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SCXI™-1122
User Manual

Sixteen-Channel Isolated Transducer Multiplexer Module for Signal Conditioning

September 1999 Edition

Part Number 320516B-01

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Worldwide Technical Support and Product Information
www.natinst.com

National Instruments Corporate Headquarters
11500 North Mopac Expressway Austin, Texas 78759-3504 USA Tel: 512 794 0100

Worldwide Offices
Australia 03 9879 5166, Austria 0662 45 79 90 0, Belgium 02 757 00 20, Brazil 011 284 5011, Canada (Calgary) 403 274 9391,
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About This Manual

This manual describes the electrical and mechanical aspects of the SCXI-1122 and contains information concerning its operation. The SCXI-1122 is a member of the National Instruments Signal Conditioning eXtensions for Instrumentation (SCXI) Series for the National Instruments DAQ plug-in boards. This module is designed for signal conditioning of strain gauges, RTDs, thermistors, thermocouples, volt and millivolt sources, and 4 to 20 mA sources or 0 to 20 mA process-current sources where high common-mode voltages exist. The SCXI-1122 operates as 16 isolated input channels, one isolated current excitation channel, and one voltage excitation channel. All 16 channels are isolated from earth ground but not from each other. The excitation circuits are both isolated from earth ground, the input channels, and between each other.

Organization of This Manual

The *SCXI-1122 User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the SCXI-1122; lists the contents of your SCXI-1122 kit; describes the optional software, optional equipment, and custom cables; and explains how to unpack the SCXI-1122.
- Chapter 2, *Configuration and Installation*, describes how to configure the SCXI-1122 jumpers and how to install the SCXI-1122 into the SCXI chassis.
- Chapter 3, *Signal Connections*, describes the input and output signal connections to the SCXI-1122 module via the SCXI-1122 front connector and rear signal connector. This chapter also includes specifications and connection instructions for the signals on the SCXI-1122 connectors.
- Chapter 4, *Theory of Operation*, contains a functional overview of the SCXI-1122 module and explains the operation of each functional unit making up the SCXI-1122.
- Chapter 5, *Calibration*, discusses the calibration procedures for the SCXI-1122.
- Appendix A, *Specifications*, lists the specifications for the SCXI-1122.
- Appendix B, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products.
- The *Glossary* contains an alphabetical list and description of terms used in this manual, including abbreviations, acronyms, metric prefixes, mnemonics, symbols, and terms.
- The *Index* contains an alphabetical list of key terms and topics in this manual, including the page where you can find each one.

Conventions Used in This Manual

The following conventions are used in this manual.



This symbol refers to a caution that must be taken when operating this equipment. This symbol is found on the equipment and near the explanation of the caution in the manual.

bold italic	Bold italic text denotes a note, caution, or warning.
italic	Italic text denotes emphasis, a cross reference, or an introduction to a key concept.
Lab board	Lab board refers to the Lab-LC, Lab-NB, Lab-PC, and Lab-PC+ boards unless otherwise noted.
MC	MC refers to the Micro Channel series computers.
MIO board	MIO board refers to the National Instruments multichannel I/O DAQ boards, AT-MIO-16, MC-MIO-16, AT-MIO-16F-5, AT-MIO-16X, AT-MIO-16D, AT-MIO-64F-5, NB-MIO-16, and NB-MIO-16X, unless otherwise noted.
`monospace`	Lowercase text in this font denotes text or characters that are to be literally input 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, variables, filenames, and extensions, and for statements and comments taken from program code.
NB	NB refers to the NuBus series computers.
PC	PC refers to the IBM PC/XT, the IBM PC AT, and compatible computers.
SCXIbus	SCXIbus refers to the backplane in the chassis. A signal on the backplane is referred to as the SCXIbus <signal name> line (or signal). The SCXIbus descriptor may be omitted when the meaning is clear. Descriptions of all SCXIbus signals are in Chapter 3, *Signal Connections*.
Slot 0	Slot 0 refers to the power supply and control circuitry in the SCXI chassis.

Abbreviations, acronyms, metric prefixes, mnemonics, symbols, and terms are listed in the *Glossary*.

The National Instruments Documentation Set

The *SCXI-1122 User Manual* is one piece of the documentation set for your SCXI system. You should have six types of manuals. Use these different types of manuals as follows:

- *Getting Started with SCXI*–This is the first manual you should read. It gives an overview of the SCXI system and contains the most commonly needed information for the modules, chassis, and software.
- Your SCXI module user manuals–These manuals contain detailed information about signals connections and module configuration. They also explain in greater detail how the module works and application hints.
- Your DAQ board user manuals–These manuals have detailed information about the DAQ board that plugs into your computer. Use these manuals for board installation and configuration instructions, specification information about your DAQ board, and application hints.
- Software manuals–Examples of software manuals you might have are the LabVIEW and LabWindows® manual sets and the NI-DAQ manuals. After you have set up your hardware system, use either the application software (LabVIEW or LabWindows) manuals or the NI-DAQ manuals to help you write your application. If you have a large and complicated system, it is worthwhile to look through the software manuals before you configure your hardware.
- Accessory manuals–These are the terminal block and cable assembly installation guides. They explain how to physically connect the relevant pieces of the system together. Consult these when you are making your connections.
- SCXI chassis manuals–These manuals contain maintenance information on the chassis, installation instructions, and information for making custom modules.

Related Documentation

The following National Instruments manual contains detailed information for the register-level programmer:

- *SCXI-1122 Register-Level Programmer Manual* (part number 340696-01)

This manual is available from National Instruments by request. If you are using NI-DAQ, LabVIEW, or LabWindows, you should not need the register-level programmer manual. Using NI-DAQ, LabVIEW, or LabWindows is quicker and easier than and as flexible as using the low-level programming described in the register-level programmer manual. Refer to *Software Programming Choices* in Chapter 1, *Introduction*, of this manual to learn about your programming options.

Customer Communication

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

Chapter 1
Introduction

This chapter describes the SCXI-1122; lists the contents of your SCXI-1122 kit; describes the optional software, optional equipment, and custom cables; and explains how to unpack the SCXI-1122.

The SCXI-1122 has 16 isolated input channels and two isolated excitation channels. The SCXI-1122 is a module for signal conditioning of strain gauges, RTDs, thermistors, thermocouples, volt and millivolt sources, 4 to 20 mA current sources, and 0 to 20 mA process-current sources. The SCXI-1122 can operate in two modes–two-wire scan mode with all 16 input channels used for input, or the four-wire scan mode with the eight upper channels configured as sense leads for connecting inputs and the lower eight channels configured as current output channels. The SCXI-1122 inputs are multiplexed to a single output, which drives a single DAQ board channel.

The SCXI-1122 operates with full functionality with the National Instruments MIO-16, Lab-PC+, and the SCXI-1200 boards. You can use the Lab and PC-LPM-16 boards with the SCXI-1122, but these boards cannot scan the module. These boards can perform only single-channel reads. You can multiplex several SCXI-1122s into a single channel, thus greatly increasing the number of isolated analog input signals that you can digitize.

You can add the SCXI-1322 shielded terminal block, which has screw terminals to which you can easily attach the input signals to the SCXI-1122. In addition, the SCXI-1322 has a temperature sensor for cold-junction compensation of thermocouples. This cold-junction reference (CJR) is multiplexed with the 16 input channels.

What Your Kit Should Contain

The contents of the SCXI-1122 kit (part number 776572-22) are listed as follows:

Kit Component	Part Number
SCXI-1122 module *SCXI-1122 User Manual*	182366-01 320516-01

If your kit is missing any of the components, contact National Instruments.

Detailed specifications of the SCXI-1122 are listed in Appendix A, *Specifications*.

Software Programming Choices

There are four options to choose from when programming your National Instruments plug-in DAQ board and SCXI hardware. You can use LabVIEW, LabWindows, NI-DAQ, or register-level programming software.

LabVIEW and LabWindows Application Software

LabVIEW and LabWindows are innovative program development software packages for data acquisition and control applications. LabVIEW uses graphical programming, whereas LabWindows enhances traditional programming languages. Both packages include extensive libraries for data acquisition, instrument control, data analysis, and graphical data presentation.

LabVIEW currently runs on three different platforms–AT/MC/EISA computers running Microsoft Windows, the Macintosh platform, and the Sun SPARCstation platform. LabVIEW features interactive graphics, a state-of-the-art user interface, and a powerful graphical programming language. The LabVIEW Data Acquisition VI Library, a series of VIs for using LabVIEW with National Instruments boards, is included with LabVIEW. The LabVIEW Data Acquisition VI Libraries are functionally equivalent to the NI-DAQ software.

LabWindows has two versions–LabWindows for DOS is for use on PCs running DOS, and LabWindows/CVI is for use on PCs running Windows and Sun SPARCstations. LabWindows/CVI features interactive graphics, a state-of-the-art user interface, and uses the ANSI standard C programming language. The LabWindows Data Acquisition Library, a series of functions for using LabWindows with National Instruments boards, is included with LabWindows for DOS and LabWindows/CVI. The LabWindows Data Acquisition libraries are functionally equivalent to the NI-DAQ software.

Using LabVIEW or LabWindows software will greatly diminish the development time for your data acquisition and control application. Part numbers for these software products are as follows:

Software	Part Number
LabVIEW for Windows	776670-01
LabVIEW for Macintosh	776141-01
LabWindows for DOS	776475-01
LabWindows/CVI for Windows	776800-01

NI-DAQ Driver Software

The NI-DAQ driver software is included at no charge with all National Instruments DAQ boards. NI-DAQ has an extensive library of functions that you can call from your application programming environment. These functions include routines for analog input (A/D conversion), buffered data acquisition (high-speed A/D conversion), analog output (D/A conversion), waveform generation, digital I/O, counter/timer operations, SCXI, RTSI, self-calibration, messaging, and acquiring data to extended memory.

NI-DAQ also internally addresses many of the complex issues between the computer and the plug-in board such as programming interrupts and DMA controllers. NI-DAQ maintains a consistent software interface among its different versions so that you can change platforms with minimal modifications to your code. Figure 1-1 illustrates the relationship between NI-DAQ and LabVIEW and LabWindows. You can see that the data acquisition parts of LabVIEW and LabWindows are functionally equivalent to the NI-DAQ software.

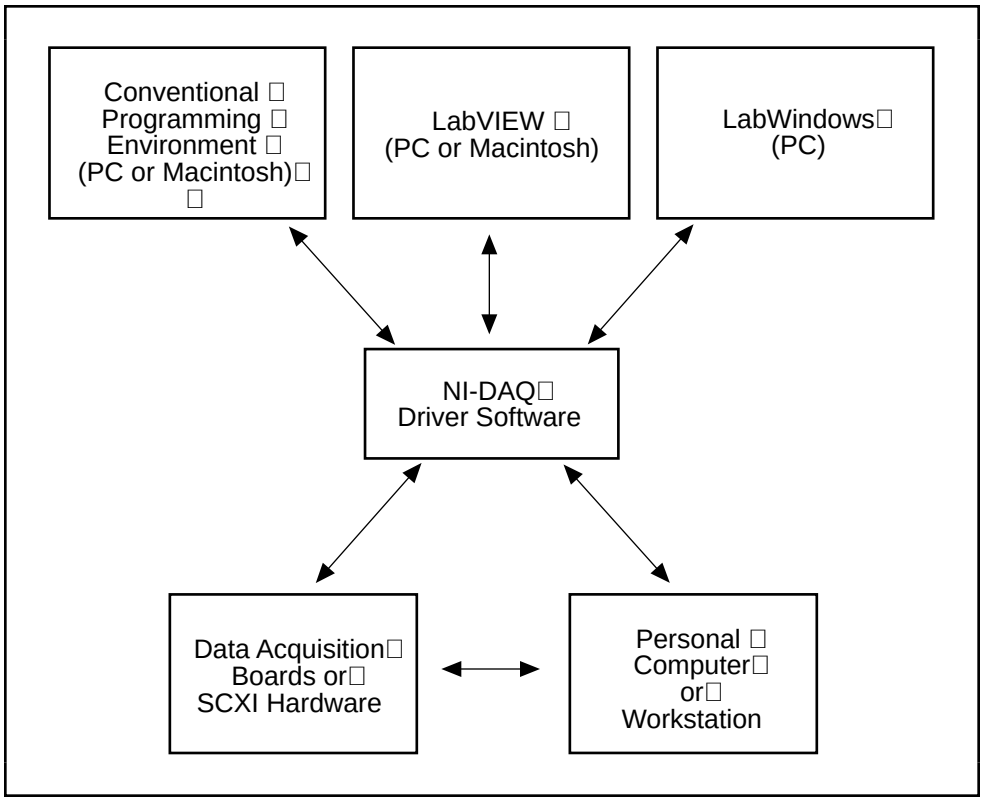


Figure 1-1. The Relationship between the Programming Environment, NI-DAQ, and Your Hardware

The National Instruments PC, AT, and MC Series DAQ boards are packaged with NI-DAQ software for PC compatibles. NI-DAQ software for PC compatibles comes with language interfaces for Professional BASIC, Turbo Pascal, Turbo C, Turbo C++, Borland C++, and Microsoft C for DOS; and Visual Basic, Turbo Pascal, Microsoft C with SDK, and Borland C++ for Windows. You can use your SCXI-1122, together with other PC, AT, and MC Series DAQ boards and SCXI hardware, with NI-DAQ software for PC compatibles.

