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DAQ

SCXI™-1161 User Manual

8-Channel Power Relay Module

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About This Manual

This manual describes the electrical and mechanical aspects of the SCXI-1161 and contains information concerning its operation and programming. The SCXI-1161 is a member of the National Instruments Signal Conditioning eXtensions for Instrumentation (SCXI) Series modules for the National Instruments data acquisition plug-in boards. This module switches and controls power signals. The SCXI-1161 operates as eight relay channels. Each channel is isolated and independently configurable.

This manual describes the installation, basic programming considerations, and theory of operation for the SCXI-1161.

Organization of This Manual

The *SCXI-1161 User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the SCXI-1161; lists the contents of your SCXI-1161 kit; describes the optional software, optional equipment, and custom cables; and explains how to unpack the SCXI-1161 kit.
- Chapter 2, *Configuration and Installation*, describes the SCXI-1161 jumper configurations, installation of the SCXI-1161 into the SCXI chassis, signal connections to the SCXI-1161, and cable wiring.
- Chapter 3, *Signal Connections*, describes the signal connections to the SCXI-1161 board via the SCXI-1161 screw terminals and rear signal connector, and includes specifications and connection instructions for the SCXI-1161 connector signals.
- Chapter 4, *Theory of Operation*, contains a functional overview of the SCXI-1161 module and explains the operation of each functional unit making up the SCXI-1161.
- Appendix A, *Specifications*, lists the specifications for the SCXI-1161.
- Appendix B, *Contact Protection*, contains technical data on contact protection when you are switching inductive loads.

- Appendix C, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products.
- The *Glossary* contains an alphabetical list and description of terms used in this manual, including abbreviations, acronyms, metric prefixes, mnemonics, and symbols.
- The *Index* contains an alphabetical list of key terms and topics in this manual, including the page where you can find each one.

Conventions Used in This Manual

The following conventions are used in this manual.



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



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

DIO board	DIO board refers to the National Instruments AT-DIO-32F, MC-DIO-24, MC-DIO-32F, NB-DIO-24, NB-DIO-32F, NB-DIO-96, PC-DIO-24, and PC-DIO-96/PnP digital I/O data acquisition boards unless otherwise noted.
DIO-type board	DIO-type board refers to National Instruments data acquisition boards that have only digital inputs and outputs. These boards include the DIO-24, DIO-32F, and DIO-96 boards unless otherwise noted.
italic	Italic text denotes emphasis, a cross reference, or an introduction to a key concept.
Lab board	Lab board refers to the National Instruments Lab-LC, Lab-NB, Lab-PC, and Lab-PC+ boards unless otherwise noted.
MC	MC refers to the Micro Channel series computers.
MIO board	MIO board refers to the National Instruments AT-MIO-16, AT-MIO-16D, AT-MIO-16F-5, AT-MIO-16X, AT-MIO-64F-5, MC-MIO-16, NB-MIO-16, and NB-MIO-16X multichannel I/O data acquisition boards unless otherwise noted.
MIO-type board	MIO-type board refers to National Instruments data acquisition boards that have at least analog and digital inputs and outputs. These boards include the MIO boards, the Lab boards, and the PC-LPM-16/PnP board unless otherwise noted.

`monospace`	Lowercase text in this font denotes text or characters that are to be literally input from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, variables, filenames, and extensions, and for statements and comments taken from program code.
NB	NB refers to the NuBus series computers.
PC	PC refers to the IBM PC/XT, the IBM PC AT, and compatible computers.
SCXIbus	SCXIbus refers to the backplane in the chassis. A signal on the backplane is referred to as the SCXIbus <signal name> line (or signal). The SCXIbus descriptor may be omitted when the meaning is clear.
Slot 0	Slot 0 refers to the power supply and control circuitry in the SCXI chassis.
	The *Glossary* lists abbreviations, acronyms, mnemonics, symbols, and terms.

National Instruments Documentation

The *SCXI-1161 User Manual* is one piece of the documentation set for your data acquisition (DAQ) and SCXI system. You could have any of several types of manuals, depending on the hardware and software in your system. Use the different types of manuals you have as follows:

- *Getting Started with SCXI*—This is the first manual you should read. It gives an overview of the SXCI system and contains the most commonly needed information for the modules, chassis, and software.
- You SCXI hardware user manuals—Read these manuals next for detailed information about signal connections and module configuration. They also explain in greater detail how the module works and contain application hints.
- Your DAQ hardware user manuals—These manuals have detailed information about DAQ hardware that plugs into or is connected to your computer. Use these manuals for hardware installation and configuration instructions, specification information about your DAQ hardware, and application hints.
- Software documentation—Examples of software documentation you may have are the LabVIEW and LabWindows/CVI

documentation sets and the NI-DAQ documentation. After you set up your hardware system, use either the application software (LabVIEW or LabWindows/CVI) or the NI-DAQ documentation to help you write your application. If you have a large, complicated system, it is worthwhile to look through the software documentation before you configure your hardware.

- Accessory installation guides or manuals—If you are using accessory products, read the terminal block and cable assembly installation guides or accessory board user manuals. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making your connections.
- *SCXI Chassis User Manual*—Read this manual for maintenance information on the chassis and for installation instructions.

Related Documentation

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

- *SCXI Register-Level Programmer Manual*

This manual is available from National Instruments by request. Using NI-DAQ, LabView, or LabWindows/CVI is as easy as using the low-level programming described in the register-level programmer manual. Refer to *Software Programming Choices* in Chapter 1, *Introduction*, of this manual to learn more about your programming options.

If you are designing your own module, the *SCXIbus System Specification* is available from National Instruments upon request. The specification describes the physical, electrical, and timing requirements for the SCXIbus.

Customer Communication

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

Chapter 1

Introduction

This chapter describes the SCXI-1161; lists the contents of your SCXI-1161 kit; describes the optional software, optional equipment, and custom cables; and explains how to unpack the SCXI-1161 kit.

About the SCXI-1161

The SCXI-1161 consists of eight isolated single-pole double-throw (SPDT), or one form C, relay channel.

With the SCXI-1161, the SCXI chassis can serve as a controller or switcher in laboratory testing, production testing, and industrial-process monitoring.

The SCXI-1161 operates with full functionality with National Instruments MIO boards; Lab-NB, Lab-PC, Lab-PC+, Lab-LC, and PC-LPM-16/PnP boards; and with the DIO-24, DIO-32F, and DIO-96 boards. You can control several SCXI-1161s in a single chassis with one data acquisition board, and in combination with other SCXI module types.

The SCXI-1161 has on-board screw terminals for easy signal attachment.

What You Need to Get Started

To set up and use your SCXI-1161, you will need the following items:

- ❑ SCXI-1161 module
- ❑ *SCXI-1161 User Manual*

Software Programming Choices

There are several options to choose from when programming your National Instruments DAQ or SCXI hardware. You can use LabVIEW, LabWindows/CVI, ComponentWorks, VirtualBench, NI-DAQ, or register-level programming.

National Instruments Application Software

LabVIEW features interactive graphics, a state-of-the-art user interface, and a powerful graphical programming language. The LabVIEW Data Acquisition Virtual Instrument (VI) Library, a series of VIs for using LabVIEW with National Instruments DAQ hardware, is included with LabVIEW. The LabVIEW Data Acquisition VI Library is functionally equivalent to the NI-DAQ software.

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

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

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

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

NI-DAQ Driver Software

The NI-DAQ driver software is included at no charge with all National Instruments DAQ hardware. NI-DAQ is not packaged with SCXI or accessory products, except for the SCXI-1200. NI-DAQ has an extensive library of functions that you can call from your application programming environment. These functions include routines for analog input (A/D conversion), buffered data acquisition (high-speed A/D conversion), analog output (D/A conversion), waveform generation (timed D/A conversion), digital I/O, counter/timer operations, SCXI, RTSI, self-calibration, messaging, and acquiring data to memory.

NI-DAQ has both high-level DAQ I/O functions for maximum ease of use and low-level DAQ I/O functions for maximum flexibility and performance. Examples of high-level functions are streaming data to disk or acquiring a certain number of data points. An example of a low-level function is writing directly to registers on the DAQ device. NI-DAQ does not sacrifice the performance of National Instruments DAQ devices because it lets multiple devices operate at their peak performance.

NI-DAQ also internally addresses many of the complex issues between the computer and the DAQ hardware such as programming interrupts and DMA controllers. NI-DAQ maintains a consistent software interface among its different versions so that you can change platforms with minimal modifications to your code. Whether you are using conventional programming languages, LabVIEW, LabWindows/CVI, or other application software, your application uses the NI-DAQ driver software, as illustrated in Figure 1-1.

