

# SCXI™

---

## SCXI-1540 User Manual

8-Channel LVDT Signal Conditioner

## **Worldwide Technical Support and Product Information**

www.ni.com

### **National Instruments Corporate Headquarters**

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

### **Worldwide Offices**

Australia 03 9879 5166, Austria 0662 45 79 90 0, Belgium 02 757 00 20, Brazil 011 284 5011,  
Canada (Calgary) 403 274 9391, Canada (Ontario) 905 785 0085, Canada (Québec) 514 694 8521,  
China 0755 3904939, Denmark 45 76 26 00, Finland 09 725 725 11, France 01 48 14 24 24,  
Germany 089 741 31 30, Greece 30 1 42 96 427, Hong Kong 2645 3186, India 91805275406,  
Israel 03 6120092, Italy 02 413091, Japan 03 5472 2970, Korea 02 596 7456, Mexico (D.F.) 5 280 7625,  
Mexico (Monterrey) 8 357 7695, Netherlands 0348 433466, New Zealand 09 914 0488, Norway 32 27 73 00,  
Poland 0 22 528 94 06, Portugal 351 1 726 9011, Singapore 2265886, Spain 91 640 0085,  
Sweden 08 587 895 00, Switzerland 056 200 51 51, Taiwan 02 2528 7227, United Kingdom 01635 523545

For further support information, see the *Technical Support Resources* appendix. To comment on the documentation, send e-mail to [techpubs@ni.com](mailto:techpubs@ni.com)

© Copyright 2000 National Instruments Corporation. All rights reserved.

# Important Information

---

## Warranty

The SCXI-1540 is warranted against defects in materials and workmanship for a period of one year from the date of shipment, as evidenced by receipts or other documentation. National Instruments will, at its option, repair or replace equipment that proves to be defective during the warranty period. This warranty includes parts and labor.

The media on which you receive National Instruments software are warranted not to fail to execute programming instructions, due to defects in materials and workmanship, for a period of 90 days from date of shipment, as evidenced by receipts or other documentation. National Instruments will, at its option, repair or replace software media that do not execute programming instructions if National Instruments receives notice of such defects during the warranty period. National Instruments does not warrant that the operation of the software shall be uninterrupted or error free.

A Return Material Authorization (RMA) number must be obtained from the factory and clearly marked on the outside of the package before any equipment will be accepted for warranty work. National Instruments will pay the shipping costs of returning to the owner parts which are covered by warranty.

National Instruments believes that the information in this document is accurate. The document has been carefully reviewed for technical accuracy. In the event that technical or typographical errors exist, National Instruments reserves the right to make changes to subsequent editions of this document without prior notice to holders of this edition. The reader should consult National Instruments if errors are suspected. In no event shall National Instruments be liable for any damages arising out of or related to this document or the information contained in it.

EXCEPT AS SPECIFIED HEREIN, NATIONAL INSTRUMENTS MAKES NO WARRANTIES, EXPRESS OR IMPLIED, AND SPECIFICALLY DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. CUSTOMER'S RIGHT TO RECOVER DAMAGES CAUSED BY FAULT OR NEGLIGENCE ON THE PART OF NATIONAL INSTRUMENTS SHALL BE LIMITED TO THE AMOUNT THEREFORE PAID BY THE CUSTOMER. NATIONAL INSTRUMENTS WILL NOT BE LIABLE FOR DAMAGES RESULTING FROM LOSS OF DATA, PROFITS, USE OF PRODUCTS, OR INCIDENTAL OR CONSEQUENTIAL DAMAGES, EVEN IF ADVISED OF THE POSSIBILITY THEREOF. This limitation of the liability of National Instruments will apply regardless of the form of action, whether in contract or tort, including negligence. Any action against National Instruments must be brought within one year after the cause of action accrues. National Instruments shall not be liable for any delay in performance due to causes beyond its reasonable control. The warranty provided herein does not cover damages, defects, malfunctions, or service failures caused by owner's failure to follow the National Instruments installation, operation, or maintenance instructions; owner's modification of the product; owner's abuse, misuse, or negligent acts; and power failure or surges, fire, flood, accident, actions of third parties, or other events outside reasonable control.

## Copyright

Under the copyright laws, this publication may not be reproduced or transmitted in any form, electronic or mechanical, including photocopying, recording, storing in an information retrieval system, or translating, in whole or in part, without the prior written consent of National Instruments Corporation.

## Trademarks

BridgeVIEW™, CVI™, ComponentWorks™, LabVIEW™, Measure™, National Instruments™, ni.com™, NI-DAQ™, PXI™, SCXI™, and VirtualBench™ are trademarks of National Instruments Corporation.

Product and company names mentioned herein are trademarks or trade names of their respective companies.

## WARNING REGARDING USE OF NATIONAL INSTRUMENTS PRODUCTS

(1) NATIONAL INSTRUMENTS PRODUCTS ARE NOT DESIGNED WITH COMPONENTS AND TESTING FOR A LEVEL OF RELIABILITY SUITABLE FOR USE IN OR IN CONNECTION WITH SURGICAL IMPLANTS OR AS CRITICAL COMPONENTS IN ANY LIFE SUPPORT SYSTEMS WHOSE FAILURE TO PERFORM CAN REASONABLY BE EXPECTED TO CAUSE SIGNIFICANT INJURY TO A HUMAN.

(2) IN ANY APPLICATION, INCLUDING THE ABOVE, RELIABILITY OF OPERATION OF THE SOFTWARE PRODUCTS CAN BE IMPAIRED BY ADVERSE FACTORS, INCLUDING BUT NOT LIMITED TO FLUCTUATIONS IN ELECTRICAL POWER SUPPLY, COMPUTER HARDWARE MALFUNCTIONS, COMPUTER OPERATING SYSTEM SOFTWARE FITNESS, FITNESS OF COMPILERS AND DEVELOPMENT SOFTWARE USED TO DEVELOP AN APPLICATION, INSTALLATION ERRORS, SOFTWARE AND HARDWARE COMPATIBILITY PROBLEMS, MALFUNCTIONS OR FAILURES OF ELECTRONIC MONITORING OR CONTROL DEVICES, TRANSIENT FAILURES OF ELECTRONIC SYSTEMS (HARDWARE AND/OR SOFTWARE), UNANTICIPATED USES OR MISUSES, OR ERRORS ON THE PART OF THE USER OR APPLICATIONS DESIGNER (ADVERSE FACTORS SUCH AS THESE ARE HEREAFTER COLLECTIVELY TERMED "SYSTEM FAILURES"). ANY APPLICATION WHERE A SYSTEM FAILURE WOULD CREATE A RISK OF HARM TO PROPERTY OR PERSONS (INCLUDING THE RISK OF BODILY INJURY AND DEATH) SHOULD NOT BE RELIANT SOLELY UPON ONE FORM OF ELECTRONIC SYSTEM DUE TO THE RISK OF SYSTEM FAILURE. TO AVOID DAMAGE, INJURY, OR DEATH, THE USER OR APPLICATION DESIGNER MUST TAKE REASONABLY PRUDENT STEPS TO PROTECT AGAINST SYSTEM FAILURES, INCLUDING BUT NOT LIMITED TO BACK-UP OR SHUT-DOWN MECHANISMS. BECAUSE EACH END-USER SYSTEM IS CUSTOMIZED AND DIFFERS FROM NATIONAL INSTRUMENTS' TESTING PLATFORMS AND BECAUSE A USER OR APPLICATION DESIGNER MAY USE NATIONAL INSTRUMENTS PRODUCTS IN COMBINATION WITH OTHER PRODUCTS IN A MANNER NOT EVALUATED OR CONTEMPLATED BY NATIONAL INSTRUMENTS, THE USER OR APPLICATION DESIGNER IS ULTIMATELY RESPONSIBLE FOR VERIFYING AND VALIDATING THE SUITABILITY OF NATIONAL INSTRUMENTS PRODUCTS WHENEVER NATIONAL INSTRUMENTS PRODUCTS ARE INCORPORATED IN A SYSTEM OR APPLICATION, INCLUDING, WITHOUT LIMITATION, THE APPROPRIATE DESIGN, PROCESS AND SAFETY LEVEL OF SUCH SYSTEM OR APPLICATION.

# Compliance

---

## FCC/Canada Radio Frequency Interference Compliance\*

### Determining FCC Class

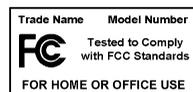
The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations).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

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

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

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

Consult the FCC web site <http://www.fcc.gov> for more information.



### FCC/DOC Warnings

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

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

### Class A

#### Federal Communications Commission

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

#### Canadian Department of Communications

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

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

### Class B

#### Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful

interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

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

### **Canadian Department of Communications**

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

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

### **European Union - Compliance to EEC Directives**

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

\* Certain exemptions may apply in the USA, see FCC Rules §15.103 **Exempted devices**, and §15.105(c). Also available in sections of CFR 47.

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

# Conventions

---

The following conventions are used in this manual:

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



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



This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.

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

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

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

**`monospace bold`** Bold text in this font denotes the messages and responses that the computer automatically prints to the screen. This font also emphasizes lines of code that are different from the other examples.

# Contents

---

## Chapter 1

### Installing and Configuring the SCXI-1540

Introduction.....	1-1
About the SCXI-1540.....	1-1
LVDTs, RVDTs, and Resolvers.....	1-2
SCXI-1540 Theory of Operation.....	1-4
Installing the Software.....	1-6
Installing the SCXI-1540.....	1-7
Unpacking.....	1-7
Installing the SCXI-1540 Module into the SCXI Chassis.....	1-7
Connecting the SCXI-1540 to a DAQ Device for Multiplexed Scanning in an SCXI Chassis.....	1-9
Connecting the SCXI-1540 to a DAQ Device for Multiplexed Scanning in a PXI Combination Chassis.....	1-10
Configuration and Self-Test.....	1-11
Auto-Detecting Modules.....	1-12
Manually Adding Modules.....	1-13
Configuring the SCXI-1540.....	1-14
Self-Test Verification.....	1-14
SCXI-1540 Configuration Settings.....	1-15
Gain.....	1-15
Excitation Level.....	1-16
Excitation Frequency.....	1-16
Wire Mode.....	1-16
External Synchronization.....	1-17
Troubleshooting Self-Test Verification.....	1-17
Removing the SCXI-1540.....	1-18
Removing the SCXI-1540 from an SCXI Chassis.....	1-18
Removing the SCXI-1540 from Measurement & Automation Explorer.....	1-19

## Chapter 2

### Using the SCXI-1540

Making Signal Connections.....	2-1
Pin Assignment.....	2-2
Connecting to LVDTs and RVDTs.....	2-3
Synchronizing Channels.....	2-4
Connecting to Resolvers.....	2-6
Operating in Multiplexed Mode.....	2-6

Theory of Multiplexed Hardware Operation .....	2-7
Using Software for Multiplexed Scanning.....	2-8
LabVIEW and the SCXI Channel String.....	2-9
LabVIEW and the Virtual Channel String .....	2-10
Performing a Multiplexed Scan .....	2-11
C and Low-Level DAQ Functions.....	2-12
Scaling LVDT and RVDT Data Using the SCXI-1540 .....	2-12
Converting Resolver Data to Angular Position .....	2-13
Calibration .....	2-14
Calibration Procedures .....	2-14
Calibration Using LabVIEW or a C-Based ADE .....	2-14

## **Appendix A Specifications**

## **Appendix B Accessories**

## **Appendix C Connectors**

## **Appendix D Common Questions**

## **Appendix E Technical Support Resources**

## **Glossary**

## **Index**

## Figures

Figure 1-1.	Cut-Away View of an LVDT .....	1-2
Figure 1-2.	LVDT Core Locations with Resulting Induced Voltage and Phase.....	1-3
Figure 1-3.	SCXI-1540 Block Diagram .....	1-5
Figure 1-4.	Installing the SCXI-1540 Module .....	1-8
Figure 1-5.	Connecting an SCXI Chassis to a DAQ Device.....	1-10
Figure 1-6.	Removing the SCXI-1540 .....	1-19
Figure 2-1.	Front Signal Connector .....	2-2
Figure 2-2.	4-Wire Connection to an LVDT or RVDT .....	2-3
Figure 2-3.	5-Wire Connection to an LVDT or RVDT .....	2-3
Figure 2-4.	Multiple Channel Synchronization.....	2-5
Figure 2-5.	Resolver Connection .....	2-6
Figure 2-6.	Rear Signal Connector Pin Assignment .....	2-8

## Tables

Table 2-1.	NI-DAQ Functions Used to Configure SCXI-1540 .....	2-12
Table A-1.	Input Range, Gain, and Required DAQ Device Limits.....	A-1
Table A-2.	Absolute System Accuracy .....	A-4
Table B-1.	Accessories Available for the SCXI-1540 .....	B-1
Table D-1.	Digital Signals on the SCXI-1540.....	D-2

---

# Installing and Configuring the SCXI-1540

## Introduction

---

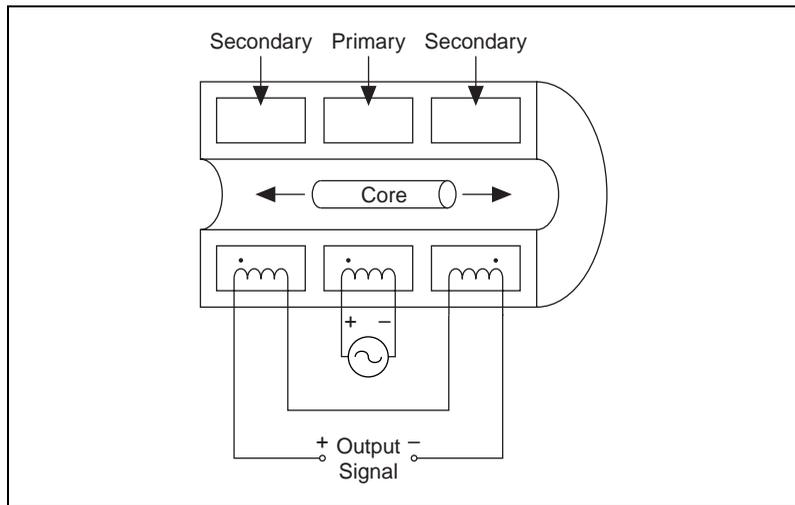
This section provides an introduction to the SCXI-1540 module, and to linear variable differential transformers (LVDTs), rotary variable differential transformers (RVDTs), and resolvers.