The National Instruments NB Series DAQ boards are packaged with NI-DAQ software for Macintosh. NI-DAQ software for Macintosh comes with language interfaces for MPW C, THINK C, Pascal, and Microsoft QuickBASIC. Any language that uses Device Manager Toolbox calls can access NI-DAQ software for Macintosh. You can use NB Series DAQ boards and SCXI hardware with NI-DAQ software for Macintosh.

Register-Level Programming

The final option for programming any National Instruments DAQ hardware is to write register-level software. Writing register-level programming software can be very time consuming and inefficient, and is not recommended for most users. The *only* users who should consider writing register-level software should meet at least one of the following criteria:

- National Instruments does not support your operating system or programming language.
- You are an experienced register-level programmer who is more comfortable writing your own register-level software.

Always consider using NI-DAQ, LabVIEW, or LabWindows to program your National Instruments DAQ hardware. Using the NI-DAQ, LabVIEW, or LabWindows software is easier than and as flexible as register-level programming, and can save you weeks of development time.

The *SCXI-1122 User Manual* and your software manuals contain complete instructions for programming your DAQ board with NI-DAQ, LabVIEW, or LabWindows. If you are using NI-DAQ, LabVIEW, or LabWindows to control your board, you should not need the register-level programmer manual. The *SCXI-1122 Register-Level Programmer Manual* contains low-level programming details, such as register maps, bit descriptions, and register programming hints, that you will need only for register-level programming. Some hardware user manuals include register map descriptions and register programming hints. If your manual does not contain a register map description and you want to obtain the register-level programmer manual, please fill out the *Register-Level Programmer Manual Request Form* at the end of this manual and send it to National Instruments.

Optional Equipment

Equipment	Part Number
SCXI-1322 front terminal block	776573-22
SCXI-1340 cable assembly	776574-40
SCXI-1341 Lab-NB/Lab-PC/Lab-PC+ cable assembly	776574-41
SCXI-1342 PC-LPM-16 cable assembly	776574-42
SCXI-1343 rear screw terminal adapter	776574-43
SCXI-1344 Lab-LC cable assembly	776574-44
SCXI-1345 shielded cable with adapter, 1 m	776574-451
2 m	776574-452
5 m	776574-455
10 m	776574-450
SCXI-1350 multichassis adapter	776575-50
SCXI process-current resistor kit[1]	776582-01
Standard ribbon cable, 0.5 m	180524-05
1.0 m	180524-10

[1] Resistor kit needed to perform current measurements. (See pages 2-4)

Refer to Chapter 3, *Signal Connections*, and to your cable installation guide for additional information on cabling, connectors, and adapters.

Custom Cables

The SCXI-1122 rear signal connector is a 50-pin male ribbon-cable header. The manufacturer part number that National Instruments uses for this header is as follows:

- AMP Inc. (part number 1-103310-0)

The mating connector for the SCXI-1122 rear signal connector is a 50-position polarized ribbon-socket connector with strain relief. National Instruments uses a polarized or keyed connector to prevent inadvertent upside-down connection to the SCXI-1122. Recommended manufacturer part numbers for this mating connector are as follows:

- Electronic Products Division/3M (part number 3425-7650)
- T&B/Ansley Corporation (part number 609-5041CE)

Standard 50-conductor, 28 AWG, stranded ribbon cables that you can use with these connectors are as follows:

- Electronic Products Division/3M (part number 3365/50)
- T&B/Ansley Corporation (part number 171-50)

The SCXI-1122 front connector is a 48-pin DIN C male connector. The manufacturer part number that National Instruments uses for this connector is as follows:

- ERNI (part number 913523)

The mating connector for the SCXI-1122 front connector is a 48-pin DIN C female connector. National Instruments uses a polarized connector to prevent inadvertent upside-down connection to the SCXI-1122. The manufacturer part number that National Instruments uses for this connector is as follows:

- ERNI (part number 913524; right-angle pins)

Unpacking

Your SCXI-1122 module is shipped in an antistatic package to prevent electrostatic damage to the module. Electrostatic discharge can damage several components on the module. To avoid such damage in handling the module, take the following precautions.

- Ground yourself via a grounding strap or by holding a grounded chassis such as your SCXI chassis.
- Touch the antistatic package to a metal part of your SCXI chassis before removing the module from the package.
- Remove the module from the package and inspect the module for loose components or any other sign of damage. Notify National Instruments if the module appears damaged in any way. *Do not* install a damaged module into your SCXI chassis.
- *Never* touch the exposed pins of connectors.

Chapter 2
Configuration and Installation

This chapter describes how to configure the SCXI-1122 jumpers and how to install the SCXI-1122 into the SCXI chassis.

Module Configuration

The SCXI-1122 contains two jumpers that are shown in the parts locator diagram in Figure 2-1.

Jumper W2 connects a pullup resistor to the SERDATOUT signal on the rear signal connector. Jumper W1 configures the guard and the analog output ground, and enables the pseudodifferential reference mode.

You must use software to further configure the module. Refer to your software manuals, or to the *SCXI-1122 Register-Level Programmer Manual* if you are a register-level programmer.

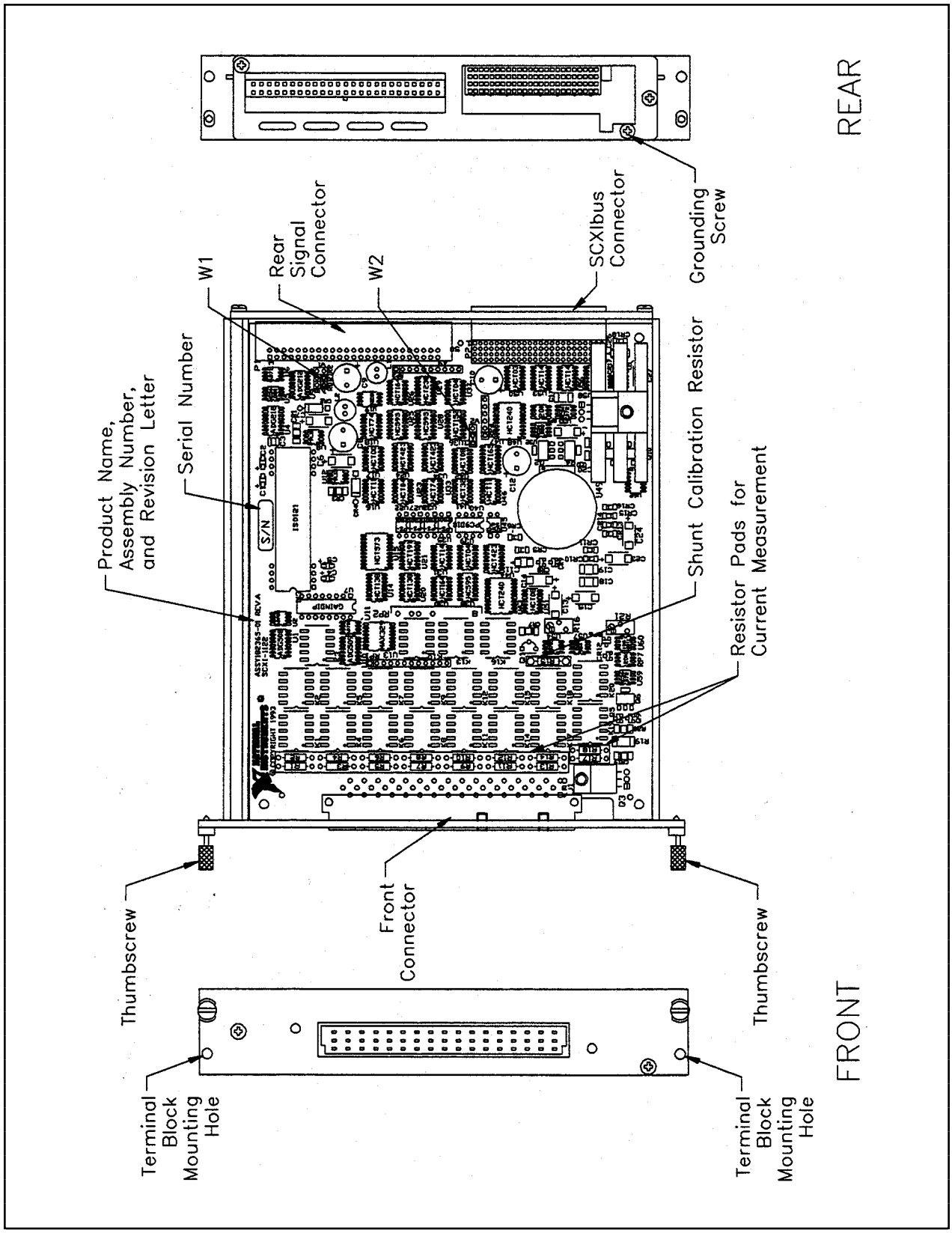


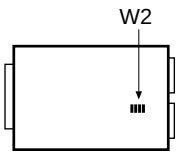
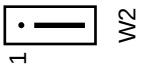
Figure 2-1. SCXI-1122 Parts Locator Diagram

Digital Signal Connections

Note: ***If nothing is cabled to the SCXI-1122 rear signal connector, the position of jumper W2 is irrelevant.***

The SCXI-1122 has one jumper–jumper W2–for communication between the DAQ board and the SCXIbus, shown in Table 2-1.

Table 2-1. Digital Signal Connection Jumper Settings

Jumper	Description	Configuration
DAQ board to SCXIbus communication	Position 1 (pullup)–Use this setting for a single-chassis system. Connects a 2.2 kΩ pullup resistor to the SERDATOUT line. (factory setting)	
	Position 3 (unmarked position, no pullup)–Use this setting for additional chassis in a multichassis system. No pullup resistor is connected to the SERDATOUT line.	

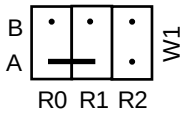
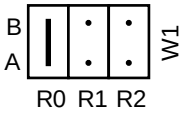
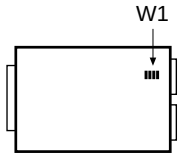
If a module is not connected to a DAQ board, the position of W2 is irrelevant. The MISO line on the SCXI-1122 module is for reading the Module ID Register, the Status Register, and the EEPROM. National Instruments software does not read the Module ID automatically–you must indicate to the software which module is in which slot.

