SCXI™

# SCXI-1104 User Manual

## 32-Channel Medium Voltage Input Module

NATIONAL INSTRUMENTS™

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# About This Manual

This manual describes the electrical and mechanical aspects of the SCXI-1104 module and contains information concerning its installation and operation.

The SCXI-1104 module is a member of the National Instruments Signal Conditioning eXtensions for Instrumentation (SCXI) Series for the National Instruments data acquisition (DAQ) plug-in devices. This module is designed for signal conditioning volt and medium voltage signals that range from –42 V to +42 V. The SCXI-1104 module has 32 differential analog input channels.

## Organization of This Manual

The *SCXI-1104 User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the SCXI-1104 module; lists what you need to get started with your SCXI-1104 module, the optional software, optional equipment, and custom cables; and explains how to unpack the SCXI-1104 module.
- Chapter 2, *Installation*, describes how to install the SCXI-1104 module into the SCXI chassis.
- Chapter 3, *Signal Connections*, describes the input and output signal connections to the SCXI-1104 module via the module front connector and rear signal connector. This chapter also includes specifications and connection instructions for the signals on the SCXI-1104 connectors.
- Chapter 4, *Theory of Operation*, contains a functional overview of the SCXI-1104 module and explains the operation of each functional unit making up the SCXI-1104 module.
- Chapter 5, *Calibration*, discusses the calibration procedures for the SCXI-1104 module.
- Appendix A, *Specifications*, lists the specifications for the SCXI-1104 module.
- Appendix B, *Calibration Sample Program*, contains a sample program to help you calibrate your submodule.
- Appendix C, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products.

- The *Glossary* contains an alphabetical list and description of 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.

| | |
|---|---|
| < > | 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). |
| ☞ | This icon to the left of bold italicized text denotes a note, which alerts you to important information. |
| ⚠ | This icon to the left of bold italicized text denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. |
| ***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 | Refers to the boards that have *Lab* in their names, such as the Lab-LC and the Lab-PC+. |
| MIO board | Refers to the multichannel I/O DAQ boards that have *MIO* in their names, such as the AT-MIO-16 and the NEC-MIO-16E-4. |
| `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. |
| 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 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*.

# National Instruments Documentation

The *SCXI-1104 User Manual* is one piece of the documentation set for your data acquisition system. You could have any of several types of manuals, depending on the hardware and software in your system. Use the manuals you have 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 hardware user manuals—Read these manuals next for detailed information about signal connections and module configuration. They also explain in greater detail how the module works and contain application hints.
- Your DAQ hardware user manuals—These manuals have detailed information about the DAQ hardware that plugs into or is connected to your computer. Use these manuals for hardware installation and configuration instructions, specification information about your DAQ hardware, and application hints.
- Software documentation—Examples of software documentation you may have are the LabVIEW and LabWindows/CVI manual sets and the NI-DAQ documentation. After you set up your hardware system, use either the application software documentation or the NI-DAQ documentation to help you write your application. If you have a large and 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. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making your connections.
- *SCXI Chassis Manual*—Read this manual for maintenance information on the chassis and installation instructions.

# Customer Communication

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

# 1

# Introduction

This chapter describes the SCXI-1104 module; lists what you need to get started with your SCXI-1104 module, the optional software, optional equipment, and custom cables; and explains how to unpack the SCXI-1104 module.

## About the SCXI-1104 Module

This module is for signal conditioning of volt and medium voltage signals. The SCXI-1104 has 32 differential analog input channels. On each channel, the SCXI-1104 has a three-pole lowpass filter with a 2 Hz cutoff frequency to reject 60 Hz noise. Each channel also has a divide by 10 attenuator stage before the amplifier. You can multiplex the SCXI-1104 inputs to a single output, which drives a single DAQ device channel.

Detailed specifications of the SCXI-1104 module are in Appendix A, *Specifications*.

## What You Need to Get Started

To set up and use your SCXI-1104, you will need the following items:

- ❑ SCXI-1104 module
- ❑ *SCXI-1104 User Manual*

- ❑ One of the following software packages and documentation:

  ComponentWorks
  LabVIEW for Macintosh
  LabVIEW for Windows
  LabWindows/CVI for Windows
  Measure
  NI-DAQ for Macintosh
  NI-DAQ for PC Compatibles
  VirtualBench

- ❑ Your computer

# Unpacking

Your SCXI-1104 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 object.
- 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.

# Software Programming Choices

You have several options to choose from when programming your National Instruments DAQ and SCXI hardware. You can use National Instruments application software, NI-DAQ, or register-level programming.

## National Instruments Application 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.

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 NI-DAQ software.

LabWindows/CVI features interactive graphics, 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.

VirtualBench features virtual instruments that combine DAQ products, software, and your computer to create a stand-alone 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 ComponentWorks, LabVIEW, LabWindows/CVI, 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 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 device, 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 your National Instruments application software.