### About the SCXI-1540

The SCXI-1540 module is an eight-channel module for interfacing with industry-standard LVDTs, RVDTs, and resolvers. It can accommodate a 4-wire or 5-wire connection to an LVDT, and can synchronize any number of channels to a common frequency. You can set the excitation level at  $1 V_{\text{rms}}$  or  $3 V_{\text{rms}}$  at a frequency of 2.5, 3.3, 5, or 10 kHz. You can set the gain over the range 0.8X to 25X to handle a wide range of LVDT sensitivities. Gain, level, frequency, and wire mode are set on a per-channel basis without the use of jumpers. The SCXI-1540 is configured using Measurement & Automation Explorer or through function calls to NI-DAQ.

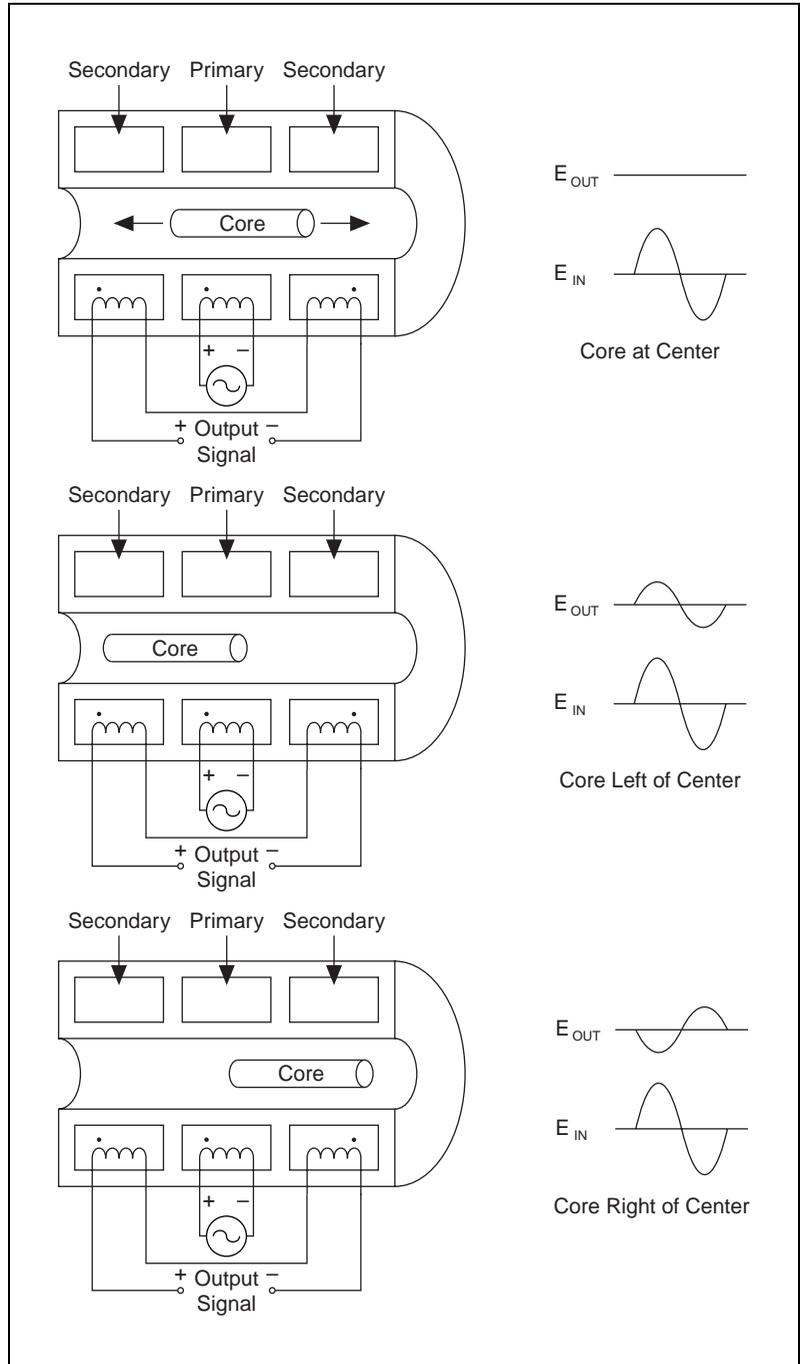
## LVDTs, RVDTs, and Resolvers

An LVDT is a device for measuring linear position. Figure 1-1 shows a cut-away view of an LVDT.



**Figure 1-1.** Cut-Away View of an LVDT

The primary winding, located at center, is excited with a sine-wave voltage. The resulting magnetic field is coupled through the movable core into the secondary windings located on either side of the primary. With the core at center, both secondaries have the same induced voltage. With the series connection and polarity shown, the resulting output signal is zero. If the core moves to the left, the left secondary is more strongly coupled to the primary than the right secondary, resulting in a stronger induced voltage in the left secondary and an output signal that is in phase with the primary excitation voltage. The more the core moves off center, the stronger the imbalance and the greater the output signal. Moving the core to the left of center results in the same behavior, but with the output signal out of phase with the excitation signal. Figure 1-2 shows these core locations and the resulting induced voltage and phase.



**Figure 1-2.** LVDT Core Locations with Resulting Induced Voltage and Phase

LVDTs are frequently used in applications where ruggedness, operation over large temperature ranges, insensitivity to contamination, or long life are important considerations. They are extremely reliable in harsh conditions.

An RVDT is simply the rotational version of an LVDT. The angular measurement range of typical RVDTs is between  $\pm 30^\circ$  and  $\pm 70^\circ$ .

Resolvers are similar to RVDTs, but employ secondaries at right angles that produce two simultaneous signal voltages proportional to the sine and cosine of the shaft angle. Thus, resolvers can measure over  $360^\circ$  of rotation and do not need to pass through  $0^\circ$  before making absolute position measurements, as is required by quadrature encoders.

Like LVDTs and RVDTs, resolvers are advantageous in hostile operating environments. Resolvers are often easier to use than RVDTs. You can originate the  $0^\circ$  position arbitrarily in software without the need to physically rotate the sensor into position. Since all that is needed to convert measured voltages to degrees is an arctangent function, there are no scaling considerations.

## SCXI-1540 Theory of Operation

Figure 1-3 is a block diagram of the SCXI-1540. Each channel has an oscillator that generates a sine wave signal at a user-selected frequency between 2.5 and 10 kHz. The oscillator signal passes through an amplifier with a gain of 1 or 1/3, depending upon the configuration setting of  $3 V_{\text{rms}}$  or  $1 V_{\text{rms}}$  respectively. If external synchronization is not enabled, the excitation signal is routed to the output buffer and then to the front signal connector pins EX+ and EX-. The output buffers are power amplifiers with a very low output impedance used for differentially driving an LVDT. EX- is  $180^\circ$  out of phase with EX+ so that a balanced signal is available to the LVDT secondary. If external synchronization is enabled, the buffered output signal to EX+ and EX- is obtained from the SYNC terminal on the front signal connector. This terminal connects to the EX+ terminal of a different channel that serves as master. Thus the frequency and phase of all slave channels are forced to be the same as the master. The level settings pass from the master to the slaves. Changing the level settings of the slave channels has no effect.



The LVDT returns a signal whose phase and amplitude is related to the position of the movable core. The return signal connects across the CH+ and CH- terminals on the front signal connector. In normal operation, this signal passes through the input selection switch to the differential amplifier where the common-mode signal on the input wires is rejected. The signal then passes to a variable gain stage that is set to a gain that best covers the expected signal range for the particular LVDT in use. The signal then passes to a block where it is multiplied by the excitation signal. The output of the multiplier is the product of two sine waves at the same frequency. Two signals result—a DC signal proportional to input magnitude or, equivalently, LVDT core position, and a double-frequency signal. The lowpass filter removes the double-frequency signal. Only the DC signal passes through, which is the final output signal for the particular channel. The analog multiplexer routes a particular channel output to either the SCXIbus connector or the rear signal connector. The SCXI-1540 features random scanning, meaning you can scan channels in any order.

The input selector switch allows calibration software to disconnect the differential amplifier from the front signal connector and reconnect it to the ground or excitation signal at either phase. It is therefore possible to calibrate gain and offset of the module with the module deployed in a test setup. You need not remove the field wiring. Calibration constants are stored in an onboard EEPROM and automatically used by LabVIEW or the NI-DAQ function `SCXI_Scale`.

## Installing the Software

---

You can control the SCXI-1540 in an application development environment (ADE) using NI-DAQ. The supported ADEs include LabVIEW, BridgeVIEW, LabWindows/CVI, Visual Basic (ComponentWorks), C, and C++ environments. You can also use the SCXI-1540 in conjunction with VirtualBench and Measure. Follow these instructions to install your SCXI-1540 software:

1. Install your ADE if you have not already done so. National Instruments ADEs have release notes containing software installation instructions.
2. Install the NI-DAQ software that came with your DAQ device. NI-DAQ version 6.7 or higher is required to configure and program your SCXI-1540 module. If you do not have NI-DAQ version 6.7 or higher, you can either contact a National Instruments sales

representative or download the latest NI-DAQ version from the National Instruments web site, [www.ni.com](http://www.ni.com).

- a. If you have the required version of NI-DAQ, insert your National Instruments NI-DAQ software CD into the CD-ROM drive.
- b. Click on the **Install NI-DAQ Software** option in the installation window. The installer guides you through the rest of the installation process.

## Installing the SCXI-1540

---

The following section describes how to install your SCXI-1540 for use with SCXI chassis and National Instruments DAQ devices.

### Unpacking

Your SCXI-1540 module is shipped in an antistatic package to prevent electrostatic damage to the module. Electrostatic discharge can damage several components in the module. To avoid damaging the module, take the following precautions:

- Ground yourself using 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.

### Installing the SCXI-1540 Module into the SCXI Chassis

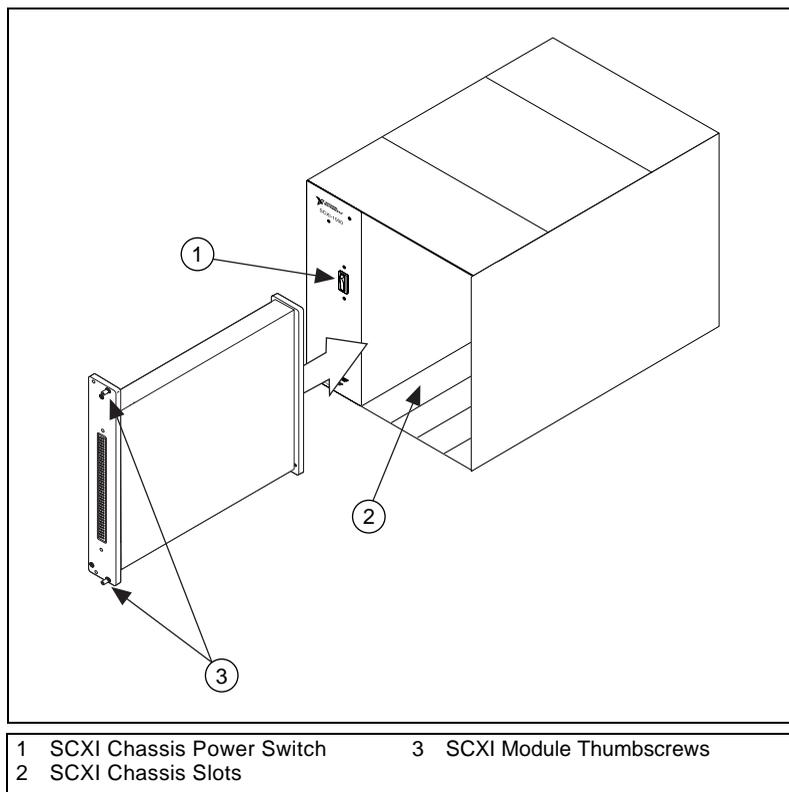
You need the following items to complete the installation:

- SCXI-1540
- SCXI chassis or PXI combination chassis
- 1/4 in. flathead screwdriver

To install your SCXI-1540 module into the SCXI chassis, follow these steps while referring to Figure 1-4:

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-1540 module into a chassis that is turned on.
3. Insert the SCXI-1540 into an open slot in the SCXI chassis. Gently guide the module into the slot guides and push it toward the back of the chassis until the front face of the module is flush with the front of the chassis.
4. Insert any other SCXI modules into the remaining slots in the same manner as described in step 3.
5. Secure all the SCXI modules to the SCXI chassis using both thumbscrews.



**Figure 1-4.** Installing the SCXI-1540 Module

To complete your SCXI-1540 installation, follow the procedure in the appropriate sections that follow.