An open-collector driver (a driver that actively drives low or goes to high-impedance state, relying on a pullup resistor to make the signal line go high) drives the SERDATOUT line. When using a single chassis, set jumper W2 in position 1 on the SCXI-1122 that is connected to the DAQ board. In this setting, the module drives MISO to SERDATOUT and connects the necessary pullup resistor to the SERDATOUT line. When using multiple chassis, set jumper W2 to position 1 on only one of the SCXI-1122s that are cabled to the DAQ board. It does not matter which of the SCXI-1122s that are cabled to the DAQ board has the pullup connected. Set jumper W2 in position 3 on all of the other SCXI-1122 modules that are cabled to the DAQ board because if too many pullup resistors are attached to the SERDATOUT line, the drivers cannot drive the line low.

Analog Configuration

The SCXI-1122 has one analog configuration jumper–jumper W1–for grounding, shielding, and reference mode selection, shown in Table 2-2.

Table 2-2. Jumper W1 Settings

Jumper	Description	Configuration
Grounding, shielding, and reference mode selection	Unconnected position (factory setting)	
	Connects the analog reference to the analog output ground AOGND (pins 1 and 2 on the rear signal connector). Select this configuration if you are using an RSE DAQ board. Do not use a differential input DAQ board when jumper W1 is in this position.	
	Connects SCXIbus guard to the analog reference	
	Enables the pseudodifferential reference mode and connects the analog reference to the OUTREF pin on the rear signal connector. Select this mode when the SCXI-1122 has to operate with DAQ boards that have a nonreferenced single-ended (NRSE) input. Do not use differential input DAQ boards when jumper W1 is in this position.	

Current-Loop Receivers

The SCXI-1122 has pads for transforming individual channels to current-to-voltage converters. National Instructments offers an SCXI process current pack, which consists of a package of four 249 Ω, 0.1%, 5 ppm, 1/4 W resistors. You can find the part number for this kit in the *Optional Equipment* section of Chapter 1, *Introduction*. Table 2-3 shows the input channel and its corresponding resistor reference designator.

Table 2-3. User-Defined Current Receiver Resistors

Input Channel	Resistor Reference Designator
0	R1
1	R2
2	R3
3	R4

(continues)

Table 2-3. User-Defined Current Receiver Resistors (Continued)

Input Channel	Resistor Reference Designator
4	R5
5	R6
6	R7
7	R8
8	R9
9	R10
10	R11
11	R12
12	R13
13	R14
14	R17
15	R18

Warning: ***Before installing the resistors in your module, make sure that there are no signals connected to your module front connector.***

⚠ ***SHOCK HAZARD–This unit should only be opened by qualified personnel aware of the dangers involved. Disconnect all power before removing the cover. Always install the grounding screw. If signal wires are connected to the module or terminal block, dangerous voltages may exist even when the equipment is turned off. Before you remove any installed module, disconnect the AC power line or any high-voltage sources (≥ 30 Vrms, 42.4 Vpk or 60 Vdc) that may be connected to the module.***

To install the resistors, you need to do the following before installing your module in the SCXI chassis:

1. Ground yourself via a grounding strap or via a ground connected to your SCXI chassis. Properly grounding yourself prevents damage to your SCXI module from electrostatic discharge.
2. Remove the module cover by unscrewing the grounding screw at the rear of the module.
3. Remove the rear panel by unscrewing the two remaining screws.
4. Slide the module out of its enclosure.
5. Insert the resistor(s) into the appropriate pad.
6. Solder the leads to the pads on the solder side of the module.
7. Trim the leads to 0.06 in. maximum.
8. Slide the module back into its enclosure.
9. Reinstall the rear panel.
10. Reinstall the top cover and grounding screw.
11. Your module is ready to be installed into the chassis.

Hardware Installation

You can install the SCXI-1122 in any available SCXI chassis slot. After you have made any necessary changes and have verified and recorded the jumper settings on the form in Appendix B, *Customer Communication*, you are ready to install the SCXI-1122. The following are general installation instructions; consult the user manual or technical reference manual of your SCXI chassis for specific instructions and warnings.

1. Turn off the computer that contains the DAQ board or disconnect it from your SCXI chassis.

2. Turn off the SCXI chassis. Do not insert the SCXI-1122 into a chassis that is turned on.

3. Insert the SCXI-1122 into the module guides. Gently guide the module into the back of the slot until the connectors make good contact. If a cable assembly has already been installed in the rear of the chassis, the module and cable assembly must be firmly engaged; however, do not *force* the module into place.

4. Screw the front mounting panel of the SCXI-1122 to the top and bottom threaded strips of your SCXI chassis.

5. If this module is to be connected to an MIO-16 DAQ board, attach the connector at the metal end of the SCXI-1340 cable assembly to the rear signal connector on the SCXI-1122 module. Screw the rear panel to the rear threaded strip. Attach the loose end of the cable to the MIO-16 board.

   Note: ***For installation procedures with other SCXI accessories and DAQ boards, consult your cable installation guide.***

6. Check the installation.

7. Turn on the SCXI chassis.

8. Turn on the computer or reconnect it to your chassis.

The SCXI-1122 module is installed. You are now ready to install and configure your software.

If you are using NI-DAQ, refer to the *NI-DAQ User Manual for PC Compatibles*. The software installation and configuration instructions are in Chapter 1, *Introduction to NI-DAQ*. Find the installation and system configuration section for your operating system and follow the instructions given there.

If you are using LabVIEW, the software installation instructions are in your LabVIEW release notes. After you have installed LabVIEW, refer to the *Configuring LabVIEW* section of Chapter 1 of your LabVIEW user manual for software configuration instructions.

If you are using LabWindows, the software installation instructions are in Part 1, *Introduction to LabWindows*, of the *Getting Started with LabWindows* manual. After you have installed LabWindows, refer to Chapter 1, *Configuring LabWindows*, of the *LabWindows User Manual* for software configuration instructions.

Chapter 3
Signal Connections

This chapter describes the input and output signal connections to the SCXI-1122 module via the SCXI-1122 front connector and rear signal connector. This chapter also includes specifications and connection instructions for the signals on the SCXI-1122 connectors.

The following warnings contain important safety information concerning hazardous voltages.

Warnings: ***You MUST insulate all of your signal connections appropriately to the HIGHEST available voltage with which the SCXI-1122 may come in contact. ANY voltage connected to the SCXI-1122 connector may appear on any other pin of this connector. Treat all signals on the SCXI-1122 front connector as hazardous if any signals on the front connector are greater than or equal to 30 Vrms, 42.4 Vpk or 60 Vdc.***

DO NOT OPERATE THE MODULE IN AN EXPLOSIVE ATMOSPHERE OR WHERE THERE MAY BE FLAMMABLE GASES OR FUMES.

⚠ ***SHOCK HAZARD–This unit should only be opened by qualified personnel aware of the dangers involved. Disconnect all power before removing the cover. Always install the grounding screw. If signal wires are connected to the module or terminal block, dangerous voltages may exist even when the equipment is turned off. Before you remove any installed terminal block or module, disconnect the AC power line or any high-voltage sources (≥ 30 Vrms, 42.4 Vpk or 60 VDC) that may be connected to the terminal block or module.***

DO NOT OPERATE DAMAGED EQUIPMENT. The safety-protection features built into this module can be impaired if the module becomes damaged in any way. If it is damaged, turn the module off and do not use it until service-trained personnel can check its safety. If necessary, return the module to National Instruments for service and repair to ensure that its safety is not compromised.

DO NOT SUBSTITUTE PARTS OR MODIFY EQUIPMENT. Because of the danger of introducing additional hazards, do not install unauthorized parts or modify the module. Return the module to National Instruments for service and repair to ensure that its safety features are not compromised.

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

When using the terminal block with high common-mode voltages, you MUST insulate your signal wires appropriately. National Instruments is NOT liable for any damages or injuries resulting from inadequate signal wire insulation.

Connections, including power signals to ground and vice versa, that exceed any of the maximum signal ratings on the SCXI-1122 can damage any or all of the boards connected to the SCXI chassis, the host computer, and the SCXI-1122 module. National Instruments is NOT LIABLE FOR ANY DAMAGES OR INJURIES resulting from incorrect signal connections.

If high voltages (≥ 30 Vrms, 42.4 Vpk or 60 Vdc) are present, YOU MUST CONNECT SAFETY EARTH GROUND TO THE STRAIN-RELIEF TAB OF THE TERMINAL BLOCK. This maintains compliance with UL and CE, and protects against electric shock when the terminal block is not connected to the chassis. To connect the safety earth ground to the strain-relief tab, run an earth ground wire in the cable from the signal source to the terminal block. National Instruments is NOT liable for any damages or injuries resulting from inadequate safety earth ground connections.

To comply with UL and CE requirements, use this module only with a UL listed SCXI chassis.

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

Caution: ***Static electricity is a major cause of component failure. To prevent damage to the electrical components in the module, observe antistatic techniques whenever removing a module from the mainframe or whenever working on a module.***

Front Connector

Figure 3-1 shows the pin assignments for the SCXI-1122 front connector.

⚠ ***If a relay fails there exists a potential shock hazard on the inputs that are not in contact with hazardous voltages. For this reason treat all inputs as potentially hazardous if any inputs are in contact with hazardous voltages (≥ 30 Vrms, 42.4 Vpk or 60 Vdc).***

