special Consideration for Digital Trigger Input Signals

Lowpass filters can function as debouncing filters to smooth noise on digital trigger input signals, thus enabling the trigger-detection circuitry of the DAQ device to understand the signal as a valid digital trigger.

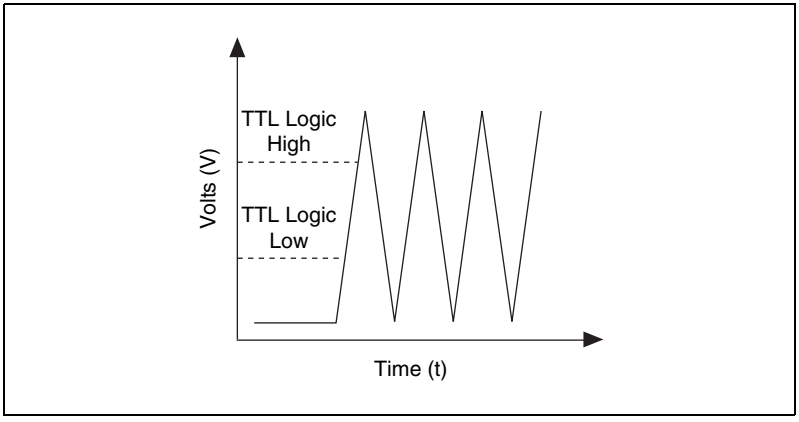


Figure 5-16. Digital Trigger Input Signal with a High-Frequency Component

Apply a lowpass filter to the signal to remove the high-frequency component for a cleaner digital signal, as Figure 5-17 shows.

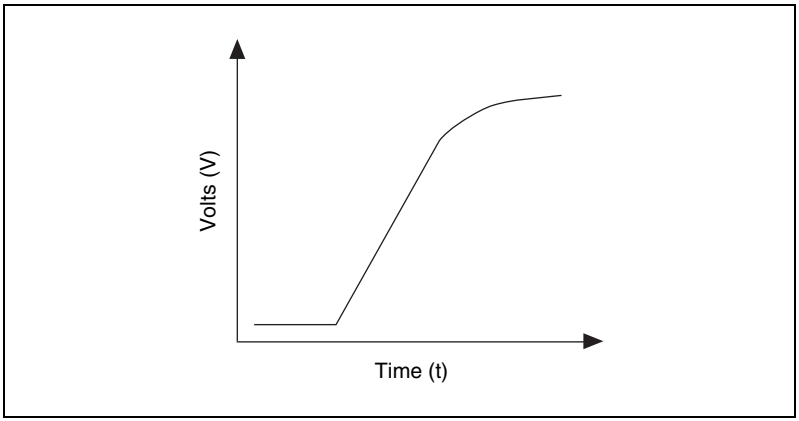


Figure 5-17. Lowpass Filtering of Digital Trigger Input Signals

Note Due to the filter order, the digital trigger input signal is delayed for a specific amount of time before the DAQ device senses the signal at the trigger input.

Measuring a 4 to 20 mA Current

Since DAQ devices cannot directly measure current, this section describes how to add components for measuring current when transistors output a current value ranging between 4 and 20 mA.

Theory of Operation

The conversion from current to voltage is based on Ohm's Law, which is summarized by Equation 5-7, where V is voltage, I is current and R is resistance:

$$V = I \times R \tag{5-7}$$

Thus, you must multiply current by a constant to convert the current to a voltage. In an electrical circuit, current must flow through a resistor to produce a voltage drop. This voltage drop then becomes the input for a DAQ device, as Figure 5-18 shows.

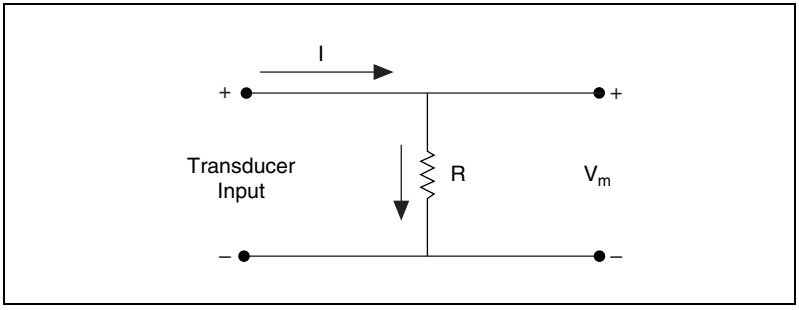


Figure 5-18. Current-to-Voltage Electrical Circuit

The application software must linearly convert voltage back to current. Equation 5-8 demonstrates this conversion, where the resistor is the denominator and V_{in} is the input voltage into the DAQ device:

$$I = \frac{V_m}{R} \tag{5-8}$$

Selecting a Resistor

For best results when measuring current, you should choose a resistor that has the following characteristics:

- Low wattage of approximately 1/8 W
- Precision of at least 5%
- Temperature stability
- Tolerance of 5%
- 232 Ω (suggested)
- AXL package (suggested)
- Carbon or metal film (suggested)

If you use the resistor described above, you can convert a 20 mA current to 4.64 V by setting the device range to either (–5 to +5 V) or (0 to 5 V).

Adding Components

Caution Do not exceed ±10 V at the analog inputs. NI is *not* liable for any device damage or personal injury resulting from improper connections.

You can build a one-resistor circuit for measuring current at the single-ended or differential inputs of the SCB-68.

Single-Ended Inputs

To build a one-resistor circuit that measures current at the single-ended analog inputs of the SCB-68, add the resistor to position B or D depending on the channel being used. Leave the jumpers in place for channel positions F and G, respectively. Calculate the current according to Equation 5-9 or 5-10.

$$I = \frac{V_m}{R_B} \quad (5\text{-}9)$$

$$I = \frac{V_m}{R_E} \quad (5\text{-}10)$$

Differential Inputs

To build a one-resistor circuit that measures current at the differential inputs of the SCB-68, add the resistor to position E for each differential channel pair that is used. Leave the jumpers in place for positions F and G. Calculate the current according to Equation 5-11:

$$I = \frac{V_m}{R_E} \quad (5\text{-}11)$$

Attenuating Voltage

This section describes how to add components for attenuating, or decreasing the amplitude of, a voltage signal. Transducers can output more than 10 V_{DC} per channel, but DAQ devices cannot read more than 10 V_{DC} per input channel. Therefore, you must attenuate output signals from the transducer to fit within the DAQ device specifications. Figure 5-19 shows how to use a voltage divider to attenuate the output signal of the transducer.

