SCXI™

SCXI-1141/1142/1143 User Manual

Eight-Channel Lowpass Filter Modules

NATIONAL INSTRUMENTS™

October 2001 Edition
Part Number 320748C-01

Worldwide Technical Support and Product Information

ni.com

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FCC/Canada Radio Frequency Interference Compliance*

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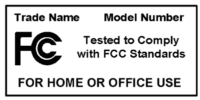
The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations). 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.

Compliance to EU Directives

Readers in the European Union (EU) must refer to the Manufacturer's Declaration of Conformity (DoC) for information** pertaining to the CE 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.

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

* 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.

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About This Manual

This manual describes the electrical and mechanical aspects of the SCXI-1141/1142/1143 module and explains how to install and use it.

The SCXI-1141/1142/1143 module is an National Instruments (NI) Signal Conditioning eXtensions for Instrumentation (SCXI) Series module. The SCXI-1141/1142/1143 module has eight configurable channels of differential amplification and filtering.

How to Use the Manual Set

The *SCXI-1141/1142/1143 User Manual* is one piece of the documentation set for the SCXI system. You could have any of several types of manuals, depending on the hardware and software in the system. Use the manuals you have as follows:

- *Getting Started with SCXI*—This is the first manual you should read. It gives an overview of the SCXI system and contains the most commonly needed information for the modules, chassis, and software.
- SCXI user manuals—Read these manuals next for detailed information about signal connections and module configuration. SCXI user manuals explain in greater detail how a particular module works and contain application hints for the module.
- DAQ hardware user manuals—These manuals have detailed information about the DAQ hardware that plugs into or is connected to the computer acquiring the data. Use these manuals for hardware installation and configuration instructions, specification information about the DAQ hardware, and application hints.
- Software manuals—After you set up the hardware system, use either the NI application development environment (ADE) software such as as LabVIEW or Measurement Studio manuals or use the NI-DAQ manuals to help you write your application. If you have a large and complicated system, look through the software manuals before you configure the hardware.
- Accessory installation guides or manuals—Consult these guides when you are installing terminal blocks, cable assemblies, or other SCXI accessories.

Conventions

The following conventions appear in this manual:

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

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

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

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

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.

SCXI-1141/1142/1143 — SCXI-1141/1142/1143 refers to the SCXI-1141 module, the SCXI-1142 module, and the SCXI-1143 module.

1 Introduction

This chapter describes the SCXI-1141/1142/1143 module, and lists the contents of the SCXI-1141/1142/1143 kit.

About the SCXI-1141/1142/1143 Module

The SCXI-1141/1142/1143 module has eight lowpass filters and eight differential-input amplifiers. The SCXI-1141 has elliptic filters; the SCXI-1142, Bessel filters; and the SCXI-1143, Butterworth filters.

You can use the SCXI-1141/1142/1143 module for lowpass filtering and antialiasing applications as well as for general-purpose signal amplification and filtering. The SCXI-1141/1142/1143 module works with National Instruments E Series MIO DAQ devices and with the SCXI-1200 data acquisition and control module. You can use one DAQ device to control several SCXI-1141/1142/1143 modules, in combination with other SCXI modules in a chassis. Each SCXI-1141/1142/1143 module can multiplex its channels into a single channel of the DAQ device, although separate outputs are also available. You can multiplex the output of several SCXI-1141/1142/1143 modules into a single channel, thus greatly increasing the number of analog input signals that the DAQ device can digitize.

The SCXI-1304 shielded terminal block has screw terminals for easily connecting signals to the SCXI-1141/1142/1143 module and is the terminal block recommended for use with this module.

Refer to Appendix A, *Specifications*, for detailed SCXI-1141/1142/1143 module specifications.

What You Need to Get Started

To set up and use the SCXI-1141/1142/1143 module, you need the following:

- ❑ SCXI-1141/1142/1143 module
- ❑ *SCXI-1141/1142/1143 User Manual*
- ❑ NI-DAQ
  - – Version 6.5.1 or later for the SCXI-1141 module
  - – Version 6.6 or later for the SCXI-1142 and SCXI-1143 modules

Note To find the latest version of NI-DAQ for your operating system, refer to `ni.com/download`.

- ❑ SCXI-1304 or SCXI-1305 terminal block (recommended)

If the shipment is missing any of the above items, contact through your NI sales representative or `ni.com`.

2

Installing and Configuring the SCXI-1141/1142/1143 Module

This chapter describes how to install the SCXI-1141/1142/1143 module into an SCXI chassis and how to configure the software.

Unpacking the SCXI-1141/1142/1143 Module

The SCXI-1141/1142/1143 module is shipped in an antistatic package to prevent electrostatic damage to the module. Electrostatic discharge can damage several components on the module.

Caution *Never* touch the exposed pins of connectors.

To avoid such damage in handling 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 the computer chassis before removing the module from the package.

Remove the module from the package and inspect the module for loose components or any sign of damage. Notify National Instruments if the module appears damaged in any way. Do *not* install a damaged module into the chassis.

Store the SCXI-1141/1142/1143 module in the antistatic envelope when it is not in use.

Safety Information

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

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

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

Do *not* operate the product in an explosive atmosphere or where there may be flammable gases or fumes. Operate the product only at or below the pollution degree stated in Appendix A, *Specifications*. Pollution is foreign matter in a solid, liquid, or gaseous state that can reduce dielectric strength or surface resistivity. The following is a description of pollution degrees:

- Pollution degree 1 means no pollution or only dry, nonconductive pollution occurs. The pollution has no influence.
- Pollution degree 2 means that only nonconductive pollution occurs in most cases. Occasionally, however, a temporary conductivity caused by condensation must be expected.
- Pollution degree 3 means that conductive pollution occurs, or dry, nonconductive pollution occurs that becomes conductive due to condensation.

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

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

Operate this product only at or below the installation category stated in Appendix A, *Specifications*.

The following is a description of installation categories:

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

  Examples of installation category I are measurements on circuits not derived from MAINS and specially protected (internal) MAINS-derived circuits.
- Installation category II is for measurements performed on circuits directly connected to the low-voltage installation. This category refers to local-level distribution such as that provided by a standard wall outlet.

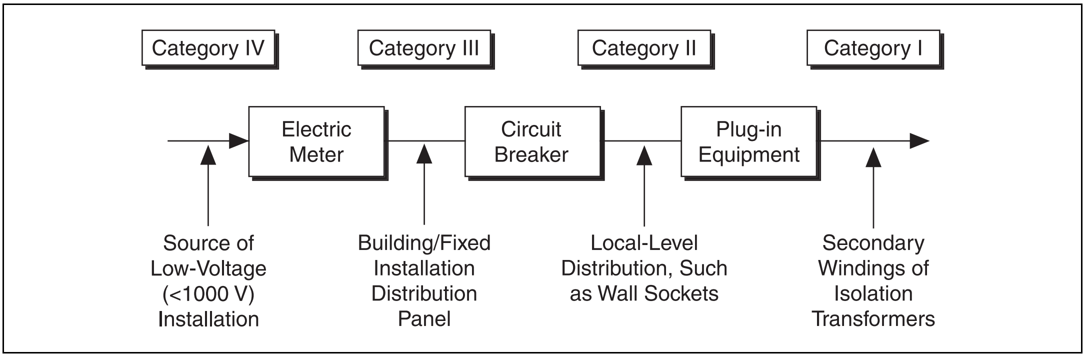
  Examples of installation category II are measurements on household appliances, portable tools, and similar equipment.
- Installation category III is for measurements performed in the building installation. This category is a distribution level referring to hardwired equipment that does not rely on standard building insulation.

  Examples of installation category III include measurements on distribution circuits and circuit breakers. Other examples of installation category III are wiring including cables, bus-bars, junction boxes, switches, socket outlets in the building/fixed installation, and equipment for industrial use, such as stationary motors with a permanent connection to the building/fixed installation.
- Installation category IV is for measurements performed at the source of the low-voltage (<1,000 V) installation.

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

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

Below is a diagram of a sample installation.



Installing Your Software

Install your software before you install the SCXI-1141/1142/1143 module. Install your application development environment (ADE), such as LabVIEW or Measurement Studio, according to the instructions on the CD and the release notes. After you have installed your ADE, install NI-DAQ according to the instructions on the CD and the *DAQ Quick Start Guide* included with the device.

Note It is important to install the NI-DAQ driver software before installing the SCXI-1141/1142/1143 module to ensure that the module is properly detected.

Installing the SCXI-1141/1142/1143 Module

The following section describes how to install the SCXI-1141/1142/1143 module for use with an SCXI chassis and National Instruments DAQ devices.

Installing the SCXI-1141/1142/1143 Module in an SCXI Chassis

To install the SCXI-1141/1142/1143 module, you need the following items:

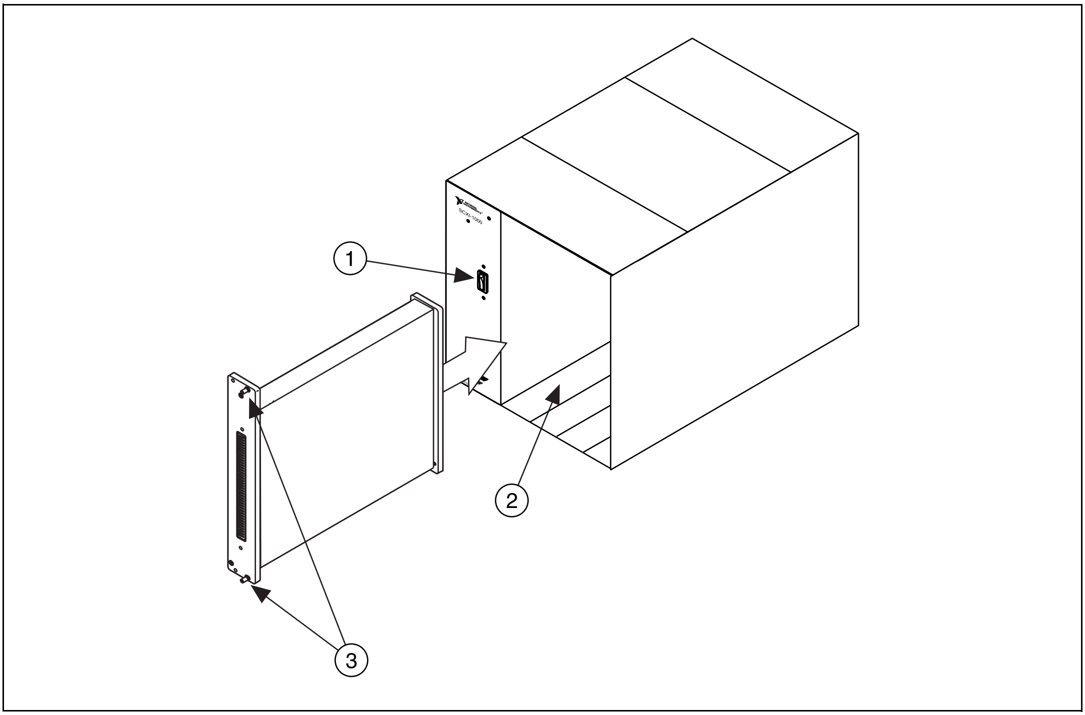
- SCXI-1141/1142/1143 module
- SCXI chassis or PXI combination chassis
- 1/4 in. flat blade screwdriver

To install the SCXI-1141/1142/1143 module in an SCXI chassis, follow these steps while referring to Figure 2-1:

1. Turn off the computer that contains the DAQ device or disconnect it from the SCXI chassis.
2. Turn off the SCXI chassis.

Caution Do *not* insert the SCXI-1141/1142/1143 module into a chassis that is turned on.

3. Insert the SCXI-1141/1142/1143 module into an open slot in the SCXI chassis. Gently guide the module into the slot guides and push it to the back of the slot 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.



1 SCXI Chassis Power Switch	2 SCXI Chassis Slots	3 SCXI Module Thumbscrews

Figure 2-1. Installing the SCXI-1141/1142/1143 Module

To finish installing the SCXI-1141/1142/1143 module, complete the following section that is appropriate for your application.