## Connecting the SCXI-1540 to a DAQ Device for Multiplexed Scanning in an SCXI Chassis

In this configuration, you can multiplex all eight input channels of the SCXI-1540 into a single channel of your DAQ device. You need the following items for this installation:

- SCXI chassis with the SCXI modules installed
- SCXI cable assembly, which consists of a cable adapter and a cable
- An installed National Instruments DAQ device
- 1/4 in. flathead screwdriver

Consult your SCXI chassis documentation, other SCXI module documentation, and DAQ device documentation for additional instructions and warnings. You should have already installed your SCXI-1540 module and any other SCXI modules in the chassis according to their installation instructions. You must select one of the analog input modules in the chassis as the cabled module, the module to which the SCXI cable assembly will connect. If the chassis contains at least one simultaneous-sampling module, such as the SCXI-1140 or SCXI-1530/1531, select it as the cabled module; otherwise, select one of the remaining analog input modules. To connect the chassis to a DAQ device for multiplexed operation, complete the following steps while referring to Figure 1-5:

1. Turn off the SCXI chassis and the computer that contains the DAQ device.
2. Insert the cable adapter into the back of the SCXI chassis aligned with the module that you intend to connect to the DAQ device. See the installation guide for your cable assembly for more information.
3. Connect the cable to the back of the cable adapter, ensuring that the cable fits securely.
4. Connect the other end of the cable to the DAQ device you will use to control the SCXI system.
5. Check the cable installation, making sure the connectors are securely fastened at both ends.
6. Turn on the SCXI chassis.
7. Turn on the computer.

If you have already installed the appropriate software, refer to [Configuration and Self-Test](#) to configure the SCXI-1540 module(s) for multiplexed mode operation.

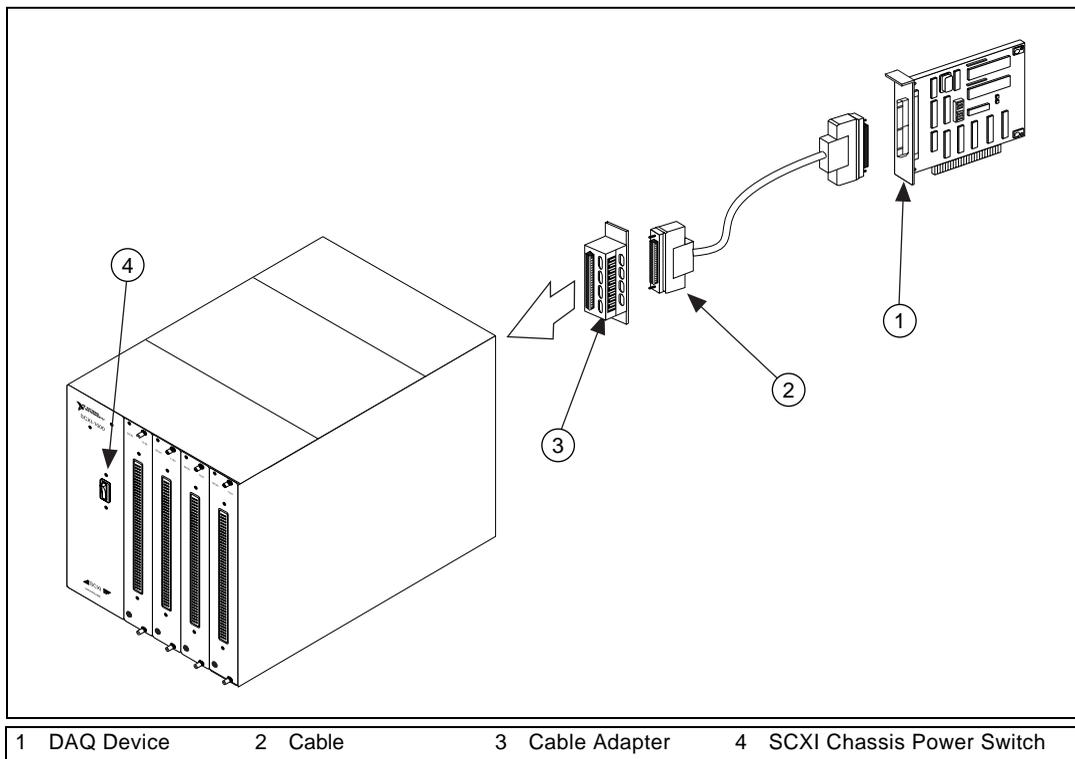


Figure 1-5. Connecting an SCXI Chassis to a DAQ Device

## Connecting the SCXI-1540 to a DAQ Device for Multiplexed Scanning in a PXI Combination Chassis

In this configuration, you can multiplex all eight channels of your SCXI-1540 into a single channel of your DAQ device in a combination PXI chassis. You need the following items for this installation:

- PXI combination chassis with the SCXI modules installed
- National Instruments PXI MIO DAQ device installed in the right-most slot

Consult your PXI chassis documentation, other SCXI module documentation, and DAQ device documentation for additional instructions and warnings. You should have already installed your SCXI-1540 module and any other SCXI modules in the chassis according to their installation instructions. To use the SCXI-1540 module in multiplexed mode with a DAQ device in a PXI combination chassis, follow these steps:

1. No cables are required between the SCXI-1540 and the DAQ device if the National Instruments PXI DAQ device is installed in the right-most slot. You can configure this device to control the SCXI system using an internal bus that connects the PXI chassis to the SCXI chassis. If the DAQ device for controlling the SCXI system is not installed in the right-most slot of the PXI combination chassis, assemble the system as described in [Connecting the SCXI-1540 to a DAQ Device for Multiplexed Scanning in an SCXI Chassis](#).
2. Turn on the SCXI chassis.

If you have already installed the appropriate software, see *Configuration and Self-Test* to configure the SCXI-1540 for multiplexed mode operation.

## Configuration and Self-Test

---

Run Measurement & Automation Explorer to configure and test your SCXI-1540. If you need help during the configuration process, open the Measurement & Automation Help file by selecting **Help Topics** from the **Help** menu. Follow these steps to configure your SCXI system:

1. Double-click the **Measurement & Automation Explorer** icon on your desktop. Click the + next to the **Devices and Interfaces** icon. If you added new modules to an existing chassis, go to step 4. If you inserted modules into an empty chassis, go to step 2.
2. Add a new chassis to the configured devices and interfaces by holding down the right mouse button on **Devices and Interfaces** and selecting **Insert**. Select the appropriate chassis from the list box and click **OK**.
3. Configure the chassis by selecting a **Chassis ID**. This is an integer value you choose to uniquely identify the chassis for programming and scanning. Select the **Chassis Address**. This is needed to address the chassis in a multichassis SCXI system. Unless you are using multiple chassis with the same DAQ device, select a Chassis Address of zero, which is the factory-default setting of all SCXI chassis. If you are using multiple chassis, refer to your SCXI chassis user manual for further information. For remote SCXI chassis, you also need to select the **Baud Rate** and **COM Port**. After completing the chassis configuration, click **Next**.

4. You now have the choice of automatically detecting which modules are installed in the chassis or manually adding them.
  - If you have just added the chassis to **Devices and Interfaces** and are using an E Series or 1200 DAQ device, you can automatically detect the modules.
  - If the chassis was already listed in **Devices and Interfaces**, you must add new modules manually.

Go to the appropriate following section to continue the software configuration of your chassis.

## Auto-Detecting Modules

If you selected auto-detect, your chassis must be connected to your DAQ device, except in the case of a remote chassis, which you connect to the computer using a serial port cable.

Before auto-detecting modules, follow the steps in [Configuration and Self-Test](#).

To auto-detect your SCXI module(s), follow these steps:

1. Make sure the chassis is turned on.
2. Select **Yes** under **Auto-Detect modules** and click **Next**. If your chassis is a remote SCXI chassis, go to step 5, otherwise go to step 3.
3. Select your communication path and click **Next**.
4. If modules were detected, select the module connected to your DAQ device as your communication path.
5. Click **Finish**.

Your Measurement & Automation Explorer software should now recognize your SCXI chassis and SCXI module(s). If the software did not recognize your modules, check your cable connections and retry auto-detecting, or try installing the modules manually before taking troubleshooting measures. If the software recognized any module as an SCXI custom module, you may be using the an old version of NI-DAQ. If you do not have NI-DAQ version 6.7 or higher, you can either contact a National Instruments sales representative or download the latest NI-DAQ version from the National Instruments web site, [www.ni.com](http://www.ni.com).

## Manually Adding Modules

If you did not auto-detect your SCXI modules, you must add each of your modules separately. If you are still in the Chassis Configuration window, select **No** under **Auto-Detect modules** and click **Finish**. Use the following steps to manually add modules:

1. Display the list of devices and interfaces by clicking the + next to the **Devices and Interfaces** icon.
2. The chassis you selected is displayed in the list. Display the list of modules in the chassis by clicking the + next to the **Chassis** icon.
3. Right-click on the appropriate installation slot and click **Insert**.
4. Select the module installed in that slot and click **Next**. If the appropriate module name does not appear on the list, you may be using the an old version of NI-DAQ. If you do not have NI-DAQ version 6.7 or higher, you can either contact a National Instruments sales representative or download the latest NI-DAQ version from the National Instruments Web site, [www.ni.com](http://www.ni.com).
5. Configure your module as follows:
  - a. If the selected module is connected to a National Instruments DAQ device, select that device by using the **Connected to control**. If it is not, select **none**. If you want this DAQ device to control the chassis, confirm that there is a check in the checkbox labeled **This device will control the chassis**.
  - b. Select the appropriate gain, level, frequency, and wire mode setting for each channel on the SCXI-1540 (refer to [SCXI-1540 Configuration Settings](#) for a detailed description of each setting). Click **Next**.
  - c. Select the terminal block you are using for this module. When you have completed configuration, click **Finish**.

If you need to manually install more SCXI-1540 modules in your chassis, repeat steps 3 through 5 to configure each module.

Your SCXI chassis and SCXI module(s) should now be configured properly. If you need to change your module configuration, see [Configuring the SCXI-1540](#). If your configuration is complete, test the system as described in [Self-Test Verification](#) to ensure your SCXI system is communicating properly with the DAQ device.

## Configuring the SCXI-1540

To configure your SCXI-1540 after auto-detection, or to alter your original configuration selections, you must use Measurement & Automation Explorer. Perform the following steps to configure your SCXI-1540:

1. Double-click the **Measurement & Automation Explorer** icon on your desktop.
2. Display the list of installed devices and interfaces by clicking the + next to the **Devices and Interfaces** icon.
3. Locate the SCXI chassis in the list. Display the list of modules in the chassis by clicking the + next to the **Chassis** icon.
4. Right-click on the SCXI-1540 module you want to configure and select **Properties**. Click on the **General** tab.
5. If the module you are configuring is connected to a National Instruments DAQ device, select that device by using the **Connected to** control. If you want this DAQ device to control the chassis, confirm there is a check in the checkbox labeled **This device will control the chassis**. If the module you are configuring is not connected to a National Instruments DAQ device, select **none**.
6. Click the **Channel** tab. Select the appropriate gain, level, frequency, synchronization, and wire mode setting for each channel on the SCXI-1540. Refer to *SCXI-1540 Configuration Settings* for a detailed description of each setting. Click **Next**.
7. Click the **Accessory** tab. Select the terminal block you are using for this module. When all of your configurations are completed, click **OK**.

Your SCXI chassis and SCXI module(s) should now be configured properly. You should now test the system in the appropriate section that follows to ensure your SCXI system is communicating properly with the DAQ device.

## Self-Test Verification

To test the successful configuration of your system, follow these steps after entering Measurement & Automation Explorer:

1. Verify that the chassis is on and is correctly connected to a DAQ device.
2. Display the list of Devices and Interfaces by clicking the + next to the **Devices and Interfaces** icon.

3. From the list that appears, locate the chassis you want to test. Right-click on the chassis and click **Test**.
4. If the communication test is successful, a message **The chassis has been verified** appears. Click **OK**.

Your SCXI system should now operate properly with your ADE software. If the test did not complete successfully, see [Troubleshooting Self-Test Verification](#) for troubleshooting steps.

## SCXI-1540 Configuration Settings

---

This section describes how to set the gain, excitation level, excitation frequency, wire mode, and external synchronization.

### Gain

If you will address an SCXI-1540 channel using a virtual channel name, see Chapter 2, [Using the SCXI-1540, LabVIEW and the Virtual Channel String](#). You need not set the gain since Measurement & Automation Explorer sets the gain for you. Otherwise, you should first determine the full-scale limits of the SCXI-1540 input signal using the following formula:

$$(V_{rms} \text{ full-scale range}) = (\text{excitation level}) \times (\text{sensor sensitivity}) \times (\text{sensor full-scale travel})$$

You then set the upper channel limit to this number and set the lower channel limit to the negative of this number. For example, if you are using an LVDT designed to measure  $\pm 0.3$  inches, the manufacturer specified sensitivity is 1.2 mV/V/mil, and the excitation voltage is set at 3  $V_{rms}$ , you obtain a full-scale input voltage of:

$$\pm 1.08 V_{rms} = (3 V_{rms}) \times ((0.0012 V_{rms}) / V_{rms} / \text{mil}) \times (\pm 300 \text{ mil})$$

You then set the upper and lower channel input limits to +1.08 V and -1.08 V, respectively. A mil is equal to 0.001 in.

If you are using an SCXI channel string in an application such as LabVIEW, Measure, or Visual Basic, you can set the channel gain indirectly by providing the quantity calculated above as a channel input-limit parameter (the channel input-limit parameter for **AI Config** in LabVIEW, for example). In this case, you need not enter or configure the gain when you use Measurement & Automation Explorer, since the gain is set automatically based on the channel input-limit parameter.