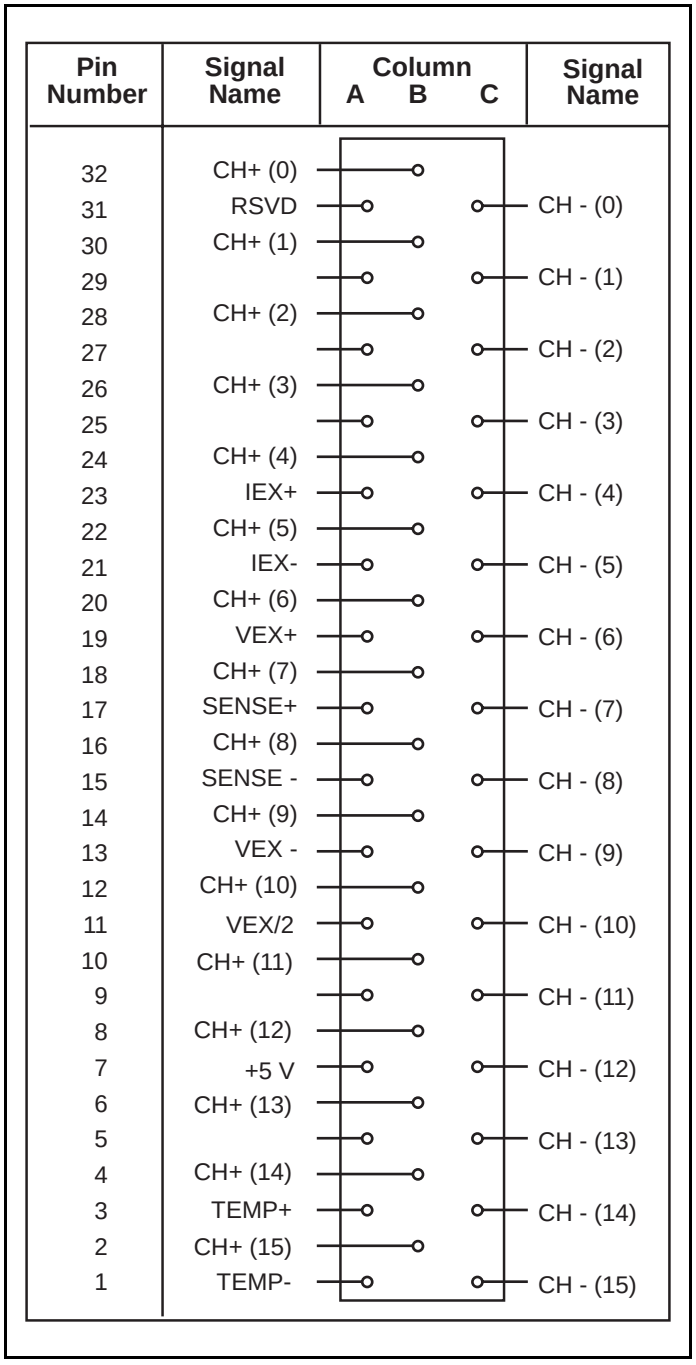


Figure 3-1. SCXI-1122 Front Connector Pin Assignments

Front Signal Connection Descriptions

Pin	Signal Name	Description
A1	TEMP-	Temperature Sensor Reference–This pin is tied to the temperature sensor reference in the terminal block and to the isolation amplifier negative input in the module.
A3	TEMP+	Temperature Sensor Output–This pin connects the temperature sensor output to the amplifier input selector.
A7	+5 V	+5 VDC Isolated Source–This pin, which powers the temperature sensor on the terminal block, has 0.5 mA of source not protected.
A11	VEX/2	Half Voltage Excitation Output–This pin connects to the internal bridge completion network for quarter-bridge and half-bridge measurements. Protected to ±20 V maximum.
A13	VEX-	Negative Voltage Excitation Output–This pin is connected to the voltage excitation negative output.
A15	SENSE-	Negative Voltage Sense–This pin must be tied to VEX- at the load for remote sensing. When using the SCXI-1322 terminal block, this pin is connected to VEX/SENSE- screw terminals.
A17	SENSE+	Positive Voltage Sense–This pin must be tied to VEX+ at the load for remote sensing. When using the SCXI-1322 terminal block, this pin is connected to VEX/SENSE+ screw terminals. This pin is *not* protected.
A19	VEX+	Positive Voltage Excitation Output–This pin is connected to the voltage excitation positive output.
A21	IEX-	Negative Current Excitation Output–This pin is connected to the current excitation negative output.
A23	IEX+	Positive Current Excitation Output–This pin is connected to the current excitation positive output.
A5, A9, A25-A29		No Connect–*Do not* connect any signal to these pins.
A31	RSVD	Reserved–This pin is reserved. Do not connect any signal to this pin.
B32-B2	CH+(0:15)	Positive Input Channel–These pins are connected to the positive input channels 0 through 15 respectively.
C31-C1	CH-(0:15)	Negative Input Channel–These pins are connected to the negative input channels 0 through 15 respectively.

The signals on the front connector are all analog except pins A7, and A31, which are digital. The analog signals are grouped into analog input channels, excitation channels, and temperature sensor signals. Signal connection guidelines for each of these groups are described in the following sections.

Notes: ***All pins are overvoltage protected to 250 Vrms except for pin A7 (+5 V signal), pin 31 (RSVD), pin A17 (SENSE+), and pin A11 (VEX/2).***

All inputs and outputs on the front connector are isolated. The maximum working common-mode voltage to earth is 480 Vrms and between channels is 250 Vrms.

Analog Input Channel Signal Connections

The positive input channel signal terminals are located in column B of the connector. Their corresponding negative input channel signal terminals are located in column C of the connector. Each input corresponds to a separate relay that are all multiplexed into the amplifier input selector. In addition to the relay inputs, the temperature sensor output from the terminal block–located on pins A3 (TEMP+) and A1 (TEMP-)–is also connected to the amplifier input selector. All inputs are fully isolated from earth ground and are in a floating single-ended configuration; hence, you can measure signals that have a common-mode voltage up to 480 Vrms. Notice that the maximum allowable channel-to-channel common-mode voltage is 250 Vrms.

Warning: ***EXCEEDING THE INPUT SIGNAL RANGE RESULTS IN DISTORTED SIGNALS. Exceeding the maximum input voltage rating (250 Vrms between positive and negative inputs or outputs, 250 Vrms between input or output channels, and 480 Vrms between input or output channels and earth ground) can damage the SCXI-1122, the SCXIbus, and the DAQ board. National Instruments is NOT liable for any damages or injuries resulting from such signal connections.***

For better noise immunity, and if all the measured signals are floating, connect the negative input channels to chassis ground on the terminal block using the solder lug attached to the strain-relief bar. Figure 3-2 shows how to connect a ground-referenced signal. Figure 3-3 shows how to connect a floating signal. Figures 3-4 and 3-5 show how to connect AC-coupled signals.

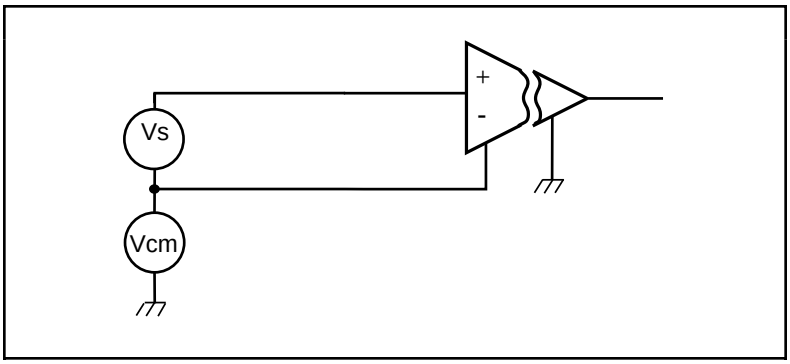


Figure 3-2. Ground-Referenced Signal Connection with High Common-Mode Voltage

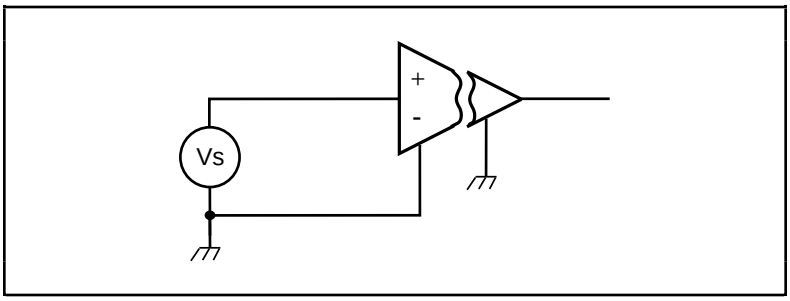


Figure 3-3. Floating Signal Connection Referenced to Chassis Ground for Better SNR

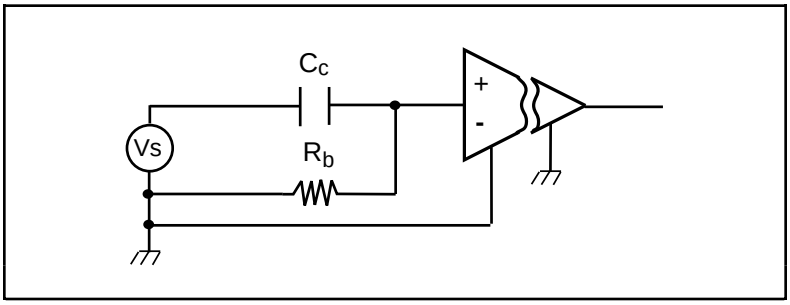


Figure 3-4. Floating AC-Coupled Signal Connection Referenced to Chassis Ground for Better SNR

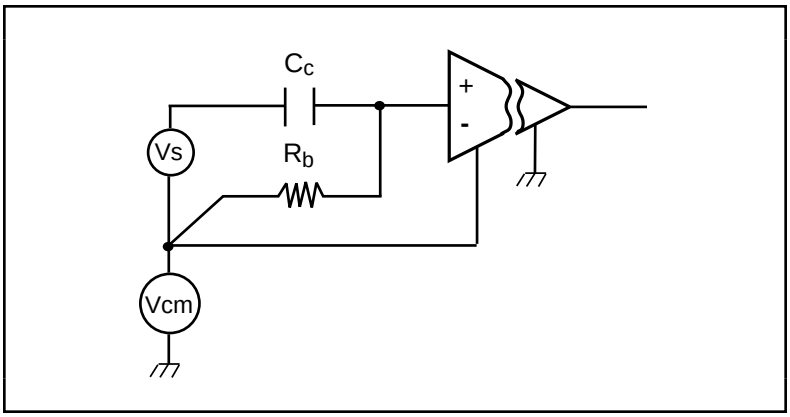


Figure 3-5. AC-Coupled Signal Connection with High Common-Mode Voltage

For AC-coupled signals, connect an external resistor from the positive input channel to the signal reference to provide the DC path for the positive input bias current. Typical resistor values range from 100 kΩ to 1 MΩ. This solution, although necessary in this case, lowers the input impedance of the input channel amplifier and introduces an additional offset voltage proportional to the input bias current and to the resistor value used. The typical input bias current of the amplifier consists of ±80 pA and a negligible offset drift current. A 100 kΩ bias resistor results in ±8 μV of offset, which is insignificant in most applications. However, if you use larger resistors, significant input offset may result. To determine the maximum offset the biasing resistor will introduce, use the following equation:

$$V_{ofsbias} = I_{bias} \times R_{bias}$$

The input signal range of an SCXI-1122 input channel is ±10 V/ G_{total} referenced to its negative input, where G_{total} is equal to the gain selected on the SCXI-1122. In addition, the input channels are overvoltage protected to 250 Vrms with power on or off at a maximum of 2.5 mArms sink or source.

Note: ***The SCXI-1122 input multiplexer is composed of relays. Relays have a certain life expectancy, as listed in Appendix A,*** *Specifications.* ***To avoid mechanical wear on the relays, and when you are acquiring a large number of points per channel and averaging, you should acquire the*** *n* ***samples on a given channel before proceeding to the next channel. For example, rather than performing 100 scans and taking a single sample from each channel during each scan, as shown in Figure 3-6a, acquire 100 points on each channel then switch to the next channel and acquire a new set of samples, as shown in Figure 3-6b.***

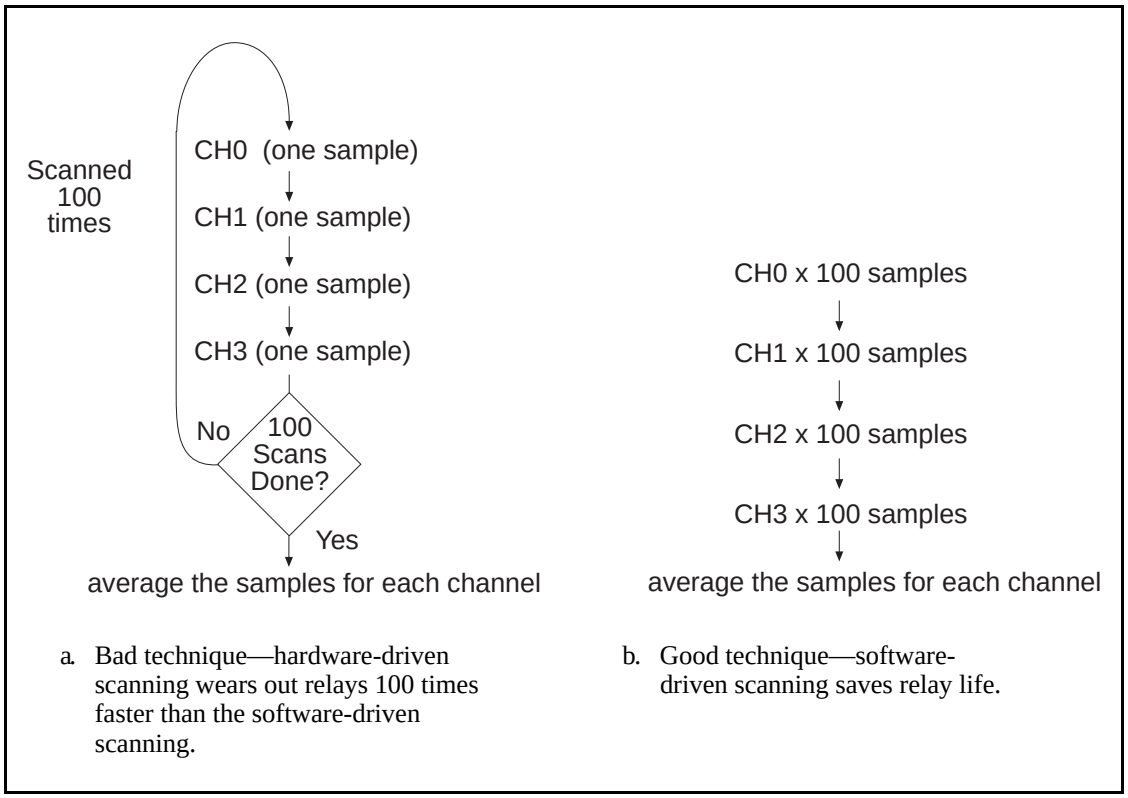


Figure 3-6. Avoiding Relay Wear by Sampling and Averaging Rather Than Single-Sample Channel Scanning

Excitation Channel Signal Connections

Your SCXI-1122 has a voltage (VEX) and a current (IEX) excitation channel, which are available at the front connector. In addition, VEX/2 is available for half-bridge and quarter-bridge transducers. Both channels are isolated from earth ground up to 480 Vrms working common-mode voltage. Notice that the voltage and current excitations are electrically isolated from each other but do not provide a *safety isolation* between them.

