Computer-Based Instruments

NI 2590 User Manual

1 × 4, 50 Ω, 1.3 GHz Multiplexer

NATIONAL INSTRUMENTS™

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FCC/DOC Radio Frequency Interference Class A Compliance

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual, 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). This equipment has been tested and found to comply with the following two regulatory agencies:

Federal Communications Commission

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

This device complies with the FCC rules only if used with shielded interface cables of suitable quality and construction. National Instruments used such cables to test this device and provides them for sale to the user. The use of inferior or nonshielded interface cables could void the user's authority to operate the equipment under the FCC rules.

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

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Conventions

The following conventions are used in this manual:

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

 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.

 This icon denotes a warning, which advises you of precautions to take to avoid being electrically shocked.

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

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

Contents

Chapter 1
Routing Signals with Your NI 2590

Chapter 2
NI 2590 Operation

Appendix A
Specifications

Appendix B
Servicing Your Module

Appendix C
Common Questions

Appendix D
Technical Support Resources

Glossary

Index

Figures

Tables

1

Routing Signals with Your NI 2590

This manual describes the electrical and mechanical characteristics of the NI 2590 1 × 4, 50 Ω, 1.3 GHz, multiplexer module for the PXI bus and contains information concerning its installation and operation.

About the NI 2590

This section summarizes the features and operation of the NI 2590 switch module. Refer to Chapter 2, *NI 2590 Operation*, for more complete details. In addition, refer to Appendix A, *Specifications*, for detailed specifications of the switch module.

The NI 2590 is a general-purpose, 4-channel, high-bandwidth multiplexing switch. The NI 2590 uses single-pole double-throw high-bandwidth relays capable of switching signals from DC to 1.3 GHz. The characteristic impedance of the channels is 50 Ω . The maximum rated voltage of the switch is 24 VDC, and the maximum rated current is 1 ADC.

Triggers

Two triggers are used for handshaking between the NI 2590 switch and other PXI instruments. The *scanner advanced* trigger indicates when the module has closed all the necessary switches for the next scan and the switches have settled, or *debounced*.

The *external trigger input* trigger is generated by another instrument or by software, and causes the NI 2590 to advance to the next entry in the scan list. The triggers can be routed to any of the PXI TTL triggers or to the PXI star trigger.

Refer to Chapter 2, *NI 2590 Operation*, for more information on triggers.

RF Switching Precautions

The NI 2590 is a *reflective switch*, meaning that any channels not switched to the common channel are unterminated, and any signal on an unterminated channel will be reflected to its source. For most low-power switching applications this is not a problem. However, operation with an unterminated output can damage some high-power RF sources. Consult your RF source documentation for more information about connecting to unterminated channels.

Caution Always disconnect all signals from the front connectors and power down the PXI chassis before removing the NI 2590 from the chassis. Observe electrostatic discharge handling precautions during and after removal of the module, or when connecting and disconnecting signals on the front panel.

Warning Do not exceed the 24 V channel-to-ground rating. Any connections that exceed the maximum voltage for the NI 2590 can result in an electrical shock hazard and damage to the switch module and any or all of the modules connected to the PXI backplane. National Instruments is *not* liable for any damages or injuries resulting from exceeding maximum voltage ratings. Refer to Appendix A, *Specifications*, for information.

Contact Protection

Caution The contacts of the relay are rated for a life of 5×10^6 mechanical operations when operated with no signal or a very small signal present. At full rated power, 1 A at 24 VDC, the life of the switch is downgraded to 100,000 operations. If your setup allows, it is always best to turn off the input signals connected to the switch module during the switching operation to avoid contact arcing within the switch. Switching large inductive loads can also cause contact arcing. In such instances, install a flyback diode or varistor across the inductance to protect the switch.

Connecting Signals

The front of the NI 2590 module has five “push-on” SMB connectors for signal connections. The center connection, labeled COM, is connected in a through path to one of the other four connections depending on the software instructions sent to the switch.

Front Connector

The following diagram shows the NI 2590 front connector. Table 1-1 describes the connector signals.