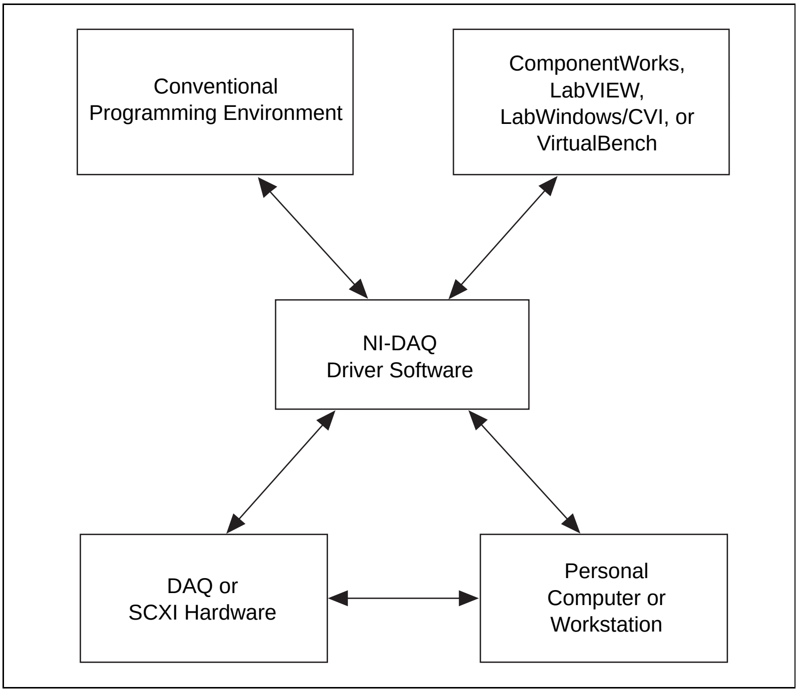


**Figure 1-1.** The Relationship between the Programming Environment, NI-DAQ, and Your Hardware

## 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.

Even if you are an experienced register-level programmer, consider using NI-DAQ or other National Instruments application software to program your National Instruments DAQ hardware. Using the application software is easier than and as flexible as register-level programming and can save weeks of development time.

# Optional Equipment

National Instruments offers a variety of products to use with your SCXI-1104 module, as follows:

- Terminal blocks and 96-pin cables that allow you to attach input signals to your module.
- Cables and cable assemblies, shielded and ribbon

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

# Custom Cables

The following table summarizes the custom cable information.

| Signal Connector | SCXI–1104 Connector | Mating Connector | Cable |
|---|---|---|---|
| Rear | AMP Inc. (1-103310-0) 50-pin male ribbon cable header | Electronic Products Division/3M (3425-7650) or T&B/Ansley Corp. (609-5041CE) 50-position polarized ribbon-socket connector | Electronic Products Division/3M (3365/50) or T&B/Ansley Corp. (171-50) 50-conductor, 28 AWG stranded ribbon cable |
| Front | Harting Electronik Inc. (09-03-396-6921) 96-pin DIN C male connector | AMP Inc. (535020; right-angle pins) or Panduit Corp. (100-096-434 straight-solder pins) 96-pin, polarized, DIN C female connector | Not applicable |

# 2

# Installation

This chapter describes how to install the SCXI-1104 module into the SCXI chassis. The SCXI-1104 is a jumperless module and requires no user modifications. There is no need for the user to remove the module cover.

**Note** ***The SCXI-1104 does not support ribbon-cabled multichassis SCXI systems. You must use the SCXI-1346 multichassis adapter in a multichassis system.***

## Hardware Installation

You can install the SCXI-1104 module in any available SCXI chassis slot. 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 device or disconnect it from your SCXI chassis.
2. Turn off the SCXI chassis. Do not insert the SCXI-1104 module into a chassis that is turned on.
3. Insert the SCXI-1104 module 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-1104 module to the top and bottom threaded strips of your SCXI chassis.
5. If this module is to be connected to a DAQ device, attach the connector at the metal end of the SCXI-1349 cable assembly to the rear signal connector on the SCXI-1104 module. Screw the rear panel to the rear threaded strip. Attach the loose end of the cable to the DAQ device.

**Note** ***For installation procedures with other SCXI accessories and DAQ devices, 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-1104 module is installed. You are now ready to install and configure your software.

If you are using NI-DAQ or other National Instruments application software, refer to the installation instructions in your documentation to install and configure your software.

# 3

# Signal Connections

This chapter describes the input and output signal connections to the SCXI-1104 module via the module front connector and rear signal connector. This chapter also includes specifications and connection instructions for the signals on the SCXI-1104 connectors.