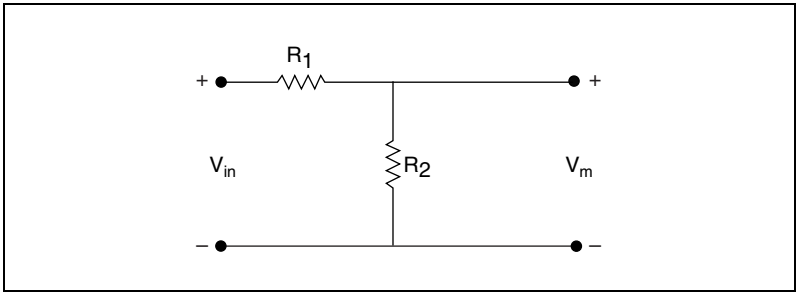


Figure 5-19. Attenuating Voltage with a Voltage Divider

Theory of Operation

The voltage divider splits the input voltage (V_{in}) between two resistors (R_1 and R_2), causing the voltage on each resistor to be noticeably lower than V_{in}. Use Equation 5-12 to determine the V_m that the DAQ device measures:

$$V_m = V_{in}\left(\frac{R_2}{R_1 + R_2}\right) \tag{5-12}$$

Use Equation 5-13 to determine the overall gain of a voltage divider circuit:

$$G = \frac{V_m}{V_{in}} = \frac{R_2}{R_1 + R_2} \tag{5-13}$$

The accuracy of Equation 5-13 depends on the tolerances of the resistors that you use.

Caution The SCB-68 is *not* designed for any input voltages greater than 42 V, even if a user-installed voltage divider reduces the voltage to within the input range of the DAQ device. Input voltages greater than 42 V can damage the SCB-68, any devices connected to it, and the host computer. Overvoltage can also cause an electric shock hazard for the operator. NI is *not* responsible for damage or injury resulting from such misuse.

Selecting Components

To set up the resistors, complete the following steps:

1. Select the value for R_2 (10 kΩ is recommended).
2. Use Equation 5-12 to calculate the value for R_1. Base the R_1 calculation on the following values:
   - Maximum V_{in} you expect from the transducer
   - Maximum voltage (<10 V_{DC}) that you want to input to the DAQ device

Accuracy Considerations

For best results when attenuating voltage, you should choose a resistor that has the following characteristics:

- Low wattage of approximately 1/8 W
- Precision of at least 5%
- Temperature stable
- Tolerance of 5%
- AXL package (suggested)
- Carbon or metal film (suggested)

Verify that R_1 and R_2 drift together with respect to temperature; otherwise, the system may consistently read incorrect values.

Adding Components

You an build a two- or three-resistor circuit for attenuating voltages at the single-ended inputs, differential inputs, analog outputs, and digital inputs of the SCB-68.

Single-Ended Input Attenuators

To build a two-resistor circuit for attenuating voltages at the single-ended inputs of the SCB-68, refer to Figure 5-20.

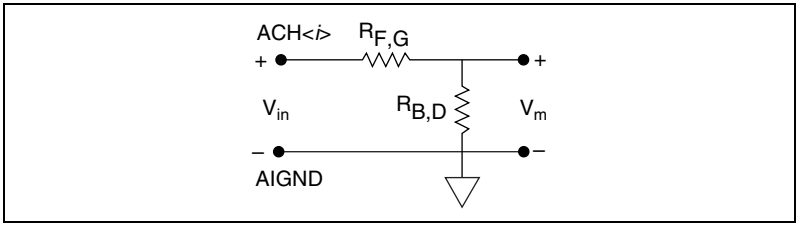


Figure 5-20. SCB-68 Circuit Diagram for SE Input Attenuation

Install resistors in positions B and F, or positions D and G, depending on the channel you are using on the SCB-68. Use Equations 5-14 or 5-15 to calculate the gain of the circuit:

$$G = \frac{R_B}{(R_B + R_F)} \tag{5-14}$$

$$G = \frac{R_D}{(R_D + R_G)} \tag{5-15}$$

Differential Input Attenuators

To build a three-resistor circuit for attenuating voltages at the differential inputs of the SCB-68, refer to Figure 5-21.

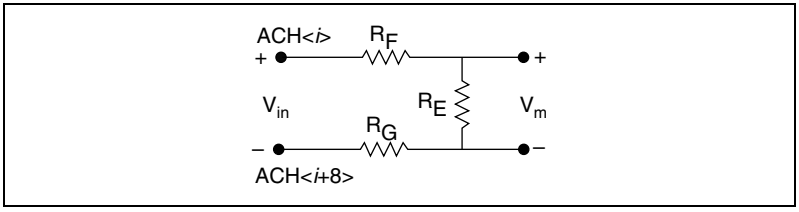


Figure 5-21. SCB-68 Circuit Diagram for DIFF Input Attenuation

Install resistors in positions E, F, and G of the chosen differential channel pair. Use Equation 5-16 to determine the gain of the circuit:

$$G = \frac{R_E}{(R_E + R_F + R_G)} \tag{5-16}$$

Analog Output and Digital Input Attenuators

To build a two-resistor circuit for attenuating voltages at the DAC0OUT, DAC1OUT, and TRIG1 pins on the SCB-68, refer to the pad positions in Figure 5-22.

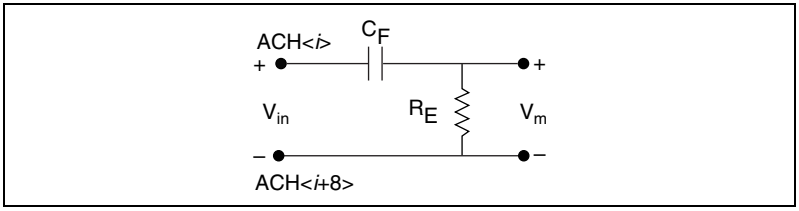


Figure 5-22. SCB-68 Circuit Diagram for Digital Input Attenuation

Use positions R1 and RC1 for TRIG1, and determine the gain according to Equation 5-17:

$$G = \frac{RC1}{(RC1 + R1)} \quad (5\text{-}17)$$

Use positions R2 and RC2 for DAC1OUT, and determine the gain according to Equation 5-18:

$$G = \frac{RC2}{(RC2 + R2)} \quad (5\text{-}18)$$

Use positions R3 and RC3 for DAC0OUT, and determine the gain according to Equation 5-19:

$$G = \frac{RC3}{(RC3 + R3)} \quad (5\text{-}19)$$

Special Considerations for Analog Input

When calculating the values for R_1 and R_2, consider the input impedance value from the point of view of V_{in}, as Figure 5-23 shows.