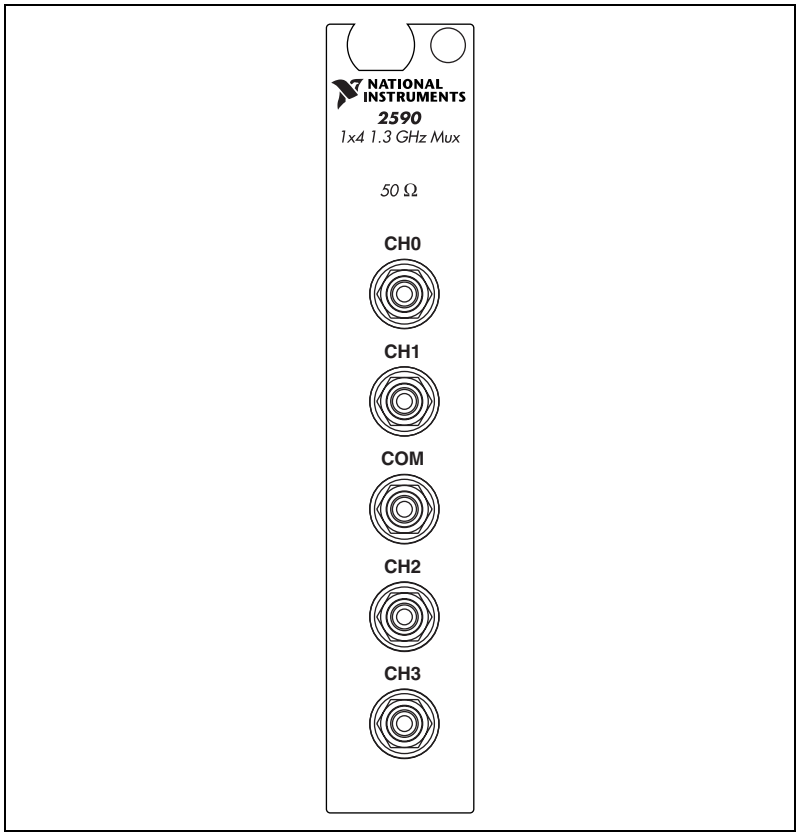


Figure 1-1. NI 2590 Front Connector

Table 1-1. Front Connector Signal Description

Signal Name	Type	Description
CH<0..3>	Input/Output	Channels—Where signals are connected to the switch module
COM	Input/Output	Common—The common for the respective channel

Software Choices

You have several options to choose from when programming your National Instruments switch module. You can use the NI-Switch driver software or National Instruments application software.

NI-Switch Driver Software

The NI-Switch instrument driver is an Interchangeable Virtual Instrument, an IVI-compliant instrument driver that is bundled with NI-Switch modules at no cost.

NI-Switch features a set of operations and attributes that exercise all the functionality of the switching hardware, including configuration, opening/closing, and scanning. In addition, NI-Switch comes with an interactive soft front panel and online documentation.

NI-Switch eliminates the need to understand complex register programming and interrupt handling in the Microsoft operating systems, and frees you to focus on creating your test system.

National Instruments Application Software

LabVIEW and LabWindows/CVI are innovative program development software packages for data acquisition and control applications. LabVIEW uses graphical programming, whereas LabWindows/CVI enhances traditional programming languages. Both packages include extensive libraries for data acquisition, instrument control, data analysis, and graphical data presentation. Using LabVIEW or LabWindows/CVI can significantly reduce the development time for your data acquisition and control application.

LabVIEW features interactive graphics, a state-of-the-art user interface, and a powerful graphical programming language. The LabVIEW NI-Switch VI Library, a series of virtual instruments (VIs) for using LabVIEW with National Instruments switch hardware, is included with the NI-Switch driver.

LabWindows/CVI features interactive graphics, a state-of-the-art user interface, and uses the ANSI standard C programming language. The LabWindows/CVI NI-Switch Library, a series of functions for using LabWindows/CVI with National Instruments switch hardware, is included with the NI-Switch driver.

Third-Party Software

The NI-Switch instrument driver also includes support files for Microsoft Visual C++ and Microsoft Visual Basic. See the *NI-SWITCH Software Readme File* for version support information.

Cabling and Accessories

National Instruments recommends the use of cables and accessories with 50 Ω characteristic impedance with the NI 2590.

2

NI 2590 Operation

This chapter contains safety instructions and a functional overview of the NI 2590 switch module, and explains the operation of each functional unit making up the switch module.

Safety Instructions

Caution *Do not operate damaged equipment.* The safety protection features built into this instrument can become impaired if the instrument becomes damaged in any way. If the instrument is damaged, do not use it until service-trained personnel can check its safety. If necessary, return the instrument to National Instruments for service and repair to ensure that its safety is not compromised.