Connecting the SCXI-1141/1142/1143 Module to a DAQ Device for Multiplexed Scanning in an SCXI Chassis

Use this configuration to multiplex all eight input channels and the cold-junction compensation (CJC) channel of the SCXI-1141/1142/1143 module into a single channel of the DAQ device. You need the following items for this installation:

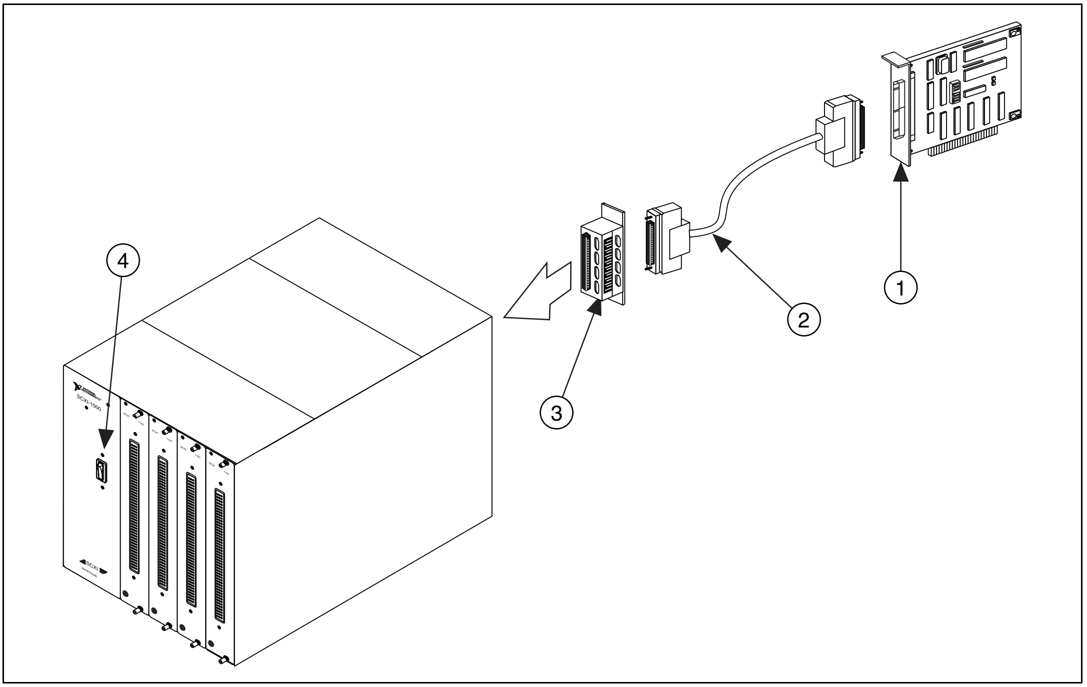
- SCXI chassis with the SCXI modules installed
- SCXI cable assembly, which consists of a cable adapter and a cable
- National Instruments DAQ device installed in the computer
- 1/4 in. flat blade screwdriver

Consult the SCXI chassis documentation, other SCXI module documentation, and DAQ device documentation for additional instructions and cautions. The SCXI-1141/1142/1143 module and any other SCXI modules should already be installed in the chassis according to their installation instructions.

You can connect the DAQ device to most modules in the chassis that are configured for multiplexed operation. However, if you use an SCXI-1140, it must be the cabled module. To connect these modules to the DAQ device for multiplexed operation, follow these steps while referring to Figure 2-2:

1. Turn off the SCXI chassis and the computer containing the DAQ device.
2. Insert the cable adapter into the back of the SCXI chassis; aligning the adapter with the module that is to be connected to the DAQ device. See the installation guide for the 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 that you 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.
8. If you have already installed the appropriate software, you are ready to configure the SCXI-1141/1142/1143 module for multiplexed mode

operation. See the *Configuring and Testing the SCXI-1141/1142/1143 Module* section in this chapter for information on configuring and testing the installation.



1 DAQ Device	2 Cable	3 Cable Adapter	4 SCXI Chassis Power Switch

Figure 2-2. Connecting the SCXI Modules for Multiplexed and Parallel Mode

Connecting the SCXI-1141/1142/1143 Module to a DAQ Device for Multiplexed Scanning in a PXI Combination Chassis

Use this configuration to multiplex all eight channels of the SCXI-1141/1142/1143 module into a single channel of the 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 DAQ device installed in the right-most slot

Consult the PXI chassis documentation, other SCXI module documentation, and DAQ device documentation for additional instructions and cautions. You should have already installed the SCXI-1141/1142/1143 module and any other SCXI modules in the chassis according to their installation instructions. To connect the SCXI-1141/1142/1143 module with a DAQ device in a PXI combination chassis for multiplexed scanning, follow these steps:

1. No cables are required for this connection if the National Instruments PXI DAQ device is installed in the right-most slot. You can configure this device to control the SCXI system. If the DAQ device for controlling the SCXI system is not installed in the right-most slot of the PXI combination chassis, configure the system as described earlier in the *Connecting the SCXI-1141/1142/1143 Module to a DAQ Device for Multiplexed Scanning in an SCXI Chassis* section.
2. Turn on the SCXI chassis.

If you have already installed the appropriate software, you are ready to configure the SCXI-1141/1142/1143 module for multiplexed scanning. See the *Configuring and Testing the SCXI-1141/1142/1143 Module* section later in this chapter for information on configuring and testing the installation.

Connecting the SCXI-1141/1142/1143 Module to a DAQ Device for Parallel Scanning

Use this configuration to route all eight channels of the SCXI-1141/1142/1143 module in parallel to eight input channels of the DAQ device with which it is connected. You can use this mode if you require a higher scanning rate than the SCXI system allows in multiplexed mode. You need the following items to complete this installation:

- SCXI chassis or PXI combination chassis with the SCXI-1141/1142/1143 module(s) installed
- For each SCXI-1141/1142/1143 module operating in parallel mode, you need one each of the following:
  - National Instruments DAQ device
  - SCXI cable assembly, which consists of a cable adapter and a cable
- 1/4 in. flat blade screwdriver

Consult the documentation for the SCXI/PXI chassis and accessories for additional instructions and cautions. All modules should already be installed according to their installation instructions. To set up the SCXI-1141/1142/1143 module for access by a DAQ device in parallel mode, follow these steps:

1. Turn off the SCXI/PXI chassis and the computer containing the DAQ device if applicable.
2. Insert the cable adapter into the back of the SCXI-1141/1142/1143 module that is to be accessed in parallel mode by the DAQ device, as described in the appropriate installation guide for the cable assembly.
3. Connect the cable to the back of the cable adapter and ensure that the cable fits securely.
4. Connect the other end of the cable to the National Instruments DAQ device that you want to use to access the SCXI-1141/1142/1143 module in parallel mode.
5. Connect additional SCXI-1141/1142/1143 modules intended for parallel mode operation by repeating steps 2 through 4.
6. Check the installation, making sure the connectors are securely fastened at both ends.
7. Turn on the SCXI/PXI chassis.
8. Turn on the computer if applicable.

You are now ready to configure and test the SCXI-1141/1142/1143 module using Measurement & Automation Explorer (MAX).

Configuring and Testing the SCXI-1141/1142/1143 Module

Use MAX to configure and test the SCXI-1141/1142/1143 module. If you need help during the configuration process, open the MAX Help file by selecting from the menu **Help»Help Topics»NI-DAQ**. Follow these steps to configure the SCXI system:

1. Double-click the **Measurement & Automation Explorer** icon on the desktop.

If you are adding new modules to an existing chassis, go to step 4. If you are inserting modules into an empty chassis, go to step 2.

2. Add a new chassis by right-clicking **Devices and Interfaces** and selecting **Insert** from the pop-up menu. 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.
   a. 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 for all SCXI chassis.
      - If you are using multiple chassis, refer to the SCXI chassis user manual for further information.
      - For remote SCXI chassis, you also need to select the **Baud Rate** and **COM Port**.
   b. 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 MIO DAQ device, you can automatically detect the modules.
   - If the chassis is already listed in **Devices and Interfaces**, you must add new modules manually.

Go to the appropriate section that follows to continue the software configuration of the chassis.

Auto-Detecting Modules

If you choose to auto-detect, you must have the chassis connected to the DAQ device, except in the case of a remote chassis. Use the serial-port cable to connect a remote chassis to the computer.

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

1. Make sure the chassis is powered on.
2. Perform the steps in the *Configuring and Testing the SCXI-1141/1142/1143 Module* section if you have not already done so.
3. Select **Yes** under **Auto-Detect modules?** and click **Next**. If the chassis is a remote SCXI chassis, go to step 7.
4. Select the communication path and click **Next**.
5. If modules were detected, select the module connected to the DAQ device as the communication path.
6. Configure the module.
    a. Complete one of the following steps depending on whether the SCXI module is connected to a DAQ device.
        - If the selected module is connected to a DAQ device, select that device by using the **Connected to** control.
        - 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**.
        - If the SCXI module is not connected to an NI device, select **None**.
    b. Select the appropriate scanning mode for the SCXI-1141/1142/1143 module by using the **Operating Mode** control. If parallel mode is selected, the checkbox labeled **This device will control the chassis** automatically becomes deselected. Click **Next**.
    c. Select the appropriate default gain and filter settings for each channel on the SCXI-1141/1142/1143 module. Click **Next**.
    d. Select the terminal block you are using with this module. If the terminal block you are using has configurable gain, click **Back** to modify the terminal block gain settings.
    e. When you have completed configuration, click **Finish**.
7. Click **Finish**.

MAX should now recognize the SCXI chassis and SCXI module(s). If the software did not recognize the module(s), check the cable connections and retry auto-detecting or try adding the modules manually before taking troubleshooting measures. If the software recognized any module as an SCXI custom module, you may be using the wrong version of NI-DAQ. To find the latest version of NI-DAQ for your application, go to `ni.com/download`.

Manually Adding Modules

If you did not auto-detect the SCXI modules, you must add each of the 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 installed 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 description.
3. Right-click the appropriate installation slot and select **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 incorrect version of NI-DAQ.
5. Configure the module.
   a. Complete one of the following steps depending on whether the SCXI module is connected to a DAQ device.
      - If the selected module is connected to a DAQ device, select that device by using the **Connected to** control.
      - 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**.
      - If the SCXI module is not connected to an NI device, select **None**.
   b. Select the appropriate scanning mode for the SCXI-1141/1142/1143 module by using the **Operating Mode** control. If parallel mode is selected, the checkbox labeled **This device will control the chassis** automatically becomes deselected. Click **Next**.
   c. Select the appropriate default gain and filter settings for each channel on the SCXI-1141/1142/1143 module. Click **Next**.

   d. Select the terminal block you are using with this module. If the terminal block you are using has configurable gain, click **Back** to modify the terminal block gain settings.
   e. When you have completed configuration, click **Finish**.
6. If you need to manually add more SCXI-1141/1142/1143 modules in the chassis, repeat steps 3 through 5 to configure each module.

The SCXI chassis and SCXI module(s) should now be configured properly. If you need to make changes in the module configuration, see the *Configuring the SCXI-1141/1142/1143 Module* section. If the configuration is complete, test the system as described in the *Self-Test Verification* section to ensure that the SCXI system is communicating properly with the DAQ device.

Configuring the SCXI-1141/1142/1143 Module

Use MAX to configure the SCXI-1141/1142/1143 module after auto-detection or to alter the original configuration selections. Perform the following steps to configure the SCXI-1141/1142/1143 module:

1. Double-click the **Measurement & Automation Explorer** icon on the 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 description.
4. Right-click the SCXI-1141/1142/1143 module you want to configure and select **Properties**. Click the **General** tab.
   a. Select the appropriate mode for the SCXI-1141/1142/1143 module by using the **Operating Mode** control. If parallel mode is selected, the checkbox labeled **This device will control the chassis** is deselected automatically.
   b. Complete one of the following steps depending on whether the SCXI module is connected to a DAQ device:
      - If the module you are configuring is connected to a DAQ device, select the cabled device by using the **Connected to** control.
      - 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**.
      - If the module you are configuring is not connected to a DAQ device, select **None**.

5. Click the **Channel** tab. Select the appropriate gain and filter settings for each channel on the SCXI-1141/1142/1143 module.
6. Click the **Accessory** tab. Select the terminal block you are using for this module.
7. When all of the configuration selections are completed, click **OK**.

The SCXI chassis and SCXI module(s) should now be configured properly. Use the procedure in *Self-Test Verification* to ensure that the SCXI system is communicating properly with the DAQ device.

Self-Test Verification

To test the successful configuration of the system, follow the steps that follow after opening MAX:

1. Verify that the chassis power is on and that the chassis is correctly connected to a DAQ device.
2. Display the list of installed 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 the chassis and click **Test**.
4. If the communication test is successful, the message **The chassis has been verified** appears. Click **OK**.

The SCXI system should now operate properly with your ADE software. If the test does not complete successfully, see the *Troubleshooting Self-Test Verification* section for troubleshooting steps.