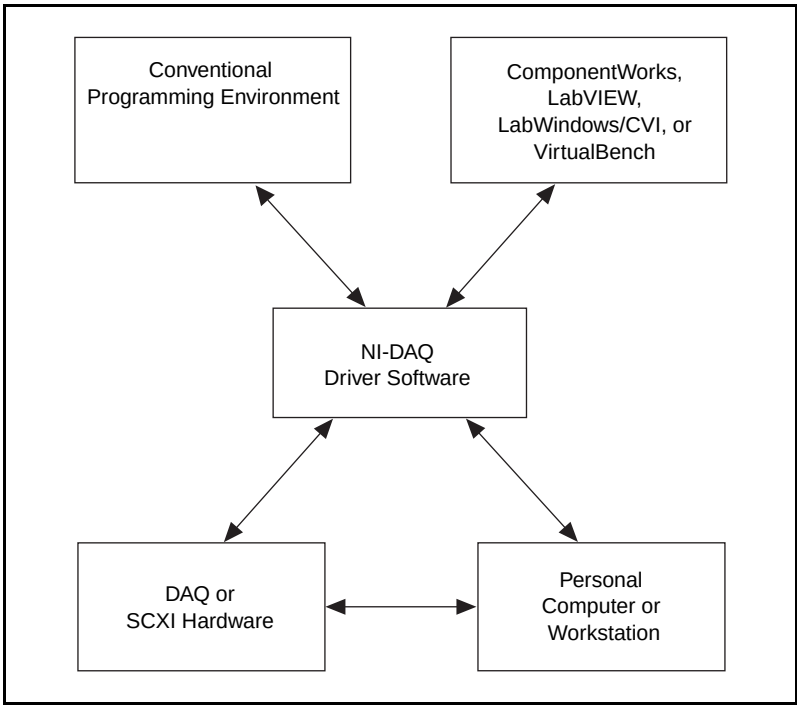


Figure 1-1. The Relationship between the Programming Environment, NI-DAQ, and Your Hardware

Register-Level Programming

The final option for programming any National Instruments DAQ hardware is to write register-level software. Writing register-level programming software can be very time-consuming and inefficient, and is not recommended for most users.

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

Optional Equipment

National Instruments offers a variety of products to use with your SCXI-1611, including cables and other accessories as follows:

- Cables and cable assemblies
- Multichassis adapter
- One-slot cable extender

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

Custom Cables

The SCXI-1161 rear signal connector is a 50-pin male ribbon-cable header. The manufacturer part number National Instruments uses for this header is as follows:

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

The mating connector for the SCXI-1161 rear signal connector is a 50-position polarized ribbon-socket connector with strain relief. National Instruments uses a polarized or keyed connector to prevent inadvertent upside-down connection to the SCXI-1161. Recommended manufacturer part numbers for this mating connector are as follows:

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

Standard 50-conductor 28 AWG stranded ribbon cables that work with these connectors are as follows:

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

Unpacking

Your SCXI-1161 module is shipped in an antistatic package to prevent electrostatic damage to the module. Electrostatic discharge can damage several components on the module. To avoid such damage in handling the module, take the following precautions:

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

Configuration and Installation

Chapter 2

This chapter describes the SCXI-1161 jumper configurations, installation of the SCXI-1161 into the SCXI chassis, signal connections to the SCXI-1161, and cable wiring.

Module Configuration

The SCXI-1161 includes five jumpers, shown in Figure 2-1.

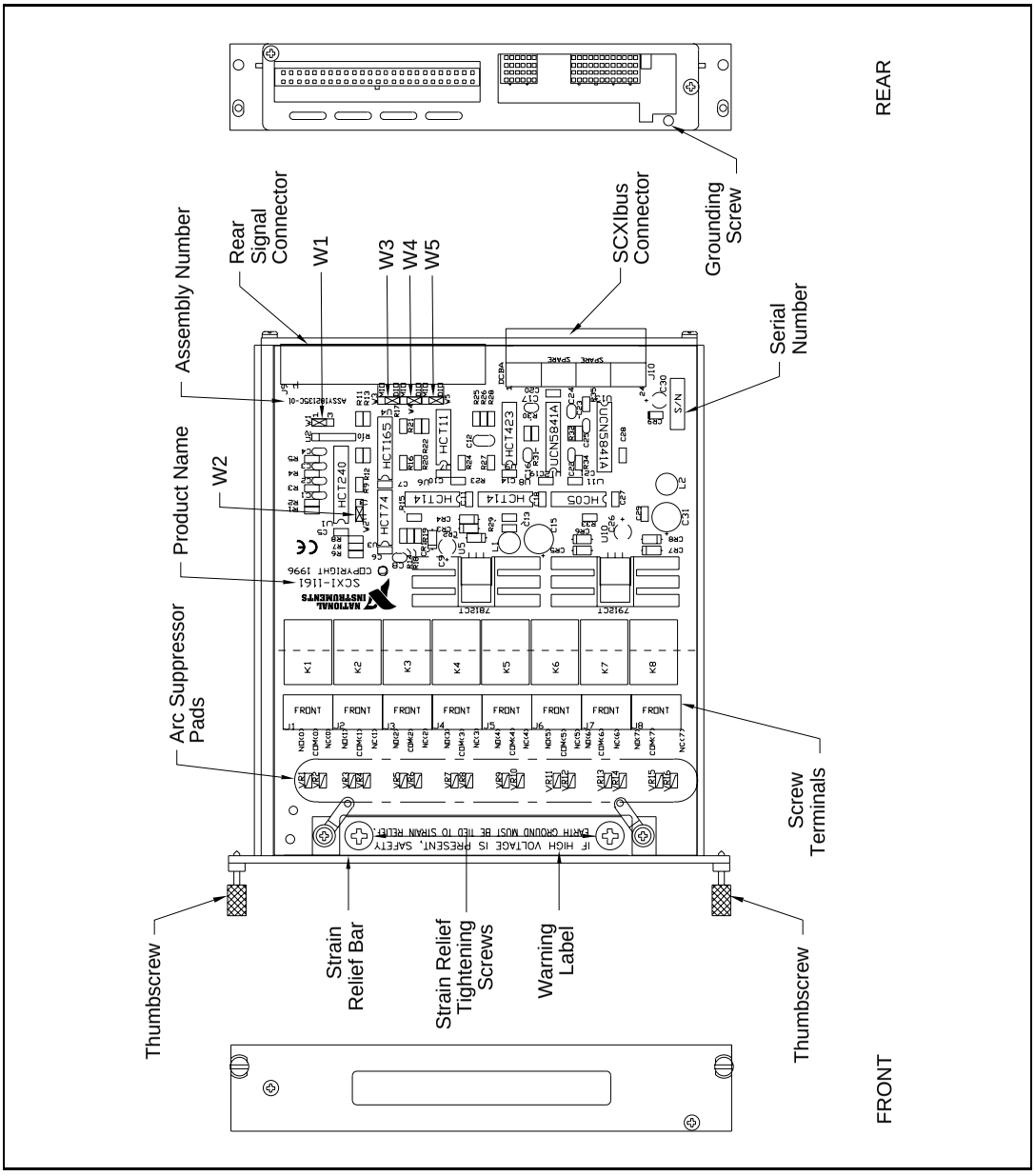


Figure 2-1. SCXI-1161 General Parts Locator Diagram

Caution: ***DO NOT OPERATE THE DEVICE IN AN EXPLOSIVE ATMOSPHERE OR WHERE THERE MAY BE FLAMMABLE GASES OR FUMES.***

KEEP AWAY FROM LIVE CIRCUITS. Do not remove equipment covers or shields unless you are trained to do so. If signal wires are connected to the device, hazardous voltages may exist even when the equipment is turned off. To avoid a shock hazard, do not perform procedures involving cover or shield removal unless you are qualified to do so and disconnect all field power prior to removing covers or shields.

Equipment described in this document must be used in an Installation Category II environment per IEC 664. This category requires local level supply mains-connected installation.

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

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

Terminals are for use only with equipment that has no accessible live parts.

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

When using the device with high common-mode voltages, you MUST insulate your signal wires for the highest input voltage. National Instruments is NOT liable for any damages or injuries resulting from inadequate signal wire insulation. Use only 26 to 14 AWG wire with a voltage rating of 300 V and 60° C for measuring 250 to 300 V; use only 600 V and 60° C for measuring 480 V. Prepare your signal wire by stripping the insulation no more than 7 mm.