**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 SCXI-1104 module front connector.

| A Signal | A Pin | B Signal | B Pin | C Signal | C Pin |
|---|---|---|---|---|---|
| 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 |
| RSVD | 4 | CH28– | 4 | CH28+ | 4 |
| RSVD | 3 | CH29– | 3 | CH29+ | 3 |
| CGND | 2 | CH30– | 2 | CH30+ | 2 |
| +5 V | 1 | CH31– | 1 | CH31+ | 1 |

**Figure 3-1.** SCXI-1104 Module Front Connector Pin Assignments

## Front Connector Signal Descriptions

| Pin | Signal Name | Description |
|---|---|---|
| A1 | +5 V | +5 VDC Source—Used to power 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 SCXI chassis. |
| A3, A4 | RSVD | Reserved |
| B1–B32 | CH31– through CH0– | Negative Input Channels —Negative side of differential input channels. |
| C1–C32 | CH31+ through CH0+ | Positive Input Channels 31 through 0—Positive side of differential input channels. |
| All other pins are not connected. | | |

## Analog Input Signal Connections

The signal terminals for the positive input channel 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 differential input signal range of an SCXI-1104 module input channel is ±42 V. This differential input range is the maximum measurable voltage difference between the positive and negative channel inputs. The common-mode input signal range of an SCXI-1104 module input channel is ±42 V. This common-mode input range for either positive or negative channel input is the maximum input voltage which will result in a valid measurement.

**Caution** ***Exceeding the input damage level (±42 VAC peak or VDC between input channels and chassis ground) can damage the SCXI-1104 module, the SCXIbus, and the DAQ device. 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 SCXI-1104 is an electrical shock hazard. National Instruments is NOT liable for any damages or injuries resulting from such voltage application.***

# Rear Signal Connector

☞ **Note** ***If you are using the SCXI-1104 module with a National Instruments DAQ device 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-1104 module, read this section.***

Figure 3-2 shows the SCXI-1104 module rear signal connector pin assignments.

| | | | |
|---|---|---|---|
| AOGND | 1 | 2 | AOGND |
| MCH0+ | 3 | 4 | MCH0– |
| NC | 5 | 6 | NC |
| NC | 7 | 8 | NC |
| NC | 9 | 10 | NC |
| NC | 11 | 12 | NC |
| NC | 13 | 14 | NC |
| NC | 15 | 16 | NC |
| NC | 17 | 18 | NC |
| OUTREF | 19 | 20 | NC |
| NC | 21 | 22 | NC |
| NC | 23 | 24 | DGND |
| SERDATIN | 25 | 26 | SERDATOUT |
| DAQD*/A | 27 | 28 | NC |
| SLOT0SEL* | 29 | 30 | NC |
| NC | 31 | 32 | NC |
| DGND | 33 | 34 | NC |
| NC | 35 | 36 | SCANCLK |
| SERCLK | 37 | 38 | NC |
| NC | 39 | 40 | NC |
| NC | 41 | 42 | NC |
| RSVD | 43 | 44 | NC |
| NC | 45 | 46 | RSVD |
| NC | 47 | 48 | NC |
| NC | 49 | 50 | NC |

**Figure 3-2.** SCXI-1104 Module Rear Signal Connector Pin Assignments

## Rear Signal Connector Descriptions

The rear signal connector on the cabled module is the interface between the DAQ device and all modules in the SCXI chassis.

| Pin | Signal Name | Direction | Description |
|---|---|---|---|
| 1, 2 | AOGND | Output | Negative Module Analog Output—With software, you can configure these pins to connect to the analog reference. |
| 3 | MCH0+ | Output | Positive Module Analog Output—This pin connects to the positive side of the differential analog input channel 0 of the DAQ device. |
| 4 | MCH0– | Output | Negative Module Analog Output—In the reset state of the module, this pin is configured to connect to the analog reference. |
| 19 | OUTREF | Output | Negative Module Analog Output—With software, you can configure this pin to connect to the analog reference. |
| 24, 33 | DGND | — | Digital Ground—These pins supply the reference for DAQ device digital signals and are tied to the module digital ground. |
| 25 | SERDATIN | Input | Serial Data In—The DAQ device uses this signal to program modules in all slots. |
| 26 | SERDATOUT | Output | Serial Data Out—A cabled module uses this signal to return data from any module to the DAQ device. |
| 27 | DAQD*/A | Input | DAQ Device Data/Address Line—The DAQ device asserts this signal to indicate to the module whether the incoming serial stream is data or address information. |
| 29 | SLOT0SEL* | Input | Slot 0 Select—The DAQ device asserts this signal low to indicate that the SERDATIN line information is going to the Slot 0 controller instead of a module. |
| 36 | SCANCLK | Input | Scan Clock—A rising edge indicates to the scanned SCXI module that the DAQ device has taken a sample and causes the module to advance channels. |
| 37 | SERCLK | Input | Serial Clock—This signal clocks the data on the SERDATIN and SERDATOUT lines. |
| 43, 46 | RSVD | Input | Reserved |
| All other pins are not connected. | | | |

The signals on the rear signal connector are analog output signals, digital I/O signals, or digital timing signals. The following section contains signal connection guidelines for each of these groups.

## 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, pin 4 is the MCH0– pin, and pin 19 is the OUTREF pin. With software, you can configure pin 1, 2, 4 or 19 to connect to the module's analog ground (AGND). You can use the pin that is connected to AGND as a general analog power ground tie point to the SCXI-1104 module, if necessary.

