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DAQ

VXI-SC-1102 User Manual

32-Channel Multiplexer Amplifier Module

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About This Manual

This manual describes the electrical and mechanical aspects of the VXI-SC-1102 and contains information concerning its installation and operation. The VXI-SC-1102 is a signal conditioning submodule in the VXI-data acquisition (VXI-DAQ) line of National Instruments products. The VXI-SC-1102 is designed for signal conditioning of thermocouples, volt and millivolt sources, and 4 to 20 mA sources or 0 to 20 mA process-current sources. The VXI-SC-1102 has 32 differential analog input channels and one cold-junction sensor channel.

Organization of This Manual

The *VXI-SC-1102 User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the VXI-SC-1102, lists what you need to get started, optional software and optional equipment, and explains how to unpack the VXI-SC-1102.
- Chapter 2, *Installation*, describes how to install current-loop receivers on your VXI-SC-1102 and gives information about installing your VXI-SC-1102 submodule into the VXI-SC-1000 carrier module.
- Chapter 3, *Signal Connections*, describes the input signal connections to the VXI-SC-1102 submodule via the front connector.
- Chapter 4, *Theory of Operation*, contains a functional overview of the VXI-SC-1102 and explains the operation of each functional unit.
- Chapter 5, *Calibration*, discusses the calibration procedures for the VXI-SC-1102.
- Appendix A, *Specifications*, lists the specifications for the VXI-SC-1102.
- 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 general data acquisition 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.

< >	Angle brackets containing numbers separated by an ellipsis represent a range of values associated with a port, bit, or signal name (for example, ACH<0..7> stands for the signals ACH0 through ACH7).
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.
`monospace`	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.
PC	Refers to the IBM PC/XT, the IBM PC AT, and compatible computers.
VXI-MIO module	Refers to any of the National Instruments VXI-MIO Series of plug-in data acquisition boards.
carrier module	Refers to the VXI-SC-1000, which plugs directly into a VXI slot and on which VXI-SC submodules are installed.
VXI-SC submodule	Refers to VXI signal conditioning hardware that installs onto the carrier module.

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

National Instruments Documentation

The *VXI-SC-1102 User Manual* is one piece of the documentation set for your VXI-DAQ system. You could have any of several types of documents, depending on the hardware and software in your system. Use the different types of documents you have as follows:

- Your VXI-DAQ hardware user manuals—These manuals have detailed information about the VXI-DAQ hardware that plugs into or is connected to your VXIbus chassis. Use these manuals for hardware installation and configuration instructions, specification information about your VXI-DAQ hardware, and application hints.
- Software documentation—You may have both application software and driver software documentation. National Instruments application software includes ComponentWorks, LabVIEW, LabWindows®/CVI, Measure, and VirtualBench. National Instruments driver software includes NI-DAQ and VXI*plug&play* instrument drivers. After you set up your hardware system, use either your application or driver software documentation to help you write your application. If you have a large, complicated system, it is worthwhile to look through the software documentation before you configure your hardware.
- Accessory installation guides or manuals—If you are using accessory products, read the terminal block and cable assembly installation guides or accessory board user manuals. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making your connections.

Customer Communication

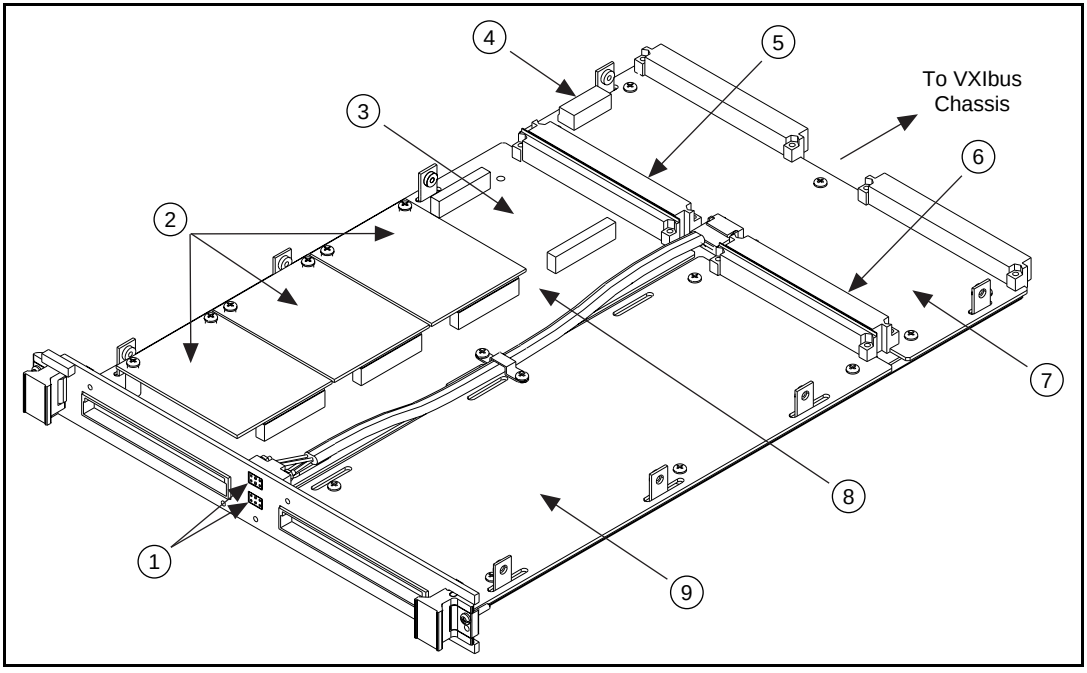
National Instruments wants to receive your comments on our products and manuals. We are interested in the applications you develop with our products, and we want to help if you have problems with them. To make it easy for you to contact us, this manual contains comment and configuration forms for you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

Chapter 1

Introduction

This chapter describes the VXI-SC-1102, lists what you need to get started, optional software and optional equipment, and explains how to unpack the VXI-SC-1102.

The VXI-SC-1102 is part of the VXI signal conditioning system, which consists of a carrier module and one or more VXI signal conditioning submodules or filler panels as shown in Figure 1-1.



1	Analog Bus Receptacle	4	Address Switch	7	VXI-SC Carrier Module
2	SCMPs	5	VXI-SC Subslot 1	8	VXI-SC-1150 Submodule
3	SCMP Socket	6	VXI-SC Subslot 2	9	VXI-SC Submodule

Figure 1-1. VXI Signal Conditioning System

The VXI-SC-1000 is a carrier module that installs into a slot in a VXIbus chassis and is populated with one or two submodules. The VXI-SC-1102 is a submodule that installs into VXI-SC subslots on a VXI-SC-1000 carrier module.

Your VXI-SC-1000 carrier module is shipped with a filler panel installed in one of the submodule sites. This filler panel is necessary for the attachment of the front panel, so you should leave it in place until you are ready to install a VXI-SC submodule.

