LabVIEW™ Modular Instruments —Switches (Online) Course Exercises Manual

Course Software Version 8.6
January 2009 Edition
Part Number 372319C-01

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Connectivity and Expansion

Exercise 4-1   Matrix Expansion

Objective: **To determine the number of switch modules necessary when a matrix of certain size is required**

1. Determine the number of SCXI-1129 modules required to create a 16 × 128 matrix with the SCXI-1336 terminal block.

💡 **Tip**   Refer to the *NI Switches Help* to determine in what topology the terminal block configures the switch. The *NI Switches Help* is installed with the NI-SWITCH driver and accessible via the Start menu in the National Instruments folder. The Help file is also available at `ni.com`.

2. Determine the number of PXI-2532 modules required to create a 2-wire 16 × 128 matrix with the TB-2643 terminal block.

Summary

Switch size can be increased by connecting the rows and columns of multiple modules. To determine how many modules your application will need, you can use a simple mathematical formula.

End of Exercise 4-1

Exercise 4-1 Solution

1. If you use a SCXI-1336, you can configure the SCXI-1129 in a 16×16 matrix.

   Rows: 16/16 = 1
   Columns: 128/16 = 8
   $1 \times 8 =$ **8 modules**

2. If you use a TB-2643, you can configure the PXI-2532 in a 2-wire 4×64 matrix

   Rows: 16/4 = 4
   Columns: 128/64 = 2
   $4 \times 2 =$ **8 modules**

6

Programming NI Switches

Exercise 6-1   Using the NI-SWITCH Soft Front Panel

Objective: To use the clickable switch schematic to manually make connections and to discover the relay position and count for the hardware.

1. Open the NI-SWITCH Soft Front Panel by selecting **Start» Programs» National Instruments» NI-SWITCH» NI-SWITCH Soft Front Panel**.

2. From the **Active Device** drop-down list, select the logical name of your NI Switch Device.

Note   In this exercise, you should only have one device connected, but in other instances it may be more difficult to determine the logical name of your switch device if you have many other devices connected. Open the Measurement and Automation Explorer and select the Devices and Interfaces tab. Examine the list of devices and find your switch device. The logical name is in the format Dev<*x*> where <*x*> is the device number.

3. From the **Topology** drop-down list, select a multiplexer topology. (Multiplexer topology names end with "Mux".) Notice that the graphical schematic changes to show the number of channels in the selected topology.

4. Click a channel. Notice that a graphical representation of a closed channel now appears.

5. Select the Relays Tab in the Soft Front Panel. Notice that the Relay Position of the connection you made in the previous step is now listed as **Closed**. Return to the Schematic Tab and click another channel. Notice the Relay Tab has updated, and the Relay Position of the old channel has reverted to **Open** while the Relay Position of the new channel is now **Closed**.

6. In the **Topology** drop-down list, change the selected topology to a **Matrix** configuration. Notice in the Schematic tab that the graphical schematic has now changed to represent the number of rows and columns in the Matrix topology you selected. Experiment with making connections in the Matrix format.

7. Click the **Disconnect all** button in the top right corner of the Soft Front Panel to clear all previous connections.

Summary

The Soft Front Panel is a useful tool that allows the programmer to manually make switch connections and troubleshoot switch systems.

End of Exercise 6-1

Exercise 6-2 Software Scanning

Objective: **To build a VI in LabVIEW that scans through a list of connections when you press a front panel button.**

This exercise familiarizes you with the NI-SWITCH Configuration VIs as well as the concept of scanning, where an event causes advancement through the scan list. In this exercise, you use a software trigger to cause the advancement.

1. Open `Software Scanning.vi` located in the `<Exercises>\Switches` directory.

   The completed program downloads the user-defined scan list to the switch hardware, then continuously polls a front panel Boolean control for user events for a signal to advance.

   Build the block diagram as shown in Figure 6-1 using the following items:
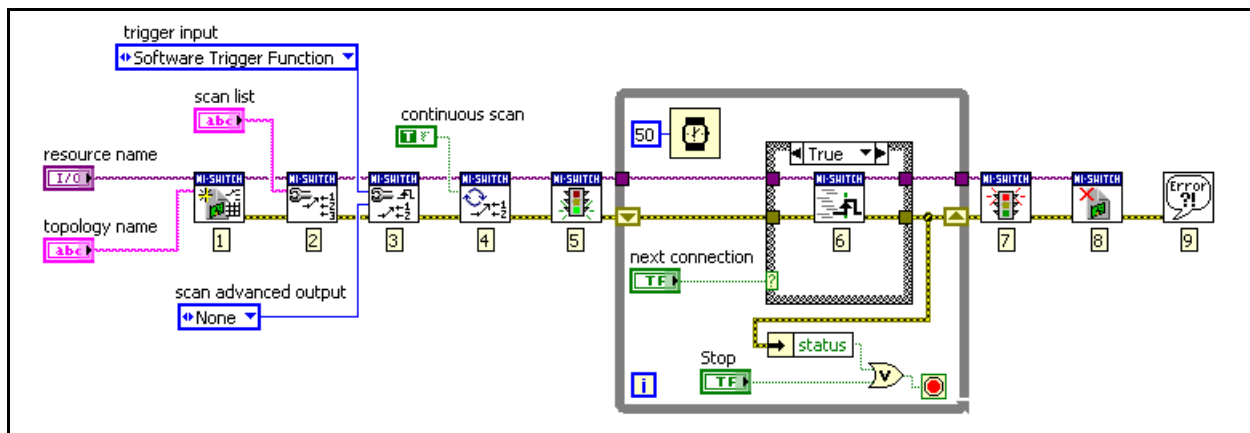
Figure 6-1. Software Scanning Block Diagram

❑ niSwitch Initialize with Topology VI —Opens a session to a switch installed on your system and configures the topology that device will be used in.

   In this exercise, you use a PXI-2503 module in the "2503/1-Wire 48x1 Mux" Topology.

   – Connect the resource name control to the Resource Name input of the VI and connect the topology name control to the Topology Name input of the VI.

❑ niSwitch Configure Scan List VI—Configures the scan list for your switch module.

   – Wire the scan list control to the Scan List input of the VI.

❑ niSwitch Configure Scan Trigger VI—Configures the trigger input that advances through the scan list configured in the previous step.

– Wire the trigger input and scan advanced output constants to the appropriate inputs of the VI. This function

Notice that the trigger input constant on the block diagram for this input is an enum constant with a drop-down list of values including: **Software Trigger Function** (which should be selected) and TTL lines and Connector options for use with hardware triggering. Refer to the documentation on this function in the *NI Switches Help* for the meaning of these values.

❑ niSwitch Set Continuous Scan VI—Configures the switch to either loop continuously through the scan list or stop scanning after one pass through the scan list.

– Connect the true Boolean constant to the Continuous Scan input of the VI.

❑ niSwitch Initiate Scan VI—Makes the first connection in the scan list and start the switch listening for trigger to advance.

– Place an niSwitch Initiate Scan VI on the block diagram next to the Continuous Scan VI.

❑ niSwitch Abort Scan and niSwitch Close VIs

– Connect the error terminals of all of the VIs together and connect the instrument handles on each VI to each other as shown in Figure 6-1.

2. Verify the controls are set as follows:

❑ Resource name: Select the logical name that MAX has assigned to the NI PXI-2503 Switch.