If you do not provide channel input limits in an application that uses SCXI channel strings, the gain the SCXI-1540 uses is the setting entered using Measurement & Automation Explorer.

If you are performing basic I/O in a C-based application, you must use the NI-DAQ function `SCXI_Set_Gain` to set the gain.

The formula for the gain setting is:

$$(\text{gain setting}) = (5 \text{ V}) / (V_{\text{rms}} \text{ full-scale range})$$

The maximum output swing of the SCXI-1540 is  $\pm 5$  VDC; therefore, the gain calculation is 5 V divided by the full-scale limit. *Gain*, in the case of the SCXI-1540, is defined as the module DC output voltage divided by the module AC input voltage where the input voltage is given in units of volts rms. You should choose the setting that is closest to the calculated value, but *less than the calculated value* so that the SCXI-1540 output does not attempt to go beyond  $\pm 5$  V at full scale.

## Excitation Level

You may set the excitation at 1 or 3  $V_{\text{rms}}$ . The higher setting is recommended in all applications except where the driven AC impedance is less than  $95 \Omega$  or where the sensor manufacturer recommends a lower excitation level.

## Excitation Frequency

You should select the frequency closest to that specified by the sensor manufacturer. The sensitivity of the sensor can vary considerably from the specified value if another excitation frequency is used.

## Wire Mode

Select 4-wire for 4-wire connections and 5-wire for 5-wire connections. Refer to [Connecting to LVDTs and RVDTs](#) in Chapter 2, [Using the SCXI-1540](#), for the advantages and disadvantages of each connection method.

## External Synchronization

Channels that are to be synchronized to the frequency and level of another channel must have external synchronization enabled. You must also make a wire connection between the SYNC terminal of the slaved channel and the EX+ terminal of the master channel. Refer to Figure 2-4, *Multiple Channel Synchronization*.

## Troubleshooting Self-Test Verification

---

If *Self-Test Verification* did not verify your chassis configuration, take the following steps to successfully complete system configuration:

1. If you get the warning message **Unable to test chassis at this time**, you have not designated at least one module as connected to a DAQ device. Return to *Configuring the SCXI-1540* and change the configuration of the cabled module in your system from **Connected to: None** to **Connected to: Device x**.
2. If you get the warning message **Failed to find** followed by the module codes and the message **Unable to communicate with chassis**, take the following troubleshooting actions:
  - a. Make sure the SCXI chassis is on.
  - b. Make sure the cable between the SCXI chassis and DAQ device is properly connected.
  - c. Inspect the cable connectors for bent pins.
  - d. Make sure you are using the correct National Instruments cable assembly.
  - e. Test your DAQ device to verify it is working properly. See your DAQ device user manual for more information.
3. If you get the warning message **Failed to find**, followed by module codes and the message **Instead found: module with ID 0x~~xx~~**, return to *Configuring the SCXI-1540* and make sure the correct module is in the specified slot. Delete the incorrect module as described in *Removing the SCXI-1540 from Measurement & Automation Explorer* and add the correct module as described in *Manually Adding Modules*.

4. If you get the warning message **Failed to find**, followed by a module code and the message **slot x is empty**, check to see if the configured module is installed in the specified slot. If not, install the module by referring to [Installing the SCXI-1540 Module into the SCXI Chassis](#). If the module is installed in the correct slot, turn off the chassis, remove the module as specified in [Removing the SCXI-1540 from an SCXI Chassis](#), and verify that no connector pins are bent on the rear signal connector. Reinstall the module as described in [Installing the SCXI-1540 Module into the SCXI Chassis](#), ensuring the module is fully inserted and properly aligned in the slot.
5. After checking the preceding items, return to [Self-Test Verification](#) and retest your SCXI chassis.

If these measures do not successfully configure your SCXI system, see Appendix D, [Common Questions](#), for more information.

## Removing the SCXI-1540

---

This section shows you how to remove the SCXI-1540 from an SCXI chassis.

### Removing the SCXI-1540 from an SCXI Chassis

You need the following items to complete this task:

- SCXI chassis or PXI combination chassis with the SCXI-1540 module installed
- 1/4 in. flathead screwdriver

Consult the documentation for your SCXI/PXI chassis and accessories for additional instructions and warnings. To remove the SCXI-1540 module from an SCXI chassis, take these steps while referring to Figure 1-6:

1. If the SCXI-1540 is the cabled module, disconnect the cable running from the SCXI-1540 to the DAQ device.
2. Remove any terminal block that connects to the SCXI-1540.
3. Turn off the SCXI chassis. Do *not* remove the SCXI-1540 module from a chassis that is turned on.
4. Rotate the thumbscrews that secure the SCXI-1540 to the chassis counter-clockwise until they are loose, but do not completely remove the thumbscrews.
5. Remove the SCXI-1540 by pulling steadily on both thumbscrews until the module slides completely out.

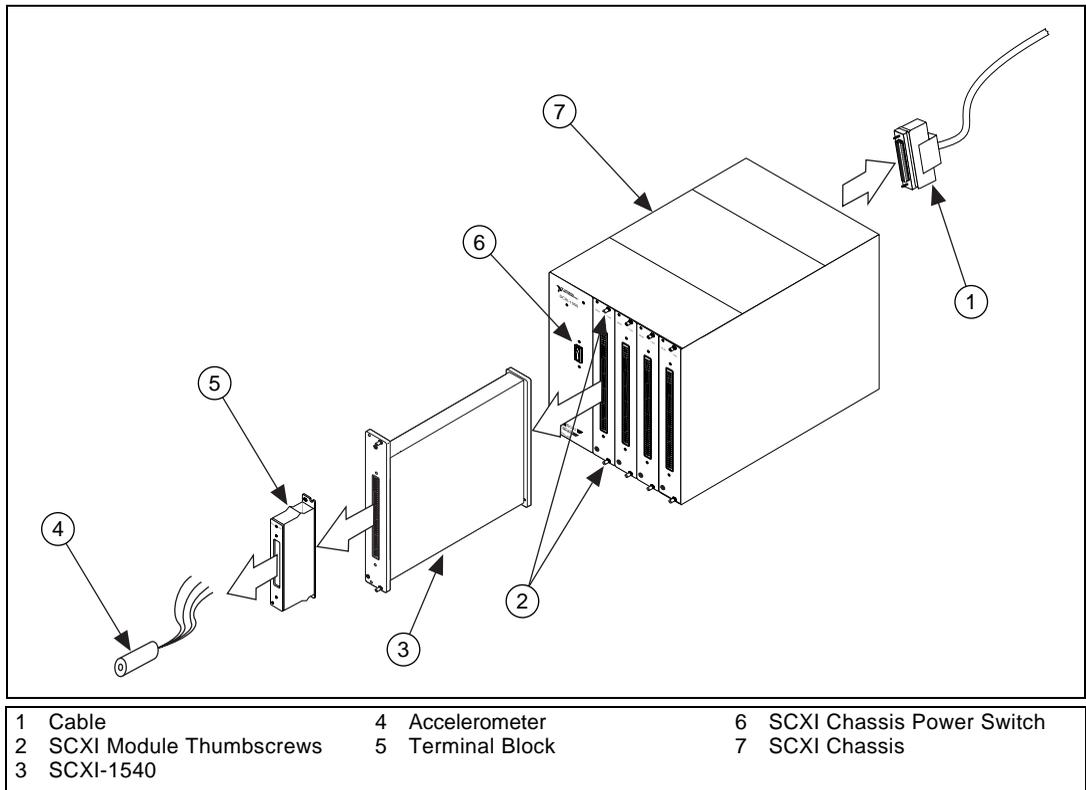


Figure 1-6. Removing the SCXI-1540

## Removing the SCXI-1540 from Measurement & Automation Explorer

To remove a module from Measurement & Automation Explorer, perform these steps after launching Measurement & Automation Explorer:

1. Display the list of installed devices and interfaces by clicking the + next to the **Devices and Interfaces** icon.
2. Locate the chassis in the list of installed devices. Display the list of modules in the chassis by clicking the + next to the **Chassis** icon.
3. Right-click on the module or chassis you want to delete and click **Delete**.
4. You will be presented a confirmation window. Click **Yes** to continue deleting the module or chassis or **No** to cancel this action.



**Note** Deleting the SCXI chassis deletes all modules in the chassis. All configuration information for these modules is also lost.

Your SCXI chassis and/or SCXI module(s) should now be removed from the list of installed devices in Measurement & Automation Explorer.

---

## Using the SCXI-1540

This chapter discusses how to take measurements using the SCXI-1540. Basic information regarding signal connection, channel set-up, and scanning is discussed, along with advanced topics such as synchronization of multiple channels and converting raw voltage data to position.

### Making Signal Connections

---

This section describes how to interface the SCXI-1540 with an LVDT, RVDT, or resolver.

## Pin Assignment

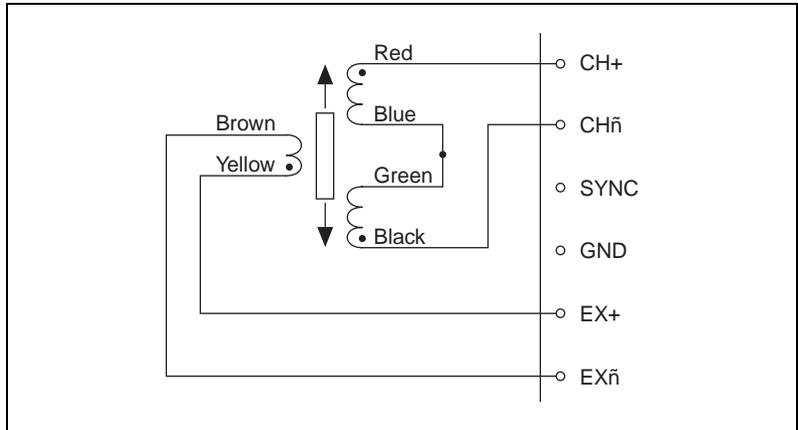
The pin assignment for the SCXI-1540 front signal connector is shown in Figure 2-1. Notice that the positive input terminal for each channel is in Column C and the negative input terminal is in Column B. The pins labeled *RSVD* and *P0*, *P1*, ... *P7* are reserved. Do not make any connections to these pins. See Appendix B, *Accessories*, for a list of accessories that you can use to connect sensors to the front signal connector of the SCXI-1540.

A		B		C
RSVD	32	CH0-	32	CH0+
RSVD	31	GND	31	SYNC0
RSVD	30	EX0-	30	EX0+
RSVD	29	GND	29	P0
RSVD	28	CH1-	28	CH1+
RSVD	27	GND	27	SYNC1
RSVD	26	EX1-	26	EX1+
RSVD	25	GND	25	P1
RSVD	24	CH2-	24	CH2+
RSVD	23	GND	23	SYNC2
RSVD	22	EX2-	22	EX2+
RSVD	21	GND	21	P2
RSVD	20	CH3-	20	CH3+
RSVD	19	GND	19	SYNC3
RSVD	18	EX3-	18	EX3+
RSVD	17	GND	17	P3
RSVD	16	CH4-	16	CH4+
RSVD	15	GND	15	SYNC4
RSVD	14	EX4-	14	EX4+
RSVD	13	GND	13	P4
RSVD	12	CH5-	12	CH5+
RSVD	11	GND	11	SYNC5
RSVD	10	EX5-	10	EX5+
RSVD	9	GND	9	P5
RSVD	8	CH6-	8	CH6+
RSVD	7	GND	7	SYNC6
RSVD	6	EX6-	6	EX6+
RSVD	5	GND	5	P6
RSVD	4	CH7-	4	CH7+
RSVD	3	GND	3	SYNC7
RSVD	2	EX7-	2	EX7+
RSVD	1	GND	1	P7

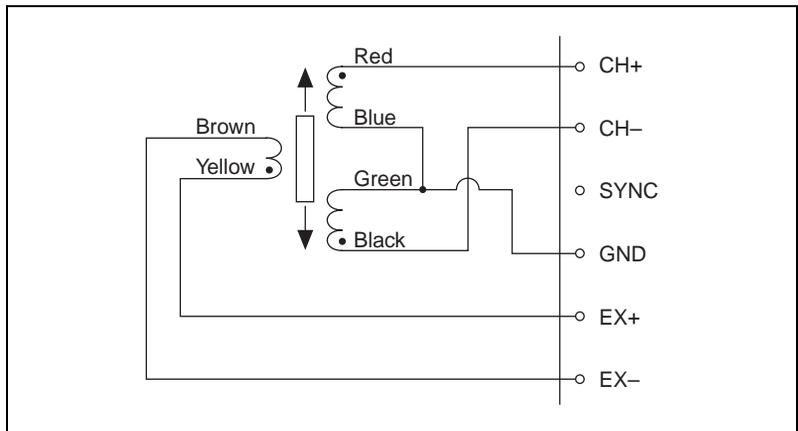
**Figure 2-1.** Front Signal Connector

## Connecting to LVDTs and RVDTs

Figures 2-2 and 2-3 show the connections made to a 4-wire and 5-wire LVDT or RVDT using the SCXI-1540 with the SCXI-1315 terminal block. Figure 2-2 shows how you can connect a device with six wires using only four wires.



**Figure 2-2.** 4-Wire Connection to an LVDT or RVDT



**Figure 2-3.** 5-Wire Connection to an LVDT or RVDT

In general, the 5-wire connection is insensitive to phase shift in the transducer and wiring, but subject to interference from common-mode voltages in the cable such as AC hum picked up from power lines, transformers, and motors. It is advisable, therefore, to use the 4-wire connection except in cases where a large phase shift in the return signal is

suspected. Causes for a large phase shift might be the use of an operating frequency other than that specified by the sensor manufacturer, or a cable length greater than 100 m.