About the VXI-SC-1102

The VXI-SC-1102 is a submodule for the signal conditioning of thermocouples, low-bandwidth volt and millivolt sources, 4 to 20 mA current sources, and 0 to 20 mA process-current sources. The VXI-SC-1102 has 32 differential analog input channels and one cold-junction sensor channel. On each channel, the VXI-SC-1102 has a three-pole lowpass filter with a 2 Hz cutoff frequency to reject 60 Hz noise. Each channel also has an amplifier with a selectable gain of 1 or 100. You can multiplex the VXI-SC-1102 inputs to a single output, which drives a single VXI-MIO board channel.

The VXI-SC-1102 operates with full functionality with National Instruments VXI-MIO modules. You can multiplex several VXI-SC-1102 submodules and other VXI signal conditioning submodules into a single channel on the VXI-MIO module, greatly increasing the number of analog input signals that you can digitize.

You can also use National Instruments terminal blocks, which have screw terminals to which you attach the input signals for the VXI-SC-1102. In addition, some of these terminal blocks have a temperature sensor for thermocouple cold-junction compensation (CJC). The VXI-SC-1102 multiplexes this cold-junction sensor with the 32 input channels during a hardware scan. A National Instruments isothermal terminal block is recommended for thermocouple applications.

Detailed specifications of the VXI-SC-1102 are listed in Appendix A, *Specifications*.

What You Need to Get Started

To set up and use your VXI-SC-1102, you will need the following items:

- ❑ VXI-SC-1102 submodule
- ❑ *VXI-SC-1102 User Manual*
- ❑ VXI-SC-1000 carrier module and documentation
- ❑ VXI-MIO module and documentation
- ❑ One of the following software packages and documentation:
  - ComponentWorks
  - LabVIEW for Windows
  - LabWindows/CVI for Windows
  - NI-DAQ for PC compatibles
  - VirtualBench
  - VXI*plug&play* instrument driver
- ❑ Your VXIbus system

Software Programming Choices

There are several options to choose from when programming your National Instruments VXI-DAQ hardware. You can use LabVIEW, LabWindows/CVI, ComponentWorks, VirtualBench, or other application development environments with either NI-DAQ or the VXI*plug&play* instrument driver. Both NI-DAQ and the VXI*plug&play* instrument driver access the VXI-DAQ hardware through the VISA driver software.

National Instruments Application Software

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 DAQ hardware, is included with LabVIEW. The LabVIEW Data Acquisition VI Library is functionally equivalent to the NI-DAQ software.

LabWindows/CVI features interactive graphics, a state-of-the-art user interface, and uses the ANSI standard C programming language. The LabWindows/CVI Data Acquisition Library, a series of functions for using LabWindows/CVI with National Instruments DAQ hardware, is included with the NI-DAQ software kit. The LabWindows/CVI Data Acquisition Library is functionally equivalent to the NI-DAQ software.

ComponentWorks contains tools for data acquisition and instrument control built on NI-DAQ driver software. ComponentWorks provides a higher-level programming interface for building virtual instruments through standard OLE controls and DLLs. With ComponentWorks, you can use all of the configuration tools, resource management utilities, and interactive control utilities included with NI-DAQ.

VirtualBench features VIs that combine DAQ products, software, and your computer to create a standalone instrument with the added benefit of the processing, display, and storage capabilities of your computer. VirtualBench instruments load and save waveform data to disk in the same forms that can be used in popular spreadsheet programs and word processors.

Using LabVIEW, LabWindows/CVI, ComponentWorks, or VirtualBench software will greatly reduce the development time for your data acquisition and control application.

NI-DAQ Driver Software

The NI-DAQ driver software is included at no charge with all National Instruments DAQ hardware. NI-DAQ is not packaged with accessory products. 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 has both high-level DAQ I/O functions for maximum ease of use and low-level DAQ I/O functions for maximum flexibility and performance. Examples of high-level functions are streaming data to disk or acquiring a certain number of data points. An example of a low-level function is writing directly to registers on the DAQ device. NI-DAQ does not sacrifice the performance of National Instruments

DAQ devices because it lets multiple devices operate at their peak performance.

NI-DAQ maintains a consistent software interface among its different versions so that you can change platforms with minimal modifications to your code.

VXI*plug&play* Instrument Driver

National Instruments distributes VXI*plug&play* instrument drivers free of charge. VXI*plug&play* instrument drivers are one level above the NI-DAQ device driver and contain high-level software functions whose architecture is specified by the VXI*plug&play* Systems Alliance. The VXI*plug&play* standards increase interoperability with other vendors, and ensure that drivers are designed and presented in a consistent fashion that facilitates ease of use. Refer to Figure 1-2 to see the relationship between your software components.

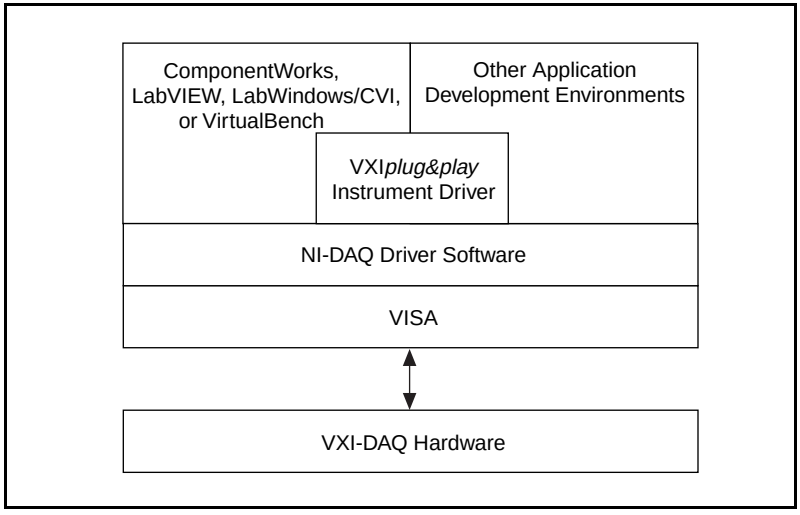


Figure 1-2. The Relationship between the Programming Environment, Your Instrument Driver, and Your VXI-DAQ Hardware

Optional Equipment

National Instruments offers a variety of products to use with your VXI-SC-1102 module, as follows:

- Terminal blocks and 96-pin cables that allow you to attach input signals to your submodule
- SCXI Process Current Resistor Kit

For more specific information about these products, refer to your National Instruments catalogue or call the office nearest you.

Unpacking

Your VXI-SC-1102 submodule is shipped in an antistatic package to prevent electrostatic damage to the submodule. Electrostatic discharge can damage several components on the submodule. To avoid such damage in handling the submodule, take the following precautions.