**Caution** ***The SCXI-1104 module analog outputs are not overvoltage-protected. Applying external voltages to these outputs can damage the SCXI-1104 module. National Instruments is NOT liable for any damages resulting from such signal connections.***

**Note** ***The SCXI-1104 module 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 SCXI-1104 module digital input and output signals match the digital I/O lines of the MIO-16 boards. When used with an SCXI-1341 cable assembly, the SCXI-1104 module signals match the digital lines of the Lab-NB/PC+ boards. Table 3-1 lists the equivalencies. For more detailed information, consult your cable installation guide.

**Table 3-1.** SCXIbus to SCXI-1104 Module Rear Signal Connector to DAQ Device Pin Equivalencies

| SCXIbus Line | SCXI-1104 Rear Signal Connector | MIO-16 | Lab Boards |
|---|---|---|---|
| MOSI | SERDATIN | ADIO0 | PB4 |
| D*/A | DAQD*/A | ADIO1 | PB5 |
| INTR* | SLOT0SEL* | ADIO2 | PB6 |
| SPICLK | SERCLK | EXTSTROBE* | PB7 |
| MISO | SERDATOUT | BDIO0 | PC1 |

## Digital Timing Signal Connection

The SCXI-1104 module uses pin 36, SCANCLK, to increment to the next channel after each DAQ device conversion during scanning.

## Digital Signal Specifications

The following specifications and ratings apply to the digital signals:

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

# 4

# Theory of Operation

This chapter contains a functional overview of the SCXI-1104 module and explains the operation of each functional unit making up the SCXI-1104 module.

## Functional Overview

The block diagram in Figure 4-1 illustrates the key functional components of the SCXI-1104 module.

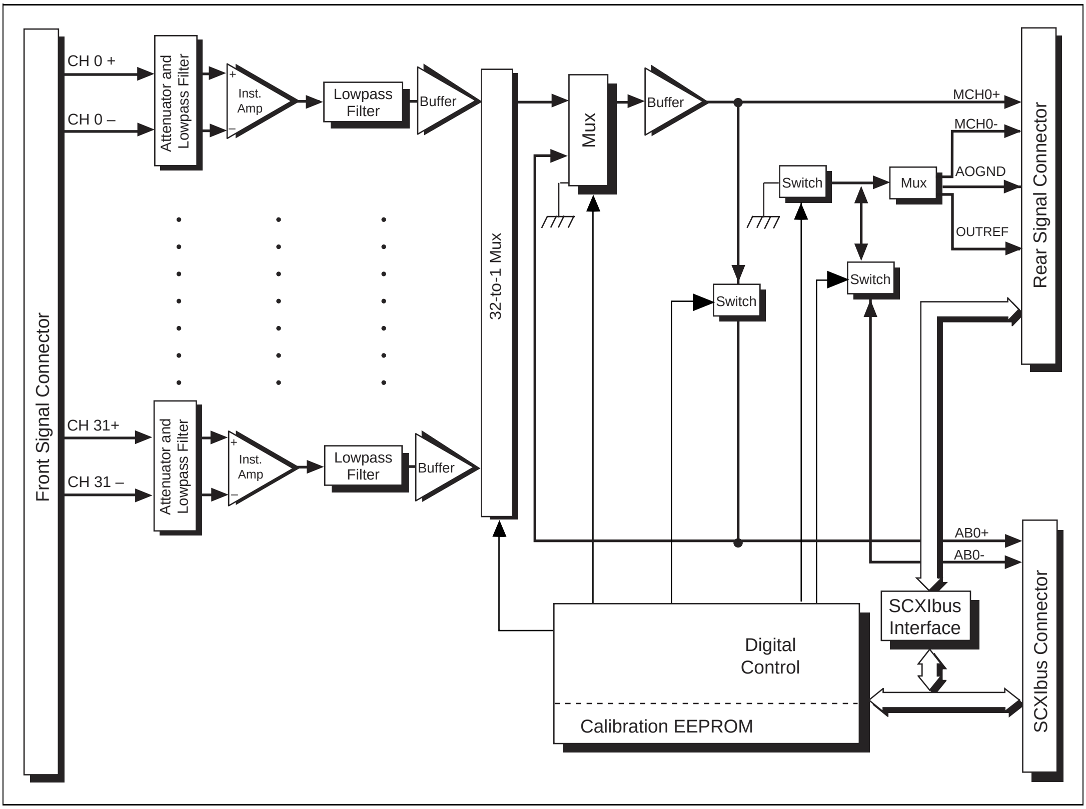


**Figure 4-1.** SCXI-1104 Module Block Diagram

The major components of the SCXI-1104 module are as follows:

- Rear signal connector
- SCXIbus connector
- SCXIbus interface
- Digital control circuitry
- Analog circuitry

The SCXI-1104 modules consist of 32 multiplexed input channels, each capable of measuring ±42 V. Each input channel has its own lowpass filter. The SCXI-1104 module also has a digital section for automatic control of channel scanning, and temperature sensor selection.