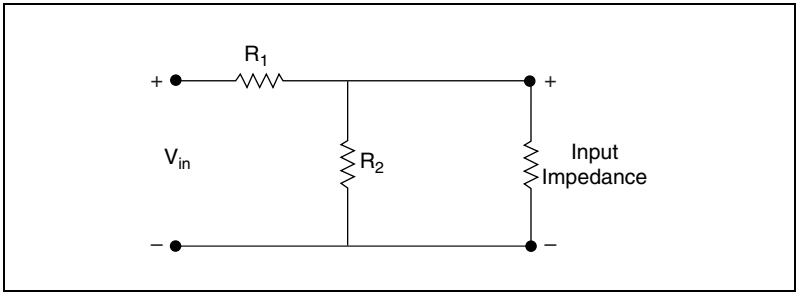


Figure 5-23. Input Impedance Electrical Circuit

Z_{in} is the new input impedance. Refer to Appendix A, *Specifications*, in the device user manuals at `ni.com/manuals` for the input impedance. Equation 5-20 shows the relationship among all of the resistor values:

$$Z_{in} = R_1 + \frac{(R_2 \times Input\ Impedance)}{(R_2 + Input\ Impedance)} \quad (5\text{-}20)$$

Special Considerations for Analog Output

When you use the circuit shown in Figure 5-19 for AO, the output impedance changes. Thus, you must choose the values for R_1 and R_2 so that the final output impedance value is as low as possible. Refer to Appendix A, *Specifications*, in the device user manuals at `ni.com/manuals` for device specifications. Figure 5-24 shows the electrical circuit you use to calculate the output impedance.

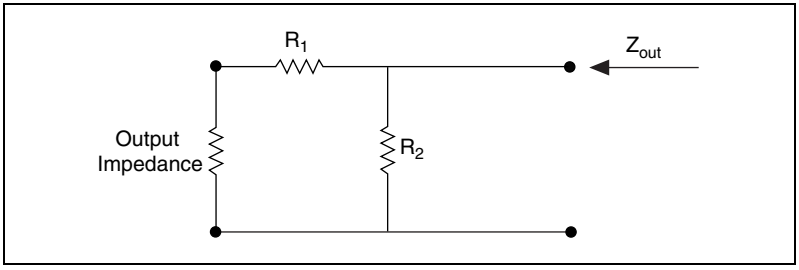


Figure 5-24. Electrical Circuit for Determining Output Impedance

Equation 5-21 shows the relationship between R_1, R_2, and Z_{out}, where Z_{out} is the old output impedance and Z_{out2} is the new output impedance:

$$Z_{out2} = \frac{(Z_{out} + R_1) \times R_2}{Z_{out} + R_1 + R_2} \quad (5\text{-}21)$$

Special Considerations for Digital Inputs

If you use the V_{in} voltage of Figure 5-20 to feed TTL signals, you must calculate V_{in} so that the voltage drop on R_2 does not exceed 5 V.

Caution A voltage drop exceeding 5 V on R_2 can damage the internal circuitry of the DAQ device. NI is *not* liable for any device damage or personal injury resulting from improper use of the SCB-68 and the DAQ device.

A

Specifications

This appendix lists the SCB-68 specifications. These ratings are typical at 25 °C unless otherwise stated.

Analog Input

Number of channels

68-pin DAQ devices ..... Eight differential, 16 single-ended

100-pin DAQ devices ..... 32 differential, 64 single-ended

Temperature sensor

Accuracy ..... ±1.0 °C over a 0 to 110 °C range

Output ..... 10 mV/°C

Power Requirement

Power consumption (at +5 VDC, ±5%)

Typical ..... 1 mA with no signal conditioning installed

Maximum ..... 800 mA from host computer

Note The power specifications pertain to the power supply of the host computer when using internal power or to the external supply connected at the +5 V screw terminal when using external power. The maximum power consumption of the SCB-68 is a function of the signal conditioning components installed and any circuits constructed on the general-purpose breadboard area. If the SCB-68 is powered from the host computer, the maximum +5 V current draw, which is limited by the fuse, is 800 mA.

Fuse

Manufacturer ..... Littelfuse

Part number 235 800

Ampere rating ..... 0.800 A

Voltage rating .....250 V

Nominal resistance .....0.195 Ω

Physical

Box dimensions (including box feet).....19.5 by 15.2 by 4.5 cm (7.7 by 6.0 by 1.8 in.)

I/O connectors.....One 68-pin male SCSI connector

Screw terminals 68

Wire gauge.....≤26 AWG

Resistor sockets .....0.032 to 0.038 in. (in diameter)

Maximum Working Voltage

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

Channel-to-earth .....42 V_{rms}, Installation Category II

Channel-to-channel.....42 V_{rms}, Installation Category II

Environmental

Operating temperature .....0 to 70 °C

Storage temperature.....–20 to 70 °C

Humidity.....5 to 90% RH, noncondensing

Maximum altitude.....2000 meters

Pollution Degree (indoor use only) II

Safety

The SCB-68 meets the requirements of the following standards for safety and electrical equipment for measurement, control, and laboratory use:

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

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

Electromagnetic Compatibility

Emissions	EN 55011 Class A at 10 m FCC Part 15A above 1 GHz
Immunity	EN 61326-1:1997 + A1:1998, Table 1
EMC/EMI	CE, C-Tick, and FCC Part 15 (Class A) Compliant

Note For EMC compliance, you *must* operate this device with shielded cabling.

CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE Marking, as follows:

Low-Voltage Directive (safety)	73/23/EEC
Electromagnetic Compatibility Directive (EMC)	89/336/EEC

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This Web site lists the DoCs by product family. Select the appropriate product family, followed by your product, and a link to the DoC appears in Adobe Acrobat format. Click the Acrobat icon to download or read the DoC.

B

Quick Reference Labels

This appendix shows the pinouts that appear on the quick reference labels for the DAQ devices that are compatible with the SCB-68.