Troubleshooting Self-Test Verification

If the configuration software does not verify the chassis configuration, perform the following steps to successfully complete the system configuration:

- 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 the *Configuring the SCXI-1141/1142/1143 Module* section of this document and change the configuration of the cabled module in the system from **Connected to: None** to **Connected to: Device *x***.

- 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 that the SCXI chassis is powered on.
  b. Make sure the cable to the SCXI system is properly connected to a DAQ device.
  c. Inspect the DAQ device connector and SCXI cable adapter for any bent pins.
  d. Make sure you are using the correct NI cable.
  e. Test the DAQ device to verify it is working properly. See the DAQ device user manual for more information.
- If you get the warning message **Failed to find** followed by module codes and then the message **Instead found: module with ID 0*Xxx***, return to the *Configuring the SCXI-1141/1142/1143 Module* section and make sure the correct module is in the specified slot. Delete the incorrect module as described in the *Removing the SCXI-1141/1142/1143 Module from MAX* section and then add the correct module as described in the *Manually Adding Modules* section.
- If you get the warning message **Failed to find** followed by a module code and then 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 the *Installing the SCXI-1141/1142/1143 Module in an SCXI Chassis* section. If the module is installed in the correct slot, power off the chassis, remove the module as specified in the *Removing the SCXI-1141/1142/1143 Module from an SCXI Chassis* section, and verify that no connector pins are bent on the rear signal connector. Reinstall the module as shown in the *Installing the SCXI-1141/1142/1143 Module in an SCXI Chassis* section, ensuring that the module is properly aligned in the slot.
- After checking the preceding items, return to the *Self-Test Verification* section and retest the SCXI system.

Removing the SCXI-1141/1142/1143 Module

This section describes how to remove the SCXI-1141/1142/1143 module from an SCXI chassis and from MAX.

Removing the SCXI-1141/1142/1143 Module from an SCXI Chassis

Only a qualified person who has read and understands all the safety information in this manual should remove an SCXI module. You need the following items to complete this task:

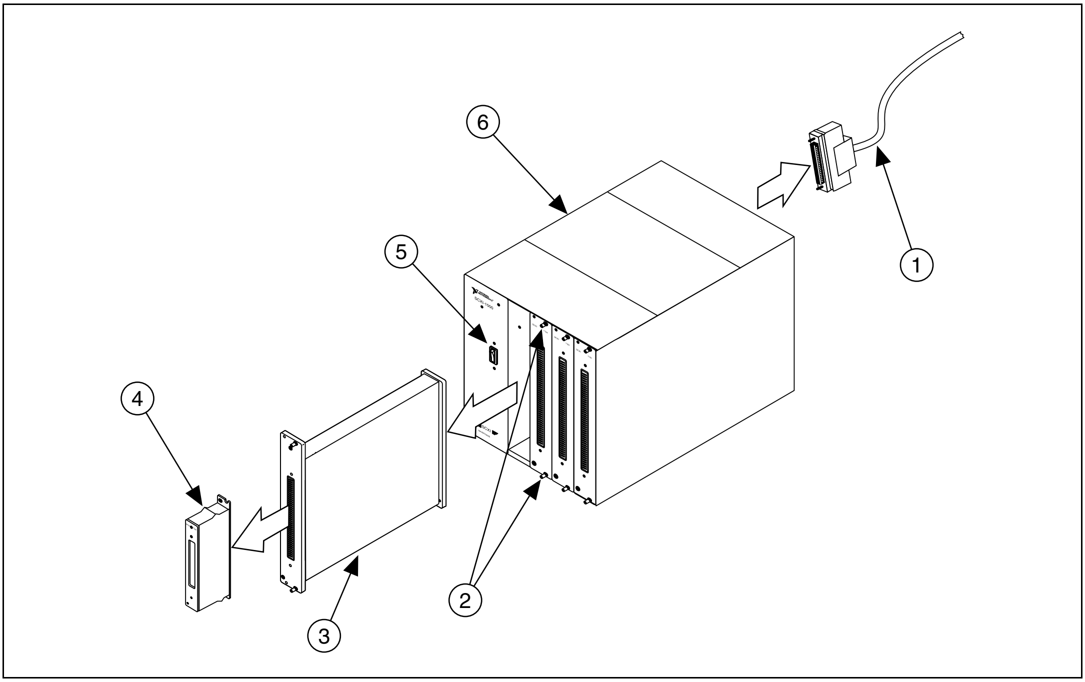
- SCXI chassis or PXI combination chassis with the SCXI-1141/1142/1143 module(s) installed
- 1/4 in. flat blade screwdriver

Consult the documentation for the SCXI/PXI chassis and accessories for additional instructions and cautions. To remove the SCXI-1141/1142/1143 module from an SCXI chassis, perform the following steps while referring to Figure 2-3:

1. Power off the SCXI chassis.
2. Disconnect the cable running from the SCXI module to the DAQ device.
3. Remove all signals from terminal blocks connected to the SCXI-1141/1142/1143 module.

Caution Read the safety information in the terminal block installation guide before adding or removing any signals from the SCXI module or terminal blocks.

4. Remove any terminal blocks that connect to the SCXI-1141/1142/1143 module.
5. Rotate the thumbscrews securing the SCXI-1141/1142/1143 module to the chassis counter-clockwise until they are loose, but do not completely remove them.
6. Remove the SCXI-1141/1142/1143 module by pulling steadily on both thumbscrews until the module slides completely out.



1	Cable	3	SCXI-1141/1142/1143 Module	5	SCXI Chassis Power Switch
2	SCXI Module Thumbscrews	4	Terminal Block	6	SCXI Chassis

Figure 2-3. Removing the SCXI-1141/1142/1143 Module

Removing the SCXI-1141/1142/1143 Module from MAX

To remove a module from MAX, open MAX and perform the following steps:

1. Display the list of installed devices and interfaces by clicking the **+** next to the **Devices and Interfaces** icon.
2. Locate the SCXI chassis in the list. Display the list of modules in the chassis by clicking the **+** next to the **Chassis** icon.
3. Right-click the module or chassis you want to delete and click **Delete**.
4. You are presented with 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 and eliminates all configuration information for these modules.

3

Connecting the Signals

This chapter describes input and output signal connections to the SCXI-1141/1142/1143 module through the front and rear signal connectors.

Caution Connections that exceed any of the maximum ratings of input or output signals on the SCXI-1141/1142/1143 module can damage the SCXI-1141/1142/1143 module, the SCXIbus, any connected DAQ device, and the computer with which the DAQ device is used. NI is not liable for any damage resulting from such signal connections.

Front Connector

Table 3-1 shows the pin assignments for the SCXI-1141/1142/1143 module front connector.

Table 3-1. SCXI-1141/1142/1143 Module Front Connector

Pin Number	Column A	Column B	Column C
32	IN0+	NC	IN0–
31	NC	NC	NC
30	IN1+	NC	IN1–
29	NC	NC	NC
28	AGND	NC	AGND
27	NC	NC	NC
26	IN2+	NC	IN2–
25	NC	NC	NC
24	IN3+	NC	IN3–
23	NC	NC	NC
22	AGND	NC	AGND
21	NC	NC	NC

Table 3-1. SCXI-1141/1142/1143 Module Front Connector (Continued)

Pin Number	Column A	Column B	Column C
20	IN4+	NC	IN4–
19	NC	NC	NC
18	IN5+	NC	IN5–
17	NC	NC	NC
16	AGND	NC	AGND
15	NC	NC	NC
14	IN6+	NC	IN6–
13	NC	NC	NC
12	IN7+	NC	IN7–
11	NC	NC	NC
10	NC	NC	NC
9	NC	NC	NC
8	RSVD	NC	RSVD
7	NC	NC	NC
6	RSVD	NC	RSVD
5	NC	NC	NC
4	RSVD	NC	EXTCLK
3	NC	NC	NC
2	DGND	NC	OUTCLK
1	NC	NC	NC
NC means not connected.			

Front Connector Signal Descriptions

Pins	Signal Names	Description
A32, A30, A26, A24, A20, A18, A14, A12	IN+<0..7+>	Positive input channels—these pins connect to the noninverting inputs of the instrumentation amplifier of each channel.
C32, C30, C26, C24, C20, C18, C14, C12	IN–<0..7–>	Negative input channels—these pins connect to the inverting inputs of the instrumentation amplifier of each channel.
A28, A22, A16, C28, C22, C16	AGND	Analog ground—these pins connect to the module analog ground.
A2, C8	DGND	Digital ground—these pins connect to the module digital ground.
A8,A6, A4, C8	RSVD	Reserved—do not connect any signals to these pins.
C4	EXTCLK	External clock—you can use this signal to set the filter cutoff frequency.
C2	OUTCLK	Output clock—this signal has a frequency that is proportional to the cutoff frequency. You can use this signal to external control the cutoff frequency.
Note: All other pins are not connected.		

Analog Input Channels

The SCXI-1141/1142/1143 module instrumentation amplifiers can reject any common-mode voltage within their common-mode input range caused by ground-potential differences between the signal source and the module. In addition, the amplifiers can reject common-mode noise pickup in the leads connecting the signal sources to the SCXI-1141/1142/1143 module. However, you should take care to minimize noise pickup. The common-mode rejection of the instrumentation amplifiers decreases significantly at high frequencies. The amplifiers do not reject normal-mode noise.

The maximum differential input voltage range of the SCXI-1141/1142/1143 module instrumentation amplifiers is a function of the gain of the amplifiers, *G*, and is equal to 5 V/*G*. The common-mode input range of the SCXI-1141/1142/1143 module, however, is not a function of gain—the differential input amplifier rejects common-mode signals as long as the signal at both inputs is within ±5 V of the module analog ground. The inputs are protected against maximum input voltages of up to ±15 V powered off and ±30 V powered on.

Caution Exceeding the differential or common-mode input voltage limits distorts input signals. Exceeding the maximum common-mode input voltage rating can damage the SCXI-1141/1142/1143 module, the SCXIbus, and the DAQ device. NI is *not* liable for any damage resulting from such signal connections.

All eight channels have fully differential inputs, so you can ground-reference the signals you measure. If the signals connected to the differential amplified inputs are not ground referenced, connect a 100 kΩ resistor from the negative input to ground to provide a DC path for the input bias currents. If you do not do this, the bias currents of the instrumentation amplifiers of the nonreferenced channels charge up stray capacitances, resulting in uncontrollable drift and possible saturation.

Note The recommended SCXI-1304 or SCXI-1305 terminal block has all necessary circuitry for AC or DC coupling and for floating or ground-referenced signals. The *SCXI-1304 AC/DC Coupling Terminal Block Installation Guide* and *SCXI-1305 AC/DC Coupling BNC Terminal Block Installation Guide* have instructions for signal connection. Figures 3-2 through 3-6 provide supplemental information on connecting signals to the SCXI-1141/1142/1143 module.

Figure 3-1 illustrates how to connect a ground-referenced signal source to an SCXI-1141/1142/1143 module channel.

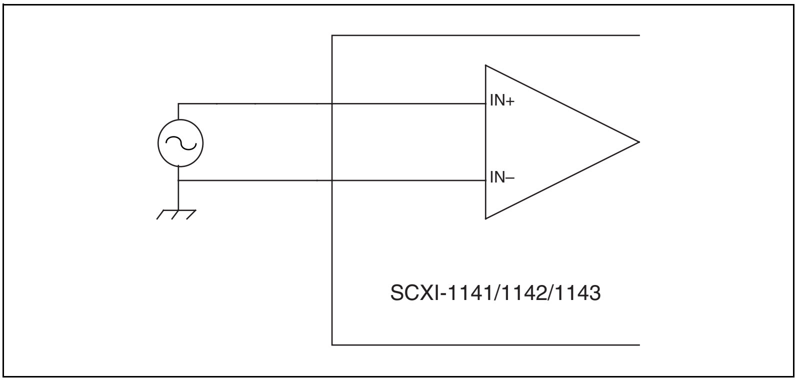


Figure 3-1. Ground-Referenced Signal Connection

Figure 3-2 illustrates how to connect a non-referenced (floating) signal source to an SCXI channel.