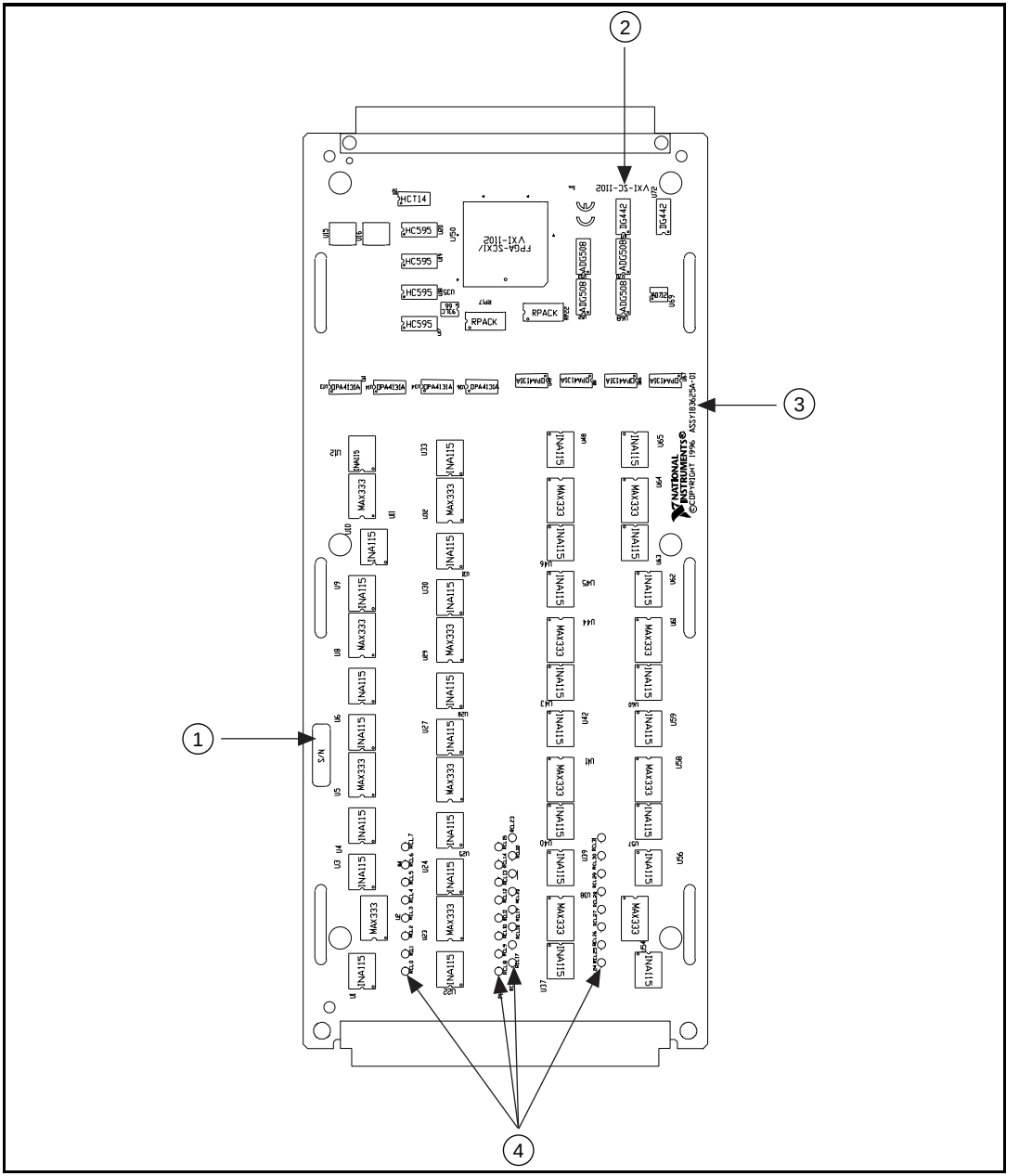
- Ground yourself via a grounding strap or by holding a grounded object.
- Touch the antistatic package to a metal part of your VXIbus chassis before removing the submodule from the package.
- Remove the submodule from the package and inspect the submodule for loose components or any other sign of damage.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

Chapter 2

Installation

This chapter describes how to install current-loop receivers on your VXI-SC-1102 and gives information about installing your VXI-SC-1102 submodule into the VXI-SC-1000 carrier module.

Refer to Figure 2-1, *VXI-SC-1102 Parts Locator Diagram*, for information as you read the instructions in this chapter.



1	Serial Number	2	Product Name	3	Assembly Number	4	RCL*x* Pads

Figure 2-1. VXI-SC-1102 Parts Locator Diagram

Current-Loop Receivers

The VXI-SC-1102 has pads for transforming individual channels to current-to-voltage converters. National Instruments offers an SCXI Process Current Resistor Kit of four 249 Ω, 0.1%, 5 ppm, 1/4 W resistors. The reference designators for the current loop resistors have the following format: for input channel *x*, the resistor is RCL*x*. For example, the resistor for channel 28 is RCL28.

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

Install the resistors by performing the following steps:

1. Follow the instructions in the *VXI-SC-1000 Carrier Module Installation Guide* to remove the VXI-SC-1102 submodule from the carrier assembly.
2. Bend and trim the resistor lead as shown in Figure 2-2. Be sure that the resistor does not extend more than 0.65 in. above the surface of the circuit board.

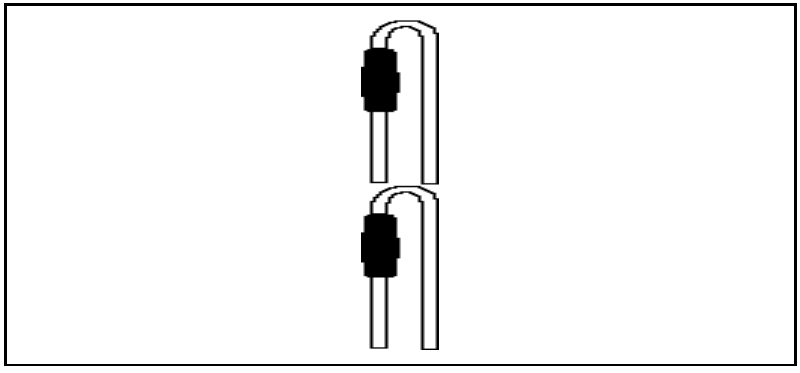


Figure 2-2. Bent and Trimmed Resistor

3. Insert the resistor into the appropriate pad, labeled RCL*x*.
4. Solder the leads to the pad on the bottom side of the module.
5. Follow the instructions in the *VXI-SC-1000 Carrier Module Installation Guide* to replace the VXI-SC-1102 submodule in the carrier assembly.

Installing Your Hardware

Follow the instructions in the *VXI-SC-1000 Carrier Module Installation Guide* to replace the VXI-SC-1102 submodule and to install the assembled VXI-SC carrier module in the VXIbus chassis.

Chapter 3

Signal Connections

This chapter describes the analog input signal connections to the VXI-SC-1102 submodule via the front connector.

⚠ **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 chassis or whenever working on a module.***

Front Connector

Figure 3-1 shows the pin assignments for the VXI-SC-1102 front connector.