❑ Topology Name: **2503/1-Wire 48x1 Mux**

❑ Scan List: `ch0:15->com0;`

3. Run the VI and advance through the scan list by clicking the **Next Connection Software** control. If the switch is near your computer, you should be able to hear the click of the changing connections.

Summary

There are a number of ways that switch scanning can be triggered. These trigger methods are configured programmatically in LabVIEW with the niSwitch functions and include software scanning and external hardware scanning. With each trigger, the switch will advance to the next connection in the scan list.

End of Exercise 6-2

A

Slides

This appendix contains the slides.

Topics

A. Switch Basics

B. National Instruments Switches

C. RF Switch Concepts

D. Connectivity and Expansion

E. Control and Install NI Switches

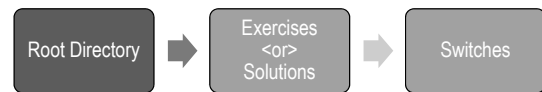F. Programming NI Switches

Modular Instruments – Switches

11500 North Mopac Expressway
Austin, Texas 78759
ni.com/training

## File Locations

The course files are in the following location:

Root Directory → Exercises <or> Solutions → Switches

You can also download them here.

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Instructional Methods

- Lecture gives a foundation in the topic
- Instructor reinforces foundation through demonstrations and quizzes
- Use concept exercises to further explore a topic
  - Watch a simulation, experiment with example VIs
- Use development exercises to gain hands-on experience
  - Demonstration of a finished development exercise further reinforces the learning process

Demonstrations | Quizzes | Concept Exercise | Lecture | **Topic** | Development Exercise
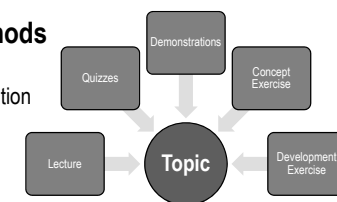
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Getting The Most Out Of This Course

- Experiment with hands-on exercises to understand the methods used
- Implementations explore a possible solution—you may find a better one
- Do not come to class prepared to develop an outside application; concentrate on the exercises given to build a good foundation

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Course Learning Map

Lesson 1	Lesson 4
Switch Basics	Connectivity and Expansion
Lesson 2	Lesson 5
National Instruments Switches	Control and Install NI Switches
Lesson 3	Lesson 6
RF Switch Concepts	Program NI Switches
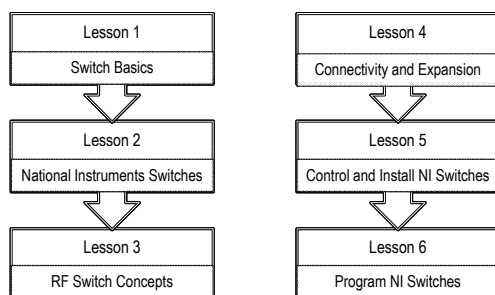
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Course Goals

This course prepares you to:
- Connect and control your NI-Switch device
- Understand Switch specifications
- Learn important considerations for RF Applications
- Use LabVIEW to program Switch applications
- Use the functions on the NI-SWITCH function palette
- Understand the difference between NI-DAQmx switch functions and NI-SWITCH functions
- Use a Switch with an NI DMM module
- Use the soft front panel of the device

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**Lesson 1
Switch Basics**

TOPICS

A. Relay Types
B. Switch Topologies
C. Switching Modes
D. Building Larger Matrices

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A. Relay Types

Relay Types

Electromechanical Armature
• Armature: Non-latching
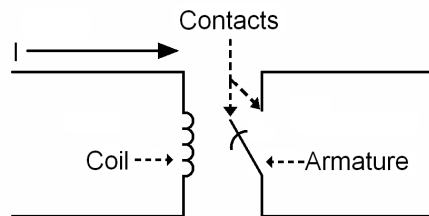• Armature: Latching

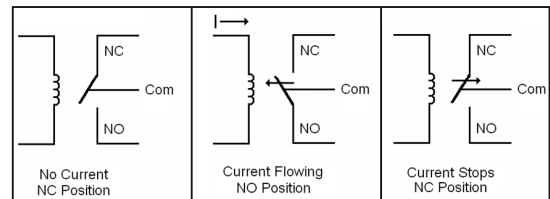Electromechanical Reed Relay

Solid State Relay

FET Switch

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Relay Types

Electromechanical Armature

Contacts

Coil --- Armature

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Relay Types

Armature: Non-latching

No Current
NC Position

Current Flowing
NO Position

Current Stops
NC Position

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Relay Types

Armature: Latching

Single Coil Latching Relay

1. Current Flows (NO Position)
2. Current Stops and Relay Stays in Position
3. Current Flows In Opposite Direction (NC Position)
4. Current Stops and Relay Stays In Position

Dual Coil Latching Relay

1. Current Flows In One Coil (NO Position)
2. Current Stops and Relay Stays in Position
3. Current Flows In the Other Coil (NC Position)
4. Current Stops and Relay Stays in Position

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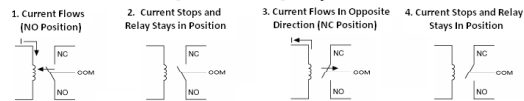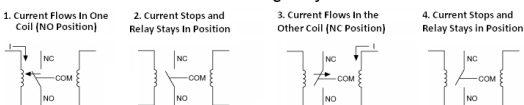
Relay Types

Electromechanical Reed Relay

• When the coil is energized, the two reeds physically contact

• When the coil is de-energized, the spring force in the reeds pulls the reeds apart

• Smaller, faster than armature relays

• Not as robust as armature relays

Coil

Reed

Contact   Inert Gas

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Relay Types

Solid State Relay

- Photo-sensitive MOSFET responds to light from LED
- Isolation barrier allows relay to switch high voltages
- Switching speeds restricted by LED
- Faster than electromechanical relays
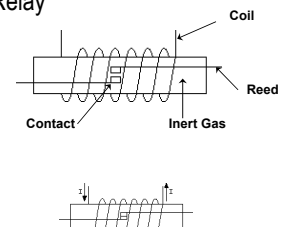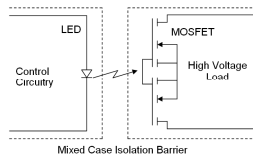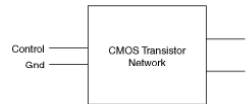
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Relay Types

FET Switch

- CMOS transistors
- No additional isolation between the control circuitry and the signal path
- Low voltage (±10V)
- Very fast switching speeds
- Unlimited lifetime

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Relay Type Comparison

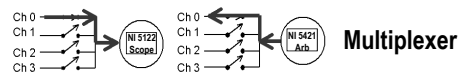| Capabilities	Armature	Reed	FET	SSR
High-Power	●	◑	○	◑
High-Speed	○	◑	●	◑
Small Package Size	◑	●	●	●
Low Path Resistance	●	◑	◑	◑
Low Thermal Offset	●	◑	◑	◑
Extended Lifetime	○	◑	●	●

○ **Good**   ◑ **Better**   ● **Best**

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B. Switch Topologies

General Purpose

Power Switching

Power Supply — Motor, Fan, or UUT

Load Switching

UUT pin — 100kΩ / 40kΩ

DMM / Scope / Arb — UUT 1, UUT 2, UUT 3

Matrix

Ch 0 / Ch 1 / Ch 2 / Ch 3 — NI 5122 Scope

Ch 0 / Ch 1 / Ch 2 / Ch 3 — NI 5421 Arb **Multiplexer**

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Switch Topologies: General Purpose