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

Do not substitute parts or modify equipment beyond what is described in Appendix B, *Servicing Your Module*. Because of the danger of introducing additional hazards, do not install unauthorized parts or modify the instrument. Return the instrument to National Instruments for service and repair to ensure that its safety is not compromised.

Connections that exceed any of the maximum signal ratings on the NI 2590 can create a shock or fire hazard or can damage any or all of the devices connected to the NI 2590. National Instruments is *not* liable for any damages or injuries resulting from incorrect signal connections.

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

Functional Overview

The following block diagram illustrates the key functional components of the NI 2590 switch module.

The major components of the NI 2590 module are as follows:

- General-purpose high-frequency relays
- Switch control circuitry
- Random scanning
- PXIbus interface
- Triggers

Relay Operation

The NI 2590 has four channels, CH0 through CH3, any one of which can be connected to the single common channel (COM) by closing the appropriate relays.

You can be control the relays individually, or you can use higher-level commands to energize the correct relays to connect a channel (such as CH0) to COM. Only one channel can be connected to the common channel at any time, and it is not possible to connect one channel to another channel bypassing the common channel.

The NI 2590 relays are single-side stable. When power is removed from the relay coil, the relay returns to its de-energized state. When all three relays are de-energized, the default connection is from CH0 to COM, as shown in Figure 2-1, *NI 2590 Module Block Diagram*. To connect CH2 to COM, you energize MUX0123; to connect CH3 to COM, you energize MUX0123 and MUX23. You can specify the channel to connect to COM and let the NI-Switch driver energize the appropriate relays for you. Refer to the *NI-SWITCH Software User Manual* for further information.