**Note** The default configuration setting for the SCXI-1540 is 4-wire. You must use Measurement & Automation Explorer or the NI-DAQ function `SCXI_Configure_Connection` to enable 5-wire operation, in addition to making the correct signal connections to the terminal block or front signal connector.

## Synchronizing Channels

Figure 2-4 shows how to synchronize multiple SCXI-1540 channels to the same frequency. You should do this for all channels that have wires sharing a single multi-conductor cable. Synchronization prevents beat frequencies from appearing in the data. Beat frequencies are the result of channel oscillators running at slightly different frequencies and coupling into adjacent channels through cable crosstalk.

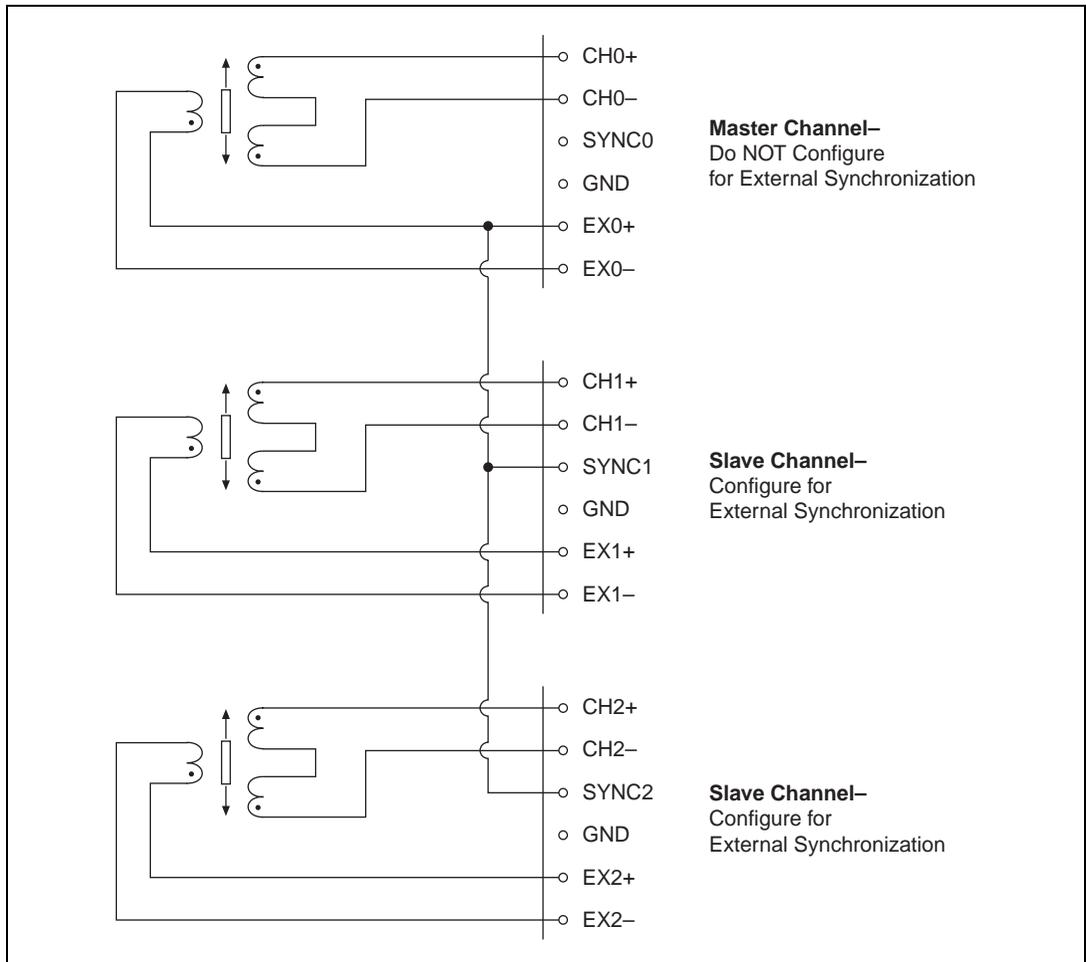


Figure 2-4. Multiple Channel Synchronization



**Note** To synchronize multiple channels, you must make the connections shown in Figure 2-4 *and* configure the slaved channels as externally synchronized. Do this through Measurement & Automation Explorer or by using the NI-DAQ function `SCXI_Configure_Connection`. You must *not* configure the channel that originates the synchronization signal from its EX+ pin (channel 0 in the example of Figure 2-4) for external synchronization since that channel serves as master and is not slaved to any other channel.

## Connecting to Resolvers

Figure 2-5 shows the connections made between a resolver and the SCXI-1540 using the SCXI-1315 terminal block. A single resolver requires the use of two channels. You must synchronize both channels using a wire connecting the EX+ on the master channel to the SYNC on the slave channel. Configure the slave channel for external synchronization as described in [Synchronizing Channels](#). You can also synchronize more than two channels used for resolvers or combinations of resolvers, LVDTs, and RVDTs by the previously described method.

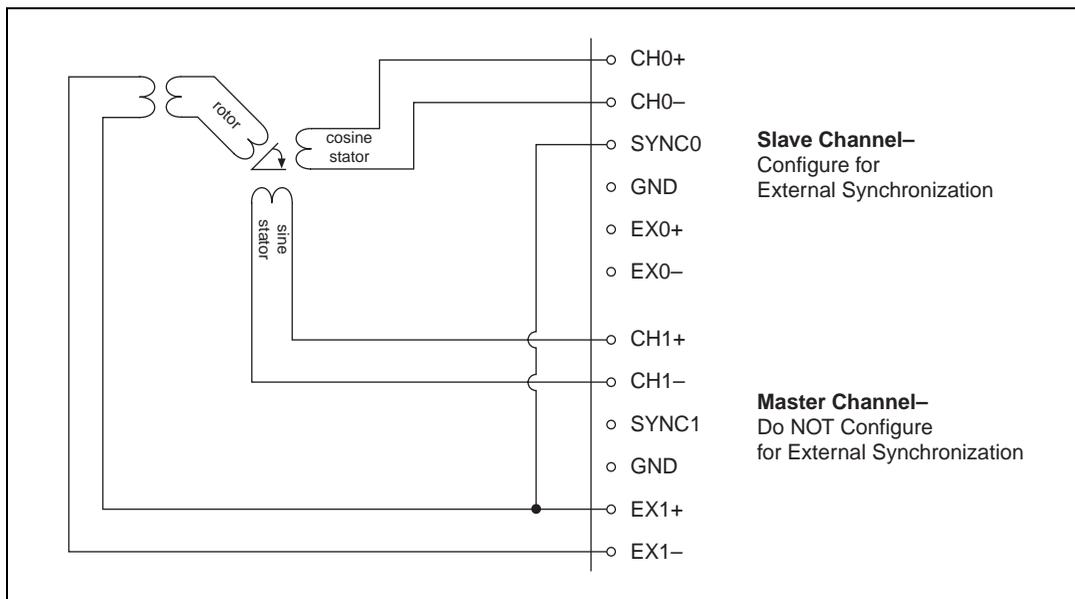


Figure 2-5. Resolver Connection

## Operating in Multiplexed Mode

The SCXI-1540 only operates in the multiplexed mode. A description of multiplexed mode operation is given in Chapter 1, [Installing and Configuring the SCXI-1540](#). In multiplexed mode, all input channels of the SCXI-1540 are multiplexed into a single analog input channel of the National Instruments DAQ device.

## Theory of Multiplexed Hardware Operation

When you configure a module for multiplexed mode operation, the routing of multiplexed signals to the DAQ device depends on which module in the SCXI system is cabled to the DAQ device. There are several possible scenarios for routing signals from the multiplexed modules to the DAQ device. If the module being scanned is not directly cabled to the DAQ device, the module sends its signals through the SCXIBus to the cabled module. The cabled module, whose routing is controlled by the SCXI chassis, routes the SCXIBus signals to the DAQ device through the MCH0 signal on the rear signal connector as shown in Figure 2-6. If the DAQ device scans the cabled module, the module routes its input signals through the MCH0 signal on the rear signal connector. The power of SCXI multiplexed scanning is its ability to route many input channels to a single channel on the DAQ device.

Multiplexed mode is typically used for performing scanning operations with the SCXI-1540. Immediately prior to a multiplexed scanning operation, the SCXI chassis is programmed with a module scan list that controls which module sends its output to the SCXIBus during a scan. You can specify this list to scan the modules in the chassis in any order, with an arbitrary number of channels for each module entry in the list, limited to a total of 512 channels per chassis. You can randomly scan the channels on the SCXI-1540, meaning channels can be in any order and occur multiple times in a single scan. When performing multiple scans, the list pointer of the module automatically wraps around and starts scanning with the first channel in the scan list.

AIGND	1	2	AIGND
MCH0+	3	4	MCH0-
MCH1+	5	6	MCH1-
MCH2+	7	8	MCH2-
MCH3+	9	10	MCH3-
MCH4+	11	12	MCH4-
MCH5+	13	14	MCH5-
MCH6+	15	16	MCH6-
MCH7+	17	18	MCH7-
OUTREF	19	20	
	21	22	
	23	24	DIGGND
SERDATIN	25	26	SERDATOUT
DAQD*/A	27	28	
SLOT0SEL*	29	30	
	31	32	
DIGGND	33	34	
	35	36	SCANCLK
SERCLK	37	38	
	39	40	
	41	42	
	43	44	
	45	46	SYNC
	47	48	
	49	50	

Figure 2-6. Rear Signal Connector Pin Assignment

## Using Software for Multiplexed Scanning

Performing scanning operations in software depends on the ADE you are using. While using LabVIEW, Measure, or Visual Basic (ComponentWorks), all scanning operations are prepared in software by using an SCXI *channel string* as the input to the channel parameter in the analog input VI or function. These ADEs also support virtual channels using Data Neighborhood (DAQ Channel Wizard) in Measurement & Automation Explorer. In LabWindows/CVI, C, or C++ development environments, you need to make several NI-DAQ function calls to set up each module involved in the scan, the chassis, and the DAQ device controlling the scan. In VirtualBench, the instruments that support SCXI scanning configure the channels of the module in a menu item in the graphical user interface. In BridgeVIEW, you must configure SCXI

channels as virtual channels (tags) in Measurement & Automation Explorer.

A discussion describing how to implement multiplexed scanning in the different ADEs follows. See your ADE manual and the DAQ analog input examples that come with your application software for more detailed information on programming your SCXI modules for scanning in multiplexed mode.

## LabVIEW and the SCXI Channel String

For LabVIEW, Measure, and Visual Basic, the channel string determines the sequence in which SCXI channels are scanned. In LabVIEW, an array of these channel strings configures multiple modules in the scan list. When the application program runs, the channel string is used for programming the channel information into the SCXI system. The format of the channel string is as follows:

```
obx ! scy ! mdz ! channels
```

where

`obx` is the onboard DAQ device channel, with  $x$  representing a particular channel where the multiplexed channels are sent. This value is 0 for DAQ channel 0 in a single-chassis system. In a multichassis or remote chassis system, however, the DAQ device channel  $x$  corresponds to chassis number  $n-1$ , where DAQ device channel  $x$  is used for scanning the  $n$ th chassis in the system.

`scy` is the SCXI chassis ID, where  $y$  is the number you chose when configuring your chassis.

`mdz` is the slot position where the module is located, with  $z$  being the particular slot number. The slots in a chassis are numbered from left to right, starting with 1.



**Note** The `obx !` specifier is optional and causes the gains on the module and DAQ device to be automatically set to fit the input limits parameter. When this specifier is omitted, the default gain on the DAQ device, usually the lowest gain, is used, but the SCXI-1540 gain is adjusted to fit the input limits.

The last parameter, *channels*, is the list of channels that are scanned for module *z*. It can have several formats:

- `obx ! scy ! mdz ! n`, where *n* is a single input channel.
- `obx ! scy ! mdz ! n1:n2`, where *n1* and *n2* represent a sequential list of input channels, inclusive.
- `obx ! scy ! mdz ! (n1, n2, n3:n4, n1, n5, n2)`, where *n1*, *n2*, and *n5* represent single channels, not necessarily sequential, and *n3* and *n4* represent the endpoints of a sequential list of channels, inclusive. In this case, channels *n1* and *n2* have explicitly been repeated in the channel list.



**Note** Repeating channels or having channels out of sequence in a scan list is not supported on all SCXI modules. Please refer to the manual of each module for information on this feature.

## LabVIEW and the Virtual Channel String

For LabVIEW, BridgeVIEW, Measure, and Visual Basic, the channel string can also contain virtual channels. For the SCXI-1540, these virtual channels are analog input channels you create that have custom names (called *tags* in BridgeVIEW), that perform all error correction and scaling without additional code. Virtual channels are particularly useful when sensors requiring different scaling factors are used on the same SCXI-1540 channel. Using virtual channels, you can use sensors needing special scaling in a generic analog input application without performing hard-coded scaling. If you change the scaling or want to connect a different sensor to your SCXI-1540, no changes are needed in the application. All that is required is creating a different virtual channel and using its name in the channel string.



**Note** You cannot mix virtual channels with the SCXI channel strings shown in the previous section.

To create a virtual channel for the SCXI-1540, insert a new analog input channel in the **Data Neighborhood** path in Measurement & Automation Explorer, name it, and then follow the software prompts to create virtual position channels, voltage channels, or customized analog input channels. For more information on virtual channels, consult the Measurement & Automation Explorer online help file.