Single -Pole Single -Throw (SPST)

  Form A

Form B

Single -Pole Double -Throw (SPDT)

Form C
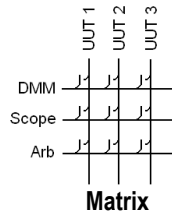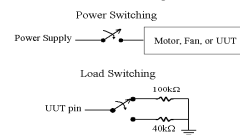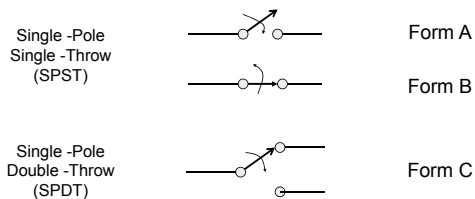
- Individually controlled electromechanical relays
- Used in automated control

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Switch Topologies: Multiplexer

Ch 0
Ch 1
Ch 2
Ch 3
Ch 4
Ch 5
Ch 6
Ch 7

COM
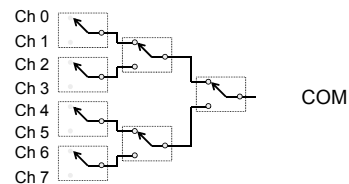
- Multiple inputs to a single output
        OR
- A single input to multiple outputs

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Switch Topologies: External Relay Driver

High voltage/current motor

Motor

NI Switch Module

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Switch Topologies: External Relay Driver

High voltage/current motor

Motor

High Power Relay

+

-
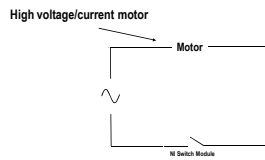
NI Relay Driver

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Switch Topologies: Matrix

C0 C1 C2 C3 C4 C5 C6 C7

R0
R1   4 x 8 Matrix
R2
R3
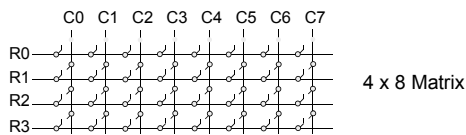
• Any row can connect to any column

OR

• Any column can connect to any row

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Switch Topologies: Matrix

Matrix Configurations

DUT DUT DUT DUT

DMM

Source   Example 1

Digitizer

DMM Source Digitizer DUT DUT DUT DUT DUT
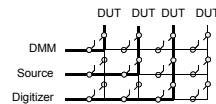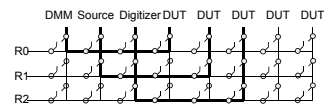
R0
R1   Example 2
R2

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Switch Topologies: Independent

• Allows you to utilize any connection that is physically possible with the module

• Allows for custom topologies

• Can control every individual relay on the board using the Relay Control functions and Connect Channels functions
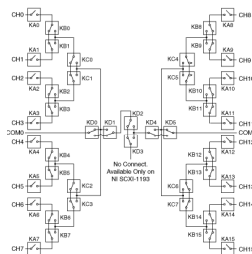
PXI-2593's Independent Topology

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Switch Topologies: Sparse Matrix

• Any row can connect to any column

• Only one path allowed at a time

• Typically used in RF applications

C0 C1C2 C3

R0
R1
R2
R3
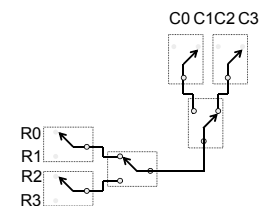
4 x 4 Sparse Matrix

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Switch Topologies: Multiple Banks

ch0
ch1
⋮
ch127

com0

ch0
ch1
⋮
ch63

com0

ch64
ch65
⋮
ch127

com4
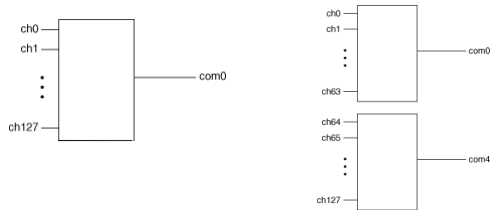
PXI-2530

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C. Switching Modes
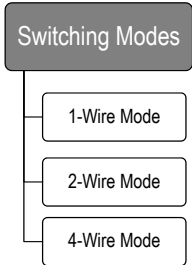
Switching Modes

1-Wire Mode

2-Wire Mode

4-Wire Mode

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C. Switching Modes

1-Wire Mode

CH0+
CH1+
HI Leads
⋮
CH63+
LO Lead — Lo Reference

COM+
COM–
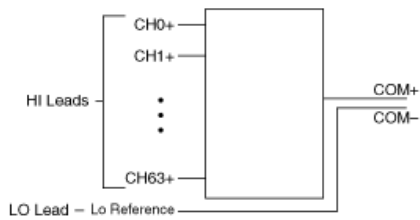
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Switching Modes

2-Wire Mode

ch0 (+)(−)
ch1 (+)(−)
⋮
ch31 (+)(−)

(+)(−) COM
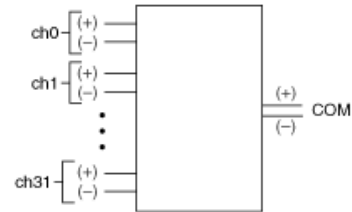
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Switching Modes

4-Wire Mode

Excitation (0A+)(0A−)(0B+)(0B−) ch0
Sense

(1A+)(1A−)(1B+)(1B−) ch1
⋮
(15A+)(15A−)(15B+)(15B−) ch15

(A+)(A−) COM (B+)(B−)

Excitation +
Excitation -
Sense +
Sense -
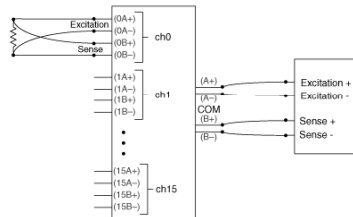
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D. Building Larger Matrices

Use individual matrix modules as building blocks for larger matrices by :
  • Connecting rows
  • Connecting columns
  • Connecting both rows and columns

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Building Larger Matrices

Column Expansion:
Increase column count by connecting rows of individual matrices

3x4   3x4

Building Larger Matrices

Column Expansion:
Increase column count by connecting rows of individual matrices

3x4   3x4

3x8

Building Larger Matrices

Row Expansion:
Increase row count by connecting columns of individual matrices

3x4

3x4

Building Larger Matrices

Row Expansion:
Increase row count by connecting columns of individual matrices

3x4

6x4

3x4

Building Larger Matrices

Row and Column Expansion

8x128 matrix
1-wire
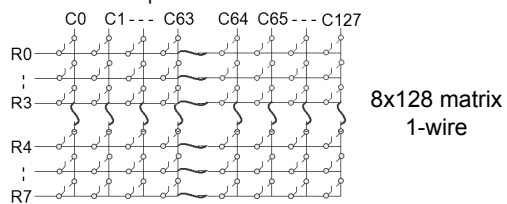
Number of wires required, using 4x64 matrices:
= 8 (rows) + 128 (columns)
= 136 wires