SCB-68 Quick Reference Label

E SERIES DEVICES

NATIONAL INSTRUMENTS

P/N 182509B-01

FACTORY DEFAULT SETTING



* TEMP. SENSOR DISABLED
* ACCESSORY POWER ON



* TEMP. SENSOR ENABLED ON SINGLE ENDED CH. 0
* ACCESSORY POWER ON



* TEMP. SENSOR ENABLED ON DIFFERENTIAL CH. 0
* ACCESSORY POWER ON



* 68 GENERIC TERMINALS (TEMP. SENSOR AND ACCESSORY POWER OFF)

PIN #	SIGNAL
68	ACH0
34	ACH8
67	AIGND
33	ACH1
66	ACH9
32	AIGND
65	ACH2
31	ACH10
64	AIGND
30	ACH3
63	ACH11
29	AIGND
62	AISENSE
28	ACH4
61	ACH12
27	AIGND
60	ACH5
26	ACH13
59	AIGND
25	ACH6
58	ACH14
24	AIGND
57	ACH7
23	ACH15

PIN #	SIGNAL
12	DGND
46	SCANCLK
13	DGND
47	DIO3
14	+5V
48	DIO7
15	DGND
49	DIO2
16	DIO6
50	DGND
17	DIO1
51	DIO5
18	DGND
52	DIO0
19	DIO4
53	DGND
20	EXTREF
54	AOGND
21	DAC1 OUT
55	AOGND
22	DAC0 OUT
56	AIGND

PIN #	SIGNAL
1	FREQ_OUT
35	DGND
2	GPCTR0_OUT
36	DGND
3	PFI9/GPCTR0_GATE
37	PFI8/GPCTR0_SOURCE
4	DGND
38	PFI7/STARTSCAN
5	PFI6/WFTRIG
39	DGND
6	PFI5/UPDATE*
40	GPCTR1_OUT
7	DGND
41	PFI4/GPCTR1_GATE
8	+5V, FUSED
42	PFI3/GPCTR1_SOURCE
9	DGND
43	PFI2/CONVERT*
10	PFI1/TRIG2
44	DGND
11	PFI0/TRIG1
45	EXTSTROBE*

Figure B-1. E Series Devices

SCB-68 Quick Reference Label

NI 670*X* DEVICES

NATIONAL INSTRUMENTS

PIN #	SIGNAL
68	AGND0/AGND16
34	VCH0
67	ICH16*
33	AGND1/AGND17
66	VCH1
32	ICH17*
65	AGND2/AGND18
31	VCH2
64	ICH18*
30	AGND3/AGND19
63	VCH3
29	ICH19*
62	AGND4/AGND20
28	VCH4
61	ICH20*
27	AGND5/AGND21
60	VCH5
26	ICH21*
59	AGND6/AGND22
25	VCH6
58	ICH22*
24	AGND7/AGND23
57	VCH7
23	ICH23*

PIN #	SIGNAL
12	VCH14
46	AGND14/AGND30
13	ICH29*
47	VCH13
14	AGND13AGND29
48	ICH28*
15	VCH12
49	AGND12/AGND28
16	ICH27*
50	AGND11/AGND27
17	VCH11
51	ICH26*
18	AGND10/AGND26
52	VCH10
19	AGND
53	ICH25*
20	AGND9/AGND25
54	VCH9
21	ICH24*
55	AGND8/AGND24
22	VCH8
56	AGND

PIN #	SIGNAL
1	+5V OUTPUT
35	DGND
2	DIO0
36	DGND
3	DIO1
37	DGND
4	DIO2
38	RFU
5	DIO3
39	DGND
6	DIO4
40	DGND
7	DIO5
41	DGND
8	DIO6
42	DGND
9	DIO7
43	AGND
10	ICH31*
44	VCH15
11	AGND15/AGND31
45	ICH30*

*NO CONNECT ON THE NI 6703



* 68 GENERIC TERMINALS (TEMP. SENSOR AND ACCESSORY POWER OFF)

Figure B-2. NI 670*X* Devices

SCB-68 Quick Reference Label

NI 671*X*/673*X* DEVICES

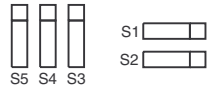
NATIONAL INSTRUMENTS

PIN #	SIGNAL
68	NC
34	AOGND
67	AOGND
33	NC
66	AOGND
32	AOGND
65	DAC7OUT
31	AOGND
64	AOGND
30	DAC6OUT
63	AOGND
29	AOGND
62	NC
28	DAC5OUT
61	AOGND
27	AOGND
60	DAC4OUT
26	AOGND
59	AOGND
25	DAC3OUT
58	AOGND
24	AOGND
57	DAC2OUT
23	AOGND

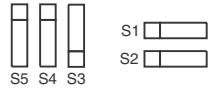
PIN #	SIGNAL
12	DGND
46	NCC
13	DGND
47	DIO3
14	+5V
48	DIO7
15	DGND
49	DIO2
16	DIO6
50	DGND
17	DIO1
51	DIO5
18	DGND
52	DIO0
19	DIO4
53	DGND
20	EXTREF
54	AOGND
21	DAC1 OUT
55	AOGND
22	DAC0 OUT
56	AIGND

PIN #	SIGNAL
1	FREQ_OUT
35	DGND
2	GPCTR0_OUT
36	DGND
3	PFI9/GPCTR0_GATE
37	PFI8/GPCTR0_SOURCE
4	DGND
38	PFI7
5	PFI6/WFTRIG
39	DGND
6	PFI5/UPDATE*
40	GPCTR1_OUT
7	DGND
41	PFI4/GPCTR1_GATE
8	+5V, FUSED
42	PFI3/GPCTR1_SOURCE
9	DGND
43	PFI2
10	PFI1
44	DGND
11	PFI0
45	EXTSTROBE*

FACTORY DEFAULT SETTING



* TEMP. SENSOR DISABLED
* ACCESSORY POWER ON



* 68 GENERIC TERMINALS (TEMP. SENSOR AND ACCESSORY POWER OFF)

Figure B-3. NI 671*X*/673*X* Devices

SCB-68 Quick Reference Label

S SERIES DEVICES

NATIONAL INSTRUMENTS

P/N 182509B-01

FACTORY DEFAULT SETTING



* TEMP. SENSOR DISABLED
* ACCESSORY POWER ON



* TEMP. SENSOR ENABLED ON DIFFERENTIAL CH. 0
* ACCESSORY POWER ON



* 68 GENERIC TERMINALS (TEMP. SENSOR AND ACCESSORY POWER OFF)

PIN #	SIGNAL
68	ACH0
34	ACH0-
67	ACH0GND
33	ACH1+
66	ACH1-
32	ACH1GND
65	ACH2+
31	ACH2-
64	ACH2GND
30	ACH3+
63	ACH3-
29	ACH3GND
62	NC
28	NC
61	NC
27	NC
60	NC
26	NC
59	NC
25	NC
58	NC
24	NC
57	NC
23	NC