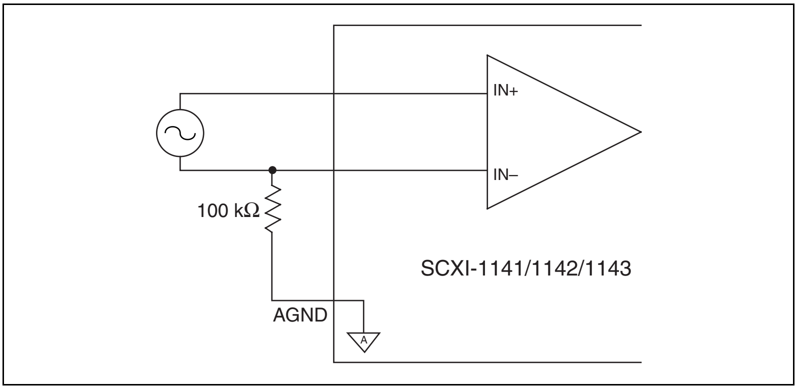


Figure 3-2. Floating Signal Connection

For AC-coupled signals, connect an external resistor from the AC-coupled input channel to ground. This provides a DC path for the amplifier input bias current. Typical resistor values range from 100 kΩ to 10 MΩ. This solution, although necessary, lowers the input impedance of the channel and introduces an additional DC offset voltage proportional to the product of the input bias current and the resistor value used. The inputs of the SCXI-1141/1142/1143 module have a typical bias current of about ±200 pA. This bias current is highly dependent on the operating temperature of the module. Using a 1 MΩ resistor results in ±200 μV of offset, which is insignificant in most applications. However, if you use larger-valued bias resistors, significant input offset can result. Lower-valued bias resistors increase loading of the source, which can result in gain error.

Figures 3-3 through 3-5 illustrate how to connect AC-coupled signals.

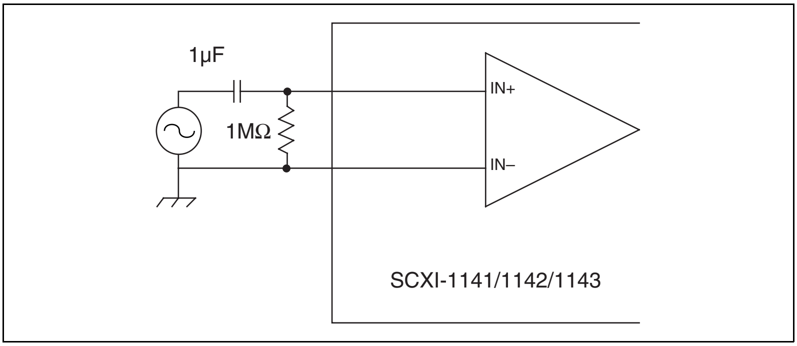


Figure 3-3. Ground-Referenced AC-Coupled Signal Connection

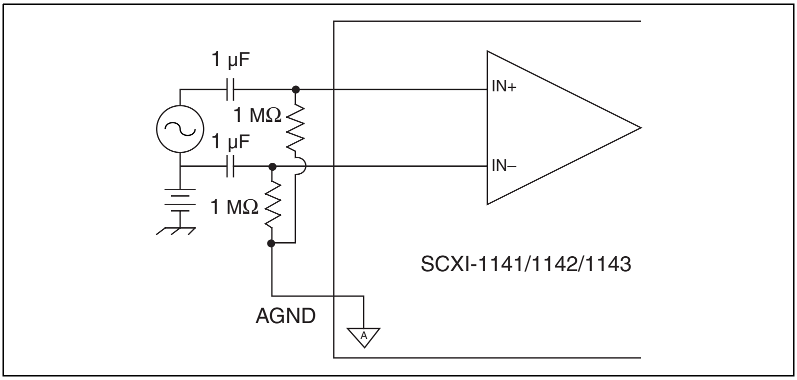


Figure 3-4. Ground-Offset AC-Coupled Signal Connection

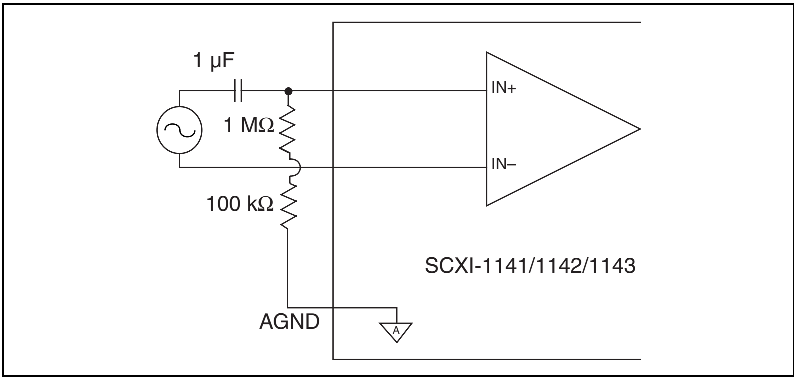


Figure 3-5. Floating AC-Coupled Signal Connection

Digital Input and Output

You can use the EXTCLK input pin on the front connector of the SCXI-1141/1142/1143 module to control filter cutoff frequency for special purposes. The clock should be a TTL-logic-level or CMOS-logic-level square wave, with a frequency of less than 2.5 MHz that is 100 times the desired cutoff frequency. The absolute maximum input voltage for the EXTCLK pin is 5.5 V with respect to DGND; the minimum input voltage is –0.5 V.

The OUTCLK pin on the front connector is a CMOS-logic-level output clock, which you can configure to have a frequency that is proportional to filter cutoff frequency.

See Chapter 4, *Theory of Operation*, for more details on using these two signals.

Rear Signal Connector

Note If you use the SCXI-1141/1142/1143 module with a National Instruments DAQ device and SCXI cable assembly, you do not need to read the remainder of this chapter. If you also use the SCXI-1180 feedthrough panel, the SCXI-1343 rear screw-terminal adapter, or the SCXI-1351 one-slot cable extender with the SCXI-1141/1142/1143 module, you should read this section.

Figure 3-6 shows the pin assignments for the SCXI-1141/1142/1143 module rear signal connector. Pins without signal labels are not connected.

	1	2	
OUTPUT	3	4	OUTPUTREF
AOUT1	5	6	AGND
AOUT2	7	8	AGND
AOUT3	9	10	AGND
AOUT4	11	12	AGND
AOUT5	13	14	AGND
AOUT6	15	16	AGND
AOUT7	17	18	AGND
	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	
RSVD	43	44	
	45	46	
	47	48	
	49	50	

Figure 3-6. SCXI-1141/1142/1143 Module Rear Signal Connector

Rear Signal Connection Descriptions

Pin	Signal Name	Description
3	OUTPUT	Output—this is the main module analog output. In multiplexed mode, the outputs of all eight channels appear here in sequence. Outputs from other modules can also appear here through the analog bus. In parallel mode, this is the output of channel 0.
5, 7, 9, 11, 13, 15, 17	AOUT<1..7>	Analog outputs—these pins are the outputs of channels 1 through 7, regardless of the scanning mode.
25	SERDATIN	Serial data in—this signal taps into the SCXIbus MOSI line to send serial input data to a module or Slot 0.
27	DAQD*/A	Board data/address line—this signal taps into the SCXIbus D*/A line to indicate to the module whether the incoming serial stream is data or address information.
29	SLOT0SEL*	Slot 0 select—this signal taps into the SCXIbus INTR* line to indicate whether the information on MOSI is being sent to a module or Slot 0.
24, 33	DIGGND	Digital ground—these pins supply the reference for DAQ digital signals and are tied to the module digital ground.
37	SERCLK	Serial clock—this signal taps into the SCXIbus SPICLK line to clock the data on the MOSI and MISO lines.
43	RSVD	Reserved.
4	OUTPUT REF	Output reference—this pin connects to the module analog ground unless an output from another module is selected through the analog bus, in which case the pins connect to the analog ground for the selected module.
6, 8, 10, 12, 14, 16, 18	AGND	Analog ground—these pins connect to the module analog ground. They are used as the reference points for AOUT1 through AOUT7.

Pin	Signal Name	Description
26	SERDATOUT	Serial data out—this signal taps into the SCXIbus MISO line to accept serial output data from a module.
36	SCANCLK	Scan clock—the signal at this pin indicates to the SCXI-1141/1142/1143 module that a sample has been taken by the DAQ device and causes the SCXI-1141/1142/1143 modules to change channels.
Notes: All other pins are not connected. An * means the signal is asserted low.		

The signals on the rear signal connector are classified as analog output, digital I/O, or timing I/O signals.

Analog Output Signal Connections

Pins 3 through 17 of the rear signal connector are analog output signal pins. Pin 3 is the main output, and pin 4 is its reference signal. All eight channels are multiplexed onto this output when the module is software-configured for multiplexed scanning mode. In parallel scanning mode, the output of pin 3 is the output of one selected channel. Channel 0 is the power-up and reset default. When scanning multiple modules, you can also connect this output to the SCXIbus analog bus and the analog bus will drive this output.

Pins 5, 7, 9, 11, 13, 15, and 17 are direct outputs from channels 1 through 7, respectively. In parallel mode, all eight channels are available simultaneously at the rear connector. Pins 6, 8, 10, 12, 14, 16, and 18 are the reference signals for outputs 1 through 7.

Caution The SCXI-1141/1142/1143 module analog outputs are not overvoltage protected, although they are short-circuit protected. Applying external voltage to these outputs can result in damage to the SCXI-1141/1142/1143 module. NI is *not* liable for any damage resulting from such signal connections.

Digital I/O Signal Connections

Pins 24 through 27, 29, 33, 36, 37, and 43 constitute the digital I/O lines of the rear signal connector. Each of these pins is in one of three categories—digital input signals, digital output signals, and timing signals. Pins 24 and 33 are the digital ground reference for all of the DAQ device digital signals and are tied to the module digital ground.

The digital input signals are pins 25, 27, 29, and 37. Each digital line emulates an SCXIbus communication signal as follows:

- Pin 25 is SERDATIN and is equivalent to the SCXIbus MOSI serial data input line.
- Pin 27 is DAQD*/A and is equivalent to the SCXIbus D*/A line. Pin 27 indicates to the module whether the incoming serial stream on SERDATIN is data (DAQD*/A = 0) or address (DAQD*/A = 1) information.
- Pin 29 is SLOT0SEL* and is equivalent to the SCXIbus INTR* line. Pin 29 indicates whether the data on the SERDATIN line is being sent to Slot 0 (SLOT0SEL* = 0) or to a module (SLOT0SEL* = 1).
- Pin 37 is SERCLK and is equivalent to the SCXIbus SPICLK line. Pin 37 is used to clock the serial data on the SERDATIN line into the module registers.

The digital output signal is pin 26. Pin 26 is SERDATOUT and is equivalent to the SCXIbus MISO serial data output line.

The digital I/O signals of the SCXI-1141/1142/1143 module correspond to the digital I/O lines of an E Series MIO DAQ device. Table 3-2 lists the equivalencies.

Table 3-2. SCXIbus to SCXI-1141/1142/1143 Module Rear Signal Connector to DAQ Device Pin Equivalencies

SCXIbus Line	SCXI-1141/1142/1143 Rear Signal Connector	E Series MIO DAQ Device
MOSI	SERDATIN	DIO0
D*/A	DAQD*/A	DIO1
INTR*	SLOT0SEL*	DIO2
SPICLK	SERCLK	EXTSTROBE*
MISO	SERDATOUT	DIO4
An * means the signal is asserted low.		

The digital timing signals are pins 36 and 43:

- Pin 36 is SCANCLK, the signal used as a clock for the SCXI-1141/1142/1143 module multiplexer counter. The DAQ device pulses this signal at the end of each conversion if the module is in multiplexed mode.
- Pin 43 is a reserved digital input.

4

Theory of Operation

This chapter contains an overview of the SCXI-1141/1142/1143 module and explains the operation of each functional unit of the module.

Functional Overview

The SCXI-1141/1142/1143 module has eight software-controlled input channels that amplify and filter signals. Each channel has an output range of ±5 V and has an input amplifier with gains of 1, 2, 5, 10, 20, 50, and 100. You can independently set each amplifier gain. The analog inputs are overvoltage protected. The SCXI-1141/1142/1143 module filters are lowpass, 8th-order elliptic, Bessel, and Butterworth filters respectively that can have a cutoff frequency from 10 Hz to 25 kHz. All eight filters have the same cutoff frequency. The outputs of all eight channels are available at the rear connector.

The major components of the SCXI-1141/1142/1143 module are as follows:

- Digital control and calibration circuitry
- Input amplifiers
- Lowpass filters

The usage and theory of operation of each of these components are explained in the remainder of this chapter.

Power-Up State

When the SCXI-1141/1142/1143 module is powered up or reset through software or the SCXI chassis reset button, the following states are defined:

- The gain of each amplifier is set to 1.
- Channel 0 is selected as the OUTPUT signal and the module defaults to multiplexed mode.
- All filters are placed in bypass mode.
- The external clock input is disabled.

The cutoff frequency of the filters and the output clock frequency are not defined at power-up.