Multiplexer Expansion

Ch 0
Ch 1
Ch 2   COM   4-Channel
Ch 3   Multiplexer

Ch 0
Ch 1
Ch 2   COM   4-Channel
Ch 3   Multiplexer

Multiplexer Expansion

Ch 0

Ch 1

Ch 2   COM

Ch 3

Ch 4   8-Channel
Multiplexer

Ch 5

Ch 6   COM

Ch 7
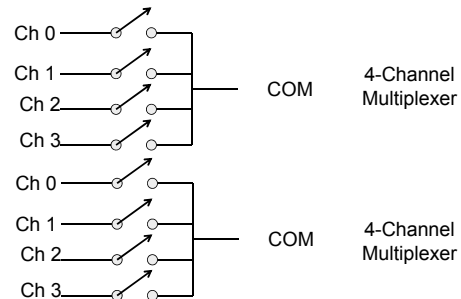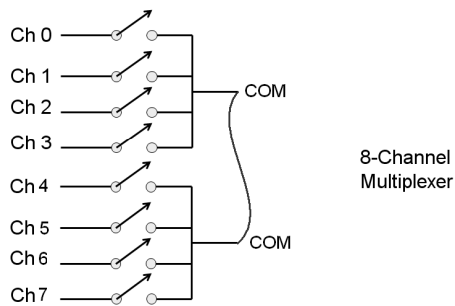
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Switch Basics — Predictive Maintenance

Predicting relay life is never
as easy as people claim
- Inductive vs. capacitive vs.
purely resistive loads
- Statistical variations on relays

Tools available to assist in
predictive maintenance
- Relay count tracking on
NI switch modules
- Relay replacement instructions
- Spare relay kits
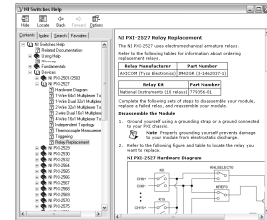
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Summary—Quiz

1. Which of the following is not a type of relay used by NI?
    a) Armature
    b) Reed
    c) Solid State
    d) FET
    e) Pull-back

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Summary—Quiz Answer

1. Which of the following is not a type of relay used by NI?
    a) Armature
    b) Reed
    c) Solid State
    d) FET
    e) Pull-back

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Summary—Quiz

2. Which of the following are types of NI Switch topologies?
    a) General Purpose
    b) Array
    c) Matrix
    d) Multiplexer
    e) Independent

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Summary—Quiz Answer

2. Which of the following are types of topologies?
    a) General Purpose
    b) Array
    c) Matrix
    d) Multiplexer
    e) Independent

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Summary—Quiz

3. True or False? A multiplexer allows one or more inputs
   to be routed to a single output, or vice versa. A matrix
   allows any number of inputs to be connected to any
   number of outputs.

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Summary—Quiz Answer

3. True or False? A multiplexer allows one or more inputs
   to be routed to a single output, or vice versa. A matrix
   allows any number of inputs to be connected to any
   number of outputs.

   True

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Lesson 2
National Instruments Switches

TOPICS

A. Why the Need for Switches?
B. NI Switch Hardware Product Offering
C. Form Factors
D. Switch Applications

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A. Why the Need for Switches?

Nearly every system can benefit from switching
   • Increases channel count
   • Adds measurement flexibility
   • Simplifies test fixture
   • Decreases cost

Test	Instruments	Test Points	Solution
Stimulus/Resp	1 Digitizer, 1 Arb	20 DUTs	SWITCHING
Temperature	1 DMM	200 RTDs	SWITCHING

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Test Architecture
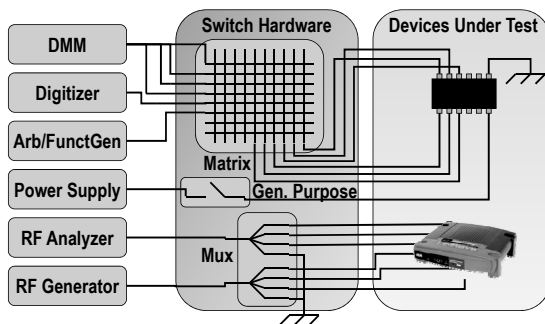
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B. NI Switch Hardware Product Offering

Voltage - Up to 600 V   Bandwidth - Up to 26.5 GHz

Channels - Up to 544 Xpt   Current - Up to 12 A
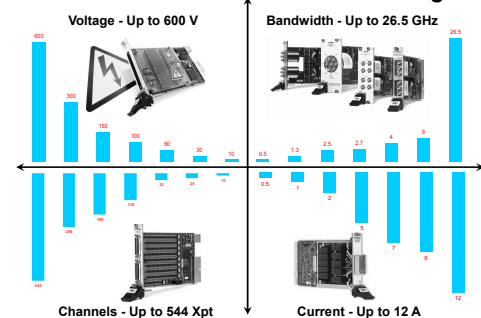
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C. Form Factors

PXI-2566

NI offers switches in both PXI and SCXI form factors

Benefits of PXI platform

- This is the future of NI switches
- Not an NI proprietary platform
- Largest selection of modules

Benefits of SCXI platform

- Good for some applications with high channel density
- Allows users to control switches via USB or PCI

SCXI-1166

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Voltage Switching

NI Switches:
- **NI makes industry's highest voltage PXI module**
- **Breadth (NI offers matrix, multiplexer, and general-purpose modules)**

High-voltage switching applications
- Fuel Cell Test
- Switching wall outlet signals (CATII)

600 V

Mid to high-voltage switching applications
- General-purpose signals
- Automotive applications (42 V signals)

300 V

Low-voltage switching applications
- ICT Test (Opens and Shorts)
- Thermocouple measurements

10 V   30 V   60 V   100 V   150 V

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Current Switching

NI Switches:
- **Breadth (NI offers matrix, multiplexer, and general-purpose modules)**

High-current switching applications
- Automotive applications
- Switching high-power loads (lights, fans, motors, etc.)
- Switching power supplies

12 A

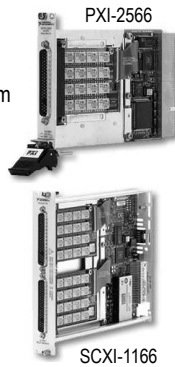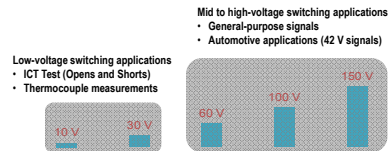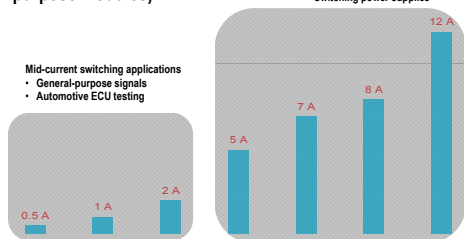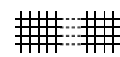Mid-current switching applications
- General-purpose signals
- Automotive ECU testing

0.5 A   1 A   2 A   5 A   7 A   8 A

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Density Switching

NI Switches:
- **Density = crosspoints/channels**
- **Continuous development**
- **High-density matrix switches with unlimited lifetime and unlimited simultaneous connections**

High-density switching applications
- ICT test (testing opens and shorts)
- Test system routing
- Usually matrix applications

544

Mid-density switching applications
- Testing small PCBs or chips
- High-density applications that require > 0.5 A switching current
- Usually multiplexer or control apps

196   256

Low-density switching applications
- Testing small number of DUTs or DUT with few channels
- Usually multiplexer or control apps

10   24   32   128

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Summary—Quiz

1. In what form factors does NI offer switch modules?
    a) PXI
    b) SCXI
    c) Both a & b

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Summary—Quiz Answer

1. In what form factors does NI offer switch modules?
    a) PXI
    b) SCXI
    c) Both a & b

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Summary—Quiz

2. Which of the following application requirements will affect what switch module you select?
   (Possible multiple answers)
   a) Voltage
   b) Current
   c) Number of channels