Warning: ***Exceeding the overvoltage protection or isolation rating on the excitation output can damage the SCXI-1122, the SCXIbus, and the DAQ board. National Instruments is NOT liable for any damages or injuries resulting from such signal connections.***

Excitation Level

Each excitation channel of your SCXI-1122 has one level:

- Current excitation–1 mA
- Voltage excitation–3.333 V

It is important that you do not exceed the maximum permissible load of each channel, listed in Table 3-1.

Table 3-1. Maximum Load per Excitation Channel

Excitation Level	Maximum Load
3.333 V	225 mA
1 mA	5 kΩ

Using the Internal Half-Bridge Completion

Your SCXI-1122 includes half-bridge completion for half-bridge and quarter-bridge setups. The completion network consists of two 2.5 kΩ ±0.02% ratio tolerance resistors with a temperature coefficient of 2 ppm/°C. These resistors are connected in series. To use the network, connect the VEX/2 screw terminal on the terminal block to the negative input of the channel of interest.

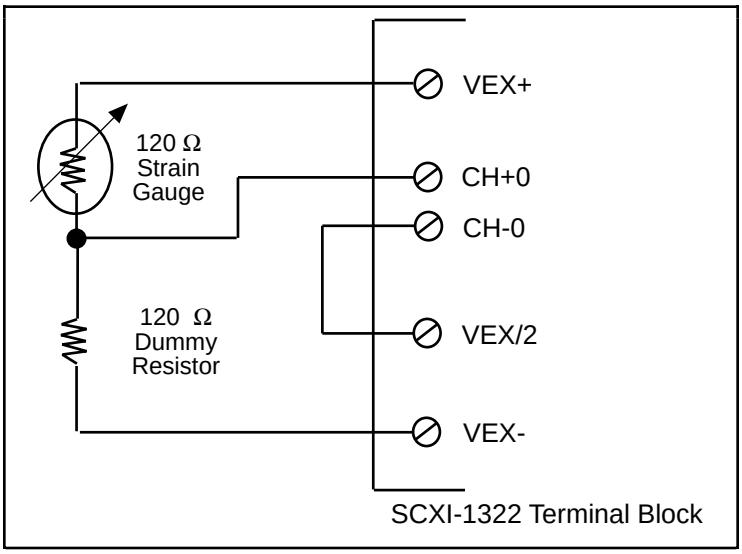


Figure 3-7. Connecting a Quarter-Bridge Strain Gauge to Channel 0

Note: ***When using the half-bridge completion network with a quarter-bridge setup, you must use an extra resistor to complete the bridge. Place this resistor on the terminal block between the positive input channel and the negative excitation output.***

Temperature Sensor Connection

Pins A1 and A3 are for connecting the isolated temperature sensor located on the SCXI-1322 terminal block for cold-junction compensation (CJC) of thermocouples connected to the SCXI-1122. The connection is overvoltage-protected to 250 Vrms with power on and off.

Warning: ***Exceeding the overvoltage protection on the temperature connections can damage the SCXI-1122, the SCXIbus, and the DAQ board. National Instruments is NOT liable for any damages resulting from such signal connections.***

Rear Signal Connector

Note: ***If you are using the SCXI-1122 with a National Instruments DAQ board and cable assembly, you do not need to read the remainder of this chapter. If you are using the SCXI-1180 feedthrough panel, the SCXI-1343 rear screw terminal adapter, or the SCXI-1351 one-slot cable extender with the SCXI-1122, read this section.***

Figure 3-8 shows the SCXI-1122 rear signal connector pin assignments.

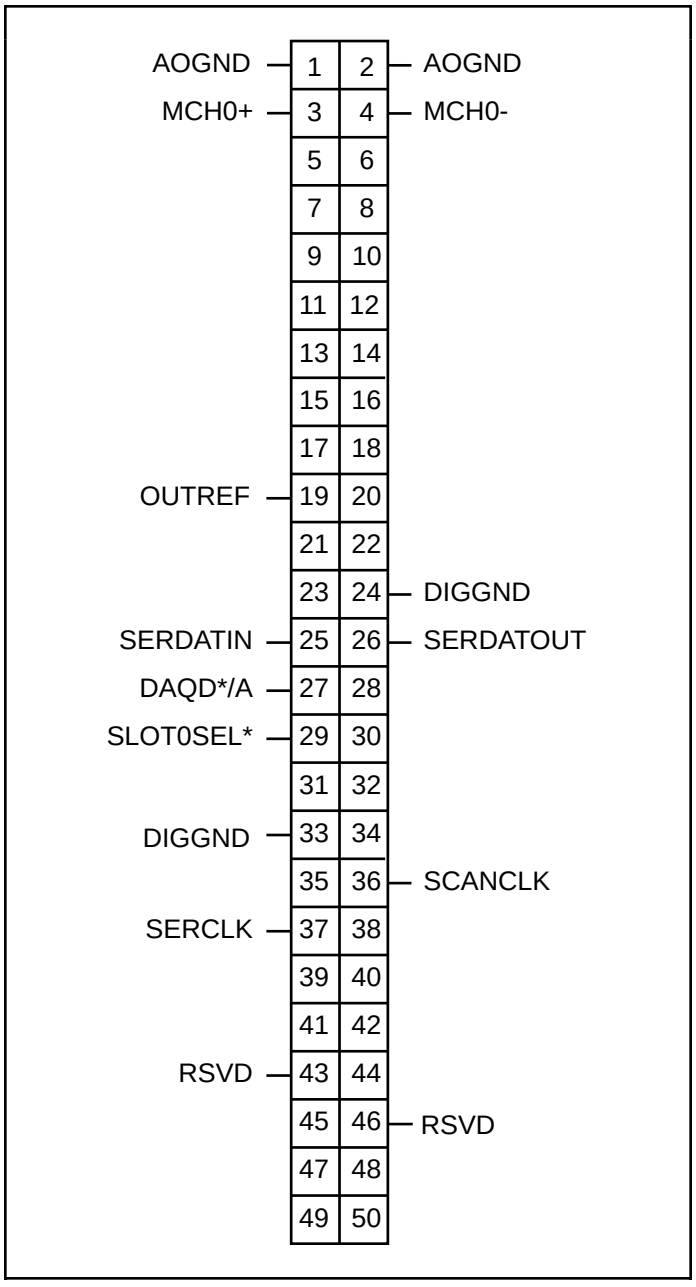


Figure 3-8. SCXI-1122 Rear Signal Connector Pin Assignments

Rear Signal Connection Descriptions

Pin	Signal Name	Description
1, 2	AOGND	Analog Output Ground–These pins are connected to the analog reference when jumper W1 is in position AB-R0.
3, 4	MCH0±	Analog Output Channels 0–Connects to the DAQ board differential analog input channels.
19	OUTREF	Output Reference–This pin serves as the reference node for the analog channels output in the pseudodifferential reference mode. It should be connected to the analog input sense of the NRSE DAQ board.
24, 33	DIGGND	Digital Ground–These pins supply the reference for DAQ board digital signals and are tied to the module digital ground.
25	SERDATIN	Serial Data In–This signal taps into the SCXIbus MOSI line to send serial input data to a module or Slot 0.
26	SERDATOUT	Serial Data Out–This signal taps into the SCXIbus MISO line to accept serial output data from a module.
27	DAQD*/A	DAQ Board Data/Address Line–This signal taps into the SCXIbus D*/A line to indicate to the module whether the incoming serial stream is data or address information.
29	SLOT0SEL*	Slot 0 Select–This signal taps into the SCXIbus INTR* line to indicate whether the information on MOSI is being sent to a module or Slot 0.
36	SCANCLK	Scan Clock–This indicates to the SCXI-1122 that a sample has been taken by the DAQ board and causes the SCXI-1122 to change channels.
37	SERCLK	Serial Clock–This signal taps into the SCXIbus SPICLK line to clock the data on the MOSI and MISO lines.
43, 46	RSVD	Reserved.

All other pins are not connected.

The signals on the rear signal connector can be classified as analog output signals, digital I/O signals, or timing I/O signals. Signal connection guidelines for each of these groups are given in the following section.

Analog Output Signal Connections

Pins 1 through 4 and pin 19 of the rear signal connector are analog output signal pins. Pins 1 and 2 are AOGND signal pins. AOGND is an analog output common signal that is routed through jumper W1 to the analog reference on the SCXI-1122. You can use these pins as a general analog power ground tie point to the SCXI-1122 if necessary.

In particular, when using differential input DAQ boards such as the MIO-16 boards, it is preferable to leave jumper W1 in its factory setting or in position AB-R1 to avoid ground loops. With DAQ boards that are configured for referenced single-ended (RSE) measurements, set jumper W1 in position AB-R0 to connect the SCXI-1122 ground to the DAQ analog ground.

Pin 19 is the OUTREF pin; this pin is connected internally to the analog reference when jumper W1 is in position AB-R2. Pins 3 and 4 are the analog output channel of the SCXI-1122. Pins 3 and 4 or MCH0± are a multiplexed output of the input channels and the temperature sensor output. Notice that the temperature sensor is located on the terminal block.

Warning: ***The SCXI-1122 analog outputs are not overvoltage-protected. Applying external voltages to these outputs can damage the SCXI-1122. National Instruments is NOT liable for any damages resulting from such signal connections.***

Note: ***The SCXI-1122 analog outputs are short-circuit protected.***

Digital I/O Signal Connections

Pins 24 through 27, 29, 33, 36, 37, 43, and 46 constitute the digital I/O lines of the rear signal connector–the digital input signals, the digital output signals, and the digital timing signals.

The digital input signals are pins 24, 25, 27, 29, 33, and 37. The DAQ board uses these pins to configure an SCXI module that is under DAQ board control. Each digital line emulates the SCXIbus communication signals as follows:

- Pin 25, SERDATIN, is equivalent to the SCXIbus MOSI serial data input line.
- Pin 27, DAQD*/A, is equivalent to the SCXIbus D*/A line. It indicates to the module whether the incoming serial stream on SERDATIN is data (DAQD*/A = 0), or address (DAQD*/A = 1) information.
- Pin 29, SLOT0SEL*, is equivalent to the SCXIbus INTR* line. It indicates whether the data on the SERDATIN line is being sent to Slot 0 (SLOT0SEL* = 0) or to a module (SLOT0SEL* = 1).
- Pins 24 and 33 are the digital ground references for the DAQ board digital signals and are tied to the module digital ground.
- Pin 37, SERCLK, is equivalent to the SCXIbus SPICLK line and is used to clock the serial data on the SERDATIN line into the module registers.