The block diagram in Figure 4-1 illustrates the key functional components of the SCXI-1141/1142/1143 module.

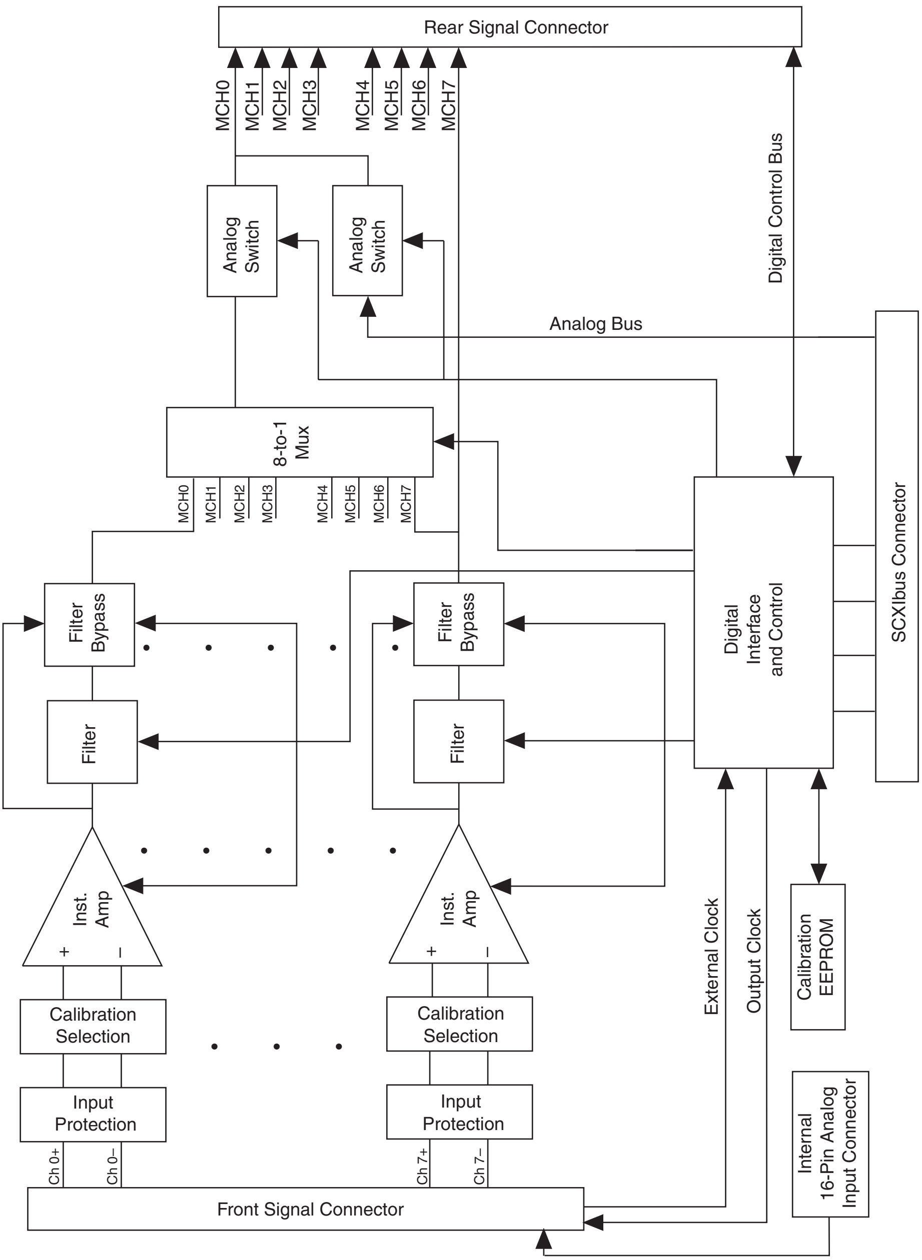


Figure 4-1. SCXI-1141/1142/1143 Module Block Diagram

Digital Control Circuitry

The digital control circuitry contains a Module ID (identification) register, a configuration register for the module, a gain register, and an EEPROM for storing gain-calibration constants.

The Module ID register contains 20 (hex) for the SCXI-1141 module, 35 (hex) for the SCXI-1142 module, and 34 (hex) for the SCXI-1143 module. You can read this module ID over the SCXIbus to determine the type of module that is in a particular slot.

Use the configuration register to select channels and configure the SCXI-1141/1142/1143 module for scanning, calibration, and control options.

The gain register sets the gain of each amplifier.

The frequency dividers control the filter cutoff frequency and the output clock frequency. For more information see the *Using the External Clock Input* section.

The EEPROM stores the calibration constants for each gain for all eight channels. Information in the EEPROM is retained when the module is power off. The SCXI-1141/1142/1143 module has calibration constants already stored in the EEPROM. You can modify these constants for your own set of operating conditions. One set of constants is reserved and cannot be modified except at the factory, which ensures that you do not accidentally erase the default calibration constants. For more information on the EEPROM and calibration, see Chapter 5, *Calibrating the SCXI-1141/1142/1143 Module*.

Input Amplifiers

The amplifiers provide gain to the differential signal between the inputs while rejecting common-mode noise voltages. The available gains are 1, 2, 5, 10, 20, 50, and 100. The output range of the amplifiers is ±5 V. Select the gain to prevent the output signals from reaching ±5 V, or distortion occurs.

The input amplifiers are fully differential amplifiers with input protection and calibration circuitry. The inputs are protected against input voltages up to ±15 V powered off and ±30 V powered on.

In general, to provide optimum measurement resolution and noise rejection, you can select as high a gain as will not cause the output to exceed this limit. However, total harmonic distortion (THD) increases at higher output levels, especially at higher input frequencies. If THD is of significant concern in a given application, a lower gain (one or two steps lower) may be more appropriate.

Correcting Gain and Offset Errors

The input amplifiers have intrinsic errors in their gains and in their DC offsets. To compensate for the gain errors, calibration constants are stored in the EEPROM for each gain and for each channel. These constants contain the adjustment factors used to correct for the gain errors. If you are using NI software, these constants are read automatically from the EEPROM and the appropriate correction factor is applied when the raw data is scaled to a voltage.

Gain errors are determined and calibration constants are loaded into the EEPROM at the factory. However, gain errors drift with temperature changes. You can add an additional set or subset of calibration constants to the EEPROM to optimize performance under a specific set of conditions. Details of this procedure are given in Chapter 5, *Calibrating the SCXI-1141/1142/1143 Module*.

To account for offset errors, you can configure the module to send a 0 V differential signal through the amplifiers. The signal at the output represents the DC offset error and should be read and subtracted from all subsequent readings. Before reading this offset error on a channel, either set the filter to bypass mode or allow it to settle for several seconds. Average several readings to minimize noise errors. This procedure is called *calibration*.

Because the offset voltage changes with each gain, you should perform a new calibration each time the gain is changed. Offset errors also drift with changes in temperature, so you should update the offset correction periodically. Measurements made during the warm-up period of the module (approximately 20 minutes) and chassis are most susceptible to drifting offset errors.

Lowpass Filters

The SCXI-1141/1142/1143 module filters are eighth-order elliptic, Bessel, and Butterworth lowpass filters, respectively. These filters are a hybrid of a switched-capacitor and a continuous-time architecture, thus providing good cutoff frequency control while avoiding the sampling errors found in conventional switched-capacitor designs. To better acquaint you with these filters, this section describes what the filters do and presents examples of how to use them on the SCXI-1141/1142/1143 module.

Filter Theory

Filters are generally grouped into one of five classifications—*lowpass, highpass, bandpass, bandstop,* and *all-pass*. These classifications refer to the frequency range (the *passband*) of signals that the filter is intended to pass from the input to the output without attenuation. Because the SCXI-1141/1142/1143 modules use a lowpass filter, this discussion is limited to lowpass filters.

The ideal lowpass filter does not attenuate any input signal frequency components in the passband, which is defined as all frequencies below the *cutoff* frequency. The ideal lowpass filter completely attenuates all signal components in the *stopband*, which includes all frequencies above the cutoff frequency. The ideal lowpass filter also has a phase shift that is linear with respect to frequency. This linear phase property means that signal components of all frequencies are delayed by a constant time independent of frequency, thereby preserving the overall shape of the signal.

In practice, real filters can only approximate the characteristics of an ideal filter. Figure 4-2 compares the attenuation of a real filter and an ideal filter.

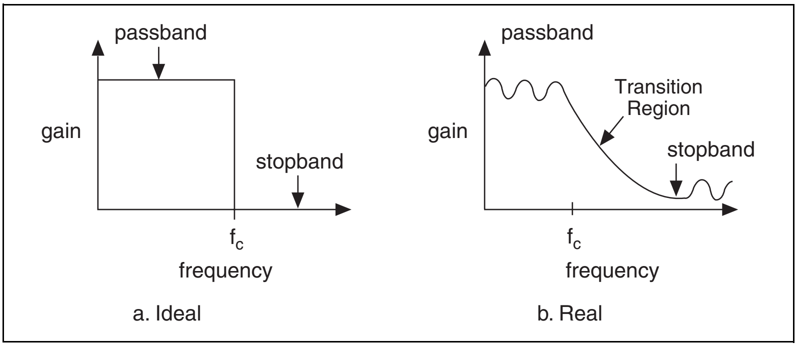


Figure 4-2. Ideal and Real Lowpass Filter Transfer Function Characteristics

As Figure 4-2b shows, a real filter has *ripple* (an uneven variation in attenuation versus frequency) in the passband, a transition region between the passband and the stopband, and a stopband with finite attenuation and ripple.

In addition, real filters have some nonlinearity in their phase response. This causes signal components at higher frequencies to be delayed by longer times than signal components at lower frequencies, resulting in an overall shape distortion of the signal. You can observe this when a square wave or step input is sent through a lowpass filter. An ideal filter simply smooths the edges of the input signal, whereas a real filter causes some ringing in the total signal because the higher-frequency components of the signal are delayed. Figure 4-3 shows examples of these responses to a step input.

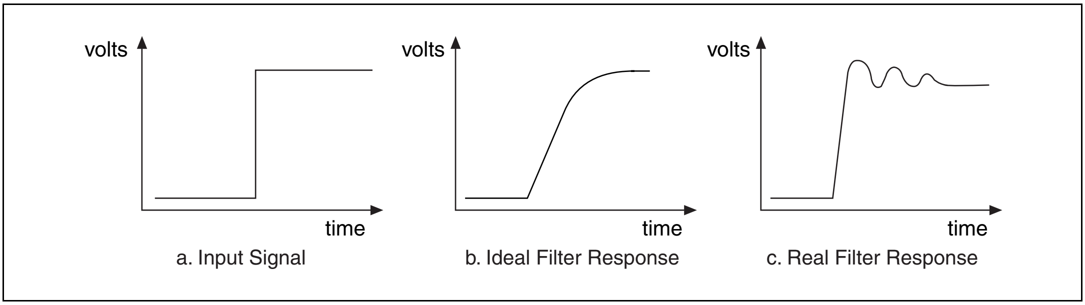


Figure 4-3. Real and Ideal Filter Responses to a Step Input Signal

Performance of the SCXI-1141/1142/1143 Module Filters

The SCXI-1141/1142/1143 module is elliptic, Bessel, and Butterworth filters, respectively. Each filter design optimizes a particular set of characteristics. Therefore, selecting the appropriate module depends on the application.

Magnitude Response

The magnitude response is the amplitude of the output at a given frequency. The typical magnitude response of the SCXI-1141/1142/1143 module filters is shown in Figures 4-4 and 4-5. Figure 4-4 shows the full magnitude response and Figure 4-5 shows the ripple in the passband. Both graphs are plotted with the frequency axis normalized to the cutoff frequency value of 1.

As Figure 4-4 shows, the SCXI-1141/1142/1143 module provides 80 dB attenuation above 1.5 times the cutoff frequency for the SCXI-1141 module, six times for the SCXI-1142 module, and 3.2 times for the

SCXI-1143 module. The SCXI-1141, which incorporates an elliptic filter, is designed to provide maximum attenuation immediately above the cutoff frequency. Therefore, it is the ideal choice for applications in which you must remove signals very near the cutoff frequency.