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Summary—Quiz Answer

2. Which of the following application requirements will affect what switch module you select?
   (Possible multiple answers)
   a) Voltage
   b) Current
   c) Number of channels

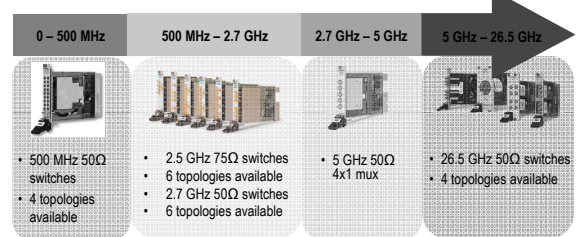**NATIONAL INSTRUMENTS** | ni.com/training
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Lesson 3
RF Switch Concepts

TOPICS

A. NI RF Switch Products
B. Insertion Loss
C. VSWR and Characteristic Impedance
D. Crosstalk and Isolation
E. Termination

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A. NI RF Switch Products

Bandwidth

0 – 500 MHz	500 MHz – 2.7 GHz	2.7 GHz – 5 GHz	5 GHz – 26.5 GHz

- 500 MHz 50Ω switches
- 4 topologies available

- 2.5 GHz 75Ω switches
- 6 topologies available
- 2.7 GHz 50Ω switches
- 6 topologies available

- 5 GHz 50Ω 4x1 mux

- 26.5 GHz 50Ω switches
- 4 topologies available

21 total modules available

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B. Insertion Loss

What is Insertion Loss?

Source P_{in} P_{out} Load

50Ω $Z_o = 50\Omega$ 50Ω
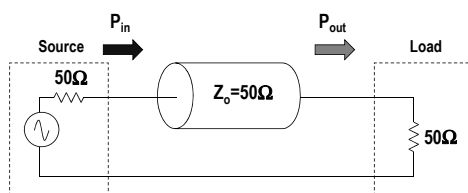
Insertion Loss (dB) = 10 * $\log_{10}$ (P_{out} / P_{in})

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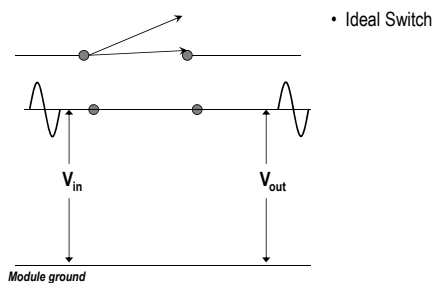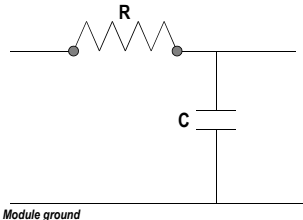
Insertion Loss

Why does Insertion Loss occur?

- Ideal Switch

V_{in} V_{out}

Module ground

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Insertion Loss

Why does Insertion Loss occur?

R

C

Module ground

- Ideal Switch
- But in reality, switch looks more like this
  - C = Net Capacitance of Circuit
  - R = Path Resistance of Switch

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Insertion Loss

Why does Insertion Loss occur?

R

V_{in} C V_{out}

Module ground

- Ideal Switch
- But in reality, switch looks more like this
  - C = Net Capacitance of Circuit
  - R = Path Resistance of Switch
- Insertion loss measures attenuation and power loss induced by switch

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Insertion Loss

Why does Insertion Loss occur?

R

V_{in} C V_{out}

Module ground

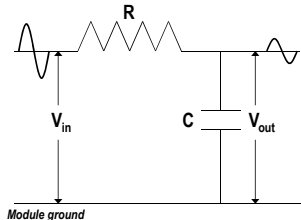$$\left| V_{out} \right| = \left| V_{in} \right| \frac{1}{\sqrt{1 + a^2 R^2 C^2}}$$
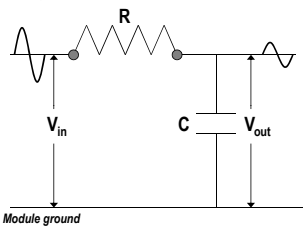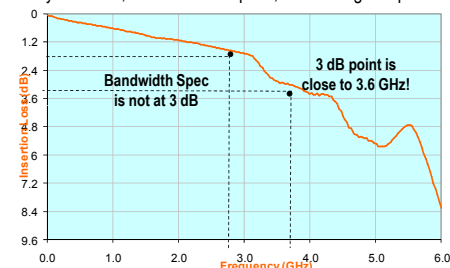
- Ideal Switch
- But in reality, switch looks more like this
  - C = Net Capacitance of Circuit
  - R = Path Resistance of Switch
- Insertion loss measures attenuation and power loss induced by switch
- For ideal DC systems, ω=0, therefore $V_{out} = V_{in}$
- Loss is higher at higher frequencies

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Insertion Loss

A PXI-2547 has a specified bandwidth of 2.7 GHz, which, as can be seen by the chart, is not the 3 dB point, as one might expect.

Bandwidth Spec is not at 3 dB

3 dB point is close to 3.6 GHz!

Insertion Loss (dB) — axis: 0, 1.2, 2.4, 3.6, 4.8, 6, 7.2, 8.4, 9.6

Frequency (GHz) — axis: 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0

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C. Voltage Standing-Wave Ratio (VSWR)

- When waves propagate **between** mediums, reflections occur (wave theory)
- VSWR is a measure of this reflection
- Sound wave example
- Greater the variation in mediums, greater the reflection

Air | **Wall**

Reflected (ECHO)   *Propagated*

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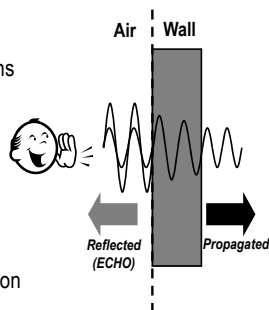
VSWR and Characteristic Impedance

- In electrical systems, reflections occur when signal propagates through components with varying characteristic impedances (connectors, relays, traces, etc.)

- VSWR measures the power of this reflected signal

- VSWR is an important consideration in systems where signal reflections can damage the source

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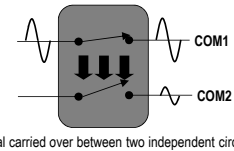
VSWR and Characteristic Impedance

- RF components are designed to have a certain per unit length impedance or 'characteristic impedance,' typically either 50 or 75 Ω
- Characteristic impedance is not a DC resistance !!!
- Matching characteristic impedance of all components in an RF system minimizes reflections and maximizes amount of power transferred from source to load
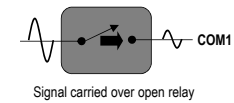

Matched 50Ω System (Ideal)

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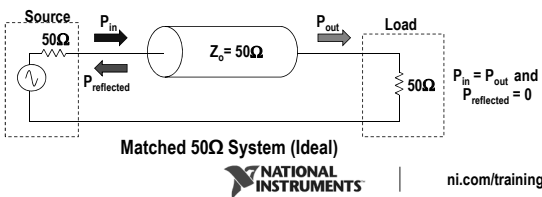
D. Crosstalk and Isolation

Crosstalk—When an unwanted signal is coupled from one circuit to another.
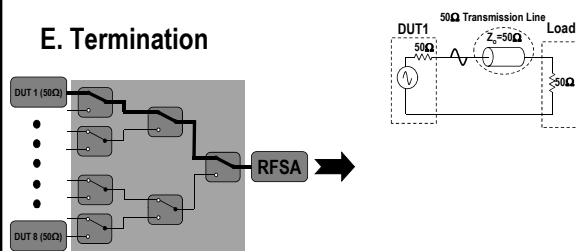
Example: Between 2 banks on switch module

Signal carried over between two independent circuits

Isolation—When an unwanted signal is coupled across an open circuit.