To use virtual channels, enter the name of a virtual channel into the analog input channel string. If using multiple virtual channels, separate them using a comma, or enter them in a different index in the channel string array. All scaling is done automatically by the application.



**Note** Since you can randomly scan virtual analog input channels, you can enter virtual channels in any order or repeatedly in the channel string.

## Performing a Multiplexed Scan

To perform a multiplexed scan in your application, take the following steps:

1. Open an analog input example in your ADE.
2. Enter the appropriate SCXI channel string or virtual channel string into the **channels** parameter.
3. Either enter the **input limits** for signals connected to your module to adjust the gain settings in your system or use the default gain settings from the configuration utility, and then run the application. When using virtual channels, the default input limits configured in the virtual channel configurator are used.

You have completed a multiplexed scan using your SCXI-1540.

This is not a comprehensive discussion of SCXI scanning using LabVIEW, BridgeVIEW, Measure, or ComponentWorks, but this should give you enough information to help you get started with the examples shipped with these software packages.

## C and Low-Level DAQ Functions

When using a C-based environment, you need to take several steps to configure the SCXI-1540 for multiplexed scanning. The following procedure outlines the steps for programming with the low-level NI-DAQ function calls:

1. Prepare your SCXI-1540 settings either by loading the original SCXI configuration settings using `SCXI_Load_Config`, or by specifying all configuration settings using the NI-DAQ function calls in Table 2-1.

**Table 2-1.** NI-DAQ Functions Used to Configure SCXI-1540

Channel Setting	NI-DAQ Function to Use
Gain	<code>SCXI_Set_Gain</code>
Excitation Frequency	<code>SCXI_Set_Excitation</code>
Excitation Level	<code>SCXI_Set_Excitation</code>
Wire Mode (4-Wire or 5-Wire)	<code>SCXI_Configure_Connection</code>
Enable External Synchronization	<code>SCXI_Configure_Connection</code>

2. Specify the module scan list, the start channel of each module, and the number of channels to scan on each module with the function `SCXI_SCAN_Setup`. This function accepts an array of start channels and an array of the number of channels to scan in each module. Therefore, it is not possible to repeat channels or use nonsequential channels using this function.
3. Use `SCXI_MuxCtr_Setup` to program the DAQ device with the correct number of channels multiplexed per scan. This number must match the total number of channels programmed in step 2.

You are now ready to acquire the channel data with the DAQ device. If you are using a multifunction DAQ device, you can use `SCAN_OP` to perform the scanning operation. After scanning, convert the binary data to voltage data using `SCXI_Scale`. Refer to the *NI-DAQ User Manual* for additional information on scanning with DAQ devices.

## Scaling LVDT and RVDT Data Using the SCXI-1540

When using an LVDT or RVDT, the fundamental measurement quantities of interest are usually linear or angular position, or some quantity derived from a position measurement. Converting the SCXI-1540 voltage output signals to these more fundamental quantities involves scaling.

The easiest way to obtain scaled data from the SCXI-1540 is to create and use a virtual channel. Refer to the section *LabVIEW and the Virtual Channel String*. Using virtual channels, the data read by your LabVIEW, BridgeVIEW, Measure, or Visual Basic application is already scaled based on the information you entered when creating the virtual channel, and your application need not perform any additional scaling.

In other cases, the analog input data read by your application has only been scaled to equal the rms voltage present at the analog input terminals of the SCXI-1540. This data is a signed quantity with the sign determined by the phase ( $0^\circ$  or  $180^\circ$ ), even though the units are in volts rms. This includes data read by LabVIEW, BridgeVIEW, or Visual Basic when the SCXI channel string is used, or when the analog input data from the connected DAQ device is converted to volts rms using the NI-DAQ function `SCXI_Scale`. In these cases you must scale the data in your application using the following formula:

$$\text{scaled data} = \frac{\text{SCXI-1540 data in volts rms}}{(\text{excitation setting in volts rms}) \times (\text{sensor sensitivity})}$$

For example, if you are working with an LVDT with a manufacturer-specified sensitivity of 1.2 mV/V/mil (or equivalently, 0.0012 V/V/mil) and the excitation level of the corresponding SCXI-1540 channel is 3 V<sub>rms</sub>, the conversion formula is:

$$\begin{aligned} \text{scaled data, in inches} &= \frac{(\text{SCXI-1540 data in volts rms})}{3 \text{ V}_{rms} \times (0.0012 \text{ volts per volt per mil}) \times (1000 \text{ mils per inch})} \\ &= \frac{(\text{SCXI-1540 data in volts rms})}{(3.6 \text{ volts per inch})} \\ &= (\text{SCXI-1540 data in volts rms}) \times (0.278 \text{ inch per volt}) \end{aligned}$$

## Converting Resolver Data to Angular Position

Converting resolver data to angular position is accomplished by simply passing the data from the two channels to a four-quadrant arctangent function, such as the LabVIEW function `Inverse Tangent (2 Input)`. This function is on the **Trigonometric** subpalette. To access this function, select **Function»Numeric»Trigonometric**.

# Calibration

---

The SCXI-1540 is shipped with a calibration certificate and is calibrated at the factory to the specifications described in Appendix A, *Specifications*. Calibration constants are stored inside the calibration EEPROM and provide software correction values your application development software uses to correct your measurements for both offset and gain errors in the module.

You may want to periodically calibrate the module for offset and gain drift using the procedures described in *Calibration Procedures*.

## Calibration Procedures

You can calibrate the offset and gain on the SCXI-1540 using National Instruments software. The SCXI-1540 provides input switching that automatically connects the input terminals to the excitation terminals when you perform a calibration. There is generally no need to change the input wiring since this connection is made internally and the front panel input signal terminals are disconnected. The excitation terminals remain connected to the front panel. This causes no problems during calibration provided there is no wiring error that might short-circuit the excitation signal.



**Caution** Ensure the calibration on the DAQ device or DMM you are using is current and traceable. If you modify the gain and offset software-correction values using an uncalibrated device, your calibration is *not* valid, or your calibration is *not* traceable.

## Calibration Using LabVIEW or a C-Based ADE

You can use the LabVIEW SCXI Calibrate VI or the NI-DAQ function `SCXI_Calibrate` to calibrate your SCXI-1540. These functions calibrate all channels for all gains and excitation levels when called.

If you are using external synchronization, National Instruments recommends that you perform a calibration with the synchronization wiring and synchronization configuration settings in place. Excitation levels and frequencies are affected slightly by synchronization which, in turn, slightly effects the calibration.

If you are using LabVIEW, use the following procedure:

1. Make sure the DAQ device or DMM you are using has a valid calibration.
2. Use the LabVIEW function SCXI Calibrate VI to calibrate your module.
  - a. Enter the DAQ device and the SCXI channel string for all eight channels. For example, your channel string might be `ob0 ! sc1 ! md3 ! 0:7`.
  - b. Select **internal calibration** as the calibration operation you are going to perform.
  - c. Select the **Default EEPROM load area** as the area you want to update.

If you are using a C-based ADE, use the following procedure:

1. Make sure the DAQ device or DMM you are using has a valid calibration and meets the accuracy specifications for your application.
2. Use the NI-DAQ function, `SCXI_Calibrate`.
  - a. Enter the DAQ device, DAQ channel, and module slot. You need not enter a channel number since `SCXI_Calibrate` automatically calibrates all channels of the SCXI-1540.
  - b. Select **internal calibration (0)** as the operation you are going to perform.
  - c. Select the **load area (1)** as the EEPROM area you want to update.

The SCXI-1540 takes a few seconds to perform the calibration. After completion, your module has new calibration constants stored for all channels, gains, and excitation settings.

# Specifications

This appendix lists the specifications for the SCXI-1540 modules. These specifications are typical at 25 °C unless otherwise noted.

## General Specifications

**Table A-1.** Input Range, Gain, and Required DAQ Device Limits

<b>Input Range (V<sub>rms</sub>)</b>	<b>Gain Setting (VDC out/V<sub>rms</sub> in)</b>	<b>DAQ Device Input Limits (V)</b>
6.0	0.8	±5.0
5.5	0.9	±5.0
5.0	1.0	±5.0
4.5	1.1	±5.0
4.0	1.25	±5.0
3.5	1.4	±5.0
3.0	1.6	±5.0
2.7	1.8	±5.0
2.5	2.0	±5.0
2.2	2.2	±5.0
2.0	2.5	±5.0
1.7	2.8	±5.0
1.5	3.2	±5.0
1.35	3.6	±5.0
1.25	4.0	±5.0
1.10	4.5	±5.0
1.00	5.0	±5.0

**Table A-1.** Input Range, Gain, and Required DAQ Device Limits (Continued)

<b>Input Range (V<sub>rms</sub>)</b>	<b>Gain Setting (VDC out/V<sub>rms</sub> in)</b>	<b>DAQ Device Input Limits (V)</b>
0.85	5.6	±5.0
0.75	6.3	±5.0
0.70	7.0	±5.0
0.62	8.0	±5.0
0.55	9.0	±5.0
0.50	10.0	±5.0
0.45	11.0	±5.0
0.40	12.5	±5.0
0.35	14.0	±5.0
0.31	16.0	±5.0
0.27	18.0	±5.0
0.25	20.0	±5.0
0.22	22.0	±5.0
0.20	25.0	±5.0
0.10	25.0	±2.5
0.05	25.0	±1.0

Input impedance ..... 100 kΩ ±2%

Frequency response ..... 250 Hz LPF, 4-pole Butterworth

Input connections ..... 4-wire or 5-wire

Synchronization ..... internal or external

Residual ripple and noise ..... < 0.1% peak of full scale

Nonlinearity ..... < 0.1% of full scale max  
0.05% of full scale typ

Output range ..... ±5.0 V

Output offset drift.....	$\pm 70 \mu\text{V}/^\circ\text{C}$ max
Input gain .....	See Table A-1
Input gain accuracy <sup>1</sup> .....	$\pm 2\%$
Gain drift .....	$\pm 300$ ppm / $^\circ\text{C}$ max
Common-mode rejection ratio .....	$>60$ dB max 75 dB typ
Maximum input working voltage.....	$6 V_{\text{rms}}$
Input damage level, power on or off.....	$32 V_{\text{rms}}$
Excitation	
Frequency.....	2.5 kHz $\pm 10\%$ 3.3 kHz $\pm 10\%$ 5.0 kHz $\pm 10\%$ 10.0 kHz $\pm 10\%$
Level	
Low setting <sup>1</sup> .....	$3 V_{\text{rms}} \pm 5\%$
High setting <sup>1</sup> .....	$1 V_{\text{rms}} \pm 5\%$
Minimum load impedance .....	$32 \Omega$ for $1 V_{\text{rms}}$ setting $95 \Omega$ for $3 V_{\text{rms}}$ setting

### Control

The gain, excitation frequency, excitation level, connection type, and external synchronization (enable/disable) are set on a per-channel basis through software. There are no jumpers.

---

<sup>1</sup> This is the error before correction in software. Input gain error, excitation level error, and output offset error are accounted for in the software correction coefficients stored in the onboard EEPROM. These constants are applied automatically when using LabVIEW or the NI-DAQ function `SCXI_scale`. The specifications in the *Absolute Accuracy* section of this appendix indicate overall accuracy of the SCXI-1540, including the application of the software correction coefficients.

## Absolute Accuracy

Absolute accuracy includes the cumulative error of both excitation and input gain after the application of software correction coefficients. The software correction coefficients reside in the onboard EEPROM and are applied automatically to acquired data when using LabVIEW or the NI-DAQ function `SCXI_Scale`. You can update the constants in the field using standard LabVIEW or NI-DAQ function calls. Specifications in this section are for an SCXI-1540 module immediately after an internal calibration.

**Table A-2.** Absolute System Accuracy

Exc. Freq (kHz)	% of reading		Max Offset (% of full scale)	System Noise (peak, % of full scale)		Temperature Drift	
	Typical	Max		Single Pt.	100 Pt. Avg.	Gain Drift	Offset Drift
2.5	±0.2%	±0.5%	±0.05%	±0.03%	±0.01%	±0.03%/°C	±0.003%/°C
3.3	±0.2%	±0.5%	±0.05%	±0.03%	±0.01%	±0.03%/°C	±0.003%/°C
5	±0.2%	±0.5%	±0.05%	±0.03%	±0.01%	±0.03%/°C	±0.003%/°C
10	±0.5%	±1.0%	±0.05%	±0.03%	±0.01%	±0.03%/°C	±0.003%/°C

Absolute accuracy is (voltage reading) × (gain error) × (full-scale voltage) + (offset error) + (system noise × full-scale voltage). To include the effects of temperature drift away from the temperature at which the module was calibrated, add the term

$$(voltage\ reading) \times (gain\ drift) \times \Delta T + (offset\ drift) \times \Delta T$$

where  $\Delta T$  is temperature change. Scan rate for 100-point averages is 200 scans per second.

## Power Requirements

V+ ..... 18.5 to 25 VDC, +170 mA min

V- ..... -18.5 to -25 VDC, -170 mA min

+5 V ..... +4.75 to 5.25 VDC, 50 mA min

## Physical

Dimensions ..... 3.0 by 17.2 by 20.3 cm  
(1.2 by 6.9 by 8.0 in.)

## Environment

Operating temperature..... 0 to 50 °C

Storage temperature ..... –20 to 70 °C

Relative humidity ..... 10 to 90% noncondensing

Electromagnetic compatibility

EMC emissions ..... Refer to the document supplied  
with the chassis for compliance  
with relevant directives.