	A		B		C
CGND	32	CH0-	32	CH0+	32
NC	31	CH1-	31	CH1+	31
NC	30	CH2-	30	CH2+	30
NC	29	CH3-	29	CH3+	29
NC	28	CH4-	28	CH4+	28
NC	27	CH5-	27	CH5+	27
NC	26	CH6-	26	CH6+	26
NC	25	CH7-	25	CH7+	25
CGND	24	CH8-	24	CH8+	24
NC	23	CH9-	23	CH9+	23
NC	22	CH10-	22	CH10+	22
NC	21	CH11-	21	CH11+	21
NC	20	CH12-	20	CH12+	20
NC	19	CH13-	19	CH13+	19
NC	18	CH14-	18	CH14+	18
NC	17	CH15-	17	CH15+	17
CGND	16	CH16-	16	CH16+	16
NC	15	CH17-	15	CH17+	15
NC	14	CH18-	14	CH18+	14
NC	13	CH19-	13	CH19+	13
NC	12	CH20-	12	CH20+	12
NC	11	CH21-	11	CH21+	11
NC	10	CH22-	10	CH22+	10
NC	9	CH23-	9	CH23+	9
NC	8	CH24-	8	CH24+	8
NC	7	CH25-	7	CH25+	7
NC	6	CH26-	6	CH26+	6
CGND	5	CH27-	5	CH27+	5
CJSENSOR	4	CH28-	4	CH28+	4
CJSENSOR	3	CH29-	3	CH29+	3
CGND	2	CH30-	2	CH30+	2
+5 V	1	CH31-	1	CH31+	1

Figure 3-1. VXI-SC-1102 Front Connector Pin Assignments

Signal Descriptions

Table 3-1. Front Connector Signal Descriptions

Pin	Signal Name	Description
A1	+5 V	+5 VDC Source—Powers the temperature sensor on the terminal block. 0.2 mA of source not protected.
A2, A5, A16, A24, A32	CGND	Chassis Ground—Tied to the VXIbus chassis.
A3, A4	CJSENSOR	Cold-Junction Temperature Sensor Input—Connects to the temperature sensor of the terminal block.
B1–B32	CH31- through CH0-	Negative Input Channels 31–0—Negative side of differential input channels.
C1–C32	CH31+ through CH0+	Positive Input Channels 31–0—Positive side of differential input channels.
All other pins are not connected.		

Channel Input Signal Connections

The signal terminals for the positive input channels are located in column C of the connector. The signal terminal for each corresponding negative input channel is located in column B of the connector. Each input goes to a separate filter and amplifier that is multiplexed to the module output buffer. The terminal block temperature sensor output—connected to pins A3 and A4 (CJSENSOR)—is also filtered and multiplexed to the module output buffer.

The differential input signal range of a VXI-SC-1102 input channel is ±10 V/G, where G is the gain selected on the VXI-SC-1102 input channel. This differential input range is the maximum measurable voltage difference between the positive and negative channel inputs. The common-mode input signal range of a VXI-SC-1102 input channel

is ±11 V. This common-mode input range for either positive or negative channel input is the maximum input voltage (relative to CGND) that will result in a valid measurement. Each channel includes input protection circuitry to withstand the accidental application of voltages up to ±42 VAC peak or VDC.

Warning: ***Exceeding the input damage level (±42 VAC peak or VDC between input channels and chassis ground) can damage the VXI-SC-1102, the VXIbus, and the VXI-MIO module. National Instruments is NOT liable for any injuries resulting from such signal connections.***

Applying a voltage greater than ±42 VAC peak or VDC to the VXI-SC-1102 is an electrical shock hazard. National Instruments is NOT liable for any damages or injuries resulting from such voltage application.

Note: ***Exceeding the differential or common-mode input channel ranges results in a distorted signal measurement.***

Ground-Referencing Your Signals

Your input signals can be either ground-referenced, as shown in Figure 3-2, or floating, as shown in Figure 3-3. Before you connect your thermocouple or any other signal, determine whether it is floating or ground-referenced. If it is a floating signal, you must ground-reference the signal in one of two ways. You can connect the negative channel input to chassis ground as shown in Figure 3-3 or you can use the clamping resistors on a VXI-TB Series terminal block. The VXI-TB Series terminal block may also have a resistor pack for pulling up the positive inputs for open-thermocouple detection. Consult the terminal block installation guide for details.

Do not ground signals which are already ground-referenced; doing so will result in a ground loop, which adversely affects your measurement accuracy.