Example: open relay

Signal carried over open relay

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E. Termination

RFSA

In the case of DUT1, the entire signal route has a characteristic impedance of 50Ω

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E. Termination

RFSA
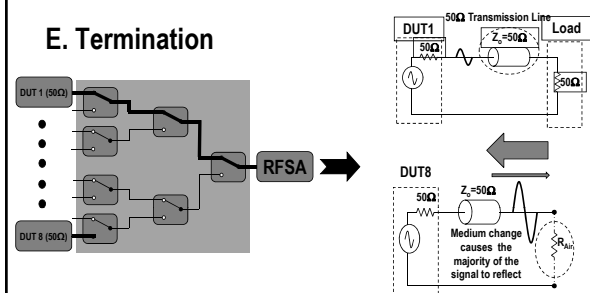
In the case of DUT1, the entire signal route has a characteristic impedance of 50Ω

In the case of DUT8, the open relay causes a break in the 50Ω characteristic impedance of the circuit which results in reflections

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E. Termination

RFSA

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E. Termination

RFSA

Termination is VERY crucial when the DUT is:
- Continuously generating signal
- Sensitive to signal reflections

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Summary—Quiz

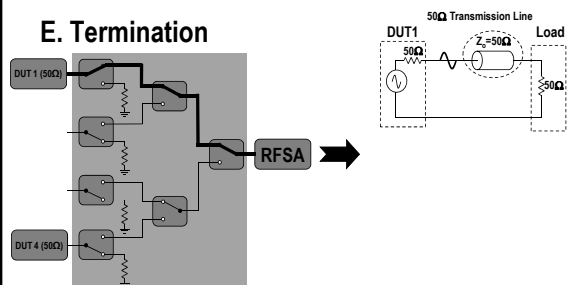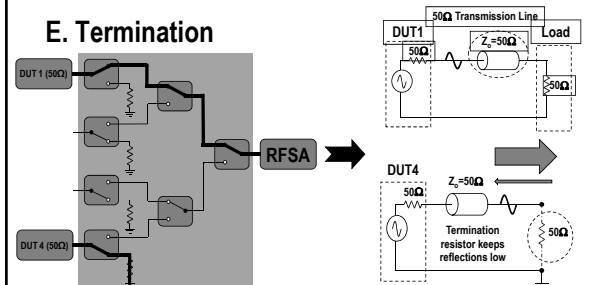1. True or False? Insertion Loss is a measure of a signal's attenuation and power loss after passing through an object such as a switch.

Summary—Quiz Answer

1. True or False? Insertion Loss is a measure of a signal's attenuation and power loss after passing through an object such as a switch.

    True

Summary—Quiz

2. Which of the following actions can RF Application Systems take in order to avoid signal reflections, which can damage the signal source PXI?

    a) Match characteristic impedance

    b) Use proper termination

    c) Both a & b

Summary—Quiz Answer

2. Which of the following actions can RF Application Systems take in order to avoid signal reflections, which can damage the signal source PXI?

    a) Match characteristic impedance

    b) Use proper termination

    c) Both a & b

Lesson 4
Connectivity and Expansion

TOPICS

A. Signal Connection
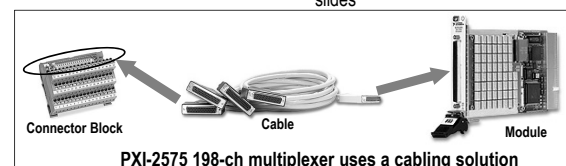B. SCXI Expansion
C. PXI Expansion

A. Signal Connection: Cables

LFH 200 to 50-pin DSUB cable

*   Cable connects directly to front connector on module
*   NOTE: Some modules that use cables also have screw-terminal connector blocks, as seen in later slides
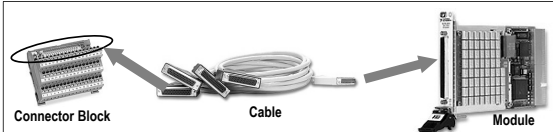

Connector Block   **Cable**   **Module**

PXI-2575 198-ch multiplexer uses a cabling solution

Signal Connection: Connector Blocks

TBX-50 Connector Block

- Not front-mounting
- Connector blocks are usually used with cables
- Connector blocks provide screw terminals to connect to signals on the DUT using bare wires

Connector Block   Cable   Module

Customers can use the TBX-50 screw terminal block when connecting signals to the PXI-2575 198-ch multiplexer

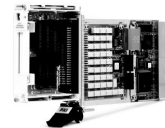**NATIONAL INSTRUMENTS** | ni.com/training

Signal Connection: Terminal Blocks

- Usually front-mounting
- Could have screw terminals or ribbon-cable headers as seen in the two images below

The PXI-2532 uses a front-mounting terminal block with ribbon cable headers

The PXI-2527 uses a front-mounting terminal block with screw terminals

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Signal Connection: RF Cables

- Coaxial/RF cables are designed to minimize losses during signal routing at higher frequencies
- All NI RF switch modules use SMA/SMB/MCX/mini SMB coaxial cables
- Typically one cable is required for each connection on the RF module (Input and output)

The NI PXI-2557 75Ω 8x1 multiplexer requires 9 mini SMB coaxial cables
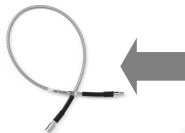
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Expansion

- Expansion connectivity is module dependent
  - Check *NI Switches Help* for details
- Expansion is not limited to specialized connectivity
- Bare wire connection is possible

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B. SCXI Expansion
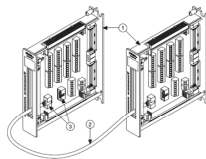
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SCXI Expansion: HVAB

High Voltage Analog Bus (HVAB)
- Routing signals from one module to the other
- Routing signals to DMM via HVAB (AB0, AB2)
- Multiplexer and Matrix (row only) expansion

CONNECTS HVAB OF ADJACENT MODULES

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SCXI Expansion: MULTIPLEXERS

For 2 modules   **For 3 modules**

1 HVAB expansion plug

For 12 modules

3 HVAB expansion plugs   **Example: SCXI-1127**

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SCXI Expansion: MATRICES

Column   SCXI-1332

Row
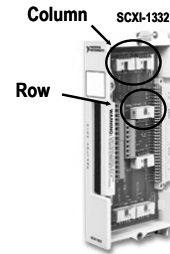
Expansion cable (8 wires)

Row and column expansion
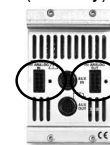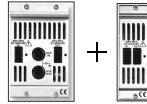
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SCXI Expansion: Matrix Row Expansion
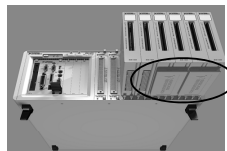
The expansion plugs connects the columns of adjacent SCXI-1129 terminal blocks and expands the rows (all terminal blocks except 1337, 1339)

Example: SCXI-1129

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SCXI Expansion: Matrix Column Expansion

Module 1   Matrix Expansion Cable   Module 2
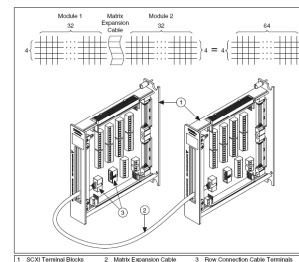
• Expansion cables connect rows and expand columns (SCXI-1334, 1335 terminal blocks)

1 SCXI Terminal Blocks   2 Matrix Expansion Cable   3 Row Connection Cable Terminals

Example: SCXI-1129

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C. PXI Expansion
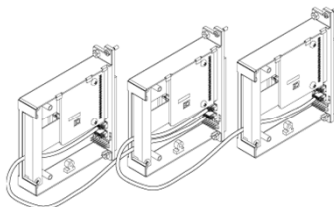
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PXI Expansion: Multiplexers

Expansion in Multiplexer mode is possible using analog bus expansion connectors in front of TB-2605.