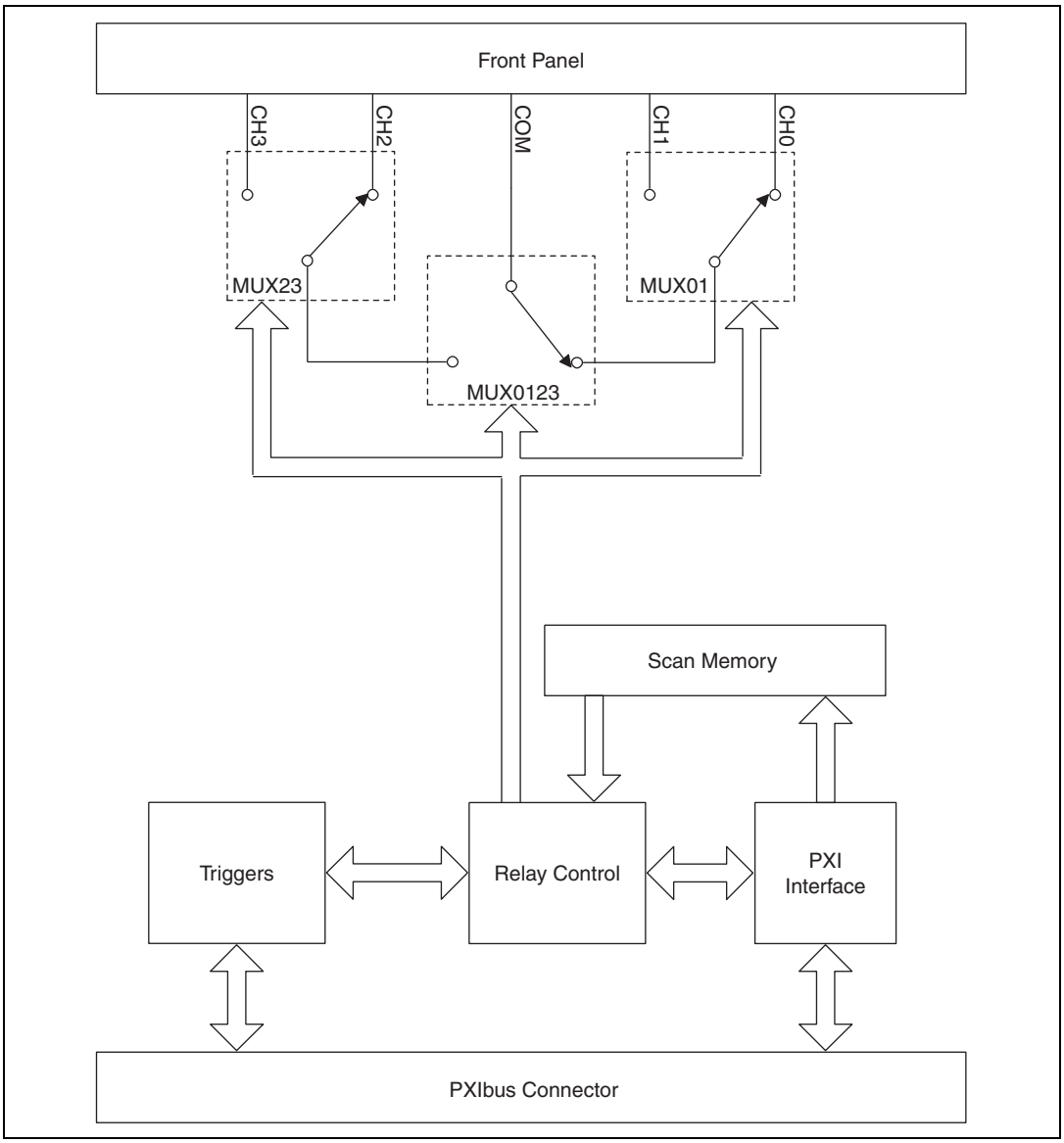


Figure 2-1. NI 2590 Module Block Diagram

Switch Control Circuitry

The switch control circuitry (SCC) is responsible for opening and closing relays on the NI 2590. You can load commands for the SCC into scan memory using the driver software you received with your kit. Consult the online help or your software documentation for specific information on the appropriate commands. There are two reasons for storing the commands in memory before the SCC can process them:

- Both the operate and release times for the NI 2590 are 15 ms. Using memory storage, the software can send multiple commands to the SCC without having to wait for a relay action to complete.
- The memory is used to store a scan list necessary for hardware random scanning.

Random Scanning

The NI 2590 can perform random scanning. In random scanning, the switch module can open or close relays in any order.

The scan list is downloaded to onboard memory. Commands in the scan list can perform the following actions:

- Open or close relays
- Wait for an external trigger
- Generate a scanner advanced trigger
- Generate a breakpoint interrupt

You can use the driver software to configure the switch module for continuous or one-time scanning. In continuous scanning, the switch module cycles through the scan list until you disable scanning. For one-time scanning, the switch module runs through the scan list only once.

You can also use software commands to clear the scan list or reset it to the beginning at any time.

The onboard control logic for the NI 2590 switch module gives you direct access to open and close the relays, and also the ability to download up to 1,024 random scanning instructions. The software included with the module automatically configures the NI 2590 and downloads the scan list to hardware for you. The scan list itself downloads directly into the memory of the module to deliver the fastest scan possible with no controller

intervention. You can configure the switch module to process the scan list once or to continuously loop through the scan list.

PXI Interface

You can configure and control your NI 2590 switch module through the PXI interface, taking advantage of PXI features. The NI 2590 uses the PXI TTL triggers to synchronize scanning with a measurement device such as the NI 5102 (PXI) 20 MS/s oscilloscope, or the NI 5411 for PXI arbitrary waveform generator.

PXI Triggers

External Trigger Input

The NI 2590 can use an external trigger input to advance between scan setups in a scan list. Using the driver software, you can configure the switch module to route the external trigger from any of the PXI TTL trigger lines or the PXI star trigger. Alternatively, you can use a software command to trigger the switch module.

All external trigger lines are compatible with TTL voltage levels and are edge sensitive. The minimum pulse width from the PXI TTL triggers and PXI star trigger is 70 ns.

Scanner Advanced

The NI 2590 can generate a scanner advanced trigger to indicate when the switch module is set up and ready to take measurements. Using the driver software, you can configure the switch module to route the scanner advanced (SCANADV) trigger to any PXI TTL trigger line or to the PXI star trigger. You can configure the switch module to generate the SCANADV trigger when a relay has settled (or debounced).

Because the NI 2590 has open-collector drivers on the PXI TTL trigger lines, you can have multiple switch modules using the same trigger line in the multiboard SCANADV mode.

Modes

SCANADV has two modes of operation. In its default mode, the SCANADV trigger asserts for 1 µs after the relay has debounced. You can also configure the switch module for handshaking mode, in which the SCANADV trigger goes high after a relay settles, and the SCANADV trigger goes low after the external trigger input asserts. You can use this handshaking mode for multiboard scanning.