EMI ..... FCC Class A compliant

---

## Accessories

This section lists and describes the optional accessories available for the SCXI-1540.

**Table B-1.** Accessories Available for the SCXI-1540

Accessory	Description
SCXI-1315	Screw terminal block specifically for the SCXI-1540. Mounts on the front of the SCXI-1540 module.
SCXI-1310	Connector and Shell Assembly. An inexpensive alternative to a terminal block. Field wiring can be soldered to eyelet-type terminals for easy hook-and-solder signal connection.
TBX-96	DIN rail mounted terminal block with 96 generic screw terminals. Also works with the SCXI-1100, SCXI-1102/B/C, and SCXI-1104/C.  One of the following cables is required to connect the TBX-96 to an SCXI module: <ul data-bbox="659 1025 1130 1095" style="list-style-type: none"><li>• SH96-96 shielded cable, 1 m</li><li>• R96-96 unshielded ribbon cable, 1 m</li></ul>



---

# Connectors

This appendix describes the front and rear signal connectors on the SCXI-1540.

## Front Signal Connector

---

The front signal connector, shown in Figure 2-1, *Front Signal Connector*, is a special 96-pin DIN C male front connector through which all signal connections are made. You must not connect sensor signals to reserved pins, marked RSVD in Figure 2-1, *Front Signal Connector*.



**Caution** Signal connections should not be made to pins in column A.

## Rear Signal Connector

---

The rear signal connector (RSC) is a 50-pin male ribbon-cable connector used for analog signal connectivity and communication between the SCXI-1540 and the connected DAQ device. The RSC is shown in Figure 2-6. The RSC allows the DAQ device to access all eight differential analog output signals from the SCXI-1540. The positive terminal of each analog output is named MCHX+ and the negative terminal MCHX-. Grounding signals AOGND and OUTREF provide reference signals needed in the various analog input referencing modes on the DAQ device. In multiplexed mode, the MCH0 signal pair is used for sending all eight channels of the SCXI-1540, and analog signals from other modules, to the connected DAQ device. If the module is directly connected to the DAQ device, the other analog channels of the DAQ device are unavailable for general-purpose analog input because they are still connected to the amplifier outputs of the SCXI-1540 in multiplexed mode.

The communication signals between the DAQ device and the SCXI system are SERDATIN, SERDATOUT, DAQD\*/A, SLOT0SEL\*, SERCLK, and SCANCLK. The digital ground, DIGGND on pins 24 and 33, provides a separate ground reference for the communication signals. SERDATIN, SERDATOUT, DAQD\*/A, SLOT0SEL\*, and SERCLK are the communication lines for programming the SCXI-1540. The SCANCLK and SYNC signals are the signals necessary for multiplexed mode scanning. If the DAQ device is connected to the SCXI-1540, these digital lines are unavailable for general-purpose digital I/O.

---

# Common Questions

This appendix lists common questions related to the use of the SCXI-1540.

## **Which version of NI-DAQ works with the SCXI-1540 and how do I get the most current version of NI-DAQ?**

You must have NI-DAQ 6.7 or later. Visit our web site and follow the link, **Download Software»Drivers and Updates»Search Drivers and Updates**, and type in the keyword NI-DAQ to find the latest version of NI-DAQ for your operating system.

## **I have gone over the *Self-Test Verification* in Chapter 1, *Installing and Configuring the SCXI-1540*, yet I still cannot correctly test and verify that my SCXI-1540 is working. What should I do now?**

Unfortunately, there always exists the chance that one or more components in your system are not operating correctly. You may have to call or e-mail a technical support representative. The technical support representative will often suggest additional troubleshooting measures. If requesting technical support by phone, have your system nearby so you can try these measures immediately. National Instruments contact information is listed in Appendix E, *Technical Support Resources*.

## **How do I configure an SCXI-1200 DAQ device for use with the SCXI-1540?**

When using the SCXI-1200 with the SCXI-1540, make sure the SCXI-1200 is configured for NRSE mode in Measurement & Automation Explorer.

## **Can I use the unused analog input channels of the DAQ device if I am directly cabled to the SCXI-1540?**

No. DAQ device channels 1 through 7 connect to the conditioned analog outputs of SCXI-1540 channels 1 through 7.

**Which digital lines are unavailable on the DAQ device if I am cabled to an SCXI-1540 module?**

Table D-1 shows the digital lines that are used by the SCXI-1540 for communication and scanning. These lines are unavailable for general-purpose digital I/O if the SCXI-1540 is connected to the DAQ device.

**Table D-1.** Digital Signals on the SCXI-1540

DAQ Signal Name	SCXI Signal Name	50-Pin Connector	68-Pin Connector	Direction (with respect to the DAQ device)
DIO0	SERDATIN	25	52	Output
DIO4	SERDATOUT	26	19	Input
DIO1	DAQD*/A	27	17	Output
DIO2	SLOT0SEL*	29	49	Output
SCANCLK	SCANCLK	36	46	Output
EXTSROBE*	SERCLK	37	45	Output
STARTSCAN	SYNC*	46	38	Output

**In LabVIEW, can I use different input limits for the same SCXI-1540 channel if I repeat the channel in the SCXI channel string array?**

No. The SCXI-1540 cannot dynamically change the gain settings during scanning. Therefore, group channels with similar input ranges together in the channel string array. Make sure that repeated channels in different indices of the channel string array have the same input limits in the corresponding input limits array.

**In LabVIEW, can I use a VI to change my SCXI-1540 configuration settings?**

Yes. You can use the AI Parameter VI to change all the SCXI-1540 configuration settings.

**In C, can I randomly scan the SCXI-1540 using low-level NI-DAQ function calls?**

No. When using C, you can scan only consecutive channels using traditional SCXI channel programming. Please refer to the *NI-DAQ Function Reference Online Help* for more details on SCXI scanning.

**Are there any cabling restrictions when using an SCXI-1540 module with a plug-in E Series DAQ device?**

Not for the SCXI-1540. However, if a chassis contains an SCXI-1140 or SCXI-1530/1531 module, at least one of these modules must be the *cabled* module. A cabled module is the module connected directly to the DAQ device. This ensures that a timing signal (from GPCTRO on the DAQ device) is available for use by all simultaneous-sampling SCXI modules in the chassis.

**Can I use the SCXI-1540 with a version of NI-DAQ that works under the Macintosh Operating System (MacOS)?**

No.

**Some SCXI modules permit *random scanning*. Does the SCXI-1540 module permit random scanning?**

Yes. Random scanning is described in Chapter 2, *Using the SCXI-1540*.

**What is the power-up state of the SCXI-1540 multiplexer, analog bus switches, and configuration settings?**

The multiplexer, analog bus switches, and configuration settings are not in a known state immediately after power on. All hardware settings are programmed automatically when beginning an acquisition in LabVIEW.

**Which accessories can I use to connect signals to the front of the SCXI-1540 module?**

Refer to Appendix B, *Accessories*, for more information.

**How do I calculate the maximum permitted scan rate when using one or more SCXI-1540 modules in multiplexed mode?**

For the SCXI-1540 and most other SCXI modules, the maximum scan rate is limited to a  $333 \text{ kS/s}/(\text{number of scanned channels})$  if the controlling DAQ device is not the limiting factor. For example, the PCI-MIO-16E-1 has a maximum sampling rate of  $1 \text{ MS/s}$  and can scan at the maximum rate of  $333 \text{ kS/s}$  for SCXI. The PCI-MIO-16XE-10 is a slower device with a maximum sample rate of  $100 \text{ kS/s}$ , so it can scan SCXI channels no faster than  $100 \text{ kS/s}/(\text{number of scanned channels})$ .

**How do I control the gain, frequency, excitation level, wire mode, and synchronization in LabVIEW?**

The gain of each SCXI-1540 channel is automatically set based on the channel limits used in setting up the acquisition. You usually use the LabVIEW AI Config VI to set the channel limits. If the channel limits are not explicitly set, the SCXI-1540 defaults to the gain setting entered when the module was configured using Measurement & Automation Explorer. Refer to Chapter 1, *Installing and Configuring the SCXI-1540* for more information.

Frequency, excitation level, wire mode, and synchronization mode are also set or changes using Measurement & Automation Explorer. However, you can also control or change these settings programmatically using the LabVIEW AI param VI.

**How do I control the gain, frequency, excitation level, wire mode, and synchronization in C-based application environments?**

You must use the NI-DAQ functions listed in Table 2-1, *NI-DAQ Functions Used to Configure SCXI-1540*.

**Can I use the SCXI-1540 with VirtualBench or Measure?**

Yes.

---

# Technical Support Resources

This appendix describes the comprehensive resources available to you in the Technical Support section of the National Instruments Web site and provides technical support telephone numbers for you to use if you have trouble connecting to our Web site or if you do not have internet access.

## NI Web Support

---

To provide you with immediate answers and solutions 24 hours a day, 365 days a year, National Instruments maintains extensive online technical support resources. They are available to you at no cost, are updated daily, and can be found in the Technical Support section of our Web site at [www.ni.com/support](http://www.ni.com/support)

### Online Problem-Solving and Diagnostic Resources

- **KnowledgeBase**—A searchable database containing thousands of frequently asked questions (FAQs) and their corresponding answers or solutions, including special sections devoted to our newest products. The database is updated daily in response to new customer experiences and feedback.
- **Troubleshooting Wizards**—Step-by-step guides lead you through common problems and answer questions about our entire product line. Wizards include screen shots that illustrate the steps being described and provide detailed information ranging from simple getting started instructions to advanced topics.
- **Product Manuals**—A comprehensive, searchable library of the latest editions of National Instruments hardware and software product manuals.
- **Hardware Reference Database**—A searchable database containing brief hardware descriptions, mechanical drawings, and helpful images of jumper settings and connector pinouts.
- **Application Notes**—A library with more than 100 short papers addressing specific topics such as creating and calling DLLs, developing your own instrument driver software, and porting applications between platforms and operating systems.

## Software-Related Resources

- **Instrument Driver Network**—A library with hundreds of instrument drivers for control of standalone instruments via GPIB, VXI, or serial interfaces. You also can submit a request for a particular instrument driver if it does not already appear in the library.
- **Example Programs Database**—A database with numerous, non-shipping example programs for National Instruments programming environments. You can use them to complement the example programs that are already included with National Instruments products.
- **Software Library**—A library with updates and patches to application software, links to the latest versions of driver software for National Instruments hardware products, and utility routines.

## Worldwide Support

---

National Instruments has offices located around the globe. Many branch offices maintain a Web site to provide information on local services. You can access these Web sites from [www.ni.com/worldwide](http://www.ni.com/worldwide)

If you have trouble connecting to our Web site, please contact your local National Instruments office or the source from which you purchased your National Instruments product(s) to obtain support.

For telephone support in the United States, dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

Australia 03 9879 5166, Austria 0662 45 79 90 0, Belgium 02 757 00 20,  
Brazil 011 284 5011, Canada (Calgary) 403 274 9391,  
Canada (Ontario) 905 785 0085, Canada (Québec) 514 694 8521,  
China 0755 3904939, Denmark 45 76 26 00, Finland 09 725 725 11,  
France 01 48 14 24 24, Germany 089 741 31 30, Greece 30 1 42 96 427,  
Hong Kong 2645 3186, India 91805275406, Israel 03 6120092,  
Italy 02 413091, Japan 03 5472 2970, Korea 02 596 7456,  
Mexico (D.F.) 5 280 7625, Mexico (Monterrey) 8 357 7695,  
Netherlands 0348 433466, New Zealand 09 914 0488,  
Norway 32 27 73 00, Poland 0 22 528 94 06, Portugal 351 1 726 9011,  
Singapore 2265886, Spain 91 640 0085, Sweden 08 587 895 00,  
Switzerland 056 200 51 51, Taiwan 02 2528 7227,  
United Kingdom 01635 523545

# Glossary

---

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

## Numbers/Symbol

%	percent
/	per
°	degrees
$\Omega$	ohms
+5 V (signal)	+5 VDC source signal

## A

A	amperes
absolute accuracy	the maximum difference between the measured value from a data acquisition device and the true voltage applied to the input, typically specified as $\pm$ voltage
AC	alternating current
AC coupled	allowing the transmission of AC signals while blocking DC signals
ADE	application development environment
AIGND	analog input ground

amplification	a type of signal conditioning that improves accuracy in the resulting digitized signal by increasing signal amplitude relative to noise
autozero	the technique of internally shorting the input terminals of a differential channel circuit, while disconnecting the signal source, to compensate for voltage offset

## **B**

bandwidth	the range of frequencies present in a signal, or the range of frequencies to which a measuring device can respond
BW	bandwidth

## **C**

C	Celsius
CE	European emissions control standard
CHSGND	chassis ground
CH <sub>x</sub> +	positive input terminal for channel <i>x</i>
CH <sub>x</sub> -	negative input terminal for channel <i>x</i>
CMRR	common-mode rejection ratio—a measure of an instrument's ability to reject interference from a common-mode signal, usually expressed in decibels (dB)
CMV	common mode voltage
crosstalk	an unwanted signal on one channel due to an input on a different channel

## **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
-----	--

DAQ device	a device that collects signals for data acquisition devices. Examples are MIO and 1200 boards.
dB	decibel—the unit for expressing a logarithmic measure of the ratio of two signal levels: $dB = 20 \log_{10} (V1/V2)$ , for signals in volts
DC	direct current
DC coupled	allowing the transmission of both AC and DC signals
differential input	an analog input consisting of two terminals, both of which are isolated from computer ground, whose difference is measured
DIGGND	digital ground signal
DIN	Deutsche Industrie Norme
DIO	digital I/O
DMM	digital multimeter
dynamic range	the ration of the largest signal level a circuit can handle to the smallest signal level it can handle (usually taken to be the noise level), normally expressed in decibels