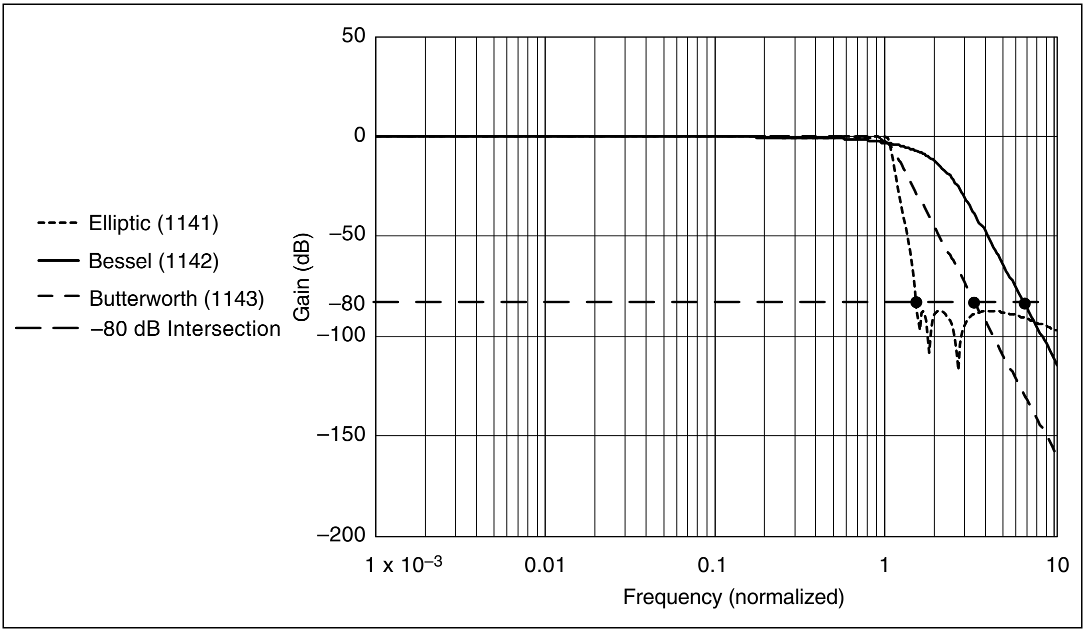


Figure 4-4. Typical Magnitude Response of the SCXI-1141/1142/1143 Module Filters

Figure 4-5 compares the magnitude response of the SCXI-1141/1142/1143 modules within the passband. The passband magnitude response begins to drop off immediately for the SCXI-1142 module. The SCXI-1141 performs much better than the SCXI-1142 in the passband, but it still exhibits about 0.1 dB of ripple in magnitude in the passband. The SCXI-1143 module Butterworth filter is designed for maximum flatness in the passband and is nearly perfectly flat in most of the passband. For this reason the SCXI-1143 module filter is the ideal choice for applications where flatness in the passband is critical.

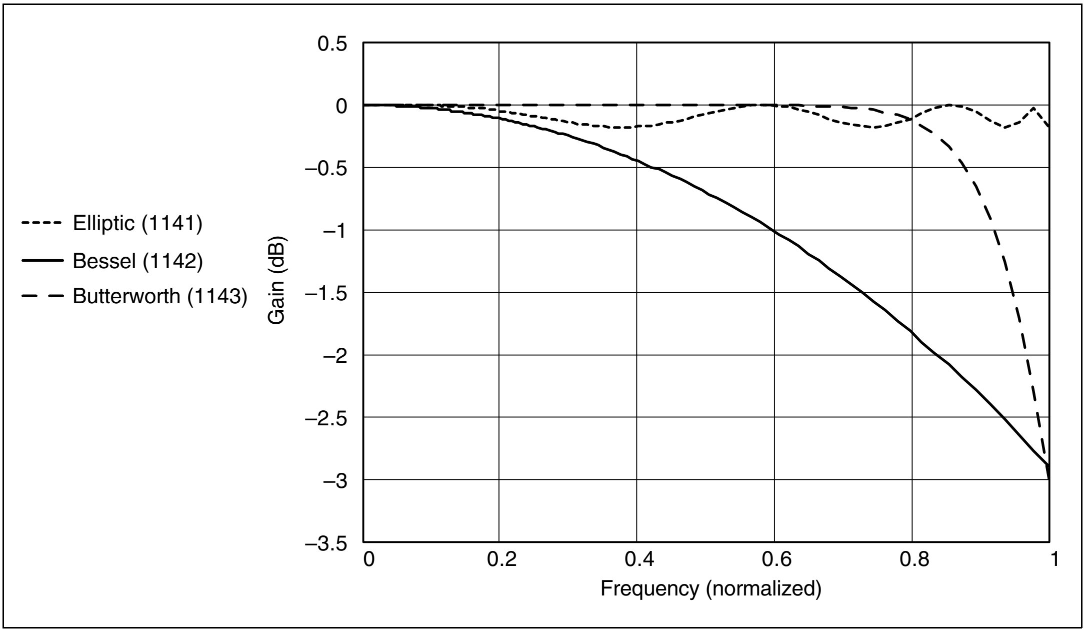


Figure 4-5. Typical Passband Responses of the SCXI-1141/1142/1143 Module

Phase Response

Figures 4-6 through 4-9 illustrate the phase response characteristics of the SCXI-1141/1142/1143 module filters. Figure 4-6 shows the phase shift as a function of frequency (normalized so that the cutoff frequency = 1). In an ideal filter, this would be a linear relationship. Figure 4-7 shows the deviation of the actual phase response from an ideal (linear) response. Generally, phase response is described in terms of the differential nonlinearity, or group delay. Group delay is defined as the negative derivative of the phase shift with respect to the frequency. In the ideal filter, group delay is a constant. The group delay of the SCXI-1141/1142/1143 module filters is shown in Figure 4-8.

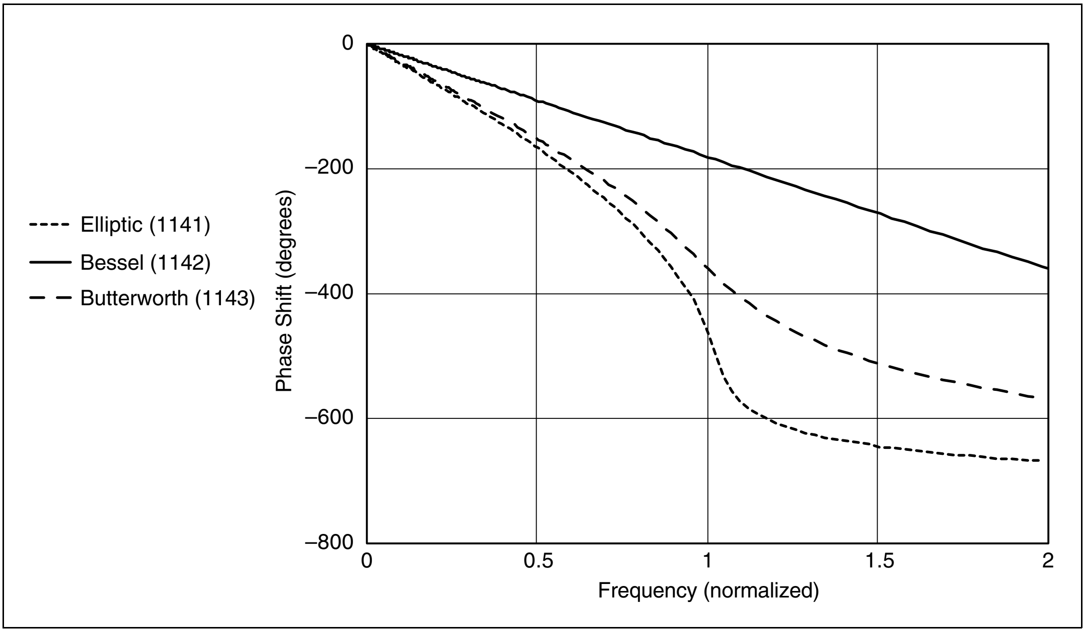


Figure 4-6. Phase Response Characteristics of the SCXI-1141/1142/1143 Module Filters

Figures 4-7 and 4-8 show the advantages of the SCXI-1142 Bessel filter. The Bessel filter is designed for constant group delay at the expense of passband gain and stopband rolloff. As a result, the SCXI-1142 Bessel filter is the best choice when the phase information of a signal is important or a signal must maintain a constant delay regardless of its frequency components.

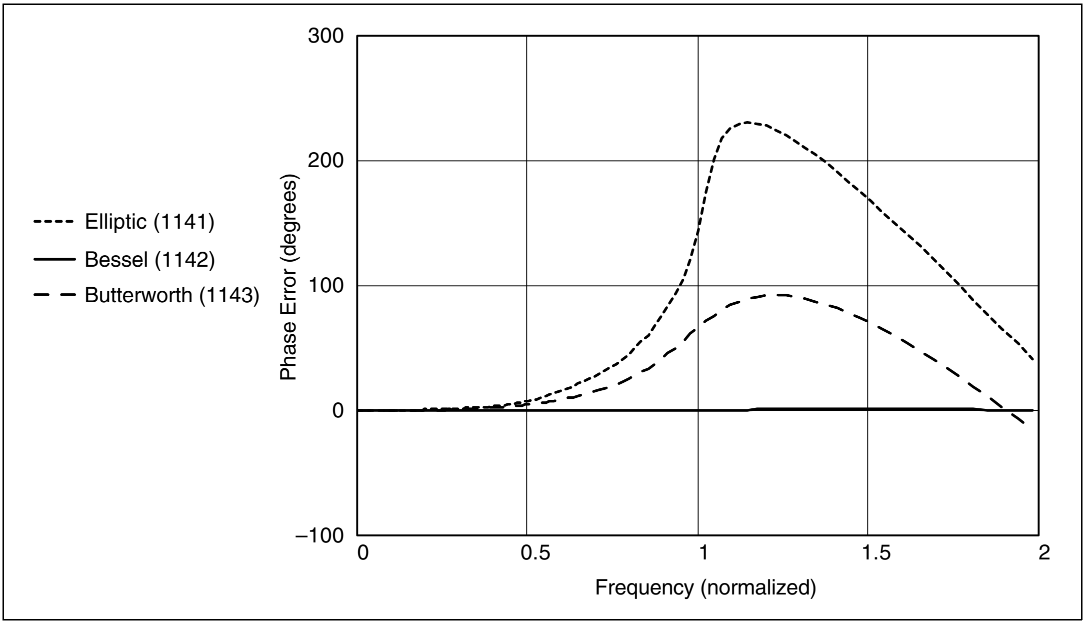


Figure 4-7. Phase Error of the SCXI-1141/1142/1143 Module

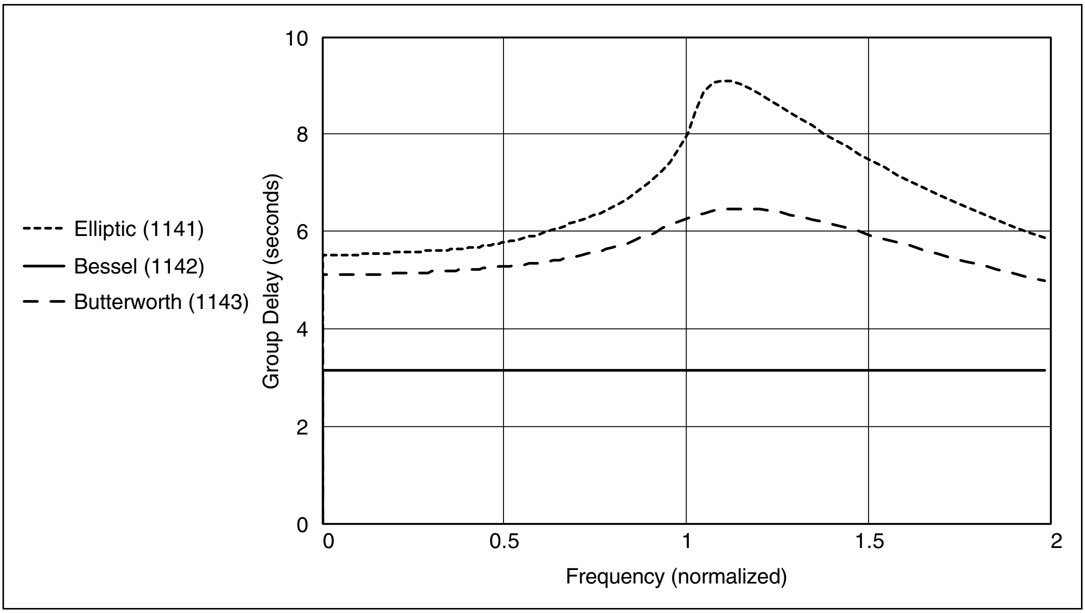


Figure 4-8. Group Delay of the SCXI-1141/1142/1143 Module

The most common effect of phase nonlinearity is ringing in response to a step input. As Figure 4-9 shows, the SCXI-1141 elliptic filter exhibits the most overshoot and ringing and the SCXI-1142 Bessel filter has no overshoot or ringing. The SCXI-1143 module Butterworth filter has a step response that is a compromise between the SCXI-1141 module and the SCXI-1142 module. The SCXI-1143 module filter has an overshoot, but it has less ringing than the SCXI-1141. You should consider the step response if the intended application is sensitive to overshoot or ringing. See Table A-1, *Settling Time with Respect to Cutoff Frequency*, for detailed settling specifications. Additionally, use care when selecting gain settings to assure that the input signal plus any overshoot voltage result in an output signal within the ±5 V range of the SCXI-1141/1142/1143 module.