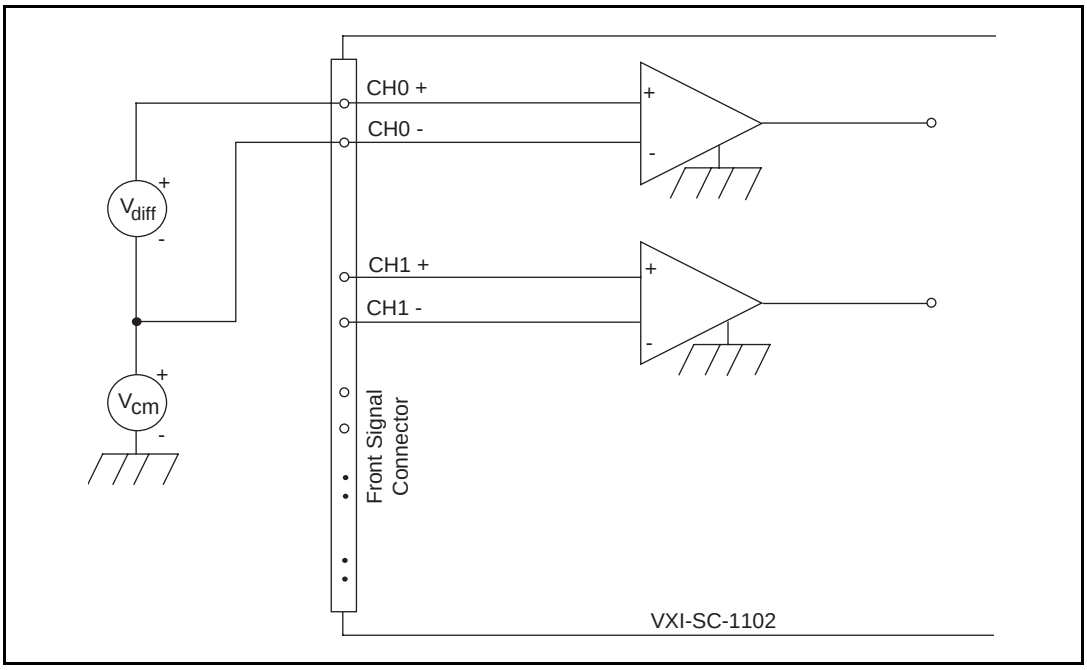


Figure 3-2. Ground-Referenced Signal Connection

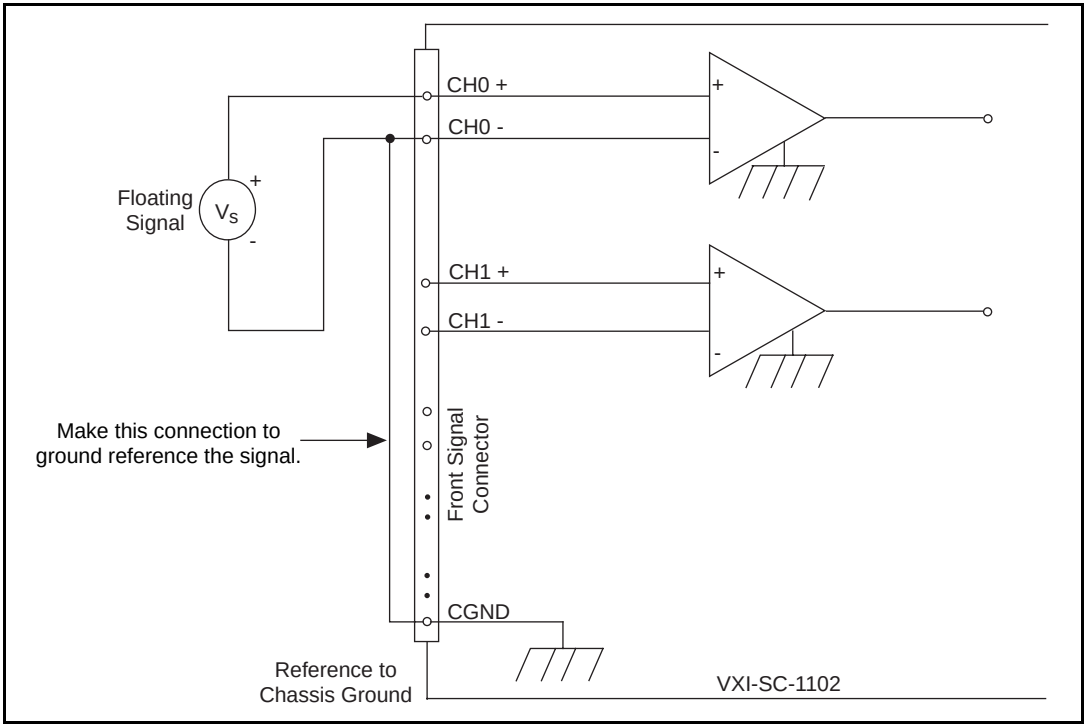


Figure 3-3. Floating Signal Connection Referenced to Chassis Ground

Cold-Junction Sensor Connection

Pins A3 and A4 (CJSENSOR) connect the temperature sensor located on the National Instruments VXI-TB Series terminal block to the VXI-SC-1102. The CJSENSOR signal is measured relative to CGND. Pins A3 and A4 are connected within the VXI-SC-1102 so the position of the MTEMP/DTEMP switch on the VXI-TB Series terminal block *does not matter*. The input is overvoltage-protected to 15 VDC with the power on and off.

Warning: ***Exceeding the overvoltage protection on the CJSENSOR input can damage the VXI-SC-1102, the VXIbus, and the VXI-MIO board. National Instruments is NOT liable for any damages or injuries resulting from such signal connections.***

Chapter 4

Theory of Operation

This chapter contains a functional overview of the VXI-SC-1102 and explains the operation of each functional unit.

Functional Overview

The block diagram in Figure 4-1 illustrates the key functional components of the VXI-SC-1102.

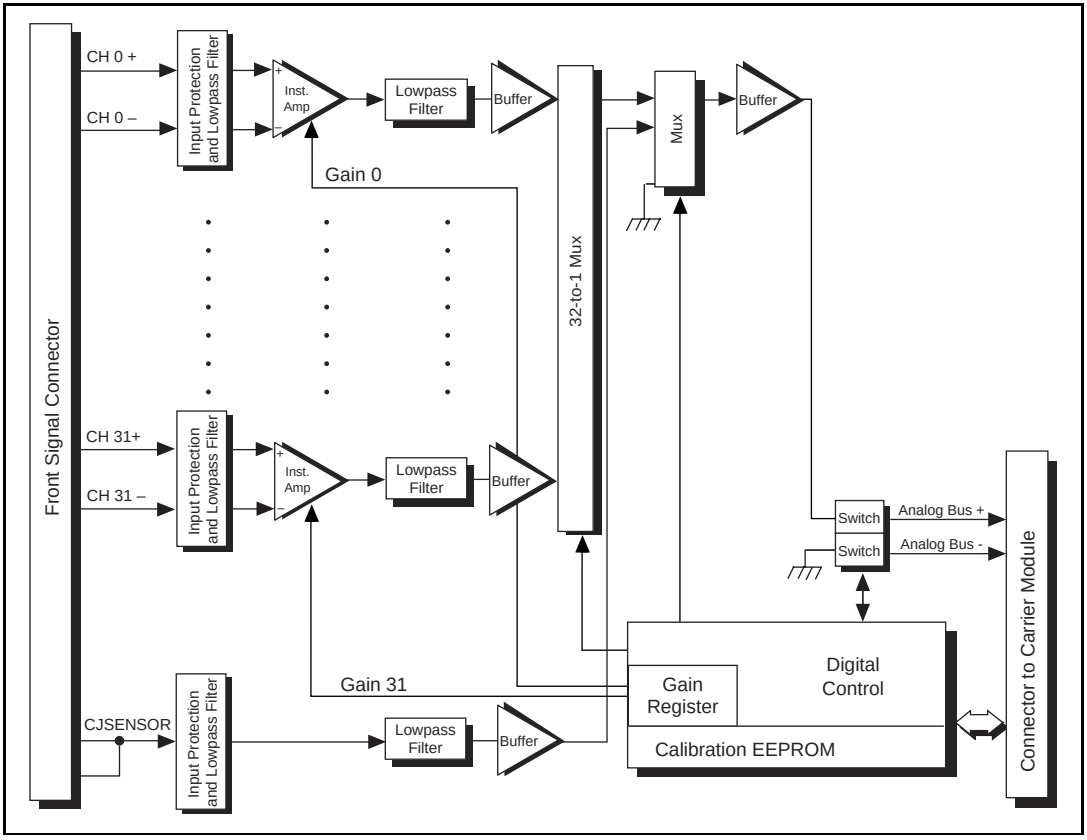


Figure 4-1. VXI-SC-1102 Block Diagram

The major components of the VXI-SC-1102 are as follows:

- VXIbus interface
- Digital control circuitry
- Analog circuitry

The VXI-SC-1102 consists of 32 multiplexed input channels, each with a software-programmable gain of 1 or 100. Each input channel has its own lowpass filter with a cutoff frequency of 2 Hz. The VXI-SC-1102 also has digital control circuitry for automatic control of channel scanning, temperature sensor selection, and gain selection.

VXIbus Interface

The VXI-DAQ module controls the VXI-SC-1102 over the VXIbus. The VXI-SC-1000 carrier module serves as an interface from the VXI-SC-1102 to the VXIbus.