Note The NI 2590 ignores external triggers when it is not in a wait-for-trigger state while scanning.

Initiating Scanning

When you use the NI 2590 to initiate a scan, make sure the measurement device is armed (waiting for trigger) before enabling scanning on the switch module. Enabling scanning causes the first switch(es) in the scan list to close and generates a scanner advanced trigger after the relay switches have settled or debounced.

When you use the measurement device to initiate a scan, make sure scanning is enabled on the NI 2590 before the measurement device starts to take measurements. This ensures that the switch module has the correct signal routed and that the switch module is waiting for an external trigger from the measurement device.

Always configure the triggers in a system before configuring the measurement device or the NI 2590 for scanning. When triggers are configured, a state change or pulse could occur on the trigger line. This is also possible when you reset the switch module.

Multiboard Triggering

You can use multiple NI 2590 switch modules—or multiple other National Instruments switch modules such as the NI 2503—together in conjunction with an instrument such as an NI oscilloscope. In multiple switch-module systems, be sure to identify one switch module as the master switch module.

All other switch modules for the system are identified as slave switch modules. The master switch module can route an external trigger from the front connector to a PXI backplane trigger. In addition, the master switch module can route the SCANADV trigger from the PXI backplane to either the front connector or another backplane trigger. This functionality makes

it possible to wire external triggers from/to only one switch module in the system, which simplifies the wiring scheme.

Note The NI 2590 does not support triggers on the front panel connector. If the trigger signal is external to the chassis, you must use a different National Instruments switch module, such as the NI 2503, as the master switch module.

For more information, refer to the *NI-SWITCH Software User Manual*.

A

Specifications

This appendix lists the specifications for the NI 2590 switch module. These specifications are typical at 25 °C unless otherwise noted.

Input Characteristics

Number of relays 3

Common-mode Voltage

Channel to Earth ..... 24 VDC

Maximum switching voltage

AC ..... 24 V_{rms}

DC ..... 24 VDC

Maximum switching capacity per channel

DC ..... 1 A at 24 V

AC ..... 1 A_{rms} at 24 V

Maximum switching
power per channel ..... 24 W

Contact on resistance (initial) ..... 100 MΩ max

Contact material ..... Gold-clad silver

RF Performance Characteristics

Characteristic impedance (Z_0)..... 50 Ω

Insertion loss at:

< 100 MHz ..... < 0.4 dB
< 500 MHz ..... < 0.9 dB
< 1.3 GHz..... < 1.5 dB

VSWR at:

< 100 MHz.....< 1.15
< 500 MHz.....< 1.35
< 1.3 GHz .....< 1.5

Isolation:

< 500 MHz.....< –62 dB
< 1.3 GHz .....< –50 dB

Risetime .....< 300 ps

Signal delay .....< 3 ns

Maximum RF carry power
at 900 MHz.....10 W

Note Refer to the Cautions and Warning in the *RF Switching Precautions* and *Contact Protection* sections of Chapter 1, *Routing Signals with Your NI 2590* for important information about using your NI 2590 with high-power signals.

Dynamic Characteristics

Relay operate time (at 20° C)

Typical.....15 ms

Relay release time (at 20 °C)

Typical.....15 ms

Expected life

Mechanical (no load).....5×10^6 operations

Electrical at maximum
switching capacity .....10^5 operations

Caution Exceeding the maximum switching capability will decrease the expected life of the NI 2590.

PXI Bus Interface

Slave

PXI Trigger Bus

Trigger lines 8

Star trigger..... 1

Power Requirement

+5 VDC

Minimum (all relays opened)..... 350 mA

Maximum (all relays closed) ..... 0.6 A

Physical

Dimensions..... 10 by 16 by 4 cm
(3.9 by 6.3 by 1.6 in.)

Weight ..... 240 g (8.5 oz)

I/O connector..... 5 SMB female

Environment

Operating temperature .....0 to 50 °C

Storage temperature.....–20 to 70 °C

Relative humidity ..... 5% to 85% noncondensing

Maximum altitude ..... 2,000 m

Certifications and Compliances

CE Mark Compliance CE

See the Declaration of Conformity sheet accompanying product.