When connecting or disconnecting signal lines to the screw terminals, make sure the lines are powered off. Potential differences between the lines and the SCXI ground create a shock hazard while you connect the lines.

Connect the signal wires to the screw terminals by inserting the stripped end of the wire full into the terminals. Tighten the terminals to a torque of 5 to 7 in.-lb.

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

If high voltages ($\geq$30 V_{rms} and 42.4 V_{peak} or 60 VDC) are present, YOU MUST CONNECT A SAFETY EARTH GROUND WIRE TO THE SAFETY GROUND SOLDER LUG. This complies with safety agency requirements and protects against electric shock when the terminal block is not connected to the chassis. To connect the safety earth ground to the safety ground solder lug, run an earth ground wire in the cable from the signal source to the terminal block. National Instruments is NOT liable for any damages or injuries resulting from inadequate safety earth ground connections.

Do not loosen or re-orient the safety ground solder lug hardware when connecting the safety ground wire. To do so reduces the safety isolation between the high voltage and safety ground.

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



Caution: ***Use this module only with a UL listed SCXI chassis.***

Jumper Use

Use the jumpers as follows:

- Jumper W1 connects a pullup resistor to the SERDATOUT signal on the rear signal connector.
- Jumper W2 carries the SCXIbus MISO line, after buffering, to the SERDATOUT signal on the rear signal connector.
- Jumpers W3, W4, and W5 select whether the SCXI-1161 is to be connected to a DIO-type board or to an MIO-type board. DIO-type boards are National Instruments boards that have only digital inputs and outputs. These boards include the DIO-24, DIO-32F, and DIO-96. MIO-type boards are National Instruments boards that have at least analog and digital inputs and digital outputs. These boards consist of MIO-16 boards; Lab-NB, Lab-PC, Lab-PC+, and Lab-LC boards; and PC-LPM-16/PnP boards. If nothing is cabled to the rear signal connector of the SCXI-1161, the positions of these jumpers is irrelevant.

Further configuration of the board is software controlled and is described later in this chapter.

Jumper Configuration

All five jumpers on the SCXI-1161 are for digital communication between the data acquisition board and the SCXI-1161 module. Only one module per chassis is connected to the data acquisition board, which allows communication with all other modules. On the other modules, the jumper settings are irrelevant.

The SCXI-1161 has two jumpers, W1 and W2, for communication between the SCXI-1161 and the data acquisition board. Jumpers W3, W4, and W5 indicate to the module what type of data acquisition board will be connected to the module rear signal connector.

Jumper W1

Position 1 connects a 2.2 kΩ pullup resistor to the SERDATOUT line. This is the factory-default setting. Position 3 disconnects the pullup resistor from the SERDATOUT line.

Jumper W2

Position 1 connects the SCXIbus MISO line, after buffering, to the SERDATOUT pin of the rear signal connector. This is the factory-default setting. In this setting, along with the proper setting of jumper W1, the data acquisition board can read the Module ID Register of the SCXI-1161. See the *SCXI Register-Level Programmers Manual*, for information on reading the Module ID Register. See the cable installation guide of your cable, for the pin equivalences of the SCXI-1161 rear signal connector and the data acquisition board I/O connector.

Position 3 disconnects SERDATOUT from the SCXIbus MISO line.

Using Jumpers W1 and W2

If you do not connect a module to a data acquisition board, the positions of jumpers W1 and W2 are irrelevant. Jumpers W1 and W2 give the data acquisition board access to the MISO line on the backplane. You can use the MISO line to read the Module ID Register of modules. National Instruments software does not use this ability. You must indicate to the software which module is in which slot.

An open-collector driver drives the SERDATOUT line. An open-collector driver actively drives low or goes to a high-impedance state, relying on a pullup resistor to make the signal line go high. When using a single chassis, set both jumpers W1 and W2 to position 1 on the SCXI-1161 that is connected to the data acquisition board. In this setting, the module drives MISO to SERDATOUT and connects the necessary pullup resistor to the SERDATOUT line. When using multiple chassis, set jumper W2 to position 1 on all of the SCXI-1161s that are cabled to the data acquisition board. Set jumper W1 to position 1 on only one of the SCXI-1161s that are cabled to the data acquisition board. It does not matter which of the SCXI-1161s that are cabled to the data acquisition board has the pullup connected. Set jumper W1 to position 3 on all of the other SCXI-1161 modules that are cabled to the data acquisition board. If too many pullup resistors are attached to the SERDATOUT line, the drivers cannot drive the line low. Tables 2-1 and 2-2 list the description and configuration of the jumper settings.

Table 2-1. Configuration of Jumpers W1 and W2

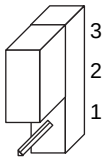
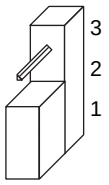
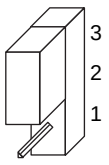
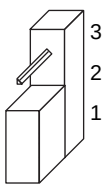
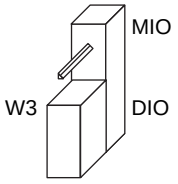
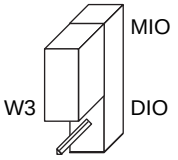
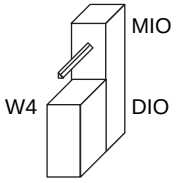
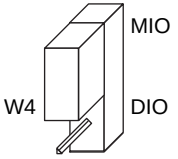
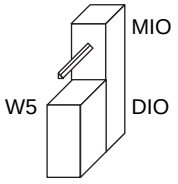
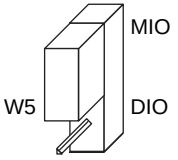
Jumper	Description	Configuration
W1	Parking position	
W1	Factory setting–Connects pullup to SERDATOUT	
W2	Parking position	
W2	Factory setting–Connects MISO to SERDATOUT	

Table 2-2. Configuration of Jumpers W3, W4, and W5 for DIO-Type and MIO-Type Boards

Jumper	Configuration for DIO-Type Board (Factory Setting)	Configuration for MIO-Type Board
W3		
W4		
W5		

Jumpers W3, W4, and W5

You can use two types of data acquisition boards with the SCXI-1161-DIO-type boards and MIO-type boards. All three jumpers have labels indicating the DIO and the MIO configurations. If you want to use the SCXI-1161 with a DIO-type board, place all three jumpers in the DIO position, the factory setting. If you want to use the SCXI-1161 with an MIO-type board, place all three jumpers in the MIO position. If nothing is cabled to the SCXI-1161 rear signal connector, the positions of these jumpers are irrelevant.

Hardware Installation

You can install the SCXI-1161 in any available SCXI chassis. After you have made any necessary changes and have verified and recorded the jumper settings on the form in Appendix C, *Customer Communication*, you are ready to install the SCXI-1161. The following are general installation instructions; consult the user manual or technical reference manual of your SCXI chassis for specific instructions and warnings.

1. Turn off the computer that contains the data acquisition board or disconnect the data acquisition board from your SCXI chassis.
2. Turn off the SCXI chassis. Do not insert the SCXI-1161 into a chassis that is turned on.
3. After you have connected your signals to the screw terminals, insert the SCXI-1161 into the board guides. Gently guide the module into the back of the slot until the connectors make good contact. If you have already installed a cable assembly in the rear of the chassis, you must firmly engage the module and cable assembly; however, do not *force* the module into place.
4. Screw the front mounting panel of the SCXI-1161 to the top and bottom threaded strips of your SCXI chassis.

☞ **Note:** ***If you will connect this module to an MIO-16 or a DIO-24 data acquisition board, attach the connector at the metal end of the SCXI-1340 cable assembly to the rear signal connector on the SCXI-1161 module. Screw the rear panel to the rear threaded strip. Attach the loose end of the cable to the data acquisition board. For installation procedures with other SCXI accessories and data acquisition boards, consult the cable installation guide of your cable.***

5. Check the installation.
6. Turn on the SCXI chassis.
7. Turn on the computer or reconnect the data acquisition board to your chassis.

The SCXI-1161 module is installed and ready for operation.

Chapter 3

Signal Connections

This section describes the signal connections to the SCXI-1161 board via the SCXI-1161 screw terminals and rear signal connector, and includes specifications and connection instructions for the SCXI-1161 connector signals.