Digital Control Circuitry

The digital control circuitry consists of the address handler and the following registers: Module ID, Configuration, Status, EEPROM, Gain, and Channel. The address handler controls which register is being addressed. The Module ID Register contains the module ID 42 decimal, a code unique to the VXI-SC-1102. The Configuration Register configures the VXI-SC-1102 for the desired scanning mode and connection to the rear signal connector. The Status Register indicates whether the input channels have settled after a change in the gains. The EEPROM Register is the address for interfacing with the submodule's EEPROM, which contains calibration information. The Gain Register selects between gains of 1 or 100 for each of the 32 channels. The Channel Register selects a channel for a single measurement or a start channel for a scan. Refer to *Software Programming Choices* in Chapter 1, *Introduction*, of this manual to learn about options for programming the control circuitry.

Analog Circuitry

The analog circuitry per channel consists of a lowpass filter and an amplifier with a software-selectable gain of 1 or 100. The CJSENSOR channel also has a buffered lowpass filter but has no amplifier. The channels and CJSENSOR are multiplexed to a single output buffer.

Analog Input Channels

Each of the 32 analog input channels drives a separate amplifier with a programmable gain of 1 or 100. Then the signal passes through a three-pole lowpass filter with a cutoff frequency of 2 Hz.

☞ **Note:** ***Because of the 2 Hz bandwidth of the input channels, you must wait approximately 3 s after changing the gains before the channels settle and you can take an accurate measurement. NI-DAQ automatically reads the Status Register to determine when the module output has settled.***

The temperature sensor consists of a thermistor located on a National Instruments VXI terminal block. The temperature sensor is for cold-junction compensation of thermocouples. The CJSENSOR channel also passes through a 2 Hz lowpass filter to reject unwanted noise. Along with the other 32 input channels, the CJSENSOR is multiplexed to the output buffer, where it can be read by the VXI-MIO module.

For a measurement accuracy of 0.012% of full scale, the minimum scan interval is 3 µs. This is the smallest interval in which you can switch between analog channels on the submodule and still measure accurate voltages. The 3 µs scan interval gives you a maximum sampling rate of 333 kHz. Because each VXI-SC-1102 channel contains a 2 Hz lowpass filter, the 333 kHz sample rate allows you to sample multiple channels without undersampling any channel.

Analog Output

The 32 input channels and the CJSENSOR are multiplexed into one output. This output is passed to the VXI-SC-1000 carrier module, where it is connected to the Analog Bus for measurement by a VXI-MIO module.

Chapter 5

Calibration

This chapter discusses the calibration procedures for the VXI-SC-1102.

Using the procedure described in this chapter, you will be able to calculate the gain error and voltage offset on a per channel per gain basis. You can store these constants in the onboard EEPROM for future use and for automatic calibration when you are using National Instruments software. The VXI-SC-1102 comes from the factory with factory-determined calibration constants in the EEPROM. However, National Instruments recommends that you recalibrate your VXI-SC-1102 at least once per year or when you operate the submodule outside the 20° to 30° C temperature range. If you are not using National Instruments software to store the calibration data in the EEPROM, refer to the *VXI-SC-1102 Register-Level Programmer Manual* for a more detailed description of the EEPROM.

In order to calibrate the VXI-SC-1102, you will need to apply precision voltages to the channel inputs and/or ground the channel inputs.

Calibration Equipment Requirements

According to standard practice, the equipment you use to calibrate the VXI-SC-1102 should be 10 times as accurate as the VXI-SC-1102. Calibration equipment with four times the accuracy of the VXI-SC-1102 is generally considered acceptable. To calibrate the VXI-SC-1102, you need a voltmeter with the following specifications:

- Accuracy ±6 ppm standard reading
±15 ppm sufficient reading
- Range ±10 V
- Resolution 8.5 digits

A multiranging 8.5-digit digital multimeter (DMM) can perform the necessary calibrations.

To make sure that the DMM does not introduce an additional offset, you can determine the offset error 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.

Measure the submodule's output at the analog bus receptacle (see Figure 1-1 for the location of this receptacle). Refer to Figure 5-1 to connect the positive DMM input to MUX+ and the negative DMM input to MUX-.

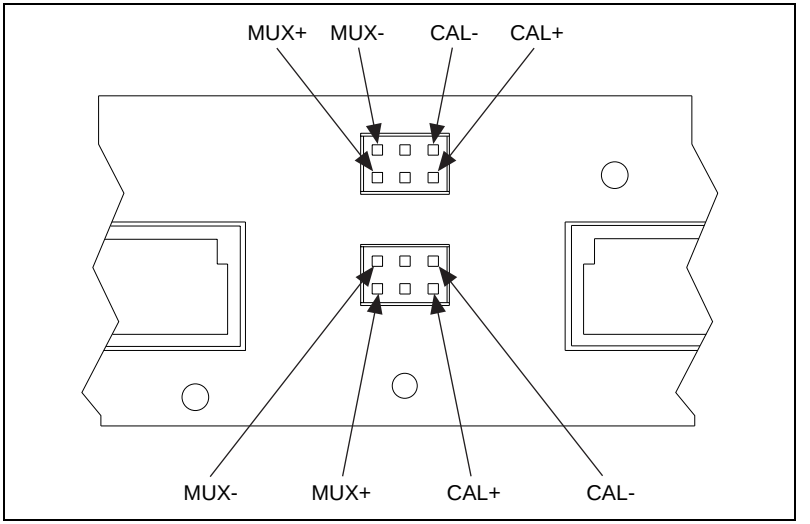


Figure 5-1. Analog Bus Receptacle Pin Assignment

Gain and Offset Calibration

To determine the offset and gain calibration factors of the VXI-SC-1102 for a given gain, perform the following steps for a two-point calibration. For two-point calibration, it is best to use input voltages that correspond to the signal range of interest. For example, to measure bipolar voltages over the submodule's full input range, choose -9.9 V/G (negative full-scale) and +9.9 V/G (positive full-scale) as your two input voltages.

1. Select the desired channel. Set the channel gain to the desired gain.
2. Apply the input for the first calibration point. To select negative full scale as the calibration point, apply -9.9 V/G for an input voltage.
   a. Apply the input voltage to the channel selected in Step 1.

☞ **Note:** ***To make one of your calibration points the zero point, connect the positive and negative channel leads to one of the chassis ground pins on the front connector or terminal block.***

b. Measure the input voltage with the DMM. Call the measured voltage `input1`.

☞ **Note:** ***If you are using a calibrator that supplies accurate voltages, you can simply use the known applied voltage for*** `input1` ***instead of measuring.***

c. Measure the module output at the analog bus receptacle with the DMM. Call the measured voltage `output1.`

3. Repeat Step 2, applying the input for the second calibration point. Call the measured voltages `input2` and `output2`. To select positive full scale as the calibration point, repeat Step 2 and apply +9.9 V/G.
4. You now have two pairs of voltages (`input1`, `output1`) and (`input2`, `output2`). Each pair consists of an input voltage and an output voltage.
5. Convert the output voltages from volt units to your VXI-MIO module binary unit. You must take into consideration the polarity of your VXI-MIO module, its resolution (12 bits or 16 bits), and gain. For example, if you are using the 12-bit VXI-MIO-64E-1 in bipolar mode with the gain set to G_{MIO}, your output voltages for the autozeroing option will be represented in binary units as given by the following formula:

$$Binary = \frac{Output}{5\ \mathrm{V}} \bullet 2^{12} \bullet G_{MIO}$$

For other VXI-MIO modules, refer to the user manual to determine the appropriate formula.