## Rear Signal Connector, SCXIbus Connector, and SCXIbus Interface

The SCXIbus controls the SCXI-1104 module. The SCXIbus interface connects the rear signal connector to the SCXIbus, allowing a DAQ device to control the SCXI-1104 module and the rest of the chassis.

## 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 a code unique to each type of SCXI module. For the SCXI-1104, the Module ID is 45 decimal.

The Configuration Register configures the SCXI-1104 module 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 module EEPROM, which contains calibration information. 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*, to learn about options for programming the control circuitry.

## Analog Circuitry

The analog circuitry per channel consists of a lowpass filter and a divide by 10 attenuator. The channels are multiplexed to a single output buffer.

## Analog Input Channels

Each of the 32 analog input channels feeds to a separate amplifier. Then the signal passes through a three-pole lowpass filter.

For 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 module and still measure accurate voltages. The 3 μs scan interval gives you a maximum sampling rate of 333 kHz. Because this rate is higher than the bandwidth of a single SCXI-1104 channel, you can sample multiple channels on multiple SCXI modules without undersampling one of the SCXI-1104 channels.

## Analog Bus Switch

The SCXI-1104 module contains switches to place their analog output on the SCXIbus to pass the output to the SCXI module cabled to the DAQ device. The SCXI-1104 module also contains a switch to receive a signal placed on the SCXIbus by another SCXI module. The output buffer of the cabled module drives a received signal onto the MCH0+ line of the rear signal connector so that the DAQ device can read it. When a signal passes on the SCXIbus from the scanned SCXI module to the cabled SCXI module, the measurement is known as *indirect scanning*.

# 5

# Calibration

This chapter discusses the calibration procedures for the SCXI-1104 module.

## Overview

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 module comes from the factory with factory-determined calibration constants in the EEPROM. However, it is recommended that you recalibrate a module at least once per year or when you operate the module outside of the 20° to 30° C temperature range.

To calibrate the SCXI-1104 module, you will need to apply precision voltages to the channel inputs and/or ground the channel inputs.

## Calibration Procedure

### Calibration Equipment Requirements

According to standard practice, the equipment you use to calibrate the SCXI-1104 module should be 10 times as accurate as the SCXI-1104 module. Calibration equipment with four times the accuracy of the SCXI-1104 is generally considered acceptable.

To calibrate the SCXI-1104 module, you need a voltmeter with the following specifications:

- Accuracy — ±6 ppm standard reading<br>±15 ppm sufficient reading
- 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.

You will need to measure the module's output between MCH0+ and MCH0–. To access these pins, connect a 50-pin ribbon cable from the CB-50 I/O connector block to the module rear signal connector or to the rear signal adapter. Then connect to MCH0+ and MCH0– on the CB-50 pins 3 and 4, respectively.

## Gain and Offset Calibration

To determine the offset and gain calibration factors of the SCXI-1104 module 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, if you are planning to measure bipolar voltages over the module's full input range, choose –42 V (negative full-scale) and +42 V (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 –42 V 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 between MCH0+ and MCH0– 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 +42 V.
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 DAQ device binary unit. You must take into consideration the polarity of your DAQ device, its resolution (12 bits or 16 bits), and gain. For example, if you are using the 12-bit AT-MIO-16E-2 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:

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

   For other DAQ devices, refer to your DAQ device 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 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 National Instruments software, the driver automatically uses the calibration constants to correct the measured voltages.***

For an example of how to calibrate your module, refer to Appendix B, *Calibration Sample Program*.

# A

# Specifications

This appendix lists the specifications for the SCXI-1104 module. These specifications are typical at 25° C unless otherwise noted.

## SCXI-1104

### Analog Input

#### Input Characteristics

Number of channels ............................32 differential

Input signal ranges................................ ±42 V

Max working voltage
(signal + common mode) ....................Each input should remain within ±42 V of CGND

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

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

#### Transfer Characteristics

Nonlinearity........................................0.01% FSR

Offset error

After calibration ....................300 µV max

Before calibration..................1 mV

Gain error (relative to calibration reference)

After calibration ....................0.02% of reading max

Before calibration..................0.1% of reading

## Amplifier Characteristics

Input impedance
- Normal powered on ..................... 1 MΩ
- Powered off ................................ 900 kΩ
- Overload..................................... 900 kΩ

Input bias current..................................±0.5 nA

Input offset current...............................±1.0 nA

CMRR

50 to 60 Hz ............................................70 dB

DC..........................................................70 dB

Output range ........................................±10 V

Output impedance .............................. 91 Ω

## Dynamic Characteristics

Bandwidth.......................................... 2 Hz

Scan interval (per channel)
- 0.012% ........................................ 3 µs
- 0.0061% ...................................... 10 µs

System noise (related to input)........... 500 µVrms

# Filters

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

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

Step response
- To 0.1%...........................................1 s
- To 0.01%.........................................10 s

## Stability

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

Offset temperature coefficient.............50 μV/°C

Gain temperature coefficient...............20 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

# B

# Calibration Sample Program

This appendix contains a sample program to help you calibrate your submodule.