TB-2605

Example: PXI-2503

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PXI Expansion: Matrices

- Expand the PXI-2529 columns using the TB-2634
- Connect adjacent terminal blocks with ribbon cables
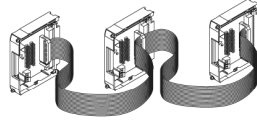
**Example:
PXI-2529**

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PXI Expansion: Matrices
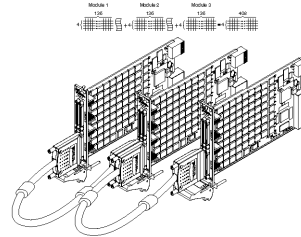
- Column expansion using SHC68-C68-S cable
- No row expansion

**Example:
PXI-2535**

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PXI Expansion: Matrices

Matrix Expansion Formula

Example: Need 21x50 Matrix from 4x8 modules

1) Divide number of rows desired by number of rows in single module and round up: $21/4 = 5.25 \rightarrow 6$ modules

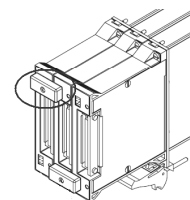2) Same operation with the columns:

$50/8 = 6.25 \rightarrow 7$ modules

3) Multiply the value found in 1) by the value found in 2):

$6 \times 7 = $ **42 modules**, which will create a 24x56 matrix.

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Exercise 4-1: Matrix Expansion

GOAL

To determine the number of switch modules necessary when a matrix of certain size is required

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Summary—Quiz

1. True or False? In order to connect a signal to a switch, you need a cable and connector block.

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Summary—Quiz Answer

1. True or False? In order to connect a signal to a switch, you need a cable and connector block.

False. You can use a front mounting terminal block in the place of a cable and connector block.

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Summary—Quiz

2. If you have multiple switch modules, how can you increase the number of rows available to you?

   a) Connect the rows of one module to those of the next module.

   b) Connect the columns of one module to those of the next module.

   c) Connect the common of one module to that of the next module.

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Summary—Quiz Answer

2. If you have multiple switch modules, how can you increase the number of rows available to you?

   a) Connect the rows of one module to those of the next module.

   b) Connect the columns of one module to those of the next module.

   c) Connect the common of one module to that of the next module.

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Lesson 5
Control and Install NI Switches

TOPICS

A. Controlling NI Switches

B. Installing NI Switches

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A. Controlling NI Switches: PXI Options

• Embedded controller

• MXI Connector Kit

Embedded Controller
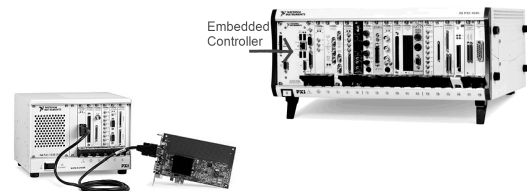
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Controlling NI Switches: SCXI Options

• DMM

• E or M Series MIO device

• USB Controller

  – This option is the preferred way to control SCXI switches, especially when using 3rd party measurement devices

• (Obsolete) NI 4021 PCI/PXI controller

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Controlling SCXI Switches with DMM
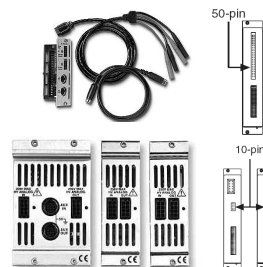
50-pin

10-pin

• 50 pin rear connector on SCXI module → SCXI-1362 adapter kit

• 10 pin rear connector on SCXI module → SCXI-1357,1358,1359 backplane adapter kit

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SCXI Installation- DMM Example

Cabling an NI 4021/4060/407x to a 10-Pin Rear Connector Switch Module
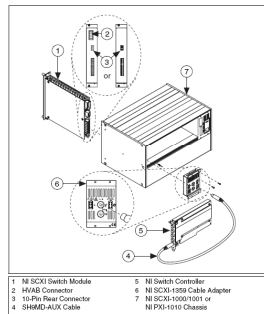
1	NI SCXI Switch Module	5	NI Switch Controller
2	HVAB Connector	6	NI SCXI-1359 Cable Adapter
3	10-Pin Rear Connector	7	NI SCXI-1000/1001 or
4	SH6MD-AUX Cable		NI PXI-1010 Chassis

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Controlling SCXI Switches with DAQ

50-pin

10-pin

- 50 pin rear connector → SCXI-1349 adapter

- 10 pin rear connector
  - Cable DAQ to another SCXI module with 50 pins OR
  - Place controlling DAQ device in rightmost slot of PXI-1050 combo chassis

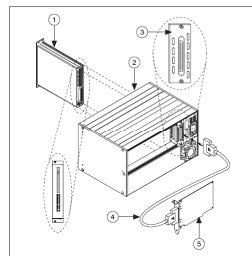ni.com/training

SCXI Installation- DAQ Example

Cabling an E or M series DAQ device to an SCXI switch module

1	NI SCXI Switch Module	3	NI SCXI-1349 Cable Adapter
2	NI SCXI-1000/1001 or	4	NI E Series or M Series Device
	NI PXI-1010 Chassis	5	NI SH6868 Cable

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SCXI Installation- Combo Chassis Example
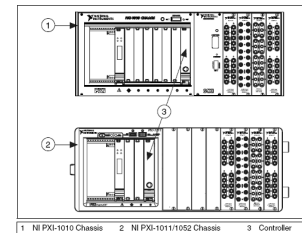
1	NI PXI-1010 Chassis	2	NI PXI-1011/1052 Chassis	3	Controller

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Controlling SCXI Switches with USB

- USB-1357,1358,1359 Plug-and-Play Backplane
- Can only connect to switches with 10-pin rear connector
- Can control switches with 50-pin rear connector when cabled to a 10-pin rear connector in same chassis

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SCXI Installation- USB Example

Use this procedure to connect an NI USB switch controller/adapter directly to an NI SCXI switch module with a 10-pin rear connector
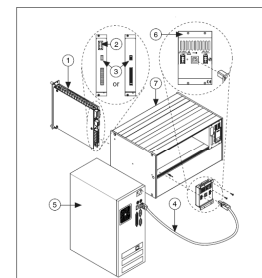
1	NI SCXI Switch Module	5	NI Switch Controller
2	HVAB Connector	6	NI 1359 Cable Adapter
3	10-Pin Rear Connector	7	NI SCXI-1000/1001 or
4	USB Cable		NI PXI-1010 Chassis

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B. Installing Switches

• PXI Switch: Power off chassis, insert module, power on chassis
• SCXI Switch: depends on controller type, switch module type, and chassis type
  • Check the NI-Switch Help Document and the module's online Installation Guide to determine the correct installation method

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Summary—Quiz

1. True or False? You need a DMM, USB, or DAQ board to control a PXI switch because the host computer (with MXI) or the PXI Embedded controller is not capable of controlling the switch for you.