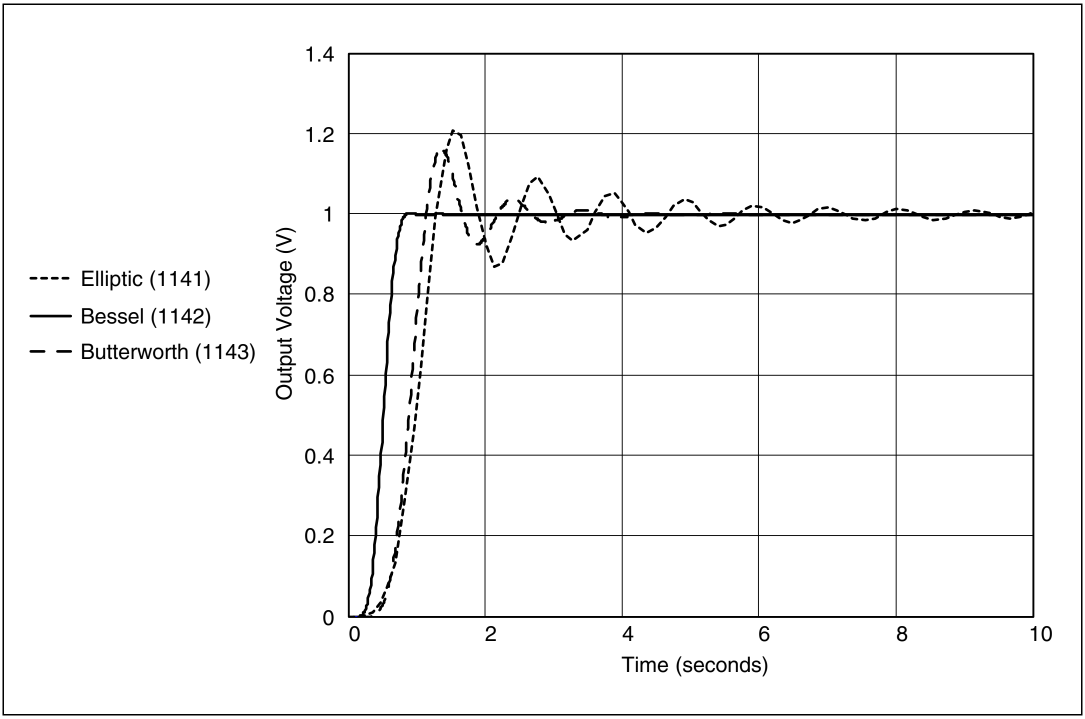


Figure 4-9. Unit Step Response of the SCXI-1141/1142/1143 Module

Setting the Cutoff Frequency

The cutoff frequencies of the filters in the SCXI-1141/1142/1143 module are set internally by dividing a base frequency of 100 kHz by an integer. You can determine the allowable cutoff frequencies for the SCXI-1141/1142/1143 module as follows:

$$f_c = \frac{100}{n} \text{ kHz}$$

where n is an integer ≥ 4 and $f_c \geq 10$ Hz. In other words, $f_c = \{25, 20, 16.7, 14.3, 12.5, ..., 0.01\}$ kHz.

If you are using NI software, the software automatically chooses a divisor, n, that best matches the cutoff frequency you specify and returns the actual cutoff frequency chosen.

The correct cutoff frequency depends on the application. If phase nonlinearity, ringing, passband ripple, or aliasing is a concern in the application, you may need to set the cutoff frequency several times higher than the signal frequency range of interest. At frequencies much lower than the cutoff frequency, passband ripple and phase nonlinearity are much less noticeable. If you use the filter to prevent aliasing, you must set the cutoff frequency no higher than one-third of the frequency at which that channel is being sampled for the SCXI-1141 module, one-twelfth of the frequency for the SCXI-1142 module, or one-sixth of the frequency for the SCXI-1143 module.

Using the SCXI-1141/1142/1143 Module as an Antialiasing Filter

Aliasing, a phenomenon of sampled data acquisition systems, causes a high-frequency signal component to take on the identity of a low-frequency signal. Figure 4-10 shows an example of aliasing.

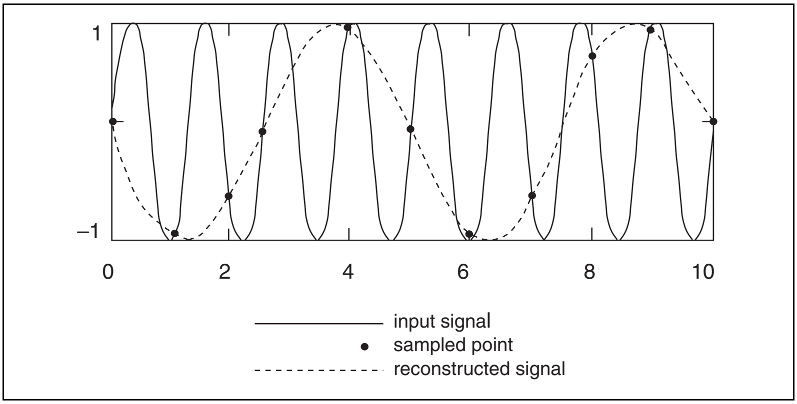


Figure 4-10. Aliasing of an Input Signal with a Frequency 0.8 Times the Sample Rate

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

To prevent aliasing, you must remove all signal components with frequencies greater than the Nyquist frequency *before* sampling an input signaled. After an unfiltered signal is sampled and aliasing has occurred, it is impossible to accurately reconstruct the original signal. The SCXI-1141/1142/1143 module removes these high-frequency signals before they reach a DAQ device and cause aliasing.

Because the SCXI-1141 module stopband begins at 1.5 times the cutoff frequency, the Nyquist frequency should be at least 1.5 times the cutoff frequency. Thus, the rate at which the DAQ device samples a channel should be at least three times the filter cutoff frequency to acquire meaningful data.

The stopband for the SCXI-1142 module begins at six times the cutoff frequency, so you should sample it at a rate of 12 times the cutoff frequency to acquire meaningful data.

The stopband for the SCXI-1143 module begins at 3.2 times the cutoff frequency, so you should sample it at a rate of 6.4 times the cutoff frequency to acquire meaningful data.

For example, if a DAQ device is scanning all eight channels of the SCXI-1141 at a rate of 120,000 channels/s, the sample rate for each of the eight channels is:

$$\frac{120{,}000}{8} = 15{,}000 \text{ S/s}$$

and the cutoff frequency for the filters should be set no higher than:

$$\frac{15{,}000}{3} = 5{,}000 \text{ Hz}$$

Using this stopband, the filter attenuates the input signal by 80 dB or more. This is enough attenuation to prevent aliasing on DAQ systems with 12 bits of precision or less. On systems with more than 12 bits of precision or systems with extremely high amounts of out-of-passband noise, higher sampling rates or lower cutoff frequencies are necessary to prevent aliasing.

You can set the filter cutoff frequency closer to the sampling rate with the consequence of having some aliasing. If you can tolerate aliasing in the transition band, you can reduce the sampling rate to 2.6 times the cutoff frequency for the SCXI-1141 module, five times the cutoff frequency for the SCXI-1142 module, and 3.5 times the cutoff frequency for the SCXI-1143 module.

Using the External Clock Input

You can set the cutoff frequencies of filters in the SCXI-1141/1142/1143 module by using the external clock input in applications that require external control of the cutoff frequency or that require finer resolution than the module provides internally. The cutoff frequency for each filter using the external clock as a base is:

$$f_{ext}/(100 \times n)$$

where f_{ext} is the frequency of the external clock and n is an integer you select such that $2 \leq n \leq 2^{16}$.

When the frequency of the external clock changes, the cutoff frequency changes proportionally.

An external clock can control the SCXI-1141/1142/1143 module filters because they use a switched-capacitor architecture, which uses analog sampling. However, this technique is also susceptible to aliasing in much the same way as the digital sampling of a DAQ device (with a Nyquist frequency of one-half the external clock frequency). Analog sampling also creates high-frequency images of the signal because the output waveform has a staircase shape.

The SCXI-1141/1142/1143 module prevents these errors by using sets of prefilters and postfilters that do not sample the signal. A different set of prefilters and postfilters is used for each of 12 ranges of input frequencies. The prefilters reduce signals that can alias into a lower frequency by at least 40 dB, and the postfilters reconstruct the output waveform, reducing high-frequency images to at least –80 dB.

NI software automatically chooses the correct set of prefilters and postfilters when you specify a cutoff frequency. However, when the external clock input is used to set the cutoff frequency of a filter, you must still supply an approximate cutoff frequency so that the software can determine the appropriate set of prefilters and postfilters.

Table 4-1 gives the ranges of cutoff frequencies that the prefilters and postfilters use.

Table 4-1. Cutoff Frequency Ranges for the SCXI-1141/1142/1143 Module Prefilters and Postfilters

Range	Cutoff Frequencies
A	10–25 kHz
B	4.3–10 kHz
C	1.9–4.4 kHz
D	1.5–3.4 kHz
E	700 Hz–1.8 kHz
F	300–700 Hz
G	130–300 Hz
H	100–225 Hz
I	49–110 Hz
J	21–49 Hz

Table 4-1. Cutoff Frequency Ranges for the SCXI-1141/1142/1143 Module Prefilters and Postfilters (Continued)

Range	Cutoff Frequencies
K	15–21 Hz
L	10–15 Hz

For best results, the cutoff frequency of a particular filter should remain within this range. If the cutoff frequency goes above this range, the prefilters and postfilters interfere with signals in the passband, causing additional attenuation near the cutoff frequency. If the cutoff frequency goes below this range, the level of protection from aliasing within the filter and from imaging in the output decreases.

DC-Correction Circuitry and Overload Recovery

The SCXI-1141/1142/1143 module incorporates circuitry that corrects for the DC gain and offset errors of the filters, leaving only the errors of the amplifiers. However, this correction circuitry takes approximately 15 s to completely respond to changes in these errors due to overload conditions (caused by driving the output signal outside of the ±5 V range) and upon power-up (no data should be taken during the first 15 s). Overload conditions result whenever the input signal exceeds ±5 V/gain. You must use a gain setting that prevents the maximum input signal from exceeding this limit, or the DC-correction circuitry will take 15 s to recover from overloads.

Filter Bypass Mode

You can bypass the filter of any channel through software control, thus making the unfiltered signal available at the output. The input amplifiers are not bypassed.

You can use the filter bypass to examine the effect that the filter has on the input signal. Using this mode, you can examine an input signal without the added effects of passband ripple and phase nonlinearities.

At power-up and at reset, all the channels of the SCXI-1141/1142/1143 module default to the filter bypass mode.

Rear Connector Analog Outputs

The connector signals AOUT<1..7> and AGND are the outputs of channels 1 through 7. You can configure the OUTPUT and OUTPUT REF signals as any channel (0 through 7) of the SCXI-1141/1142/1143 module or as the output of a channel passed along the SCXIbus from any other module in the chassis. Thus, the SCXI-1141/1142/1143 modules can present its outputs in both parallel and multiplexed modes.

Multiplexed Mode (Recommended)

In multiplexed mode, the output signals for channels 1 through 7 are sent to the rear signal connector but are usually ignored. All samples from the module are from the OUTPUT signal of the rear signal connector, which you can configure as the output of any channel of the SCXI-1141/1142/1143 module or as the output of any other module in multiplexed mode that is sending its output onto the SCXIbus. You can also configure the SCXI-1141/1142/1143 module to send any one of its outputs to the SCXIbus. Thus, in multiplexed mode only, one module in a chassis needs to be connected to a DAQ device. You can pass signals from the other modules to the DAQ device through the SCXIbus.

Multiplexed mode is also useful for performing scanning operations with the SCXI-1141/1142/1143 module. E Series MIO devices and the SCXI-1200 support scanning. The SCXI chassis is programmed with a module scan list that dynamically controls which module sends its output to the SCXIbus during a scan. You can specify this list to scan the modules in any order, with an arbitrary number of channels for each module entry in the list. However, you must scan the channels on the SCXI-1141/1142/1143 module in consecutive, ascending order. After channel 7 is scanned, the module wraps back to channel 0 and continues. You can program the SCXI-1141/1142/1143 module to start scans with any channel.