## Sample Program for Calibration

The following is a sample C program that implements the procedure discussed in the *Gain and Offset Calibration* section and `SCXI_Cal_Constants` in Chapter 5, *Calibration*:

```
/*   This sample program assists the user in calibrating the SCXI-1104. 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 running this
     programed must run the NI-DAQ Configuration Utility to set up the DAQ board
     that will communicate with the SCXI-1104.

     This program is written for the four-slot SCXI-1000 chassis. The program
     prompts for all required configuration information about the SCXI chassis. */

#include <ansi_c.h>
#include <dataacq.h>

#define SCXI1104 45                        /* the SCXI-1104 module ID */
#define TWOPOINT  2
#define NIDAQMEM  0

void main()
{
     char       entry[4];
     int        SCXI_Chassis_ID,
                moduleSlot,                /* chassis slot of module
                                           to calibrate */
                moduleChan;
     long       modulesPresent[] = {-1, -1, -1, -1};
     short      operatingModes[] = {0, 0, 0, 0},
                connectionMap[] = {0, 0, 0, 0},
                commPath,                  /* DAQ board that communicates with
                                              SCXI chassis */

                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. */
            ret;
double      scale,
            gain,
            vinput1,
            voutput1,
            vinput2,
            voutput2,
            bin_output1,
            bin_output2,
            bin_offset,
            gainerr,
            offset;
do
{
      printf("Enter the slot of the SCXI-1104:  ");
      fflush(stdin);
      ret = scanf("%d", &moduleSlot);
} while (!ret || moduleSlot < 1 || moduleSlot > 4);
modulesPresent[moduleSlot - 1] = SCXI1104;
do
{
      printf("Enter the chassis ID of the chassis containing the SCXI-1104: ");
      fflush(stdin);
      ret = scanf("%d", &SCXI_Chassis_ID);
} while (!ret);
commPath = SCXI_Chassis_ID;
do
{
      printf("Enter the device number of the DAQ board communicating \n");
      printf("with the chassis (default %d):  ", SCXI_Chassis_ID);
      fflush(stdin);
      fgets(entry, 3, stdin);
      if (strlen(entry) - 1) commPath = atof(entry);
} while (!commPath);
dummyDAQboard = connectionMap[moduleSlot - 1] = commPath;
                                               /*  Since the DAQ board is not
                                                   used to acquire data, the
                                                   connectionMap does not need to
                                                   be accurate. */
dummyDAQrange = 5.0 / dummyDAQgain;
scale = pow(2.0, 12.0) * dummyDAQgain / 5;  /*  factor for converting to
                                                   format of 12-bit bipolar DAQ
                                                   board with 5 V full scale*/
SCXI_Set_Config(SCXI_Chassis_ID, 0, 0, 1, commPath, 4,
                      modulesPresent, operatingModes, connectionMap);
                                               /*  Set up communication path to
                                                   module. */
```

```
      SCXI_Reset(SCXI_Chassis_ID, moduleSlot);
                                                /*  In reset state, the module
                                                    will drive the MCH0+ output */
SCXI_Single_Chan_Setup(SCXI_Chassis_ID, moduleSlot, 0, dummyDAQboard);
                                                /*  This is necessary only so that
                                                    SCXI_Change_Chan won't return
                                                    an error. */
      for (moduleChan = 0; moduleChan < 31; moduleChan++)
      {
            SCXI_Change_Chan(SCXI_Chassis_ID, moduleSlot, moduleChan);
            SCXI_Set_Gain(SCXI_Chassis_ID, moduleSlot, moduleChan, gain);
                                                /* Select the channel and gain. */
            printf("Apply input voltage for point 1, channel %d, gain %.0f.\n",
                    moduleChan, gain);
            do
            {
                  printf("Enter SCXI-1104 input voltage:  ");
                  fflush(stdin);
                  ret = scanf("%lf", &vinput1);/* User enters vinput1. */
            } while (!ret);
            do
            {
                  printf("Enter SCXI-1104 output voltage:  ");
                  fflush(stdin);
                  ret = scanf("%lf", &voutput1);/* User enters voutput1. */
            } while (!ret);
            printf("Apply input voltage for point 2, channel %d,
                    gain %.0f.\n", moduleChan, gain);
            do
            {
                  printf("Enter SCXI-1104 input voltage:  ");
                  fflush(stdin);
                  ret = scanf("%lf", &vinput2);/* User enters vinput2. */
            } while (!ret);
            do
            {
                  printf("Enter SCXI-1104 output voltage:  ");
                  fflush(stdin);
                  ret = scanf("%lf", &voutput2);/* User enters voutput2. */
            } while (!ret);
            bin_output1 = voutput1 * scale;
            bin_output2 = voutput2 * scale;    /* Convert to format of DAQ
                                                   board. */
```

```
                SCXI_Cal_Constants(SCXI_Chassis_ID, moduleSlot, moduleChan,
                                  TWOPOINT, NIDAQMEM, dummyRangeCode, gain,
                                  dummyDAQboard, dummyDAQchan, dummyDAQgain, 1,
                                  vinput1, bin_output1, vinput2, bin_output2,
                                  &bin_offset, &gainerr);
                                                 /* Calculate offset and gain
                                                    error. */
                offset = bin_offset / scale;     /* Convert from DAQ board
                                                    format. */
                printf("Calculated offset %f V, gain error %f%% ", offset,
                        gainerr);
                printf("and stored in NI-DAQ memory.\n\n");
     }
}
```