Screw Terminal Connections

The SCXI-1161 has 24 screw terminals for easy signal connection to the inputs. Each input consists of a common (COM) position, a normally closed (NC) position, and a normally open (NO) position. At power up and at reset, the SCXI-1161 COM positions on all the channels connect to the NC positions.

All contacts have a working common-mode voltage of 250 VAC or VDC. The contact-to-contact breakdown voltage is 750 V_{rms}. The contact-to-coil breakdown voltage is 1,500 V_{rms}. Please refer to the module specifications listed in Appendix A, *Specifications*, for further details before connecting the signals to the relay contacts.

Contact Protection for Inductive Load Connections

When inductive loads are connected to the relays, a large counter-electromotive force can occur at relay switching time because of the energy stored in the inductive load. These flyback voltages can severely damage the relay contacts and greatly shorten the life of the relay.

It is best to limit these flyback voltages at your inductive load by installing, across your inductive load, a flyback diode for DC loads (see Figure 3-1) or an MOV for AC loads. Refer to Appendix B, *Contact Protection*, for further details.

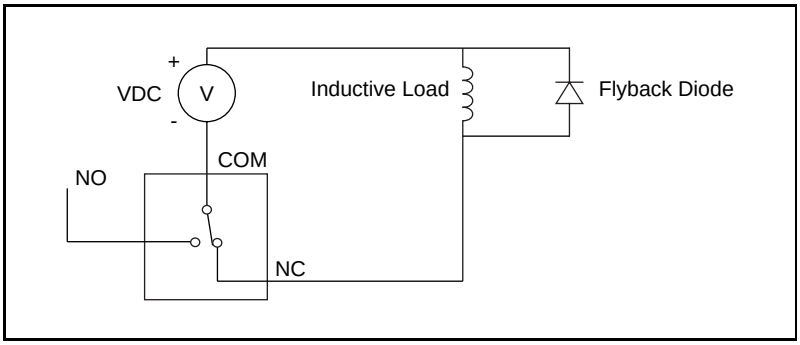


Figure 3-1. Contact Protection Using a Flyback Diode for DC Inductive Loads

In addition, the module has pads on which you can place an arc suppressor protection circuit to limit the voltage spike generated during the switching of inductive loads. These pads are between the COM position and the NO position and between the COM position and the NC position of the relays.

To determine where to place each arc suppressor, refer to Tables 3-1 and 3-2, which indicate the channel and suppressor pad assignments.

Table 3-1. Arc Suppressor Placement, COM to NO

COM to NO Channel Number	Transient Voltage Suppressor Reference Designator
0	VR1
1	VR3
2	VR5
3	VR7
4	VR9
5	VR11
6	VR13
7	VR15

Table 3-2. Arc Suppressor Placement, COM to NC

COM to NC Channel Number	Transient Voltage Suppressor Reference Designator
0	VR2
1	VR4
2	VR6
3	VR8
4	VR10
5	VR12
6	VR14
7	VR16

Figure 3-2 shows how to connect a transient voltage suppressor for AC and DC inductive loads.

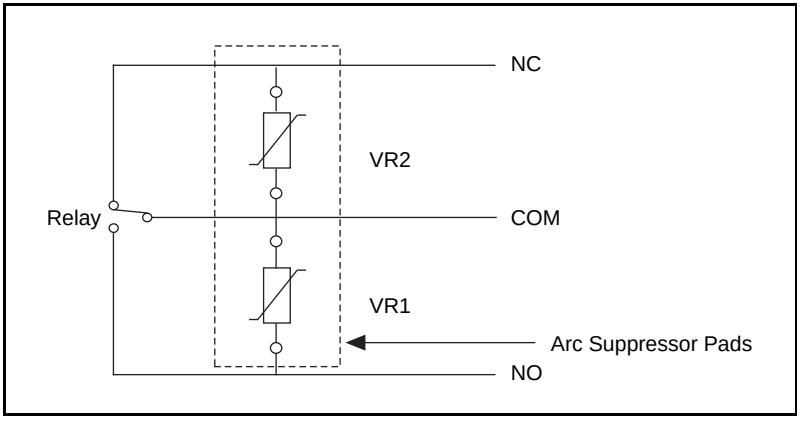


Figure 3-2. Arc Suppressor Pad Locations

Signal Connection

To connect the signal to the screw terminals, use the following procedure:

1. Remove the grounding screw of the top cover.
2. Snap out the top cover of the shield by placing a screwdriver in the groove at the bottom of the module.
3. Install contact protection, preferably across your load, as described in the previous section, if your load is inductive.
4. Slide the signal wires one at a time through the front panel strain relief. You can use additional insulation or padding if necessary.
5. Connect the wires to the screw terminals.
6. Tighten the strain relief by tightening the larger screws.
7. Snap the top cover back in place.
8. Replace the grounding screw to ensure proper shielding.

Rear Signal Connector

☞ **Note:** ***If you will use the SCXI-1161 with a National Instruments data acquisition board and cable assembly, you do not need to read the remainder of this chapter. If you will 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-1161, read this section.***

Figure 3-3 shows the pin assignments for the SCXI-1161 rear signal connector.

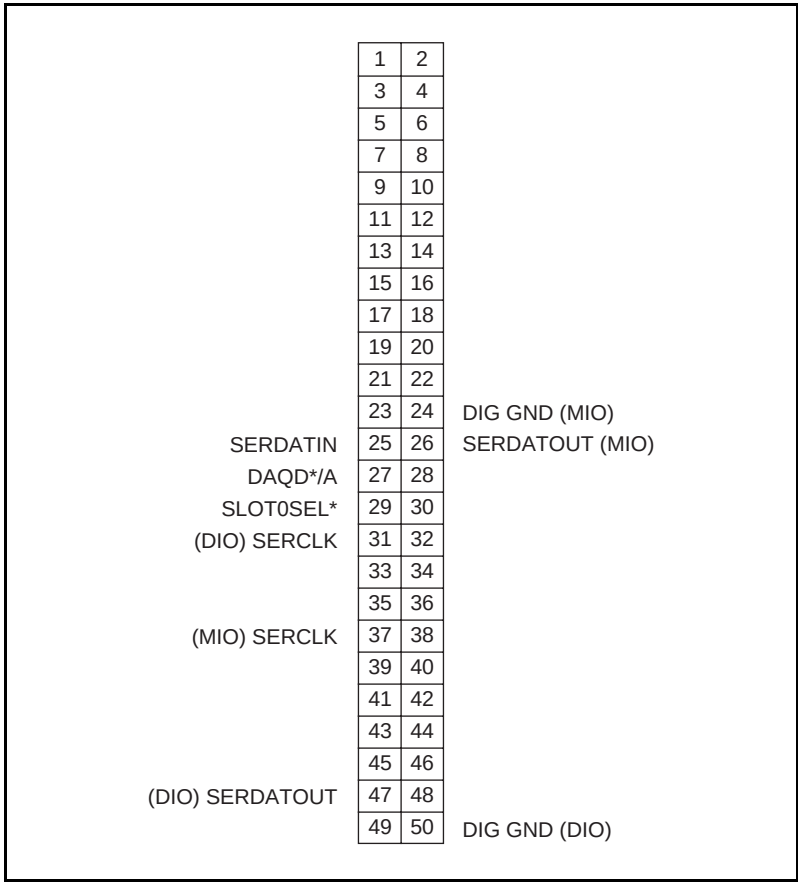


Figure 3-3. SCXI-1161 Rear Signal Connector Pin Assignment

Rear Signal Connector Signal Descriptions

Table 3-3 shows the rear signal connector signal descriptions.

Table 3-3. Rear Signal Connector Signal Descriptions

Pin	Signal Name	Description
24 or 50	DIG GND	Digital Ground—Supplies the reference for data acquisition board digital signals and is tied to the module digital ground. Pin 50 is for DIO-type boards. Pin 24 is for MIO-type boards. Jumper W3 selects the pin.
25	SERDATIN	Serial Data In—Taps into the SCXIbus MOSI line to provide serial input data to a module or Slot 0.
26 or 47	SERDATOUT	Serial Data Out—Taps into the SCXIbus MISO line to accept serial output data from a module. Pin 47 is for DIO-type boards. Pin 26 is for MIO-type boards. Jumper W5 selects the pin.
27	DAQ*/A	Data Acquisition Board Data/Address Line—Taps into the SCXIbus D*/A line to indicate to the module whether the incoming serial stream is data or address information.