The digital output signal, pin 26, is SERDATOUT and is equivalent to SCXIbus MISO.

The SCXI-1122 digital input and output signals match the digital I/O lines of the MIO-16 boards. When used with an SCXI-1341, SCXI-1342, or SCXI-1344 cable assembly, the SCXI-1122 signals match the digital lines of the Lab-NB/PC/PC+, the PC-LPM-16, and the Lab-LC boards, respectively. Table 3-2 lists the equivalences. For more detailed information, consult your cable installation guide.

Table 3-2. SCXIbus to SCXI-1122 Rear Signal Connector to DAQ Board Pin Equivalences

SCXIbus Line	SCXI-1122 Rear Signal Connector	MIO-16	Lab Boards	PC-LPM-16
MOSI	SERDATIN	ADIO0	PB4	DOUT4
D*/A	DAQD*/A	ADIO1	PB5	DOUT5
INTR*	SLOT0SEL*	ADIO2	PB6	DOUT6
SPICLK	SERCLK	EXTSTROBE*	PB7	DOUT7
MISO	SERDATOUT	BDIO0	PC1	DIN6

The digital timing signals are pins 36, 43, and 46.

- Pin 36 is used as a clock by the SCXI-1122 to increment to the next channel after each conversion by the DAQ board during scanning. This signal is referred to as SCANCLK.
- Pin 43 is a reserved digital input.
- Pin 46 is a reserved digital input.

The following specifications and ratings apply to the digital I/O lines:

- Absolute maximum voltage input rating — 5.5 V with respect to DIGGND
- Digital input specifications (referenced to DIGGND):
  - V_{IH} input logic high voltage — 2 V minimum
  - V_{IL} input logic low voltage — 0.8 V maximum
  - I_I input current leakage — ±1 µA maximum
- Digital output specifications (referenced to DIGGND):
  - V_{OH} output logic high voltage — 3.7 V minimum at 4 mA maximum
  - V_{OL} output logic low voltage — 0.4 V maximum at 4 mA maximum

Chapter 4
Theory of Operation

This chapter contains a functional overview of the SCXI-1122 module and explains the operation of each functional unit making up the SCXI-1122.

Functional Overview

The block diagram in Figure 4-1 illustrates the key functional components of the SCXI-1122.

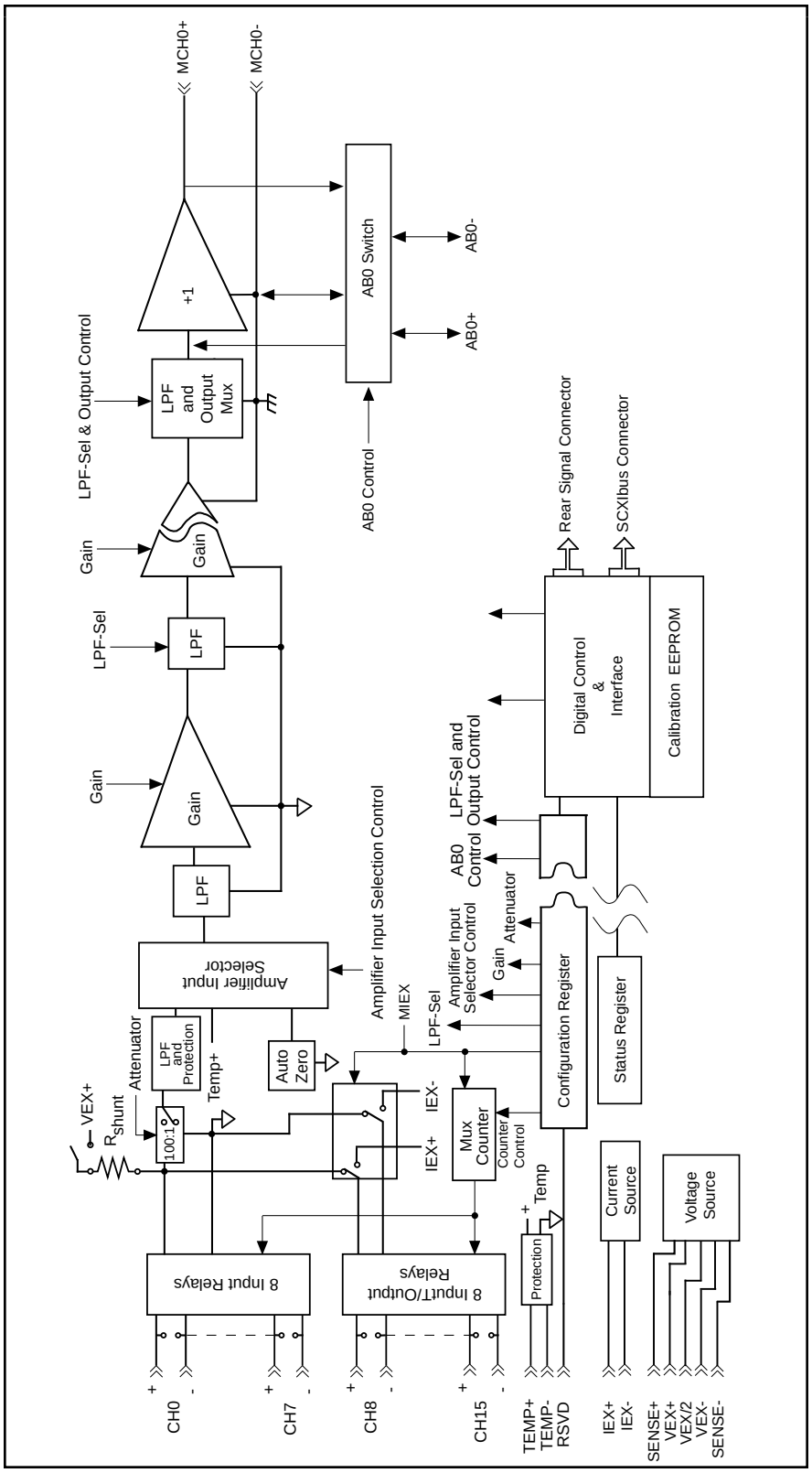


Figure 4-1. SCXI-1122 Block Diagram

The major components of the SCXI-1122 are as follows:

- The rear signal connector
- The SCXIbus connector
- The SCXIbus interface
- The digital control circuitry
- The analog circuitry

The SCXI-1122 consists of 16 isolated multiplexed channels with gains of 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, 500, 1,000, and 2,000, and two isolated excitation channels with voltage and current excitation. The SCXI-1122 also has a digital section for automatic control of channel scanning, temperature selection, gain selection, and filter selection.

The remainder of this chapter describes the theory of operation for each of these components.

Rear Signal Connector, SCXIbus Connector, and SCXIbus Interface

The SCXIbus controls the SCXI-1122. The SCXIbus interface interfaces the signals of the rear signal connector to the SCXIbus, allowing a DAQ board to control the SCXI-1122 and the rest of the chassis.

Digital Control Circuitry

The digital control section consists of the Address Handler Register, the Configuration Register, the Status Register, and the Module ID Register. The Address Handler Register controls which register is being addressed. The Configuration Register configures the SCXI-1122 such as gain selection, shunt calibration, filter bandwidth, two-wire or four-wire scanning, CJS selection, and auto-zeroing. The Status Register indicates if the SCXI-1122 is done configuring its internal circuitry or is still in progress of doing so. The Module ID Register contains the module ID A hex, a code unique to the SCXI-1122. You can read this module ID over the SCXIbus to determine the type of module in a particular slot.

Analog Circuitry

The analog circuitry consists of a relay multiplexer, a software-programmable gain isolation amplifier, software-programmable filtering, a temperature sensor channel for cold-junction compensation, calibration hardware, and voltage and current excitation channel outputs.

Analog Input Channels

The relay multiplexer feeds into the isolation amplifier. This relay multiplexer can be configured in two-wire or four-wire mode scanning. In two-wire scan mode all sixteen channels operate as voltage sense channels. At any point in time one and only one of sixteen channels is connected to the isolation amplifier. In the four-wire scan mode the sixteen channels are divided into two

banks which switch synchronously. The eight upper channels (0 through 7) operate as voltage sense channels and one out of eight is connected to the amplifier at any given point in time. In addition, the eight lower channels (8 through 15) operate as current output channels which switch in tandem with the sense channels. At any given point in time one and only one channel is connected to the current output channels. Table 4-1 indicates the sense/current output channel associations.

Table 4-1. Sense/Current Output Channel Associations

Sense	Current Output
Channel 0	Channel 8
Channel 1	Channel 9
Channel 2	Channel 10
Channel 3	Channel 11
Channel 4	Channel 12
Channel 5	Channel 13
Channel 6	Channel 14
Channel 7	Channel 15

The temperature sensor consists of a thermistor located on the SCXI-1322 terminal block. This thermistor connects via the temperature channel to the isolation amplifier. The temperature sensor is for cold junction compensation of thermocouples. When measuring the temperature sensor output, set your SCXI-1122 for a gain of five and 4 Hz filter. This will increase the measurement resolution and accuracy as well as reduce noise.

Note: ***With a 4 Hz bandwidth you must wait one second before you take the temperature measurement to permit the system to settle. If you want to use the 4 kHz filter, take a large number of samples and average them. To achieve 50 or 60 Hz rejection, you should acquire data over an integral number of power line cycles, then average this data.***

The filtering consists of one of two low pass filters, 4 kHz (-3 dB) or 4 Hz (-10 dB), which you can select via software control. These filters are cascaded and are located in two stages. This is done to eliminate noise introduced by the isolation amplifier.

The isolation amplifier fulfills two purposes on the SCXI-1122 module. The isolation amplifier converts a small signal riding on a high common-mode voltage into a single-ended signal with respect to the SCXI chassis ground. With this conversion, you can extract the input analog signal from a high common-mode voltage or noise before it is sampled and converted by the DAQ board. The isolation amplifier also amplifies and conditions an input signal, which results in an increase in measurement resolution and accuracy. The isolation amplifier drives the analog output stage which consists of hardware circuitry which permits several module outputs to multiplex into one DAQ board channel.

The calibration hardware consists of a software-controlled shunt calibration resistor for strain gauge calibration, an auto-zero calibration for nulling the amplifier offsets, and of an EEPROM which holds calibration constants for software correction of gain and offset of the isolation amplifier and of the current and voltage excitations. Refer to your software user manual (NI-DAQ, LabVIEW, or LabWindows) for further details and to the *Excitation Calibration* section in Chapter 5, *Calibration*.

Excitation Output Channels

In addition to the isolated input channels, the SCXI-1122 has isolated excitation channels, one 3.333 V voltage output source and one 1 mA current output source. Both–like the relay input channel–have a 480 Vrms common-mode voltage with respect to earth ground and 250 Vrms common-mode voltage between each other and any other channel. Both channels are overvoltage protected to 250 Vrms and are current limited. The voltage excitation channel is provided for transducers, such as strain gauges, which need voltage excitation to operate properly. The maximum current sourcing that this channel can provide is 225 mA. Exceeding this limit will cause the channel to lose regulation. This channel has four terminals, two sense terminals (SENSE+ and SENSE-) and two excitation terminals (VEX+ and VEX-). This is done to provide remote load regulation. For proper operation, the SENSE+ terminal must always be connected to the VEX+, and the SENSE- terminal to the VEX-. Refer to the *SCXI-1322 Terminal Block Installation Guide* for further details on using the sense terminals for remote load sensing.

One of the primary applications of this channel is to provide power to a strain gauge configured in a Wheatstone bridge. To permit verification of proper bridge operation, we have provided you with shunt calibration means. This can be done programmatically.