# C

# Customer Communication

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

National Instruments has technical assistance through electronic, fax, and telephone systems to quickly provide the information you need. Our electronic services include a bulletin board service, an FTP site, a fax-on-demand system, and e-mail support. If you have a hardware or software problem, first try the electronic support systems. If the information available on these systems does not answer your questions, we offer fax and telephone support through our technical support centers, which are staffed by applications engineers.

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National Instruments has BBS and FTP sites dedicated for 24-hour support with a collection of files and documents to answer most common customer questions. From these sites, you can also download the latest instrument drivers, updates, and example programs. For recorded instructions on how to use the bulletin board and FTP services and for BBS automated information, call 512 795 6990. You can access these services at:

United States: 512 794 5422
Up to 14,400 baud, 8 data bits, 1 stop bit, no parity

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

France: 01 48 65 15 59
Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

### FTP Support

To access our FTP site, log on to our Internet host, `ftp.natinst.com`, as `anonymous` and use your Internet address, such as `joesmith@anywhere.com`, as your password. The support files and documents are located in the `/support` directories.

### Fax-on-Demand Support

Fax-on-Demand is a 24-hour information retrieval system containing a library of documents on a wide range of technical information. You can access Fax-on-Demand from a touch-tone telephone at 512 418 1111.

### E-Mail Support (Currently USA Only)

You can submit technical support questions to the applications engineering team through e-mail at the Internet address listed below. Remember to include your name, address, and phone number so we can contact you with solutions and suggestions.

`support@natinst.com`

## Telephone and Fax Support

National Instruments has branch offices all over the world. Use the list below to find the technical support number for your country. If there is no National Instruments office in your country, contact the source from which you purchased your software to obtain support.

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|---|---|---|
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| Austria | 0662 45 79 90 0 | 0662 45 79 90 19 |
| Belgium | 02 757 00 20 | 02 757 03 11 |
| Brazil | 011 288 3336 | 011 288 8528 |
| Canada (Ontario) | 905 785 0085 | 905 785 0086 |
| Canada (Québec) | 514 694 8521 | 514 694 4399 |
| Denmark | 45 76 26 00 | 45 76 26 02 |
| Finland | 09 725 725 11 | 09 725 725 55 |
| France | 01 48 14 24 24 | 01 48 14 24 14 |
| Germany | 089 741 31 30 | 089 714 60 35 |
| Hong Kong | 2645 3186 | 2686 8505 |
| Israel | 03 6120092 | 03 6120095 |
| 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 |
| Switzerland | 056 200 51 51 | 056 200 51 55 |
| Taiwan | 02 377 1200 | 02 737 4644 |
| United Kingdom | 01635 523545 | 01635 523154 |
| United States | 512 795 8248 | 512 794 5678 |

# 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 (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:_____________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

# SCXI-1104 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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Interrupt level of hardware ______________________________

DMA channels of hardware ______________________________

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Base I/O address of other boards ______________________________

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Interrupt level of other boards ______________________________

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Computer make and model ______________________________

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Base I/O address of other boards ______________________________

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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-1104 User Manual*

**Edition Date:** September 1998

**Part Number:** 322147A-01

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

______________________________________________________________________________

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

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Thank you for your help.

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# Glossary

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

## Numbers/Symbols

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

## A

| | |
|---|---|
| A | amperes |
| AC | alternating current |
| ACH | analog input channel signal |
| 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 |
| AIGND | analog input ground signal |
| AOGND | analog output ground signal |
| AWG | American Wire Gauge |
| B | |
| BCD | binary-coded decimal |
| 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 |
| CE | card enable signal |
| 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. |
| CJSENSOR | cold-junction sensor |
| CLK | clock input signal |
| CMOS | complementary metallic oxide semiconductor |
| CMRR | common-mode rejection ratio |