6. You now have a new set of pairs referred to as voltage binary pairs (`input1`, `bin_output1`) and (`input2`, `bin_output2`). Pass these pairs to the `SCXI_Cal_Constants` function or VI as described in your software user documentation.

☞ **Note:** ***When you use 0 V and positive full-scale for your two calibration points, you eliminate the error 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 make a measurement using LabVIEW, ComponentWorks, or VirtualBench, the driver automatically uses the calibration constants to correct the measured voltages.

When you use application development environments other than LabVIEW, ComponentWorks, or VirtualBench, you have the option to apply the calibration constants to measured voltages through the NI-DAQ API.

Sample Program for Calibration

The following sample C program will help you calibrate the VXI-SC-1102. The calibration constants are stored only in NI-DAQ memory. The (input, output) voltage pairs read by a DMM must be entered by hand. Before this program is run, the NI-DAQ Configuration Utility must be run to configure the VXI-SC chassis and to configure the DAQ board which will be used to communicate with the VXI-SC-1102.

The program is written to work for a DAQ board, such as the VXI-MIO-64E-1, with a 5 V full-scale input.

```
#include <stdio.h>
#include <math.h>
#include <dataacq.h>

#define MIO_FULL_SCALE     5.0                /* valid for VXI-MIO-64E-1 */
#define N_VXI_SC_SLOTS     24
#define NIDAQMEM           0
#define ALL                -1

int
enterInt (char *prompt)
{
     short
          ret;
     int
          value;
```

```
      do
      {
            fputs(prompt, stdout);
            fflush(stdin);
            ret = scanf("%d", &value);
      } while (!ret);
      return (value);
}

double
enterFloat (char *prompt)
{
      short
            ret;
      double
            value;

      do
      {
            fputs(prompt, stdout);
            fflush(stdin);
            ret = scanf("%lf", &value);
      } while (!ret);
      return (value);
}

void
main()
{
      int
            vxiChassisID,
            commPath,
            moduleSlot,                     /* slot of module to calibrate */
            moduleChan;
      short
            dummyRangeCode = 0,
            dummyDAQboard,
            dummyDAQchan = 0,
            dummyDAQgain = 1,
            dummyDAQrange;                  /* These dummy variables would be
                                               used if the measurement actually
                                               came from a DAQ board and not an
                                               external DMM. */
```

```
double
      scale,
      gain,
      vInput1,
      vOutput1,
      vInput2,
      vOutput2,
      binOutput1,
      binOutput2,
      binOffset,
      gainerr,
      offset;

do
{
      vxiChassisID   = enterInt ("\nEnter chassis ID of the VXI-SC chassis:");
} while (vxiChassisID < 1);
do
{
      moduleSlot     = enterInt ("Enter slot of the VXI-SC-1102:  ");
} while (moduleSlot < 1 || N_VXI_SC_SLOTS < moduleSlot);
do
{
      commPath       = enterInt ("Enter device number of the DAQ board"
                                 "controlling the chassis:  ");
} while (commPath < 0);
dummyDAQboard       = commPath;
dummyDAQrange       = MIO_FULL_SCALE / dummyDAQgain;
scale               = pow(2.0, 12.0) * dummyDAQgain / 10;
                                          /* factor for converting to format
                                             of 12-bit bipolar DAQ board */
SCXI_Reset (vxiChassisID, moduleSlot);
SCXI_Single_Chan_Setup (vxiChassisID, moduleSlot, 0, dummyDAQboard);
                                          /* This is necessary only so that
                                             SCXI_Change_Chan won't return
                                             an error. */
for (gain = 1; gain <= 100; gain = gain + 99)
{
      SCXI_Set_Gain (vxiChassisID, moduleSlot, ALL, gain);
                                          /* Set the gain on all channels. */
      for  (moduleChan = 0; moduleChan < 32; moduleChan++)
      {
         SCXI_Change_Chan (vxiChassisID, moduleSlot, moduleChan);
                                          /* Select the channel. */
```

```
            printf("Apply input voltage for point 1, channel %d, gain %.0f.\n"
                    moduleChan, gain);,
            vInput1    = enterFloat ("Enter VXI-SC-1102 input voltage:  ");
                                    /* User enters vInput1. */
            vOutput1 = enterFloat ("Enter VXI-SC-1102 output voltage:  ");
                                    /* User enters vOutput1. */
            printf("Apply input voltage for point 2, channel %d, gain
                   %.0f.\n",moduleChan, gain);
            vInput2  = enterFloat ("Enter VXI-SC-1102 input voltage:  ");
                                    /* User enters vInput2. */
            vOutput2 = enterFloat ("Enter VXI-SC-1102 output voltage:  ");
                                    /* User enters vOutput2. */
            binOutput1= vOutput1*scale;
            binOutput2= vOutput2*scale;    /* Convert to DAQ board's format. */
            SCXI_Cal_Constants (vxiChassisID, moduleSlot, moduleChan,
                                2, NIDAQMEM, dummyRangeCode, gain,
                                dummyDAQboard, dummyDAQchan, dummyDAQgain, 1,
                                vInput1, binOutput1, vInput2, binOutput2,
                                &binOffset, &gainerr);
                                    /* Calculate offset & gain error. */
            offset   = binOffset/scale;    /* Convert from DAQ board format. */
            printf("Calculated offset %f V, gain ratio (actual/ideal) %f"
                   "and stored in NI-DAQ memory.\n\n", offset, gainerr);
        }
    }
}
```

Specifications

Appendix A

This appendix lists the specifications for the VXI-SC-1102. These specifications are typical at 25° C unless otherwise noted.

Analog Input

Input Characteristics

Number of channels ..... 32 differential

Input signal ranges ..... ±100 mV (gain = 100) or ±10 V (gain = 1)

Max working voltage
(signal + common mode) ..... Each input should remain within ±10 V of CGND

Input damage level ..... ±42 VAC peak or VDC

Inputs protected..... CH<0..31>, CJSENSOR

Transfer Characteristics

Nonlinearity ..... 0.005% FSR

Offset error

Gain = 1

After calibration..... 150 µV max

Before calibration ..... 600 µV

Gain = 100

After calibration..... 15 µV max

Before calibration ..... 100 µV

Gain error (relative to calibration reference)

Gain = 1

After calibration..... 0.015% of reading max

Before calibration ..... 0.04% of reading

Gain = 100
After calibration .....0.017% of reading max
Before calibration.....0.1% of reading

Amplifier Characteristics

Input impedance
Normal powered on .....> 1 GΩ
Powered off .....10 kΩ
Overload .....10 kΩ

Input bias current .....±0.5 nA

Input offset current .....±1.0 nA

CMRR
50 to 60 Hz, either gain .....110 dB
0 Hz, gain 1.....75 dB min
0 Hz, gain 100.....100 dB min

Output range .....±10 V

Output impedance.....91 Ω

Dynamic Characteristics

Bandwidth.....2 Hz

Scan interval (per channel, any gain)
0.012%.....3 µs
0.0061%.....10 µs

System noise (related to input
Gain = 1 .....50 µVrms
Gain = 100 .....5 µVrms

Filters

Cutoff frequency (-3 dB) .....2 Hz

NMR (60 Hz).....40 dB

Step response (either gain)

To 0.1%..... 1 s

To 0.01%..... 10 s

Stability

Recommended warm-up time ..... 20 min.