When you select shunt calibration while you are performing a Wheatstone bridge strain measurement , a 301 kΩ 1% resistor internally shunts across the strain gauge between the VEX+ and the CH+; this resistor is socketed to permit you to change its value to meet your requirements. If you are performing several strain measurements, you can enable the shunt calibration then proceed with scanning all of the channels of interest. When you have completed your check, you can disable the shunt calibration and proceed with your measurement. Notice that when you are either enabling or disabling the shunt calibration resistor, you must wait 1 s if you have selected 4 Hz bandwidth or 10 ms if you have selected 4 kHz bandwidth before making your measurement to permit the system to settle. Finally, to determine the effect of the shunt resistor on your measurement, follow the procedure below.

Assuming a quarter-bridge strain-gauge configuration with a gauge factor of GF = 2, the equivalent strain change the R_{SCAL} shunting resistor introduces is -199 με. This is determined as follows:

1. Determine the change the shunting resistor causes using the following formula:

$$V_{change} = \frac{V_{ex} R (R_{SCAL} + R_g)}{R_{SCAL} + R(R_{SCAL} + R_g)} - \frac{V_{ex}}{2}$$

2. Using the appropriate strain-gauge strain formula, and assuming that you have no static voltage, determine the equivalent strain that the R_{SCAL} resistor should produce. For example, if your SCXI system is configured with R_{SCAL} = 301 kΩ, a quarter-bridge 120 Ω strain gauge with a gauge factor of GF = 2, V_{EX} = 3.333 V, and R = 120 Ω, the following result occurs:

   V_{change} = 0.3321 mV

   Replacing the strained voltage with V_{change} in the quarter-bridge strain equation produces an equivalent -199 με of change.

Also, the module has an internal completion network that you can use with half-bridge or quarter-bridge networks. To use this completion network, simply connect the VEX/2 terminal to the negative input channel of the appropriate transducer channel. In case of a quarter-bridge configuration, you must provide an additional resistor–equal in value to your nominal strain

gauge resistor–to complete the bridge network. Connect this resistor in your SCXI-1322 terminal block between the CH+ and VEX- terminals.

The current output channel is provided for transducers–such as thermistors and RTDs–which need a current excitation to operate properly. The current output has a value of 1 mA and has a maximum permissible load of 5 kΩ. If you connect loads greater than 5 kΩ, the current source will lose regulation. When connecting several loads which need current excitation, you have two possible approaches. The first is to connect them all in series (as long as they do not exceed 5 kΩ total) and use the two-wire scan mode as shown in Figure 4-2 or use the four-wire scan mode and have them connected as shown in Figure 4-3.

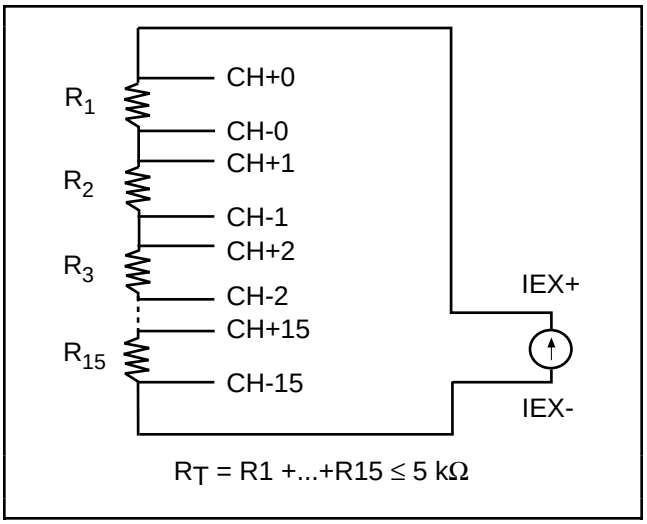


Figure 4-2. Series Connection with Current Excitation

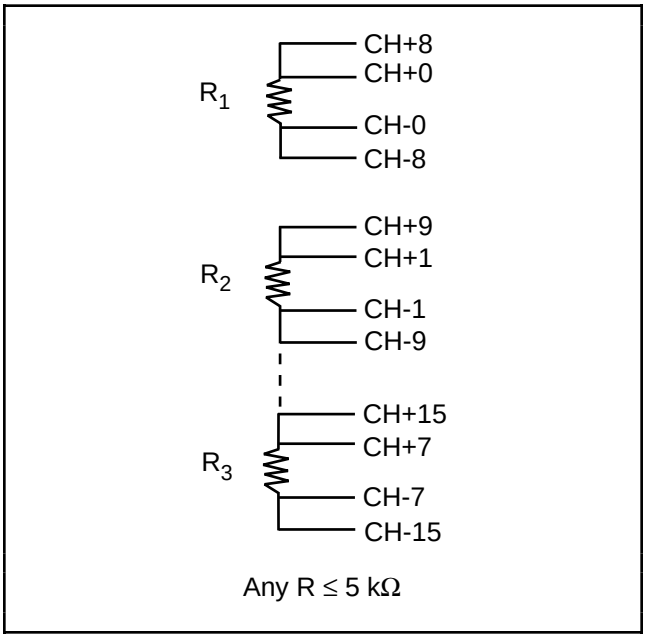


Figure 4-3. Four-Wire Scan Connection with Multiplexed Current Excitation

Note: ***Always connect the current excitation terminals outside the sense terminals as shown in both Figures 4-2 and 4-3.***

Each approach has its advantages and disadvantages as listed in Table 4-2.

Table 4-2. Pros and Cons of Two-Wire and Four-Wire Connections with Current Excited Transducers

Type	Pros	Cons
Series connection with two-wire scanning	16 transducers per module All transducers are continuously excited Two-wire connections are easier to connect because of fewer wires	Limited to 5 kΩ total resistance No isolation between channels
Independent connection with four-wire scanning	5 kΩ per channel 250 Vrms CMV between transducers	Eight transducers maximum per module More connections

Chapter 5
Calibration

This chapter discusses the calibration procedures for the SCXI-1122.

Overview

The onboard calibration hardware that calibrates the SCXI-1122, consists of an EEPROM to store the calibration constants and an auto-zero channel on the amplifier input selector. When the auto-zero channel is selected, the input relay multiplexer is disconnected from the amplifier inputs and the isolation amplifier inputs are connected to its ground reference.

Auto-zeroing is a method for nulling error sources that compromise the quality of measurements. Auto-zeroing determines the amount of offset at the output of the SCXI-1122 at a given gain of the amplifier. It is recommended to perform auto-zeroing at the start of an experiment for each gain to be used to eliminate error due to drift in the amplifier internal circuitry and increase the accuracy of the measurement. Notice that the auto-zero path is different from the analog input path; therefore, even after auto-zeroing, a residual input offset still exists and has a value of less than 6 µV. Refer to Appendix A, *Specifications*, for further details.

You can store this offset in the onboard EEPROM for future use and for automatic calibration when you are using National Instruments software. The EEPROM also stores correction factors for each gain of the SCXI-1122 as well as for the excitation channels. If you are not using National Instruments software, refer to the *SCXI-1122 Register-Level Programmer Manual* if you need a more a detailed description of the EEPROM.

When using National Instruments software such as NI-DAQ, LabVIEW, and LabWindows, and you are using the factory-determined calibration constants, you do not need to read the following section; continue reading the *Excitation Calibration* section. You need to read the following section only if you are using National Instruments software and you intend to determine new calibration constants.

Calibration Procedure

Calibration Equipment Requirements

According to standard practice, the equipment used to calibrate the SCXI-1122 should be 10 times as accurate as the SCXI-1122. Practically speaking, calibration equipment with four times the accuracy of the item under calibration is generally considered acceptable. To calibrate the SCXI-1122, you need the following equipment.

- For the amplifier gains, you need a voltmeter with the following specifications:
  - Accuracy ±0.002% standard
±0.08% sufficient
  - Range -10 to +10 V

  - Resolution 8 $^1/_2$ digits

- For the excitation channels, you need a voltmeter with the following specifications:

  - Accuracy ±0.004% standard
±0.16% sufficient

  - Range 0 to +5 V

  - Resolution 5 $^1/_2$ digits

- You need an ammeter with the following specifications:

  - Accuracy ±0.004% standard
±0.16% sufficient

  - Range 1 mA

  - Resolution 6 $^1/_2$ digits

A multiranging 8 $^1/_2$-digit digital multimeter can perform all of the necessary functions previously described. In the rest of this section, the measuring instrument is referred to as a digital multimeter (DMM).

To make sure that the DMM does not introduce an additional offset, you can determine the offset errors of the DMM by shorting its leads together and reading the measured value. This value, the DMM offset, must be subtracted from all subsequent measurements.

Gain and Offset Calibration

To determine the offset and gain calibration factors of the SCXI-1122 at a given gain, G_S, perform the following steps for a two-point calibration.

1. Set the SCXI-1122 to the desired gain.

2. Depending on how you want to calibrate your module, you can perform one of the following procedures.

   - Auto-zeroing selects one of the calibration points to be at 0 V input and you must provide the other calibration point at positive or negative full scale:

     a. Enable auto-zeroing.

     b. Measure the SCXI-1122 output with the DMM and store the measured value for future use.

     c. Disable auto-zeroing.

     d. Apply 9.9 V/G_S or -9.9 V/G_S to the amplifier input.

     e. Go to step 3.

- To select positive and negative full scale to be the two calibration points, apply -9.9 V/G_S and 9.9 V/G_S.

  a. Apply -9.9 V/G_S to the amplifier input.

  b. Measure the input voltage with the DMM and store the measured value.

  c. Measure the SCXI-1122 output with the DMM and store the measured value.

  d. Apply 9.9 V/G_S at the amplifier input.

  e. Go to step 3.

Note: ***If you are using a calibrator that supplies accurate voltages, you can skip step c directly above and step 3 below.***

3. Measure the input voltage with the DMM and the store the measured value.

4. Measure the SCXI-1122 output with the DMM and store the measured value.

5. You now have two pairs of voltages. Each pair consists of an input voltage and an output voltage. For the autozeroing option, the pairs are {0 V input, offset output} and {9.9 V/G_S input, 9.9 V output} or {-9.9 V/G_S input, -9.9 V output}. For the positive or negative full-scale calibration points option, the pairs are {-9.9 V/G_S input, -9.9 V output} and {9.9 V/G_S input, 9.9 V output}.

6. Convert the output voltage from volt units to your DAQ board binary unit. You must take into consideration the polarity of your DAQ board, its resolution (12 bits or 16 bits), and gain. For example, if you are using an AT-MIO-16F-5 in bipolar mode and are using a gain of $G_{MIO} = 0.5$, your output voltages for the autozeroing option will be represented in binary units as given by the following formula:

$$\text{Binary} = \text{Voltage} \bullet \frac{2^{12}}{10} \bullet G_{MIO}$$

   Refer to your DAQ board user manual to determine the appropriate formula for you to use.

7. You now have a new set of pairs referred to as voltage binary pairs {V input1, Binary output1} and {V input2, Binary output2}. Pass these pairs to the `SCXI_Cal_Constants` function or VI as described in your software user manual.

Notes: ***When you are using the autozeroing option with 0 V and 9.9 V/G_S, this sets your gain error to 0% at 0 V and at positive full-scale voltage. However, because of nonlinearity, the error at the negative full-scale voltage will be two times the nonlinearity error. This is also true for the positive full-scale voltage if you use the negative full-scale voltage and 0 V as your two calibration points.***

When you are making a measurement and using National Instruments software, the driver automatically performs the software correction.

Excitation Calibration

When using the excitation channels, you must retrieve the correction factors for the current and voltage from the EEPROM before using them in your transducer conversion formulas. Refer to your software user manual for how to use the `SCXI_Cal_Constants` function or VI to perform this task.

You do not need to read the following section if you are going to use the factory-determined correction factors and you are using National Instruments software.

If you want to determine a new set of voltage excitation calibration constants and you are using National Instruments software, use the following procedure:

1. Connect a 15 Ω resistor to the excitation channel.
2. Connect the DMM across the 15 Ω load and measure the voltage.
3. Pass this voltage to the `SCXI_Cal_Constants` function or VI.