Parallel Mode

When the OUTPUT signal is configured as the rear connector output of channel 0, the rear signal connector simultaneously carries each of the rear connector outputs of the SCXI-1141/1142/1143 module channels on a different pin, and the module is in parallel mode. In this mode, you can use an SCXI-1180 feedthrough panel to make each of the outputs available at the front of the chassis. A DAQ device cabled to an SCXI-1141/1142/1143 module in parallel mode reads a separate output signal from the module on each of its analog inputs. You cannot multiplex the parallel outputs of a module onto the SCXIbus. Only a DAQ device directly cabled to the module has access to the outputs.

5 Calibrating the SCXI-1141/1142/1143 Module

The onboard calibration hardware that calibrates the SCXI-1141/1142/1143 module consists of an EEPROM to store the gain calibration constants, calibration circuitry on the amplifier inputs, and a potentiometer to adjust the AC gain of the filter.

Calibration is a method for nulling offset-error sources that reduce measurement accuracy. Before calibrating, disconnect all input signals from the amplifier inputs and connect the inputs to ground. Calibration determines each output of the SCXI-1141/1142/1143 module at a given gain of the amplifier. You should calibrate at the start of an application for each gain to be used. Doing this helps eliminate error due to drift in the amplifier internal circuitry and increases the accuracy of the measurement.

The calibration path is different from the analog input path. Therefore, even after calibration, a residual input offset still exists and has a value of less than 6 μV. The offsets of the filters are compensated for internally; generally only the offsets of the amplifiers need to be calibrated. The filters should be in bypass mode during calibration to avoid long settling times. If you are calibrating the offsets of both the amplifiers and the filters, the filters must not be in bypass mode and the filters should be given 15 s to completely settle to the calibration voltage.

The DC gain errors of the filters (below 0.1 Hz) are also compensated for internally. You can adjust the AC gain of each filter with a trimming potentiometer that has an adjustment range of ±0.15 dB. The gain errors of the amplifiers are the same for DC and AC signals. Calibration constants representing these errors for each gain of each amplifier are stored in the onboard EEPROM for future use and for automatic calibration.

The AC gain of the filters is calibrated at the factory, and the calibration constants for the amplifiers are already loaded into the EEPROM. When you need to recalibrate SCXI-1141/1142/1143 modules download the *SCXI-1141/1142/1143 Calibration Procedure* from `ni.com/calibration`.

A

Specifications

This appendix lists the specifications for the SCXI-1141/1142/1143 module. These specifications are typical at 25 °C and 50% humidity unless otherwise stated.

Amplifier Characteristics

Number of channels .... 8 differential

Output signal range .... ±5 V

Channel gains (software-selectable) 1, 2, 5, 10, 20, 50, 100

Input overvoltage protection
- Powered on .... ±30 V
- Powered off..................................... ±15 V

Input coupling .... DC (AC available with SCXI-1304 or SCXI-1305 terminal block)

Input impedance
- Powered on .... 10 GΩ in parallel with 40 pF
- Powered off..................................... 2.4 kΩ

Input bias current .... 450 pA

Input bias current temperature coefficient .... 0.8 pA/°C

Input offset current................................. 250 pA

Temperature coefficient .... 20mV/°C

Common-mode rejection ratio .... 60 dB (G = 1)

DC gain error ....±0.6% before calibration, ±0.02% after calibration[1]

DC input offset ....0.6 mV (can be calibrated)

Filter Characteristics

Filter type

- SCXI-1141 module..........................8th-order elliptic
- SCXI-1142 module..........................8th-order Bessel
- SCXI-1143 module..........................8th-order Butterworth

Filter architecture...................................Switched capacitor with prefilters and postfilters

Rolloff rate...135 dB/octave

Cutoff frequency (f_c) range.....................10 Hz to 25 kHz

Cutoff choices (software-selectable) ......Divided from 100 kHz or external clock (for example, 25 kHz, 20 kHz, 16.7 kHz, 14.3 kHz, or from external)

Passband ripple
(SCXI-1141 module only)......................0.2 dB, DC to f_c

Phase matching
(SCXI-1142 only)..................................3° max error at f_c

Stopband attenuation

- SCXI-1141module...........................80 dB at $1.5 \times f_c$
- SCXI-1142 module..........................80 dB at $6 \times f_c$
- SCXI-1143 module..........................80 dB at $3.2 \times f_c$

Prefilter aliasing rejection......................> 80 dB below $99 \times f_c$
> 40 dB above $99 \times f_c$

Sampled image + clock feedthrough ......<–75 dB

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[1] SCXI-1141/1142/1143 module factory calibration conditions: $V_{in}(-) = 0$ V, $V_{in}(+) = \pm$fullscale

Bandwidth and response time

Table A-1. Settling Time with Respect to Cutoff Frequency

Module	Bandwidth	Step Response Settling Time in ms (Full-Scale Input Step)		
		±1%	±0.1%	±0.024%
SCXI-1141	10	5250	10805	14585
	100	103	4500	7380
	1000	10	887	4090
	25000	0.575	0.97	2600
SCXI-1142	10	3595	9335	13960
	100	4480	8085	11365
	1000	815	5965	9590
	25000	19.55	250	3174
SCXI-1143	10	5000	10676	13514
	100	547	8140	11567
	1000	270	6207	10419
	25000	73	1399	4838

System Noise

THD

1 kHz .... –70 dB

0–25 kHz .... –60 dB

Input noise .... $30\ nV \times \sqrt{f_c}$

Output noise .... 230 μV_{rms}

Stability

Gain temperature coefficient.................. 20 ppm/°C

Input offset drift .... 10 µV/°C

Output offset drift................................... 0.1 mV/°C

Digital Input/Output

EXTCLK pin input voltage
with respect to DIGGND........................5.5 V max
–0.5 V min

Absolute maximum voltage input rating
with respect to DIGGND........................–0.5 to 5.5 V

Digital input referenced to DIGGND
VIH, input logic high voltage..........2 V min
VIL, input logic low voltage ....0.8 V max

Digital output referenced to DIGGND
VOH, output logic high voltage ......3.7 V min at 4 mA
VOL, output logic low voltage........0.4 V max at 4 mA

Physical

Dimensions ....1.2 by 6.8 by 8.0 in.
(3.0 by 17.3 by 24.4 cm)

I/O connectors
Rear connector................................50-pin male ribbon-cable
Front connector...............................96-pin DIN C male
(screw-terminal adapters available)

Maximum Working Voltage

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

Channel-to-earth ....±5 V, Installation Category I

Channel-to-channel................................±10 V, Installation Category I

Environmental

Operating temperature .... 0 to 50 °C

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

Humidity .... 5 to 90% noncondensing

Maximum altitude .... 2000 m

Pollution degree (indoor use only) 2

Safety

The SCXI-1141/1142/1143 meets the requirements of the following standards for safety and electrical equipment for measurement, control, and laboratory use:

- EN 61010-1:1993/A2:1995, IEC 61010-1:1990/A2:1995
- UL 3111-1:1994
- CAN/CSA c22.2 no. 1010.1:1992/A2:1997

Electromagnetic Compatibility

CE, C-Tick, and FCC Part 15 (Class A) Compliant

Electrical emissions .... EN 55011 Class A at 10 m
FCC Part 15A above 1 GHz

Electrical immunity .... Evaluated to EN 61326:1997/
A1:1998, Table 1

Note For full EMC compliance, you must operate this device with shielded cabling. In addition, all covers and filler panels must be installed. Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This web site lists the DoCs by product family. Select the appropriate product family, followed by the product, and a link to the DoC appears in Adobe Acrobat format. Click the Acrobat icon to download or read the DoC.

B

Technical Support Resources

Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`.

NI Developer Zone

The NI Developer Zone at `ni.com/zone` is the essential resource for building measurement and automation systems. At the NI Developer Zone, you can easily access the latest example programs, system configurators, tutorials, technical news, as well as a community of developers ready to share their own techniques.

Customer Education

National Instruments provides a number of alternatives to satisfy your training needs, from self-paced tutorials, videos, and interactive CDs to instructor-led hands-on courses at locations around the world. Visit the Customer Education section of `ni.com` for online course schedules, syllabi, training centers, and class registration.

System Integration

If you have time constraints, limited in-house technical resources, or other dilemmas, you may prefer to employ consulting or system integration services. You can rely on the expertise available through our worldwide network of Alliance Program members. To find out more about our Alliance system integration solutions, visit the System Integration section of `ni.com`.

Worldwide Support

National Instruments has offices located around the world to help address your support needs. You can access our branch office Web sites from the Worldwide Offices section of `ni.com`. Branch office Web sites provide up-to-date contact information, support phone numbers, e-mail addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. Phone numbers for our worldwide offices are listed at the front of this manual.

Glossary

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

Numbers/Symbols

° degrees

> greater than

≥ greater than or equal to

< less than

≤ less than or equal to

– negative of, or minus

Ω ohms

% percent

± plus or minus

+ positive of, or plus

A

A	amperes
AC	alternating current
ADE	application development environment
AGND	analog ground signal
AGND/NC	analog ground/no connect signal
aliasing	the consequence of sampling that causes signals with frequencies higher than half the sampling frequency to appear as lower frequency components
ANSI	American National Standards Institute
AOGND/GUARD	analog output ground
AOUT	analog output signal
AWG	American Wire Gauge

B

bias current	the small input current flowing into or out of the input terminals of an amplifier
BNC	a type of coaxial signal connector

C

C	Celsius
CMOS	complementary metal-oxide semiconductor
CMRR	common-mode rejection ratio
common-mode noise	noise that appears on both inputs of a differential amplifier
cutoff frequency	the frequency that defines the upper end of the passband of a lowpass filter

D

D/A	digital-to-analog
DAQ	data acquisition
DAQD*/A	data acquisition board data/address line signal
dB	decibels
DC	direct current
DIGGND	digital ground signal
DIN	Deutsche Industrie Norme (German Industrial Standard)
DMM	digital multimeter

E

EEPROM	electrically erasable programmable read-only memory
EXTCLK	external clock signal

F

f_c	cutoff frequency
F_{ext}	external frequency

G

G	gain
gain error	the difference between the actual and intended gain of a system

H

hex	hexadecimal (base 16)
Hz	hertz

I

in.	inch
IN+	positive input channel signal
IN–	negative input channel signal
I/O	input/output
INTR*	interrupt signal

L

lowpass filter	a filter that passes signals below a cutoff frequency while blocking signals above that frequency

M

max	maximum
MB	megabytes
min	minutes, or minimum
MIO	multifunction I/O
MISO	Master-In-Slave-Out signal
MOSI	Master-Out-Slave-In signal
multiplex	to route one of many input signals to a single output

N

normal-mode noise	noise that appears in only one input of a differential amplifier
NRSE	nonreferenced single-ended
Nyquist frequency	the frequency that a sampling system can accurately reproduce, which is half the sampling frequency

O

offset error	the output of a system with a zero volt input
OUTCLK	output clock signal
OUTPUT	output signal
OUTPUT REF	output reference signal

P

passband	the range of input frequencies that are passed to the filter output without attenuation
ppm	parts per million

R

rms	root mean square
rolloff	the ratio that a system attenuates signals in the stopband with respect to the passband, usually defined in decibels per octave
RSVD	reserved signal/bit

S

s	seconds
S/s	samples per second—used to express the rate at which a DAQ device samples an analog signal
sample	an instantaneous measurement of a signal, normally using an analog-to-digital convertor in a DAQ device
sample rate	the number of samples a system takes over a given time period, usually expressed in samples per second
scan	a collection of samples, usually with each sample coming from a different input channel

scan rate	the number of scans a system takes during a given time period, usually expressed in scans per second
SCXI	Signal Conditioning eXtensions for Instrumentation
SCXIbus	located in the rear of an SCXI chassis, the SCXIbus is the backplane that connects modules in the same chassis to each other
SCANCLK	scan clock signal
SERCLK	serial clock signal
SERDATIN	serial data in signal
SERDATOUT	serial data out signal
SLOT0SEL	slot 0 select signal
SPICLK	serial peripheral interface clock signal
stopband	the portion of a frequency spectrum blocked by a filter

T

THD	total harmonic distortion
TTL	transistor-transistor logic

V

V	volts
VI	virtual instrument (a LabVIEW program)
V_{rms}	volts, root mean square

W

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

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