Table 3-3. Rear Signal Connector Signal Descriptions (Continued)

Pin	Signal Name	Description
29	SLOT0SEL*	Slot 0 Select—Taps into the SCXIbus INTR* line to indicate whether the information on MOSI is sent to a module or to Slot 0.
31 or 37	SERCLK	Serial Clock—Taps into the SCXIbus SPICLK line to clock the data on the MOSI and MISO lines. Pin 31 is for DIO-type boards. Pin 37 is for MIO-type boards. Jumper W4 selects the pin.
* Indicates active low.		

All other pins are not connected.

Digital I/O Signal Connections

When you configure the SCXI-1161 for an MIO-type board, the digital I/O signals of the SCXI-1161 match the digital I/O lines of the MIO-type board. When you use the SCXI-1161 with an SCXI-1341, SCXI-1342, or SCXI-1344 cable assembly, the SCXI-1161 signals match the digital lines of the Lab-NB/Lab-PC/Lab-PC+ boards, the PC-LPM-16/PnP board, and the Lab-LC board, respectively. When you configure the SCXI-1161 for a DIO-type board, the digital I/O signals of the SCXI-1161 match the digital I/O lines of the DIO-24 and DIO-96 boards. When you use the SCXI-1161 with an SCXI-1348 cable assembly, the SCXI-1161 signals match the digital lines of the DIO-32F board.

Table 3-4 lists the pin equivalences. For more information, consult the installation guide of your cable.

Table 3-4. SCXIbus to SCXI-1161 Rear Signal Connector to Data Acquisition Board Pin Equivalences

SCXIbus Line	SCXI-1161 Rear Signal Connector	MIO Boards	Lab-NB/ Lab-PC/ Lab-PC+/ Lab-LC	PC-LPM-16/PnP	DIO-24	DIO-96	DIO-32F
MOSI	SERDATIN	ADIO0	PB4	DOUT4	PB3	APB3	DIOB3
D*/A	DAQD*/A	ADIO1	PB5	DOUT5	PB2	APB2	DIOB2
INTR*	SLOT0SEL*	ADIO2	PB6	DOUT6	PB1	APB1	DIOB1
SPICLK	SERCLK	EXTSTROBE*	PB7	DOUT7	PB0	APB0	DIOB0
MISO	SERDATOUT	BDIO0	PC1	DIN6	PA0	APA0	DIOA0

Chapter 4

Theory of Operation

This chapter contains a functional overview of the SCXI-1161 module and explains the operation of each functional unit making up the SCXI-1161.

Functional Overview

The block diagram in Figure 4-1 shows the key functional components of the SCXI-1161.

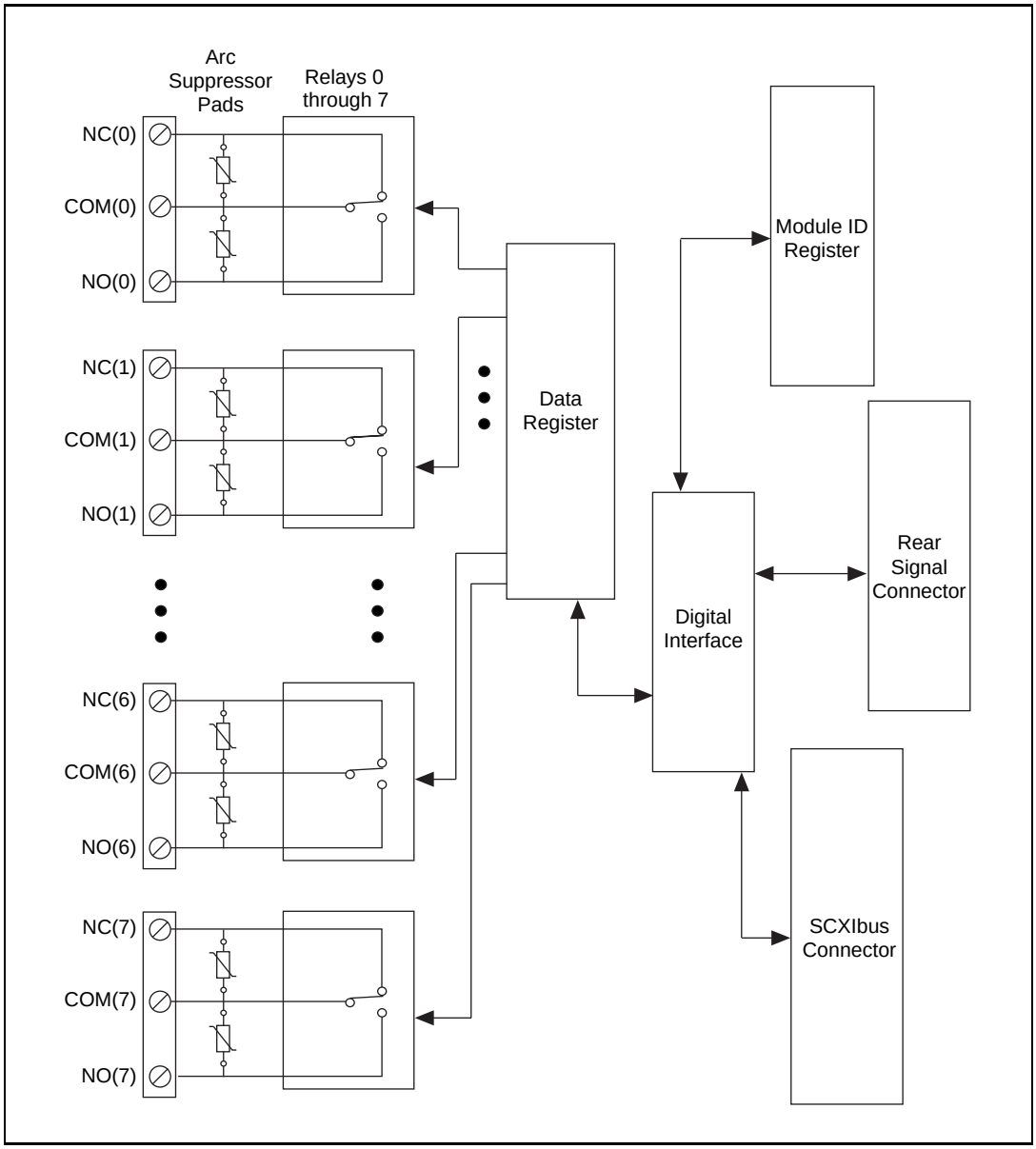


Figure 4-1. SCXI-1161 Block Diagram

The major components of the SCXI-1161 are as follows:

- The digital interface
- The digital control circuitry
- The relay channels

The SCXI-1161 module is dedicated to switching and controlling power signal sources. The theory of operation of each of the SCXI-1161 components is explained in the rest of this chapter.

Digital Interface

Figure 4-2 shows a diagram of the SCXI-1161 and SCXIbus digital interface circuitry.

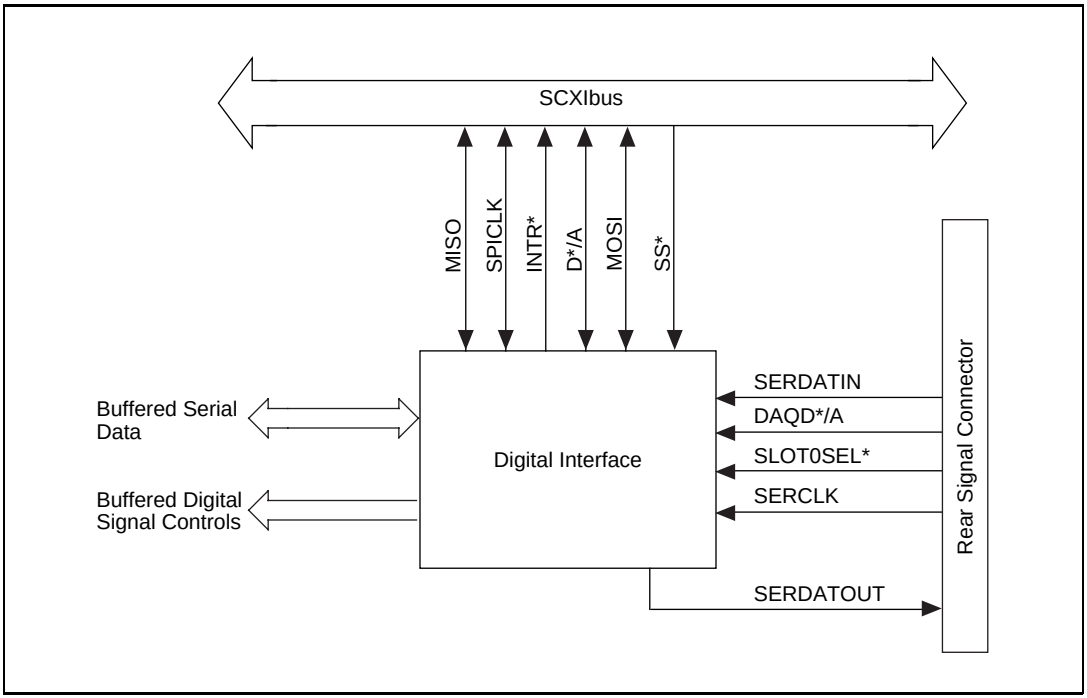


Figure 4-2. Digital Interface Circuitry Block Diagram

The digital interface circuitry is divided into a data acquisition section and an SCXIbus section. The SCXI-1161 connects to the SCXIbus via a 4x24 metral receptacle and to the data acquisition board via a 50-pin ribbon-cable header. The digital interface circuitry buffers the digital

signals from the data acquisition board and the SCXIbus and sends signals back and forth between the data acquisition board and the SCXIbus.