## E

EEPROM	electrically erasable programmable read-only memory—ROM that can be erased with an electrical signal and reprogrammed
EMC	electromechanical compliance
EMI	electromagnetic interference
EX+	a positive excitation output terminal of channel <i>X</i>
EX–	a negative excitation output terminal of channel <i>X</i>

## F

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

FSR full-scale range

## G

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

gain accuracy a measure of deviation of the gain of an amplifier from the ideal gain

gain error *see* [gain accuracy](#)

## H

Hz hertz

## I

in. inch

input bias current the current that flows into the inputs of a circuit

input impedance the measured resistance and capacitance between the input terminals of a circuit

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

## L

LPF lowpass filter

LVDT linear variable differential transformer—a transformer-based sensor for measuring linear displacement

**M**

m	meters
M	(1) Mega, the standard metric prefix for 1 million or $10^6$ , when used with units of measure such as volts and hertz; (2) mega, the prefix for 1,048,576, or $2^{20}$ , when used with B to quantify data or computer memory
MCH $x$ +	positive analog output channel terminal for channel $x$
MCH $x$ -	negative analog output channel terminal for channel $x$
mil	a unit of measure equal to 0.001 of an inch
MIO	multifunction I/O
multiplexed mode	an SCXI operating mode in which analog input channels are multiplexed into one module output so that your cabled DAQ device has access to the module's multiplexed output as well as the outputs of all other multiplexed modules in the chassis that are coupled to the SCXIBus
mux	multiplexer—a switching device with multiple inputs that sequentially connects each of its inputs to its single output, typically at high speeds, in order to measure several signals with a single analog-to-digital converter

**N**

NC	not connected
NI-DAQ	National Instruments driver software for DAQ hardware
noise	an undesirable electrical signal—Noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, 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 measure.
nonlinearity	For an amplifier, a measure of the maximum output deviation from an ideal linear response in units of percent relative to full scale. The ideal linear response is taken to be a straight line on a plot of measured output voltage to measured input voltage with the ends of the line connecting the extremes of the plot at the full-scale limits.
NRSE	nonreferenced single-ended (input)

## O

offset error                      a measure of deviation of the offset of an amplifier from the ideal offset

## P

parallel mode                    a type of SCXI operating mode in which the module sends each of its output channels directly to a separate analog input channel of the DAQ device connected to the module

ppm                                parts per million

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

## Q

quadrature encoder            A device that converts linear or rotary movement into electrical pulses on two channels. The pulse stream of one channel either leads or lags the pulse stream of the other channel depending on the direction of movement.

## R

resolution                        The smallest signal increment that can be detected by a measurement system. Resolution can be expressed in bits, in proportions, or in percent of full scale. For example, a system has 12-bit resolution, one part in 4,096 resolution, and 0.0244% of full scale resolution.

resolver                         A transformer-based sensor for measuring absolute angular displacement over 360°. Measurement is continuous for any number of revolutions. The simultaneous conditioning of a sine and a cosine signal is required.

rms                                 root mean square

RSC                                rear signal connector

RSE                                referenced single-ended mode—all measurements are made with respect to a common reference measurement system or a ground. Also called a grounded measurement system.

RSVD                              reserved bit/signal

RTI	referred to input—calculates a specification relative to the input range
RVDT	rotary variable differential transformer—a transformer-based sensor for measuring absolute angular displacement whose measurement range is typically between $\pm 30^\circ$ and $\pm 70^\circ$ of rotation
<b>S</b>	
s	seconds
S/s	samples per second
scan	one or more analog or digital input samples. Typically, the number of input samples in a scan is equal to the number of channels in the input group. For example, one pulse from the scan clock produces one scan which acquires one new sample from every analog input channel in the group.
SCANCLK	clock that triggers scanning
scan rate	the number of scans per second. For example, a scan rate of 10 Hz means sampling each channel 10 times per second.
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
SCXIbus	the analog bus where SCXI analog signals are routed
sensitivity	for an LVDT or RVDT, the ratio of output voltage change to input position change for a primary excitation level of one volt rms
SERDATOUT	serial data out to cabled DAQ device
settling time	the amount of time required for a voltage to reach its final value within specified limits
shunt	<i>see</i> <a href="#">autozero</a>
signal conditioning	the manipulation of signals to prepare them for digitizing

SYNC	synchronization pulse for scanning
system noise	a measure of the amount of noise seen by an analog circuit or an ADC when the analog inputs are grounded

## U

UL	Underwriters Laboratory
----	-------------------------

## V

V	volts
VAC	volts alternating current
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
virtual channels	input channels that can be defined outside the application and used without having to code scaling constants
$V_{\text{rms}}$	volts, root mean square

## W

working voltage	the highest voltage that should be applied to a product in normal use, normally well under the breakdown voltage for safety margin
-----------------	--

# Index

---

## A

- accessories for connecting signals, B-1, D-3
- accuracy, absolute, A-4
- analog input channels, unused, D-1
- auto-detection of modules, 1-12

## C

- C language, and low-level DAQ functions, 2-12
- calibration, 2-14 to 2-15
  - procedures, 2-14
  - using LabVIEW or C-based ADE, 2-14 to 2-15
- channel scanning. *See* multiplexed scanning.
- channel synchronization, 2-4 to 2-5
- common questions, D-1 to D-4
- configuration, 1-11 to 1-17
  - auto-detecting modules, 1-12
  - changing with LabVIEW AI Parameter VI, D-2, D-4
  - common questions, D-4
  - configuration/reconfiguration, 1-14
  - excitation frequency, 1-16
  - excitation level, 1-16
  - external synchronization, 1-17
  - gain setting, 1-15 to 1-16
  - manually adding modules, 1-13
  - SCXI-1200 device for use with SCXI-1540, D-1
  - self-test verification, 1-14 to 1-15
  - steps for, 1-11 to 1-12
  - troubleshooting self-test verification, 1-17 to 1-18, D-1
  - wire mode, 1-16
- connecting SCXI-1540 to DAQ device
  - in PXI combination chassis, 1-10 to 1-11
  - in SCXI chassis, 1-9 to 1-11

- connectors
  - front signal connector
    - overview, C-1
    - pin assignments (figure), 2-1 to 2-2
  - rear signal connector
    - pin assignments (figure), 2-8
    - signal descriptions, C-1 to C-2
- conventions used in manual, *vi*

## D

- DAQ device
  - cabling restrictions with plug-in E Series DAQ device, D-3
  - connecting with SCXI-1540 for multiplexed scanning
    - in PXI combination chassis, 1-10 to 1-11
    - in SCXI chassis, 1-9 to 1-10
  - low-level DAQ functions and multiplexed scanning, 2-12
  - unavailable digital lines, D-2
- diagnostic resources, online, E-1
- digital signals, unavailable with DAQ device connected (table), D-2

## E

- E Series DAQ device, cabling restrictions, D-3
- environment specifications, A-5
- excitation frequency, setting, 1-16
- excitation level, setting, 1-16
- external synchronization, setting, 1-17

**F**

- front signal connector
  - overview, C-1
  - pin assignments (figure), 2-1 to 2-2

**G**

- gain, setting, 1-15 to 1-16

**I**

- installation, 1-7 to 1-11
  - connecting SCXI-1540 to DAQ device for multiplexed scanning
    - in PXI combination chassis, 1-10 to 1-11
    - in SCXI chassis, 1-9 to 1-10
  - removing SCXI-1540, 1-18 to 1-20
    - from Measurement & Automation Explorer, 1-19 to 1-20
    - from SCXI chassis, 1-18 to 1-19
  - into SCXI chassis, 1-7 to 1-8
  - software installation, 1-6 to 1-7
  - unpacking SCXI-1540, 1-7

**L**

- LabVIEW
  - calibration procedure, 2-14 to 2-15
  - changing configuration settings, D-2, D-4
  - input limits, D-2
  - SCXI channel string, 2-9 to 2-10
  - virtual channel string, 2-10 to 2-11
- low-level DAQ functions
  - in multiplexed scanning, 2-12
  - random scanning not available, D-3
- LVDTs (linear variable differential transformers)
  - core locations with resulting induced voltage and phase (figure), 1-3
  - cut-away view (figure), 1-2
  - description, 1-2

- scaling data in multiplexed scanning, 2-12 to 2-13
- signal connections, 2-3 to 2-4
  - 4-wire (figure), 2-3
  - 5-wire (figure), 2-3
- use of, 1-4

**M**

- Measure software, D-4
- Measurement & Automation Explorer
  - auto-detecting modules, 1-12
  - configuration procedure, 1-11 to 1-12
  - configuration/reconfiguration, 1-14
  - manually adding modules, 1-13
  - removing SCXI-1540, 1-19 to 1-20
  - self-test verification, 1-14 to 1-15
    - troubleshooting, 1-17 to 1-18, D-1
- multiple channel synchronization, 2-4 to 2-5
- multiplexed scanning, 2-6 to 2-13
  - calculating maximum permitted scan rate, D-4
  - channel scanning, 2-8 to 2-11
    - LabVIEW and SCXI channel string, 2-9 to 2-10
    - LabVIEW and virtual channel string, 2-10 to 2-11
  - connecting SCXI-1540 to DAQ device
    - in PXI combination chassis, 1-10 to 1-11
    - in SCXI chassis, 1-9 to 1-10
- performing scans
  - C and low-level DAQ functions, 2-12
  - converting resolver data to angular position, 2-13
  - scaling LVDT and RVDT data, 2-12 to 2-13
  - steps, 2-11
  - using software, 2-8 to 2-11
- theory of multiplexed hardware operation, 2-7

**N**

National Instruments Web support, E-1 to E-2  
 NI-DAQ software  
   and Macintosh OS, D-3  
   version required, D-1

**O**

online problem-solving and diagnostic resources, E-1

**P**

physical specifications, A-5  
 pin assignments  
   front signal connector (figure), 2-1 to 2-2  
   rear signal connector (figure), 2-8  
 power requirements, A-5  
 power-up state of SCXI-1540, D-3  
 problem-solving and diagnostic resources,  
   online, E-1  
 PXI combination chassis, 1-10 to 1-11

**Q**

questions and answers, D-1 to D-4

**R**

random scanning. *See* multiplexed scanning.  
 rear signal connector  
   pin assignments (figure), 2-8  
   signal descriptions, C-1 to C-2  
 removing SCXI-1540, 1-18 to 1-20  
   from Measurement & Automation Explorer, 1-19 to 1-20  
   from SCXI chassis, 1-18 to 1-19  
 resolvers  
   converting resolver data to angular position, 2-13  
   defined, 1-4

  signal connections, 2-6

RVDTs (rotary variable differential transformers)  
   defined, 1-4  
   scaling data in multiplexed scanning, 2-12 to 2-13  
   signal connections, 2-3 to 2-4  
     4-wire (figure), 2-3  
     5-wire (figure), 2-3

**S**

SCXI channel string. *See also* multiplexed scanning.  
   defined, 2-8  
   LabVIEW channel scanning, 2-9 to 2-10  
 SCXI-1200 device, configuring for use with SCXI-1540, D-1  
 SCXI-1310 connector and shell assembly (table), B-2  
 SCXI-1315 terminal block (table), B-1  
 SCXI-1540  
   block diagram, 1-5  
   cabling restrictions with plug-in E Series DAQ device, D-3  
   calibration, 2-14 to 2-15  
   common questions, D-1 to D-4  
   configuration and self-test, 1-11 to 1-15  
   digital signals (table), D-2  
   installation, 1-7 to 1-11  
   LVDTs, RVDTs, and resolvers, 1-2 to 1-4  
   multiplexed scanning, 2-6 to 2-13  
   overview, 1-1  
   power-up state, D-3  
   signal connections, 2-1 to 2-6  
   specifications, A-1 to A-5  
   theory of operation, 1-4 to 1-6  
   unpacking, 1-7  
 self-test verification, 1-14 to 1-15  
   troubleshooting, 1-17 to 1-18, D-1  
 signal connections, 2-1 to 2-2

- digital signals (table), D-2
- front signal connector, C-1
  - accessories for connecting signals, B-1, D-
  - pin assignments (figure), 2-1 to 2-2
- LVDTs and RVDTs, 2-3 to 2-5
- rear signal connector
  - pin assignments (figure), 2-8
  - signal descriptions, C-1 to C-2
- resolvers, 2-6
- synchronizing channels, 2-4 to 2-5
- software
  - installation, 1-6 to 1-7
  - NI-DAQ version required, D-1
- software-related resources, E-2
- specifications
  - absolute accuracy, A-4
  - environment, A-5
  - general specifications, A-1 to A-3
  - input range, gain, and required DAQ device limits (table), A-1 to A-2
  - physical, A-5
  - power requirements, A-5
- synchronization
  - external, 1-17
  - multiple channel synchronization, 2-4 to 2-5

## T

- TBX-96 DIN rail mounted block (table), B-2
- technical support resources, E-1 to E-2
- theory of operation, 1-4 to 1-6
- troubleshooting. *See* questions and answers.

## U

- unpacking SCXI-1540, 1-7

## V

- virtual channel string, 2-10 to 2-11
- VirtualBench software, D-4

## W

- Web support from National Instruments, E-1 to E-2
  - online problem-solving and diagnostic resources, E-1
  - software-related resources, E-2
- wire mode, setting, 1-16
- Worldwide technical support, E-2