B

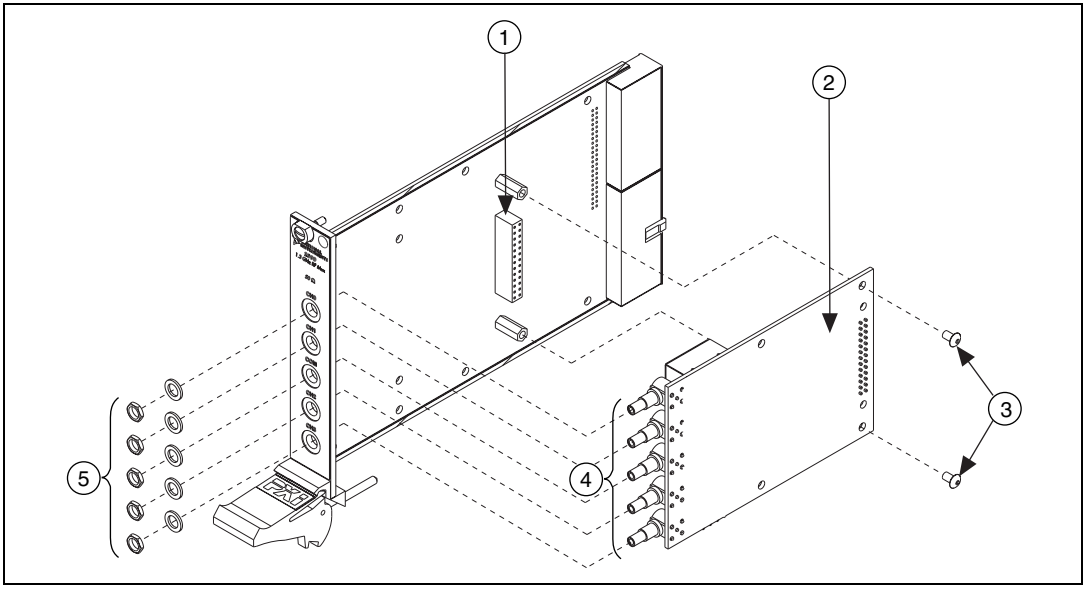
Servicing Your Module

This appendix describes procedures for servicing your NI 2590 module.

Replacing the Relay Module

The NI 2590 is constructed so that the relay module can be replaced by the user when the relays fail. The life of the relay is nominally 10^5 operations when switching the maximum rated load.

You can order an RF 2590 replacement relay module for your NI 2590 from National Instruments. The replacement kit contains the fully assembled module. Follow these instructions to replace the failed module. Refer to Figure B-1.



1 Header	3 Screws	5 Hex Nuts and Washers
2 Relay Module	4 SMB Connectors	

Figure B-1. NI 2590 Parts Locator Diagram

1. Ground yourself with a grounding strap or a ground connected to your PXI chassis. Properly grounding yourself prevents damage to your PXI module from electrostatic discharge.
2. Remove the two Phillips-head screws that fasten the NI 2590 relay module board to the module carrier.
3. Remove the hex nuts and washers from the SMB connectors on the front panel.
4. Gently disconnect the rear of the module from the header, then carefully remove the module.
5. Install the replacement module and screws in reverse order, taking care not to damage the connector pins on the module.

C

Common Questions

This appendix addresses common questions you may have while using your NI 2590 switch module.

What should I do if the software detects the module but the switches do not switch?

- Verify that the switches do not switch. Close your application program and then launch the soft front panel as described in the *Set up and Test* document you received with your kit. The soft front panel shows the state of each relay on the module. Try closing and opening the switches.
- Also be sure to check the return codes of the NI-Switch operation to ensure that there are no errors (negative value) or warnings (positive value). You can also use the NI-Spy utility to check for error codes.
- Finally, verify that your code is correct. For reference, see the examples described in the *NI-SWITCH Software User Manual*. The NI-Switch driver also ships with several examples in source code. Compare your algorithm to those in the examples.

What should I do if scanning does not work?

- First, ensure that you have configured the switch module and the instrument to match trigger lines. The output trigger of the instrument should connect to the trigger input of the switch module. In addition, the scanner advanced trigger of the switch module should be connected to the input trigger of the instrument.
- If the switch module is used to initiate the scan, make sure the scope or arb is waiting for a trigger before enabling scanning on the switch module. This is the recommended method for hardware scanning.
- If the scope or arb is used to initiate the scan, enable scanning on the switch module before configuring the scope or arb to start taking measurements.
- Also be sure to check the return codes of the NI-Switch operation to ensure that there are no errors (negative value) or warnings (positive value). You can also use the NI-Spy utility to check for error codes.