Digital Control Circuitry

Figure 4-3 diagrams the SCXI-1161 digital control.

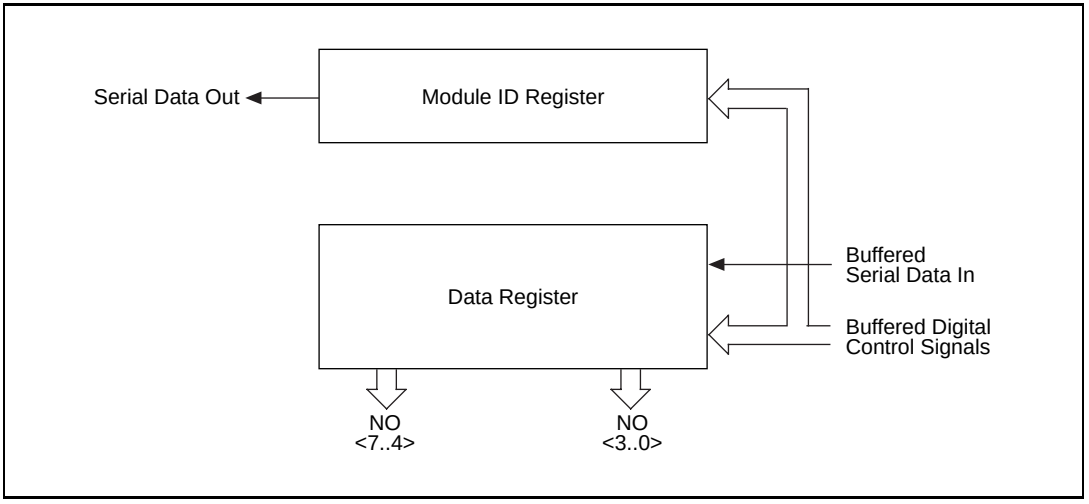


Figure 4-3. SCXI-1161 Digital Control

The digital control section consists of the Data Register and the Module ID Register.

The Data Register is a 2-byte serial-in, parallel-out shift register with relay drive capabilities. The Data Register controls the state of the SCXI-1161 relays. The complete descriptions of the register bits are given in the *SCXI Register-Level Programmers Manual*.

At reset or at power up, the relays are set to the NC position.

The Module ID Register is an 8-bit parallel serial-in, serial-out shift register. The contents of the Module ID Register are written onto MISO during the first four bytes of transfer after you select the module. Zeros are written to MISO thereafter until you deselect the module. The SCXI-1161 module ID is hex E.

Relay Channels

The SCXI-1161 has eight independent one form C (single-pole double-throw) relays. Each relay has three connections at the front screw terminals–the common (COM), the normally closed (NC), and the normally open (NO) positions. Each relay has pads for arc suppressors to protect the relays from inductive loads. Refer to the *Contact Protection for Inductive Load Connections* section of Chapter 3, *Signal Connections*, for further details on contact protection.

All eight relays are single-side stable relays. When you energize the relay coil, the COM connects to the NO position. The Data Register controls the relays as follows. The four LSBs of the least significant byte of the Data Register control the coils of relays 0 through 3. The four LSBs of the most significant byte of the Data Register control the coils of relays 4 through 7. When you do not energize the coils, the COM connects to the NC position.

After a write to the Data Register, the data is latched and the selected relay coils are continuously driven.

Each relay can be set (the relay COM position connected to the NO position) or reset (the relay COM position connected to the NC position) without affecting the other relays, or all relays can change states at the same time. However, each time a relay changes its state, the Data Register is rewritten to. Refer to the *SCXI-1161 Register-Level Programmers Manual* for further details.

The relays are break-before-make, but only if you do not exceed the specified relay operation speed. In addition, each relay is fully isolated from the other relays and from earth ground, with a working common-mode voltage of 250 V_{rms}.

☞ **Note:** ***It is important to notice that this module has no access to the analog backplane; this protects the backplane from faults when high voltages are available on the relay contacts.***

Specifications

Appendix A

This appendix lists the specifications for the SCXI-1161. These are typical at 25° C and 50% humidity unless otherwise stated. The operating temperature range is 0° to 50° C.

Channel Rating

Maximum switching capacity (resistive load)[1]

AC .....8 A at 125 VAC
6 A at 250 VAC

DC .....5 A at 30 VDC

Switching current.....8 A maximum per channel
50 A maximum per module

Channel on resistance .....175 mΩ

Contact material.....Silver alloy

Life[2]

Mechanical (at 180 cpm).....10^7 operations minimum

Electrical (at 20 cpm).....10^5 at rated load

Isolation

Terminal to terminal and
terminal to earth .....250 V_{rms}[3]

Maximum speed.....20 cpm at maximum load
180 cpm at no load

[1] If you operate the module at high currents, later operation at low currents may not be possible.

[2] Relays are subject to normal wear based on the number of operations.

[3] Module tested following the UL 3111 and IEC 1010 standard for voltage installation category II for reinforced or double insulation.

Operate time..... 15 msec

Release time..... 15 msec

Physical

Dimensions ..... 1.2 by 6.8 by 8.0 in.

Connectors ..... 50-pin male ribbon-cable rear connector 24-screw terminal adapter

Operating Environment

Temperature ..... 0 to 50 °C

Relative humidity..... 5% to 90% at 35 °C

Storage Environment

Temperature ..... –20 to 70 °C

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

Safety

Designed in accordance with UL 3121-1,
for Installation Category II Pollution Degree 2,
for altitudes up to 2,000 meters.

Contact Protection

Appendix
B

This appendix contains technical data on contact protection when you are switching inductive loads.[1]

[1] Copyright © Aromat Corporation, 1991. Reprinted with permission of copyright owner. All rights reserved. Aromat Corporation. 1991 *Relay Technical Data Book.*

General Application Guidelines

CONTACT

The contacts are the most important elements of relay construction. Contact performance conspicuously influenced by contact material, and voltage and current values applied to the contacts (in particular, the voltage and current waveforms at the time of application and release), the type of load, frequency of switching, ambient atmosphere, form of contact, contact switching speed, and of bounce.

Because of contact transfer, welding, abnormal wear, increase in contact resistance, and the various other damages which bring about unsuitable operation, the following items require full investigation.

1. Contact circuit voltage, current, and load

[Voltage, AC and DC]

When there is inductance included in the circuit, a rather high counter emf is generated as a contact circuit voltage, and since, to the extent of the value of that voltage, the energy applied to the contacts causes damage with consequent wear of the contacts, and transfer of the contacts, it is necesary to exercise care with regard to control capacity. In the case of DC, there is no zero current point such as there is with AC, and accordingly, once a cathode arc has been generated, because it is difficult to quench that arc, the extended time of the arc is a major cause. In addition, due to the direction of the current being fixed, the phenomenon of contact shift, as noted separately below, occurs in relation to the contact wear. Ordinarily, the approximate control capacity is mentioned in catalogues or similar data sheets, but this alone is not sufficient. With special contact circuits, for the individual case, the maker either estimates from the past experience or makes test on each occasion. Also, in catalogues and similar data sheets, the control capacity that is mentioned is limited to resistive load, but there is a broad meaning indicated for that class of relay, and ordinarily it is proper to think of current capacity as that for 125V AC circuits.