PIN #	SIGNAL
12	DGND
46	SCANCLK
13	DGND
47	DIO3
14	+5V
48	DIO7
15	DGND
49	DIO2
16	DIO6
50	DGND
17	DIO1
51	DIO5
18	DGND
52	DIO0
19	DIO4
53	DGND
20	NC
54	AOGND
21	DAC1OUT
55	AOGND
22	DAC0OUT
56	NC

PIN #	SIGNAL
1	FREQ_OUT
35	DGND
2	GPCTR0_OUT
36	DGND
3	PFI9/GPCTR0_GATE
37	PFI8/GPCTR0_SOURCE
4	DGND
38	PFI7/STARTSCAN
5	PFI6/WFTRIG
39	DGND
6	PFI5/UPDATE*
40	GPCTR1_OUT
7	DGND
41	PFI4/GPCTR1_GATE
8	+5V, FUSED
42	PFI3/GPCTR1_SOURCE
9	DGND
43	PFI2/CONVERT*
10	PFI1/TRIG2
44	DGND
11	PFI0/TRIG1
45	EXTSTROBE*

Figure B-4. S Series Devices

SCB-68 Quick Reference Label

NI 660*X* DEVICES

NATIONAL INSTRUMENTS

If using an NI 660*X* device with an optional SCB-68 shielded connector block accessory, affix this label to the inside of the SCB-68 and set the switches as shown below.

P/N 185974A-01

SET SWITCHES AS FOLLOWS FOR NI 660*X* DEVICES.



Application Contexts:

Counter
As shown on label

DIO (n= 0..31)
DIO_0 maps to PFI_0
DIO_n maps to PFI_n

Motion Encoder (n= 0..7)
SOURCE_n maps to CH_A_n
UP_DOWN_n maps to CH_B_n
GATE_n maps to CH_Z_n

For details, refer to *ni.com/manuals* for the user manual for NI 660*X* devices.

PIN#	SIGNAL	PIN#	SIGNAL	PIN#	SIGNAL
68	GND				
34	PFI_31 (SOURCE_2)	12	PFI_3	1	+5V
67	PFI_30 (GATE_2)	46	GND	35	RG
33	GND	13	PFI_4	2	PFI_39 (SOURCE_0)
66	PFI_29 (UP_DOWN_2)	47	PFI_5	36	GND
32	PFI_28 (OUT_2)	14	GND	3	PFI_38 (GATE_0)
65	GND	48	PFI_6	37	RESERVED
31	PFI_27 (SOURCE_3)	15	PFI_7	4	RESERVED
64	PFI_26 (GATE_3)	49	GND	38	RESERVED
30	GND	16	PFI_8 (OUT_7)	5	PFI_36 (OUT_0)
63	PFI_25 (UP_DOWN_3)	50	GND	39	GND
29	PFI_24 (OUT_3)	17	PFI_9 (UP_DOWN_7)	6	PFI_33 (UP_DOWN_1)
62	GND	51	PFI_10 (GATE_7)	40	PFI_37 (UP_DOWN_0)
28	PFI_23 (SOURCE_4)	18	GND	7	PFI_35 (SOURCE_1)
61	PFI_22 (GATE_4)	52	PFI_11 (SOURCE_7)	41	GND
27	GND	19	RG	8	PFI_34 (GATE_1)
60	PFI_21 (UP_DOWN_4)	53	PFI_12 (OUT_6)	42	GND
26	PFI_20 (OUT_4)	20	GND	9	PFI_32 (OUT_1)
59	GND	54	PFI_13 (UP_DOWN_6)	43	RG
25	PFI_19 (SOURCE_5)	21	PFI_14 (GATE_6)	10	PFI_0
58	PFI_18 (GATE_5)	55	GND	44	PFI_1
24	GND	22	PFI_15 (SOURCE_6)	11	GND
57	PFI_17 (UP_DOWN_5)	56	RG	45	PFI_2
23	PFI_16 (OUT_5)				

Figure B-5. NI 660*X* Devices

SCB-68 Quick Reference Label

NI 653*X* DEVICES

NATIONAL INSTRUMENTS

If using an NI 653*X* with an optional SCB-68 shielded connector block accessory, affix this label to the inside of the SCB-68 and set the switches as shown below.

P/N 185754A-01 Rev. 2

*SET SWITCHES AS FOLLOWS FOR THE NI 653*X*



PIN#	SIGNAL
68	GND
34	DIOD7
67	DIOD6
33	GND
66	DIOD5
32	DIOD4
65	GND
31	DIOD3
64	DIOD2
30	GND
63	DIOD1
29	DIOD0
62	GND
28	DIOC7
61	DIOC6
27	GND
60	DIOC5
26	DIOC4
59	GND
25	DIOC3
58	DIOC2
24	GND
57	DIOC1
23	DIOC0

PIN#	SIGNAL
12	DIOA3
46	GND
13	DIOA4
47	DIOA5
14	GND
48	DIOA6
15	DIOA7
49	GND
16	DIOB0
50	GND
17	DIOB1
51	DIOB2
18	GND
52	DIOB3
19	RGND
53	DIOB4
20	GND
54	DIOB5
21	DIOB6
55	GND
22	DIOB7
56	RGND

PIN#	SIGNAL
1	+5V
35	RGND
2	REQ1
36	GND
3	ACK1 (STARTTRIG1)
37	GND
4	STOPTRIG1
38	DPULL
5	PCLK1
39	GND
6	PCLK2
40	CPULL
7	STOPTRIG2
41	GND
8	ACK2 (STARTTRIG2)
42	GND
9	REQ2
43	RGND
10	DIOA0
44	DIOA1
11	GND
45	DIOA2

Figure B-6. NI 653*X* Devices

SCB-68 Quick Reference Label

NATIONAL INSTRUMENTS

NI 7811R/7831R DEVICES[1]