- Finally, verify that your code is correct. For reference, see the examples described in the *NI-SWITCH Software User Manual*. The NI-Switch driver also ships with several examples in source code. Compare your algorithm to the ones in the examples.

Do I need to program the switch module myself?

The NI 2590 comes with the NI-Switch driver software, which exports the full functionality of the module. NI-Switch handles the complex issues of direct memory access, interrupts, and operating system interfacing.

D

Technical Support Resources

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

NI Web Support

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

Online Problem-Solving and Diagnostic Resources

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

Software-Related Resources

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

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Mexico (Monterrey) 8 357 7695, Netherlands 0348 433466,
Norway 32 27 73 00, Singapore 2265886, Spain (Madrid) 91 640 0085,
Spain (Barcelona) 93 582 0251, Sweden 08 587 895 00,
Switzerland 056 200 51 51, Taiwan 02 2377 1200,
United Kingdom 01635 523545

Glossary

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

Numbers and Symbols

°	degrees
Ω	ohms
%	percent
>	greater than
<	less than

A

A	amperes
AC	alternating current
ADC	amperes direct current
ANSI	American National Standards Institute

B

breakpoint	a specified point in program code where the program pauses to perform some action; a breakpoint interrupt can be added to a scan list for debugging or other special needs.
bus	the group of conductors that interconnect individual circuitry in a computer. Typically, a bus is the expansion vehicle to which I/O or other devices are connected. Examples of PC buses are the ISA and PCI bus.

C

C	Celsius
channel	pin or wire lead on the multiplexer to which you apply or from which you read the signal
common	a channel that is typically the output of a switch module
contact bounce	the intermittent switching that occurs when the movable metal parts of a relay make or break contact

D

DC	direct current
debounced	indicates when the contact bounce has ended. *See* contact bounce.
device	a plug-in module, board, or pad that can contain multiple channels and conversion devices. Some examples of devices are computers, multimeters, multiplexers, oscillators, operator interfaces, and counters.
diode	an electronic component that acts primarily as a one-way valve
drivers/driver software	software that controls a specific hardware device such as a switch module

E

external trigger	a voltage pulse from an external source that triggers an event such as A/D conversion

F

flyback voltage	the voltage spike generated the instant current stops flowing through an inductor

H

handshaking	the use of two trigger lines between two instruments, such as a switch and a DMM, to synchronize their actions
Hz	hertz—the number of scans read or updates written per second

I

in.	inches
Interchangeable Virtual Instrument	an advanced architecture for instrument drivers that includes features such as simulation and state caching
I/O	input/output—the transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces
ISA	Industry Standard Architecture
IVI	*See* Interchangeable Virtual Instrument.

N

NI-Switch	an IVI-based instrument driver that supports the National Instruments line of switch modules

P

PXI	PCI with extensions for instrumentation

R

random scanning	scanning the channels in a mux in any order
reflective switch	a switch architecture in which the unused channels are NOT terminated in the characteristic impedance of the system. The unused channels are open circuits.
relay	a switch that connects or disconnects the signal to a common through the physical movement of a metal arm
rms	root mean square—the square root of the average value of the square of the instantaneous signal amplitude; a measure of signal amplitude

S

s	seconds
scan	the data acquisition of signals connected to multiple channels of a multiplexer. Typically, the measurement device uses a trigger to advance the multiplexer to the next channel in the scan.
scan list	a list of channels supplied to NI-Switch that indicates the order in which channels will be scanned
scanner advanced trigger	the trigger generated by the switch module when scanning. The trigger occurs after the switch module has closed a switch and the switch has settled.
SCC	switch control circuitry
SMB	sub-miniature snap-on connector
soft front panel	a graphical program included with NI-Switch that you can use to interactively control the switch

T

trigger	any event that causes or starts some form of data capture
TTL	Transistor-Transistor Logic

V

V	volts
varistor	an electrical resistor whose resistance depends on the applied voltage
VDC	volts, direct current
VI	virtual instrument—(1) a combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument (2) a LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program
VSWR	Voltage Standing Wave Ratio. The impedance match of the device to the overall system.

W

W	watts
wire	data path between nodes

Index

O

P

Q

R

S

T

W