[Current]

The current at both the closing and opening time of the contact circuit exerts an important influence. For example, when the load is either a motor or a lamp, to the extent of the inrush current at the time of closing the circuit, wear of the contacts, and the amount of contact transfer increase, and contact welding and contact transfer make contact separation impossible.

3. Contact Protection

• Counter EMF

When switching inductive loads with a DC relay such as relay sequence circuits, DC motors, DC clutches, and DC solenoids, it is always important to absorb surges (e.g. with a diode) to protect the contacts.

When these inductive loads are switched off, a counter emf of several hundred to several thousand volts develops which can severely damage contacts and greatly shorten life. If the current in these loads is relatively small at around 1A or less, the counter emf will cause the ignition of a glow or arc discharge. The discharge decomposes organic matter contained in the air and causes black deposits (oxides, carbides) to develop on the contacts. This may result in contact failure.

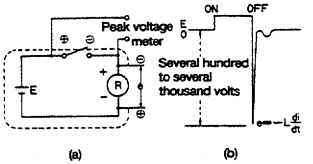


Fig. 13 Example of counter emf and actual measurement on a peak hold meter.

In Fig. 13(a), an emf ($e=-L\frac{di}{dt}$) with a steep waveform is generated across the coil with the polarity shown in Fig. 13(b) at the instant the inductive load is switched off. The counter emf passes through the power supply line and reaches both contacts.

Generally, the critical dielectric breakdown voltage at standard temperature and pressure in air is about 200 to 300 volts. Therefore, if the counter emf exceeds this, discharge occurs at the contacts to dissipate the energy ($\frac{1}{2}Li^2$) stored in the coil. For this reason, it is desirable to absorb the counter emf so that it is 200V or less.

A memory oscilloscope, digital memory, peak hold meter, etc., can be used to measure the counter emf. However, since the waveform is extremely steep, considerable discrepancies may result depending on the precision of the equipment used. The table shows the counter emf of various relays measured on a high precision peak hold meter.

Actual measurement of counter emf on a peak hold meter

Nominal Coil Voltage / Relay Type	6V DC	12V DC	24V DC
R relay (single side stable)	144V	165V	188V
NF4 relay	410V	470V	510V

• Material Transfer Phenomenon

Material transfer of contacts occurs when one contact melts or boils and the contact material transfers to the other contact. As the number of switching operations increases, uneven contact surfaces develop such as those shown in Fig. 14. After a while, the uneven contacts lock as if they were welded together. This often occurs in circuits where sparks are produced at the moment the contacts "make" such as when the DC current is large for DC inductive or capacitive loads or when the inrush current is large (several amperes or several tens of amperes).

Contact protection circuits and contact materials resistant to material transfer such as AgW or AgCu are used as countermeasures. Generally, a concave formation appears on the cathode and a convex formation appears on the anode. For DC capacitive loads (several amperes to several tens of amperes), it is always necessary to conduct actual confirmation tests.

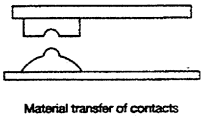
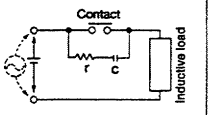
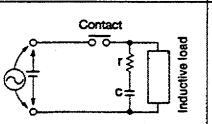
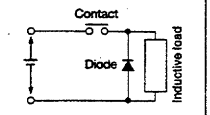
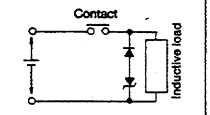
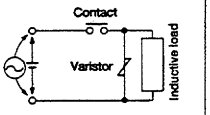


Fig. 14

• Contact Protection Circuit

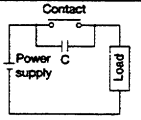
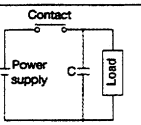
Use of contact protective devices or protection circuits can suppress the counter emf to a low level. However, note that incorrect use will result in an adverse effect. Typical contact protection circuits are given in the table below.

(○: Good ×: No Good)

Circuit		Application AC	Application DC	Features/Others	Device Selection
CR circuit		*	○	If the load is a timer, leakage current flows through the CR circuit causing faulty operation. * If used with AC voltage, be sure the impedance of the load is sufficiently smaller than that of the CR circuit.	As a guide in selecting r and c, r: 0.5 to 1Ω per 1V contact voltage c: 0.5 to 1μF per 1A contact current Values vary depending on the properties of the load and variations in relay characteristics. Capacitor c acts to suppress the discharge the moment the contacts open. Resistor r acts to limit the current when the power is turned on the next time. Test to confirm. Use a capacitor with a breakdown voltage of 200 to 300V. Use AC type capacitors (non-polarized) for AC circuits.
		○	○	If the load is a relay or solenoid, the release time lengthens. Effective when connected to both contacts if the power supply voltage is 24 or 48V and the voltage across the load is 100 to 200V.	
Diode circuit		×	○	The diode connected in parallel causes the energy stored in the coil to flow to the coil in the form of current and dissipates it as joule heat at the resistance component of the inductive load. This circuit further delays the release time compared to the CR circuit. (2 to 5 times the release time listed in the catalog)	Use a diode with a reverse breakdown voltage at least 10 times the circuit voltage and a forward current at least as large as the load current. In electronic circuits where the circuit voltages are not so high, a diode can be used with a reverse breakdown voltage of about 2 to 3 times the power supply voltage.
Diode and zener diode circuit		×	○	Effective when the release time in the diode circuit is too long.	Use a zener diode with a zener voltage about the same as the power supply voltage.
Varistor circuit		○	○	Using the stable voltage characteristics of the varistor, this circuit prevents excessively high voltages from being applied across the contacts. This circuit also slightly delays the release time. Effective when connected to both contacts if the power supply voltage is 24 or 48V and the voltage across the load is 100 to 200V.	———

• Avoid using the protection circuits shown in the figures on the right. Although DC inductive loads are usually more difficult to switch than resistive loads, use of the proper protection circuit will raise the characteristics to that for resistive loads. (Fig. 15)

Fig. 15

No good 	No good 
Although extremely effective in arc suppression as the contacts open, the contacts are susceptible to welding since energy is stored in C when the contacts open and discharge current flows from C when the contacts close.	Although extremely effective in arc suppression as the contacts open, the contacts are susceptible to welding since charging current flows to C when the contacts close.

• Mounting the Protective Device
In the actual circuit, it is necessary to locate the protective device (diode, resistor, capacitor, varistor, etc.) in the immediate vicinity of the load or contact. If located too far away, the effectiveness of the protective device may diminish. As a guide, the distance should be within 50cm.

• Abnormal Corrosion During High Frequency Switching of DC Loads (spark generation)
If, for example, a DC valve or clutch is switched at a high frequency, a blue-green corrosion may develop. This occurs from the reaction with nitrogen in the air when sparks (arc discharge) are generated during switching. For relays with a case, the case must be removed or air holes drilled in the case. A similar phenomenon occurs in the presence of ammonia-based gas. Therefore, care is required in circuits where sparks are generated at a high frequency.

• Type of Load and Inrush Current
The type of load and its inrush current characteristics, together with the switching frequency are important factors which cause contact welding. Particularly for loads with inrush currents, measure the steady state current and inrush current and select a relay which provides an ample margin of safety. The table on the right shows the relationship between typical loads and their inrush currents.

Type of load	Inrush current
Resistive load	Steady state current
Solenoid load	10 to 20 times the steady state current
Motor load	5 to 10 times the steady state current
Incandescent lamp load	10 to 15 times the steady state current
Mercury lamp load	Approx. 3 times the steady state current
Sodium vapor lamp load	1 to 3 times the steady state current
Capacitive load	20 to 40 times the steady state current
Transformer load	5 to 15 times the steady state current

• When Using Long Wires
If long wires (100 to 300m) are to be used in a relay contact circuit, inrush current may become a problem due to the stray capacitance existing between wires. Add a resistor (approx. 10 to 50Ω) in series with the contacts. (Fig. 16)

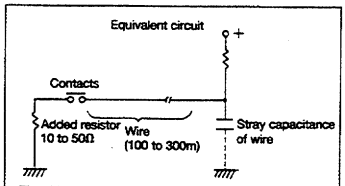


Fig. 16

• Phase Synchronization in Switching AC Loads
If switching of the relay contacts is synchronized with the phase of the AC power, reduced electrical life, welded contacts, or a locking phenomenon (incomplete release) due to contact material transfer may occur. Therefore, check the relay while it is operating in the actual system. However, if problems develop, control the relay using an appropriate phase. (Fig. 17)

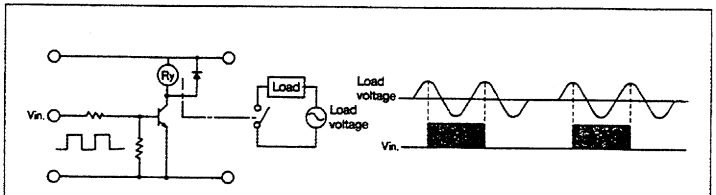


Fig. 17

4. Cautions on Use Related to Contacts

• Connection of load and contacts
Connect the load to one side of the power supply as shown in Fig. 18(a). Connect the contacts to the other side. This prevents high voltages from developing between contacts. If contacts are connected to both side of the power supply as shown in (b), there is a risk of shorting the power supply when relatively close contacts short.