PIN#	MIO	DIO	PIN#	MIO	DIO	PIN#	MIO	DIO
68	AI0+	DIO39						
34	AI0-	DIO38	PIN#	MIO	DIO	PIN#	MIO	DIO
67	AIGND0	DIO37	12	DIO12	DGND	1	+5V	DGND
33	AIGND1	DIO36	46	DIO13	DIO11	35	+5V	DIO0
66	AI1+	DIO35	13	DIO14	DGND	2	DGND	DGND
32	AI1-	DIO34	47	DIO15	DIO12	36	DIO0	DIO1
65	AI2+	DIO33	14	AOGND7	DGND	3	DGND	DGND
31	AI2-	DIO32	48	AO7	DIO13	37	DIO1	DIO2
64	AIGND2	DIO31	15	AOGND6	DGND	4	DGND	DGND
30	AIGND3	DIO30	49	AO6	DIO14	38	DIO2	DIO3
63	AI3+	DIO29	16	AOGND5	DGND	5	DGND	DGND
29	AI3-	DIO28	50	AO5	DIO15	39	DIO3	DIO4
62	AI4+	DIO27	17	AOGND4	DGND	6	DGND	DGND
28	AI4-	+5V	51	AO4	DIO16	40	DIO4	DIO5
61	AIGND4	DIO26	18	AOGND3	DGND	7	DGND	DGND
27	AIGND5	+5V	52	AO3	DIO17	41	DIO5	DIO6
60	AI5+	DIO25	19	AOGND2	DGND	8	DGND	DGND
26	AI5-	DGND	53	AO2	DIO18	42	DIO6	DIO7
59	AI6+	DIO24	20	AOGND0	DGND	9	DGND	DGND
25	AI6-	DGND	54	AO1	DIO19	43	DIO7	DIO8
58	AIGND6	DIO23	21	AOGND0	DGND	10	DIO8	DGND
24	AIGND7	DGND	55	AO0	DIO20	44	DIO9	DIO9
57	AI7+	DIO22	22	NC	DGND	11	DIO10	DGND
23	AI7-	DGND	56	AISENSE	DIO21	45	DIO11	DIO10

[1] THE MIO COLUMN CORRESPONDS TO THE MIO CONNECTOR ON THE NI 7831R, AND THE DIO COLUMN CORRESPONDS TO THE DIO CONNECTORS ON THE NI 7811R / 7831R.

NC = No Connect

SET SWITCHES IN THIS CONFIGURATION TO USE THE SCB-68 WITH THE NI 7811R/7831R



Figure B-7. NI 7811R/7831R Devices

C

Fuse and Power

One of the +5 V lines from the DAQ device (pin 8) is protected by an 800 mA fuse. Pin 14 is also +5 V, but it is not fuse-protected on the SCB-68. Shorting pin 14 to ground blows the fuse, which is usually socketed. If the SBC-68 does not work when you turn on the DAQ device, first check the switch settings, then check both the 800 mA fuse on the SCB-68 and the output fuse (if any) on the DAQ device. Before replacing any fuses, check for short circuits from power to ground.

A 470 Ω series resistor (R21) filters the +5 V power on the SCB-68. As the filtered +5 V is loaded, the voltage decreases. Pad R20 is in parallel with R21, and you can install a resistor if needed. Shorting R20 bypasses the filter while capacitively coupling DGND and AGND, and this configuration is not recommended.

Caution NI is *not* liable for any device damage or personal injury resulting from improper use of the SCB-68 and the DAQ device.

Refer to Figure 2-1, *SCB-68 Printed Circuit Diagram*, to locate the fuse and other components on the SCB-68. A suitable replacement fuse for the SCB-68 is made by Littelfuse and has part number 235 800.

D

SCB-68 Circuit Diagrams

This appendix contains illustrations of circuit diagrams for the SCB-68.