# D

| | |
|---|---|
| D/A | digital-to-analog |
| 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 |
| DAQD*/A | data acquisition digital to analog signal |
| dB | decibel—the unit for expressing a logarithmic measure of the ratio of two signal levels: dB=20log10 V1/V2, for signals in volts |
| DC | direct current |
| device | a plug-in data acquisition board, card, or pad that can contain multiple channels and conversion devices. Plug-in boards, PC cards, and devices such as the DAQPad-1200, which connects to your computer parallel port, are all examples of DAQ devices. SCXI modules are distinct from devices, with the exception of the SCXI-1200, which is a hybrid. |
| DGND | digital ground signal |
| DIFF | differential configuration |
| differential input | an analog input consisting of two terminals, both of which are isolated from computer ground, whose difference is measured |
| DIN | Deutsche Industrie Norme |
| DLL | dynamic-link library |
| DMA | direct memory access—a method by which data can be transferred to/from computer memory from/to a device or memory on the bus while the processor does something else. DMA is the fastest method of transferring data to/from computer memory. |
| DMM | digital multimeter |
| DNL | differential nonlinearity—a measure in LSB of the worst-case deviation of code widths from their ideal value of 1 LSB |

| | |
|---|---|
| DOUT | digital output signal |
| drivers/driver software | software that controls a specific hardware device such as a DAQ device |

## E

| | |
|---|---|
| EEPROM | electrically erasable programmable read-only memory—ROM that can be erased with an electrical signal and reprogrammed |
| EISA | Extended Industry Standard Architecture |
| ESP | Engineering Software Package |
| EXTCONV | external control signal to trigger A/D conversions |
| EXTINT | external interrupt signal |

## F

| | |
|---|---|
| F | farads |
| FIFO | first-in first-out memory buffer—the first data stored is the first data sent to the acceptor. FIFOs are often used on DAQ devices to temporarily store incoming or outgoing data until that data can be retrieved or output. For example, an analog input FIFO stores the results of A/D conversions until the data can be retrieved into system memory, a process that requires the servicing of interrupts and often the programming of the DMA controller. This process can take several milliseconds in some cases. During this time, data accumulates in the FIFO for future retrieval. With a larger FIFO, longer latencies can be tolerated. In the case of analog output, a FIFO permits faster update rates, because the waveform data can be stored on the FIFO ahead of time. This again reduces the effect of latencies associated with getting the data from system memory to the DAQ device. |
| ft | feet |

## G

| | |
|---|---|
| G | gain |
| GATE | gate input signal |

## H

| | |
|---|---|
| hex | hexadecimal |
| Hz | hertz—the number of scans read or updates written per second |

## I

| | |
|---|---|
| in. | inches |
| indirect scanning | The measurement that occurs when a signal passes on the SCXIbus from the scanned SCXI module to the cabled SCXI module |
| I/O | input/output—the transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces |
| ISA | Industry Standard Architecture |

## L

| | |
|---|---|
| LED | light-emitting diode |
| LSB | least significant bit |

## M

| | |
|---|---|
| MB | megabytes of memory |
| MSB | most significant bit |

## N

| | |
|---|---|
| NC | not connected (signal) |
| NRSE | nonreferenced single-ended mode—all measurements are made with respect to a common (NRSE) measurement system reference, but the voltage at this reference can vary with respect to the measurement system ground |

# O

| | |
|---|---|
| OUT | output signal |
| OUTREF | output reference signal |

# P

| | |
|---|---|
| PCMCIA | an expansion bus architecture that has found widespread acceptance as a de facto standard in notebook-size computers. It originated as a specification for add-on memory cards written by the Personal Computer Memory Card International Association. |

# R

| | |
|---|---|
| RAM | random-access memory |
| RMA | Return Material Authorization |
| rms | root mean square—the square root of the average value of the square of the instantaneous signal amplitude; a measure of signal amplitude |
| RSVD | reserved bit |
| RTSI bus | real-time system integration bus—the National Instruments timing bus that connects DAQ devices directly, by means of connectors on top of the boards, for precise synchronization of functions |

# S

| | |
|---|---|
| S | samples |
| s | seconds |
| SCANCLK | scan clock signal |
| SCXI | Signal Conditioning eXtensions for Instrumentation—the National Instruments product line for conditioning low-level signals within an external chassis near sensors so only high-level signals are sent to DAQ devices in the noisy PC environment |
| SERCLK | serial clock signal |

| | |
|---|---|
| SERDATIN | serial data input signal |
| SERDATOUT | serial data output signal |
| signal conditioning | the manipulation of signals to prepare them for digitizing |
| SLOT0SEL* | Slot 0 select signal |

# T

| | |
|---|---|
| TTL | transistor-transistor logic |

# V

| | |
|---|---|
| V | volts |
| VCC | positive supply voltage from the PCMCIA bus (usually +5V) |
| VDC | volts, direct current |
| VI | virtual instrument—(1) a combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument (2) a LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program |
| $V_{IH}$ | volts, input high |
| $V_{IL}$ | volts, input low |
| $V_{in}$ | volts in |
| $V_{OH}$ | volts, output high |
| $V_{OL}$ | volts, output low |

# Index

## Numbers



## A



## B



## C



## D



## E



## F



## G

## I



## L



## M



## N



## O



## P



## R



## S

## T



## U



## V