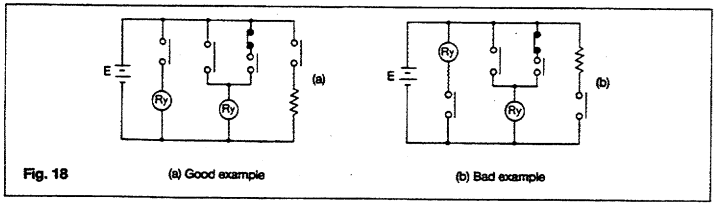


Fig. 18 (a) Good example (b) Bad example

• Dummy Resistor

Since voltage levels at the contacts used in low current circuits (dry circuits) are low, poor conduction is often the result. One method to increase reliability is to add a dummy resistor in parallel with the load to intentionally raise the load current reaching the contacts. Care is required especially for low-level switching circuits (0.1V or less, 0.2mA or less). Contact material and, of course, use of bifurcated contacts must also be taken into consideration.

• Avoid Circuits Where Shorts Occur Between Form A and B Contacts (Fig. 19)

1) The clearance between form A and B contacts in compact control components is small. The occurrence of shorts due to arcing must be assumed.
2) Even if the three N.C., N.O., and COM contacts are connected so that they short, a circuit must never be designed to allow the possibility of burning or generating an overcurrent.
3) A forward and reverse motor rotation circuit using switching of form A and B contacts must never be designed.

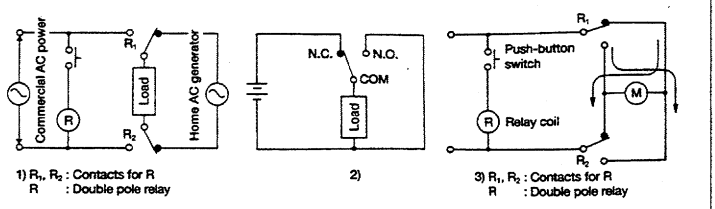


Fig. 19 Bad example of form A and B use

• Shorts Between Different Electrodes

Although there is a tendency to select miniature control components because of the trend toward miniaturizing electrical control units, care must be taken when selecting the type of relay in circuits where different voltages are applied between electrodes in a multi-pole relay, especially when switching two different power supply circuits. This is not a problem that can be determined from sequence circuit diagrams. The construction of the control component itself must be examined and sufficient margin of safety must be provided especially in creepage between electrodes, space distance, presence of barrier, etc.

Applications of Relays in Electronic Circuits

ELECTRONIC CIRCUIT DRIVE BY MEANS OF A RELAY

• Chatterless electronic circuit

Even though a chatterless characteristic is a feature of relays, this is to the fullest extent a chatterless electrical circuit, much the same as a mercury relay. To meet the requirement for such circuits as the input to a binary counter, there is an electronic chatterless method in which chattering is absolutely not permissible. Even if chattering develops on one side, either the N.O. side contacts or the N.C. side contacts, the flip flop does not reverse, and the counter circuit can be fed pulsed without a miss. (However, bouncing from the N.O. side to N.C. side must be absolutely avoided.) (Fig. 10)

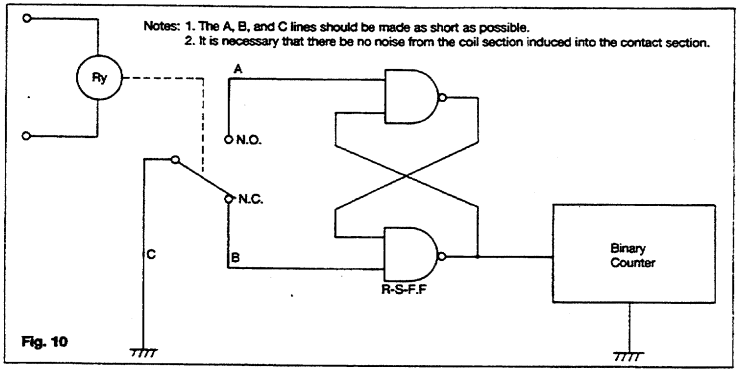


Fig. 10

• Triac drive

With an electronic circuit using a direct drive from a triac, the electronic circuit will not be isolated from the power circuit, and because of this, troubles due to erroneous operation and damage can develop easily. The introduction of a relay drive is the most economical and most effective solution. (Photo coupler and pulse transformer circuits are complicated.)
When a zero cross switching characteristic is necessary, a solid state relay (SSR) should be used. (Fig. 11)

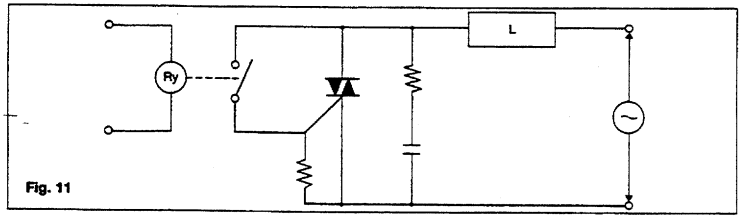


Fig. 11

Customer Communication

Appendix C

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.

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- **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.

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Operating system (include version number) _____

Clock speed _____MHz RAM _____MB Display adapter _____

Mouse ___yes ___no Other adapters installed _____

Hard disk capacity _____MB Brand _____

Instruments used _____

_____

National Instruments hardware product model _____ Revision _____

Configuration _____

National Instruments software product _____ Version _____

Configuration _____

The problem is: _____

_____

_____

_____

_____

List any error messages: _____

_____

_____

The following steps reproduce the problem:_____

_____

_____

_____

_____

_____

SCXI-1161 Hardware and Software Configuration Form

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

Numbers/Symbols

°	degrees
Ω	ohms
+5 V (signal)	+5 VDC Source

A

A	amperes
AC	alternating current
A/D	analog-to-digital
AWG	American Wire Gauge

C

C	Celsius
CHS	Chassis
CHSGND	Chassis Ground
COM	common
cpm	cycles per minute

D

D/A	digital-to-analog
D*/A	Data/Address
DAQD*/A	Data Acquisition Board Data/Address Line
DC	direct current
DIG GND	Digital Ground
DIO	digital I/O

F

FIFO	first-in-first-out
ft	feet

H

hex	hexadecimal
HSCR	Hardscan Control Register
Hz	hertz

I

I/O	input/output
I_I	input current leakage
I_{in}	input current
in.	inches
INTR*	Interrupt
I_{out}	output current

L

LSB	least significant bit

M

M	megabytes of memory
m	meters
MIO	multifunction I/O
MISO	Master-In-Slave-Out
MOSI	Master-Out-Slave-In
MOV	metal oxide varistor
MSB	most significant bit

N

NC	normally closed
NO	normally open

R

RAM	random-access memory
RESET*	reset
RMA	Return Material Authorization
rms	root mean square
RTSI	Real-Time System Integration

S

SCXI	Signal Conditioning eXtensions for Instrumentation (bus)
SDK	Software Developer's Kit
sec	seconds
SERCLK	Serial Clock
SERDATIN	Serial Data In
SERDATOUT	Serial Data Out
SL	Slot
SLOT0SEL*	Slot 0 Select
SPDT	single-pole double-throw
SPI	Serial Peripheral Interface
SPICLK	Serial Peripheral Interface Clock
SS*	Slot Select

U

UL	Underwriters Laboratory

V

V	volts
V+	Positive Analog Supply
V–	Negative Analog Supply
VAC	volts alternating current
VDC	volts direct current
V_{IH}	volts input high
V_{IL}	volts input low
V_{in}	volts in
V_{OH}	volts output high
V_{OL}	volts output low
V_{out}	volts out
V_{rms}	volts, root mean square

W

W	watts

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