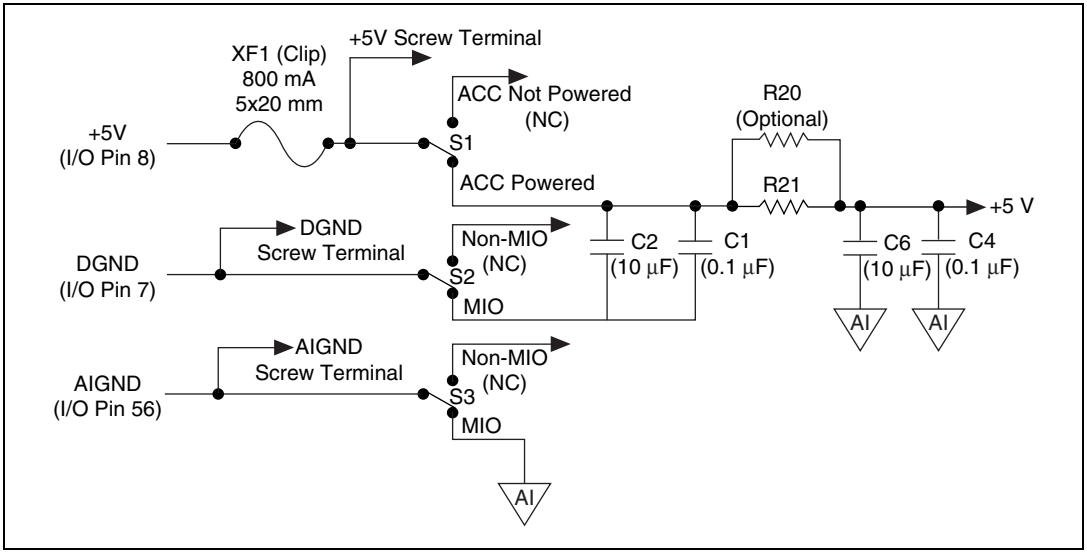


Figure D-1. +5 V Power Supply

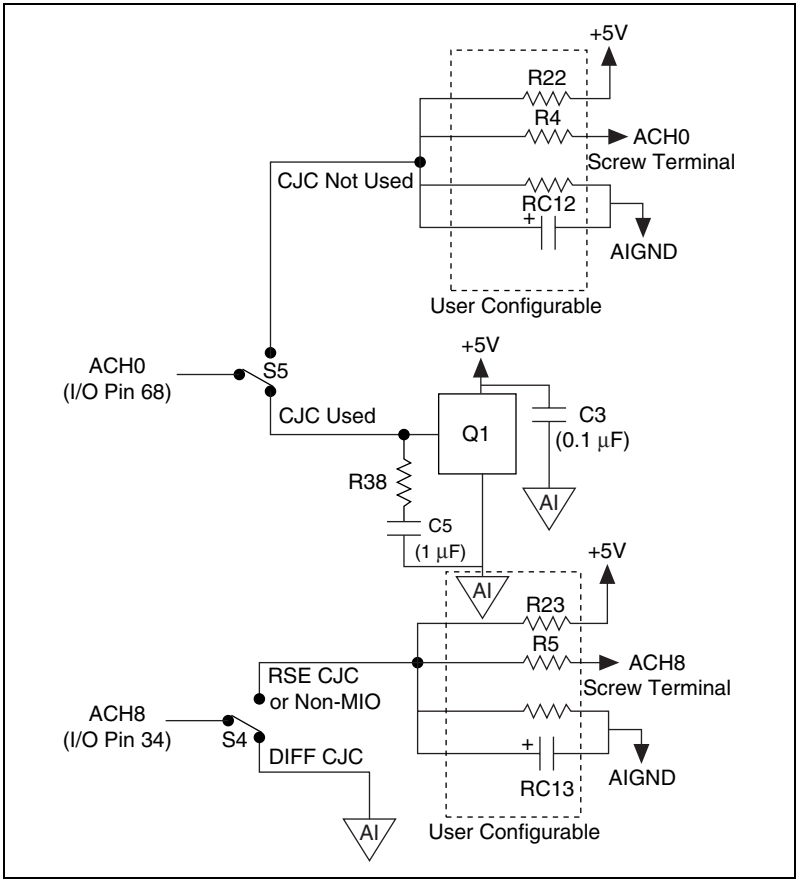


Figure D-2. Cold-Junction Compensation Circuitry

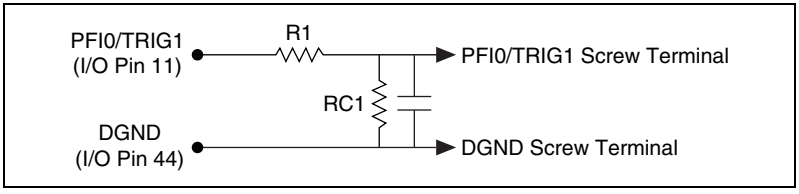


Figure D-3. Digital Trigger Circuitry

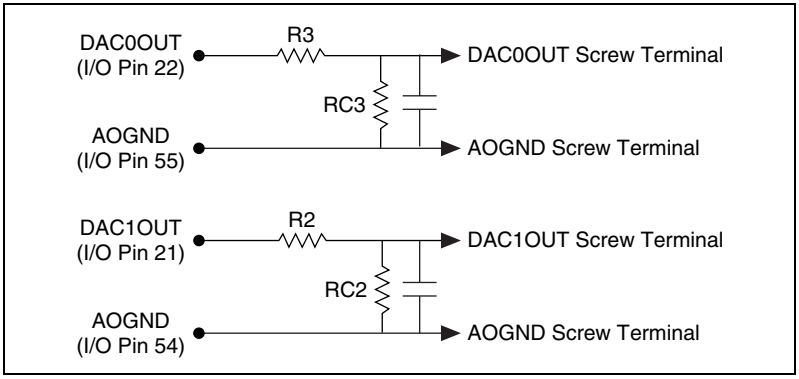


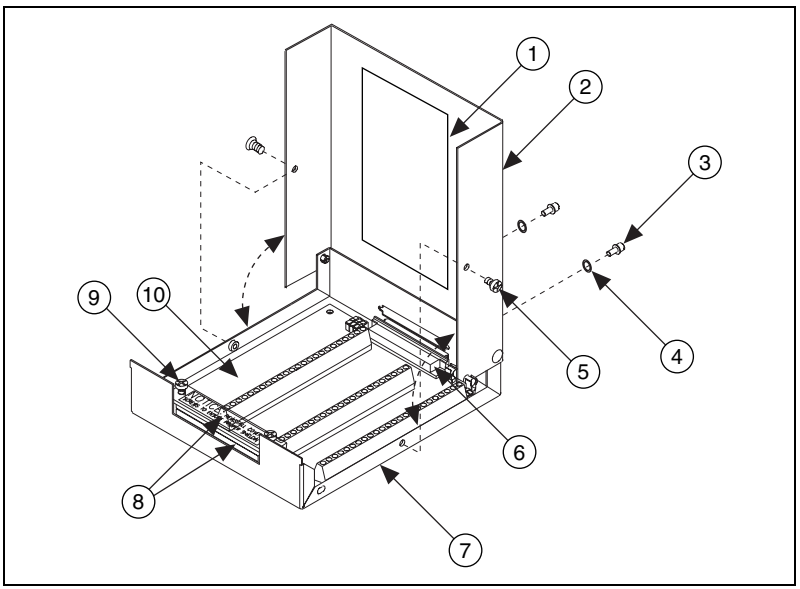
Figure D-4. Analog Output Circuitry

E

Soldering and Desoldering on the SCB-68

Some applications discussed here require you to make modifications to the SCB-68, usually in the form of adding components to the printed circuit device.

To solder and desolder components on the SCB-68, refer to Figure 2-1, *SCB-68 Printed Circuit Diagram*, and to Figure E-1, and complete the following steps to remove the SCB-68 from its box.



1	Quick Reference Label	4	Lock Washers	8	Strain-Relief Bars
2	Cover	5	Shielding Screws	9	Strain-Relief Screws
3	68-Pin Connector Screws	6	68-Pin I/O Connector	10	Circuit Card Assembly
		7	Base		

Figure E-1. SCB-68 Parts Locator Diagram

Note If the kit is missing any of the components in Figure E-1, contact NI by selecting **Contact NI** at `ni.com`.

1. Disconnect the 68-pin cable from the SCB-68 if it is connected.
2. Remove the shielding screws on either side of the top cover with a Phillips-head number 1 screwdriver. You can now open the box.
3. Loosen the strain-relief screws with a Phillips-head number 2 screwdriver.
4. Remove the signal wires from screw terminals.
5. Remove the device-mount screws and the 68-pin connector screws.
6. Tilt the SCB-68 up and pull it out.

To reinstall the SCB-68, reverse the order of the steps.

The SCB-68 ships with wire jumpers in the F and G positions, as Figure 2-1, *SCB-68 Printed Circuit Diagram*, shows. You must remove the wire jumpers to use the positions. Use a low-wattage soldering iron (20 to 30 W) when soldering to the SCB-68.

To desolder on the SCB-68, vacuum-type tools work best. Be careful to avoid damaging the component pads when desoldering. Use only rosin-core electronic-grade solder, because acid-core solder damages the printed-circuit device and components.