To determine the current excitation calibration constants, follow this procedure:

1. Set your DMM to DC current measurements.
2. Connect the DMM across the IEX+ and IEX- terminals and measure the current.
3. Pass this current to the `SCXI_Cal_Constants` function or VI.

Note: ***When calibrating your system, you must verify that your offsets, gain errors, and excitation errors do not exceed the ranges listed in Table 5-1.***

Table 5-1. Maximum Allowable Error Ranges

Error Type	Error Range
All gains	±2%
Offset at G = 0.01	±40 mV
Offset at G = 0.02	±40 mV
Offset at G = 0.05	±50 mV
Offset at G = 0.1	±50 mV
Offset at G = 0.2	±50 mV
Offset at G = 0.5	±50 mV
Offset at G = 1	±40 mV
Offset at G = 2	±40 mV
Offset at G = 5	±50 mV
Offset at G = 10	±50 mV
Offset at G = 20	±50 mV
Offset at G = 50	±50 mV
Offset at G = 100	±60 mV
Offset at G = 200	±70 mV
Offset at G = 500	±100 mV
Offset at G = 1,000	±200 mV
Offset at G = 2,000	±400 mV
Current excitation	±3%
Voltage excitation	±1%

Appendix A
Specifications

This appendix lists the specifications for the SCXI-1122. These are typical at 25° C unless otherwise stated.

Analog Input

Input Characteristics

Number of channels: 16 differential, 8 4-wire, software selectable

Input signal ranges

Module Gain Max (Software Selectable)	Module Range[1] ±10 V
0.01	±250 VDC or Vrms
0.02	±250 V
0.05	±200 V
0.1	±100 V
0.2	±50 V
0.5	±20 V
1	±10 V
2	±5 V
5	±2 V
10	±1 V
20	±500 mV
50	±200 mV
100	±100 mV
200	±50 mV
500	±20 mV
1,000	±10 mV
2,000	±5 mV

Input coupling: DC

Max working voltage (signal + common mode): Each input should remain within 480 Vrms of ground, and within 250 Vrms of any other channel

Overvoltage protection: 250 Vrms powered on, 250 V powered off

Protected terminals: CH < 0..15 >, IEX+, IEX-, VEX+, VEX-

[1] Vrms refers to sinusoidal waveform; V refers to DC or AC peak.

Transfer Characteristics

Nonlinearity	0.01% FSR
Offset error	
Gain ≥ 1	±(6 µV + 1,240 µV/gain)
Gain < 1	±(352 µV + 1,240 µV/gain)
Gain error	
Gain ≥ 1	±0.02% of reading
Gain < 1	±0.10% of reading

Amplifier Characteristics

Input impedance	
Normal powered on	1 GΩ in parallel with 100 pF for gain ≥ 1, 1 MΩ in parallel with 100 pF for gain < 1
Powered off	100 kΩ
Overload	100 kΩ
Input bias current	±80 pA
CMRR	

Filter Bandwidth	CMRR 50 or 60 Hz
4 Hz	160 dB
4 kHz	100 dB

Output range	±10 V
Output impedance	75 Ω

Dynamic Characteristics

Bandwidth (-3 dB)	4 Hz (-10 dB) or 4 kHz, software selectable
Settling time to full-scale step (all gains)	
with 4 kHz filter enabled	10 ms
with 4 kHz filter enabled	1 s
System noise	

Gain	4 Hz Filter	4 kHz Filter
1	150 µVrms	1 mVrms
1,000	1,000 nVrms	4 µVrms

Slew rate	0.10 V/µs

Filters

Type	3-pole RC
Cutoff frequency (-3 dB)	4 Hz (-10 dB) or 4 kHz, software selectable
NMR (50 or 60 Hz)	60 dB at 4 Hz bandwidth

Stability

Recommended warm-up time	20 minutes
Offset temperature coefficient	±(0.2 + 150/gain) µV/°C
Gain temperature coefficient	±10 ppm/°C for gain ≥ 1, ± 25 ppm/°C for gain < 1

Excitation

Output Characteristics

Channels	2 (1 voltage and 1 current)
Bridge type	Quarter, half, or full
Bridge completion	Two 2.5 kΩ ±0.02% ratio tolerance resistors

Voltage Mode

Level	3.333 V ±0.04%
Current drive	225 mA
Drift	30 ppm/°C

Current Mode

Level	1.0 mA ±0.04%
Max load resistance	5 kΩ
Drift	40 ppm/°C

Physical

Dimensions	3.0 by 17.3 by 20.3 cm (1.2 by 6.8 by 8.0 in.)
I/O connectors	50-pin male ribbon cable rear connector 48-pin male DIN C front I/O connector

Environment

Operating temperature	0 to 50 °C
Storage temperature	-20 to 70 °C
Relative humidity	10% to 90%
Maximum altitude	<2000 meters

Safety

Electrical Measuring and Test Equipment	IEC/EN 61010-1, UL 3111-1, CAN/CSA C22.2, No. 1010.1
Installation Category	Category II
Pollution degree	2

Appendix B
Customer Communication

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve technical problems you might have as well as a form you can use to comment on the product documentation. Filling out a copy of the *Technical Support Form* before contacting National Instruments helps us help you better and faster.

National Instruments provides comprehensive technical assistance around the world. In the U.S. and Canada, applications engineers are available Monday through Friday from 8:00 a.m. to 6:00 p.m. (central time). In other countries, contact the nearest branch office. You may fax questions to us at any time.

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Denmark	45 76 26 00
Finland	90 725 725 11
France	1 48 14 24 24
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Greece	30 1 42 96 427
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Italy	02 413091
Japan	03 5472 2970
Korea	02 596 7456
Mexico (D.F.)	5 280 7625
Mexico (Monterrey)	8 357 7695
Netherlands	0348 433466
Norway	32 27 73 00
Singapore	2265886
Spain (Barcelona)	93 582 0251
Spain (Madrid)	91 640 0085
Sweden	08 587 895 00
Switzerland	056 200 51 51
Taiwan	02 2377 1200
U.K.	0635 523545

Technical Support Form

Photocopy this form and update it each time you make changes to your software or hardware, and use the completed copy of this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

If you are using any National Instruments hardware or software products related to this problem, include the configuration forms from their user manuals. Include additional pages if necessary.

Name _____

Company _____

Address _____

_____

Fax (___)_____ Phone (___)_____

Computer brand _____ Model _____ Processor _____

Operating system _____

Speed _____ MHz RAM _____ MB Display adapter _____

Mouse _____ yes _____ no Other adapters installed _____

Hard disk capacity _____ MB Brand _____

Instruments used _____

National Instruments hardware product model _____ Revision _____

Configuration _____

National Instruments software product _____ Version _____

Configuration _____

The problem is _____

_____

_____

_____

_____

List any error messages _____

_____

_____

_____

_____

The following steps will reproduce the problem _____

_____

_____

SCXI-1122 Hardware Configuration Form

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

- SCXI-1122 Revision Letter _____
- Chassis Slot _____
- Grounding, Shielding, and Reference Mode Selection (Factory Setting: Parking position, W1, A-R0R1) _____
- SERDATOUT Resistor Pull-up Jumper (Factory Setting: Enabled, W2, position 1) _____
- Other Modules in System _____
  _____
- DAQ Boards Installed _____
  _____

Register-Level Programmer Manual Request Form

National Instruments encourages you to comment on the documentation supplied with our products. This information helps us provide quality products to meet your needs.

Title: **SCXI-1122 Register-Level Programmer Manual**

Part Number: **340696-01**

Please indicate your reasons for obtaining the register-level programmer manual. Check all that apply.

☐ National Instruments does not support your operating system or programming language.

☐ You are an experienced register-level programmer who is more comfortable writing your own register-level software.

☐ Other. Please explain.

Thank you for your help.

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Documentation Comment Form

National Instruments encourages you to comment on the documentation supplied with our products. This information helps us provide quality products to meet your needs.

Title: **SCXI-1122 User Manual**

Edition Date: **September 1999**

Part Number: **320516B-01**

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

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

Thank you for your help.

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Glossary

Prefix	Meaning	Value
p-	pico-	10^{-12}
n-	nano-	10^{-9}
µ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}

Numbers/Symbols

°	degrees
ε	strain
>	greater than
≥	greater than or equal to
<	less than
-	negative of, or minus
Ω	ohms
%	percent
±	plus or minus
+	positive of, or plus
+5 V (signal)	+5 VDC Isolated Source signal

A

A	amperes
AC	alternating current
A/D	analog-to-digital
ADIO#	Port A Digital Input/Output signal ($0 \leq \# \leq 5$)
ANSI	American National Standards Institute
AOGND	Analog Output Ground signal
Arms	amperes, root mean square
AWG	American Wire Gauge

B

BDIO	Port B Digital Input/Output signal

C

C	Celsius
C_c	AC coupling capacitor

CH#+	Positive Input Channel Number signal
CH#-	Negative Input Channel Number signal
CJC	cold-junction compensation
CJR	cold-junction reference
CJS	cold junction sensor
CMRR	common-mode rejection ratio
CMV	common-mode voltage

D

D/A	digital-to-analog
DAQD*/A	Data Acquisition Board Data/Address Line signal
dB	decibels
DC	direct current
DIGGND	Digital Ground signal
DIN	Deutsche Industrie Norme
DOUT#	Data Out Number signal

E

EEPROM	electrically erased programmable read-only memory

F

F	Farads
FSR	full-scale range

G

GF	gauge factor
G_{MIO}	MIO gain
G_s	SCXI gain
G_{total}	total gain

H

Hz	hertz

I

I_{bias}	bias current
IEX	current excitation channel
IEX-	Negative Current Excitation Output signal
IEX+	Positive Current Excitation Output signal
I_I	input current leakage
in.	inches

INTR*	Interrupt signal
I/O	input/output

M

m	meters
MB	megabytes of memory
MCH#+	Positive Analog Output Channel Number signal
MCH#-	Negative Analog Output Channel Number signal
min	minutes
MIO	multifunction I/O
MISO	Master-In-Slave-Out signal
MOSI	Master-Out-Slave-In signal

N

NMR	normal mode rejection
NRSE	nonreferenced single-ended (input)

O

OUTREF	Output Reference signal

P

ppm	parts per million

R

R	resistor
RAM	random-access memory
R_b	bias resistor
R_{bias}	bias resistor
RC	resistor-capacitor filter
R_g	strain gauge nominal resistance
R_{SCAL}	shunt resistor
RSE	referenced single-ended (input)
RSVD	Reserved bit/signal
RTD	resistance temperature detector
RTSI	Real-Time System Integration

S

SCANCLK	Scan Clock signal
SCXI	Signal Conditioning eXtensions for Instrumentation (bus)
SDK	Software Developer's Kit

s	seconds
SENSE-	Negative Voltage Sense signal
SENSE+	Positive Voltage Sense signal
SERCLK	Serial Clock signal
SERDATIN	Serial Data In signal
SERDATOUT	Serial Data Out signal
SLOT0SEL*	Slot 0 Select signal
SNR	signal-to-noise ratio
SPICLK	Serial Peripheral Interface Clock signal

T

TEMP-	Temperature Sensor Reference signal
TEMP+	Temperature Sensor Output signal

V

V	volts
V_{cm}	common-mode voltage
VDC	volts direct current
VEX	Voltage Excitation Channel signal
VEX-	Negative Voltage Excitation Output signal
VEX+	Positive Voltage Excitation Output signal
VEX/2	Half Voltage Excitation Output signal
VI	Virtual Instrument
V_{IH}	input logic high voltage
V_{IL}	input logic low voltage
$V_{ofsbias}$	offset bias voltage
V_{OH}	output logic high voltage
V_{OL}	output logic low voltage
Vrms	volts, root mean square

W

W	watts

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