Offset temperature coefficient

Gain = 1 ..... 20 µV/°C

Gain = 100 ..... 1 µV/°C

Gain temperature coefficient..... 10 ppm/°C

Physical

Dimensions..... 115 by 273 mm (4.54 by 10.75 in.)

I/O connector..... 50-pin male ribbon cable rear connector

96-pin male DIN C front connector

Environment

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

Storage temperature ..... -55° to 150° C

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

Power Requirements

5 V supply ..... 15 mA max

±15 V supply (regulated from ±24 V supply)..... 150 mA max

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Customer Communication

Appendix B

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Canada (Quebec)	514 694 8521	514 694 4399
Denmark	45 76 26 00	45 76 26 02
Finland	09 527 2321	09 502 2930
France	01 48 14 24 24	01 48 14 24 14
Germany	089 741 31 30	089 714 60 35
Hong Kong	2645 3186	2686 8505
Israel	03 5734815	03 5734816
Italy	02 413091	02 41309215
Japan	03 5472 2970	03 5472 2977
Korea	02 596 7456	02 596 7455
Mexico	5 520 2635	5 520 3282
Netherlands	0348 433466	0348 430673
Norway	32 84 84 00	32 84 86 00
Singapore	2265886	2265887
Spain	91 640 0085	91 640 0533
Sweden	08 730 49 70	08 730 43 70
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Company _____

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Fax (___)_____ Phone (___) _____

Computer brand _____ Model _____ Processor_____

Operating system (include version number) _____

Clock speed _____MHz RAM _____MB Display adapter _____

Mouse ___yes ___no Other adapters installed _____

Hard disk capacity _____MB Brand _____

Instruments used _____

_____

National Instruments hardware product model _____ Revision _____

Configuration _____

National Instruments software product _____ Version _____

Configuration _____

The problem is: _____

_____

_____

_____

_____

List any error messages: _____

_____

_____

The following steps reproduce the problem:_____

_____

_____

_____

_____

_____

VXI-SC-1102 Hardware and Software Configuration Form

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

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Operating system _____

Operating system version _____

Programming language _____

Programming language version _____

Other boards in system _____

Base I/O address of other boards _____

DMA channels of other boards _____

Interrupt level of other boards _____

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

Numbers/Symbols

+5 V	+5 volt signal
°	degrees
Ω	ohms
%	percent
±	plus or minus

A

AC	alternating current
A/D	analog-to-digital

ADC	analog-to-digital converter–an electronic device, often an integrated circuit, that converts an analog voltage to a digital number
amplification	a type of signal conditioning that improves accuracy in the resulting digitized signal and reduces noise
API	application programming interface

B

bus	the group of conductors that interconnect individual circuitry in a computer. Typically, a bus is the expansion vehicle to which I/O or other devices are connected. Examples of PC buses are the AT bus, NuBus, Micro Channel, and EISA bus.

C

C	Celsius
CGND	chassis ground signal
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.
CH<0..31> -	negative input channels 0 through 31
CH<0..31>+	positive input channels 0 through 31
CJSENSOR	cold-junction sensor
cold-junction compensation	a method of compensating for inaccuracies in thermocouple circuits

D

DAQ	data acquisition–(1) collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and inputting them to a computer for processing; (2) collecting and measuring the same kinds of electrical signals with A/D and/or DIO boards plugged into a

	computer, and possibly generating control signals with D/A and/or DIO boards in the same computer
DC	direct current
DIFF	differential configuration
differential input	an analog input consisting of two terminals, both of which are isolated from computer ground, whose difference is measured
drivers/driver software	software that controls a specific hardware device such as a DAQ board

F

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

G

G	gain—the factor by which a signal is amplified, sometimes expressed in decibels

H

hex	hexadecimal
Hz	hertz

I

in.	inches
input impedance	the measured resistance and capacitance between the input terminals of a circuit
instrument driver	a set of high-level software functions that controls a specific VXI or RS-232 programmable instrument or a specific plug-in DAQ board. Instrument drivers are available in several forms, ranging from a function callable language to a virtual instrument (VI) in LabVIEW.

L

logical address	An 8-bit number that uniquely identifies each VXIbus device in a system. It defines the A16 register addresses of a device, and indicates Commander and Servant relationships.
LSB	least significant bit

M

mainframe	The chassis of a VXIbus system that mechanically contains VXI modules inserted into the backplane, ensuring that connectors fit properly and that adjacent modules do not contact each other. It also provides cooling airflow, and ensures that modules do not disengage from the backplane due to vibration or shock.
MB	megabytes of memory
MIO	multifunction I/O
MSB	most significant bit
mux	multiplexer—a switching device with multiple inputs that sequentially connects each of its inputs to its output, typically at high speeds, in order to measure several signals with a single analog input channel

N

NC	not connected (signal)
noise	an undesirable electrical signal—Noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to send or receive.

R

RMA	Return Material Authorization

rms	root mean square

S

S/s	samples per second
signal conditioning	the manipulation of signals to prepare them for digitizing
slot	A position where a module can be inserted into a VXIbus backplane. Each slot provides the 96-pin J connectors to interface with the board P connectors. A slot can have one, two, or three connectors.

T

thermocouple	a temperature sensor created by joining two dissimilar metals. The junction produces a small voltage as a function of the temperature.
transducer excitation	a type of signal conditioning that uses external voltages and currents to excite the circuitry of a signal conditioning system into measuring physical phenomena

V

V	volts
V_{em}	common-mode voltage
VDC	volts, direct current
V_{diff}	differential voltage
VI	virtual instrument
V_{IH}	volts, input high
V_{IL}	volts, input low
V_{in}	volts in
VISA	a new driver software architecture developed by National Instruments to unify instrumentation softwareGPIB, DAQ, and VXI. It has been accepted as a standard for VXI by the VXIplug&play Systems Alliance.

V_{OH}	volts, output high
V_{OL}	volts, output low
VXIbus	VMEbus eXtensions for Instrumentation
VXI*plug&play* Systems Alliance	A group of VXI developers dedicated to making VXI devices as easy to use as possible, primarily by simplifying software development

W

waveform	a time-varying physical phenomenon, often measured in voltage

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