F

Technical Support and Professional Services

Visit the following sections of the National Instruments Web site at `ni.com` for technical support and professional services:

- **Support**—Online technical support resources include the following:
  - **Self-Help Resources**—For immediate answers and solutions, visit our extensive library of technical support resources available in English, Japanese, and Spanish at `ni.com/support`. These resources are available for most products at no cost to registered users and include software drivers and updates, a KnowledgeBase, product manuals, step-by-step troubleshooting wizards, hardware schematics and conformity documentation, example code, tutorials and application notes, instrument drivers, discussion forums, a measurement glossary, and so on.
  - **Assisted Support Options**—Contact NI engineers and other measurement and automation professionals by visiting `ni.com/ask`. Our online system helps you define your question and connects you to the experts by phone, discussion forum, or email.
- **Training**—Visit `ni.com/custed` for self-paced tutorials, videos, and interactive CDs. You also can register for instructor-led, hands-on courses at locations around the world.
- **System Integration**—If you have time constraints, limited in-house technical resources, or other project challenges, NI Alliance Program members can help. To learn more, call your local NI office or visit `ni.com/alliance`.
- **Declaration of Conformity (DoC)**—A DoC is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electronic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting `ni.com/hardref.nsf`.

- **Calibration Certificate**—If your product supports calibration, you can obtain the calibration certificate for your product at `ni.com/calibration`.

If you searched `ni.com` and could not find the answers you need, contact your local office or NI corporate headquarters. Phone numbers for our worldwide offices are listed at the front of this manual. You also can visit the Worldwide Offices section of `ni.com/niglobal` to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

Glossary

Prefix	Meanings	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

°	degrees
>	greater than
≤	less than or equal to
≥	greater than or equal to
<	less than
–	negative of, or minus
Ω	ohms
/	per
%	percent
±	plus or minus
+	positive of, or plus

$\sqrt{\ }$	square root of
+5V	+5 VDC source signal

A

A	amperes
A/D	analog-to-digital
AC	alternating current
ACH	analog input channel signal
ADC	analog-to-digital converter—an electronic device, often an integrated circuit, that converts an analog voltage to a digital number
AI	analog input
AIGND	analog input ground signal
AISENSE	analog input sense signal
AO	analog output
AOGND	analog output ground signal
ASIC	Application-Specific Integrated Circuit—a proprietary semiconductor component designed and manufactured to perform a set of specific functions
attenuate	to decrease the amplitude of a signal
AWG	American wire gauge

C

C	Celsius
CH	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

cm	centimeter
cold-junction compensation	CJC—an artificial reference level that compensates for ambient temperature variations in thermocouple measurement circuits
CompactPCI	refers to the core specification defined by the PCI Industrial Computer Manufacturer's Group (PICMG)
CONVERT*	convert signal
counter/timer	a circuit that counts external pulses or clock pulses (timing)
CTR	counter

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
DAC0OUT	analog channel 0 output signal
DAC1OUT	analog channel 1 output signal
DAQ	data acquisition—a system that uses the computer to collect, receive, and generate electrical signals
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
DGND	digital ground signal
DIFF	differential mode
DIO	digital input/output
DMA	direct memory access—a method by which data can be transferred to/from computer memory from/to a device or memory on the bus while the processor does something else; DMA is the fastest method of transferring data to/from computer memory
DoC	Declaration of Conformity

E

EXTREF	external reference signal
EXTSTROBE	external strobe signal
EXTTRIG	external trigger signal

F

FREQ_OUT	frequency output signal
ft	feet

G

gain	the factor by which a signal is amplified, often expressed in dB
GATE	gate signal
GPCTR	general purpose counter
GPCTR0_GATE	general purpose counter 0 gate signal
GPCTR1_GATE	general purpose counter 1 gate signal
GPCTR0_OUT	general purpose counter 0 output signal
GPCTR1_OUT	general purpose counter 1 output signal
GPCTR0_SOURCE	general purpose counter 0 clock source signal
GPCTR1_SOURCE	general purpose counter 1 clock source signal
g_{rms}	level of random vibration

H

Hz	hertz

I

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
I_{OH}	current, output high
I_{OL}	current, output low

L

lowpass filter	a filter that passes low frequencies
LSB	least significant bit

M

m	meter
MB	megabytes of memory
MIO	multifunction I/O

N

NC	normally closed, or not connected
NI-DAQ	NI driver software for DAQ hardware
noise	an undesirable electrical signal—noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, 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

Nyquist frequency	a frequency that is half of the sampling frequency

O

OUT	output pin—a counter output pin where the counter can generate various TTL pulse waveforms

P

PCI	Peripheral Component Interconnect—a high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA. It is achieving widespread acceptance as a standard for PCs and work-stations; it offers a theoretical maximum transfer rate of 132 MB/s.
PFI	Programmable Function Input
PFI0/TRIG1	PFI0/trigger 1
PFI1/TRIG2	PFI1/trigger 2
PFI2/CONVERT*	PFI2/convert
PFI3/GPCTR1_ SOURCE	PFI3/general purpose counter 1 source
PFI4/GPCTR1_GATE	PFI4/general purpose counter 1 gate
PFI5/UPDATE*	PFI5/update
PFI6/WFTRIG	PFI6/waveform trigger
PFI7/STARTSCAN	PFI7/start of scan
PFI8/GPCTR0_ SOURCE	PFI8/general purpose counter 0 source
PFI9/GPCTR0_GATE	PFI9/general purpose counter 0 gate
PGIA	Programmable Gain Instrumentation Amplifier
port	(1) a communications connection on a computer or a remote controller (2) a digital port, consisting of four or eight lines of digital input and/or output

PXI	PCI eXtensions for Instrumentation—an open specification that builds off the CompactPCI specification by adding instrumentation-specific features

R

range	the maximum and minimum parameters between which a device operates with a specified set of characteristics
RC filter	resistor-capacitor filter
resolution	the smallest signal increment that can be detected by a measurement system; is expressed in bits, proportions, or percent of full scale
RH	relative humidity
rms	root mean square
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

S

s	seconds
S	samples
SCANCLK	scan clock signal
SCSI	small computer system interface
SE	single-ended—a term used to describe an analog input that is measured with respect to a common ground
settling time	the amount of time required for a voltage to reach its final value within specified limits
signal conditioning	the manipulation of signals to prepare them for digitizing
SOURCE	source signal
STARTSCAN	start scan signal

T

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
TTL	transistor-transistor logic

U

unipolar	a signal range that is always positive (for example, 0 to +10 V)
UPDATE	update signal

V

V	volts
V_{DC}	volts direct current
V_{in}	volts in
V_m	measured voltage
V_{out}	volts out
V_{rms}	volts, root mean square

W

waveform	multiple voltage readings taken at a specific sampling rate
WFTRIG	waveform generation trigger signal

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