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Summary—Quiz Answer

1. True or False? You need a DMM, USB, or DAQ board to control a PXI switch because the host computer (with MXI) or the PXI Embedded controller is not capable of controlling the switch for you.

   False

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Summary—Quiz

2. Where can you find information about installing and configuring NI switches?
   a) *NI Switches Getting Started*
   b) *NI Switches Help*
   c) Both a & b

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Summary—Quiz Answer

2. Where can you find information about installing and configuring NI switches?
   a) *NI Switches Getting Started*
   b) *NI Switches Help*
   c) Both a & b

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Summary—Quiz

3. Cabling to SCXI switches depends on which connectors?
   a) 10-pin
   b) 50-pin
   c) 68-pin
   d) 100-pin

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Summary—Quiz Answer

3. Cabling to SCXI switches depends on which connectors?

   a) 10-pin
   b) 50-pin
   c) 68-pin
   d) 100-pin

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Lesson 6
Programming NI Switches

TOPICS

A. The NI-SWITCH Driver
B. Programming NI Switches in LabVIEW
C. Scanning with Switches
D. DMM/Switch Express VI

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A. The NI-SWITCH Driver

The NI-SWITCH Driver will install the following on your computer:

• The NI-SWITCH Function Library
• SWITCH Soft Front Panel
• Documentation
• Support and Examples for LabVIEW, CVI, C/C++, and VB
• LabVIEW Run-Time Engine, NI-DAQmx, IVI Compliance Package, NI-VISA, and MAX

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NI-SWITCH Soft Front Panel

• Can be used as a monitor panel with adjustable refresh rate
• Equivalent to a test panel for DAQ devices
• Easily make your first connection
• Debugging tools
• Clickable switch schematics
• Individual relay control for advanced users

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NI-SWITCH Soft Front Panel

Matrix

General Purpose

MUX

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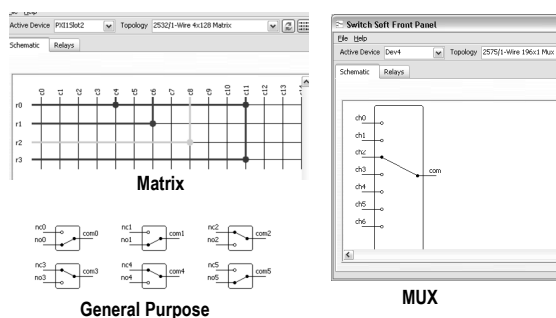
NI-SWITCH Soft Front Panel

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Exercise 6-1: Using the NI-SWITCH Soft Front Panel

GOAL

To manually make connections with the clickable switch schematic and discover the relay position and count for the hardware

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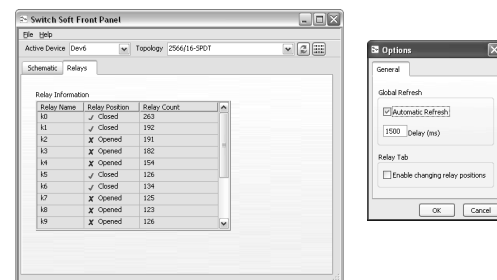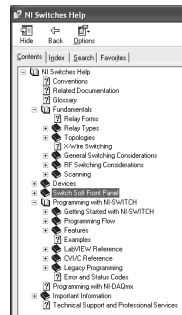**NATIONAL INSTRUMENTS** | ni.com/training

NI-SWITCH Documentation

- Specifications
- Terminal block installation instructions
- Getting Started Guide
- NI Switches Help
- Readme
- Instrument Driver Quick Reference Guide

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NI-SWITCH Help

- Fundamentals (relay types, topologies, switching considerations, RF, Scanning)
- Devices (topologies, programming mode, triggering, expansion, etc.)
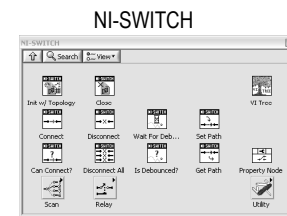- Programming (flow, mode, DMM scanning)

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B. Programming NI Switches in LabVIEW

NI-DAQmx

NI-SWITCH

NI Switch Executive

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Programming NI Switches in LabVIEW

NI-DAQmx versus NI-SWITCH

- Similar switching functionality
- Both supported on RT

NI-DAQmx

- Not IVI-compliant
- Can create scan lists that span multiple devices
- Supported for some Linux distributions
- Generally NI-DAQmx is the recommended API

NI-SWITCH

- IVI driver
- Session based; unique session for each module

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Programming NI Switches in LabVIEW

NI Switch Executive is an intelligent switch management and routing application that is accessible from MAX. With NISE, you can accelerate development time and simplify switch system maintenance.

NI Switch Executive

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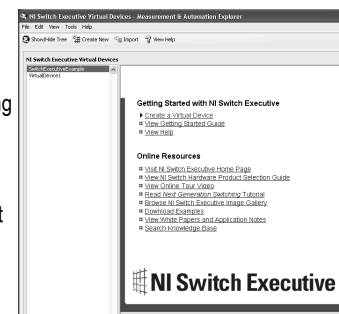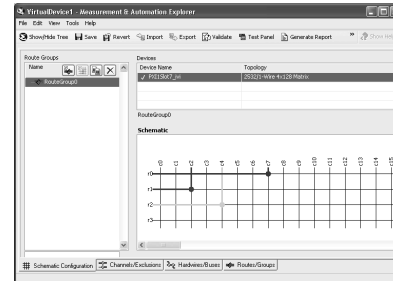
Programming NI Switches in LabVIEW

NI Switch Executive benefits include:

- Virtual Device configurations can contain channel connections from multiple switch devices, including third party IVI Compliant switches
- Configuring switch modules graphically
- Controlling switches from any application software
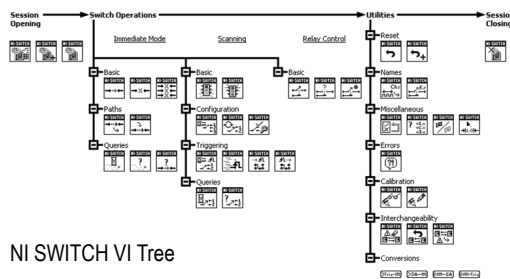- You can import and export switch configurations for easy deployment on multiple systems

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Programming NI Switches in LabVIEW

NI Switch Executive

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Programming NI Switches in LabVIEW

NI SWITCH VI Tree

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Programming NI Switches in LabVIEW
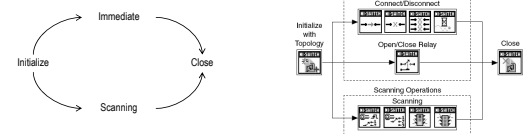
Immediate Mode: Actuation after function call
- Connect/Disconnect Channels
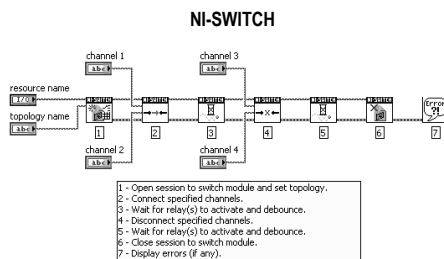- Individual relay control (open and close)

Scanning: Connections are synchronized with an event
- From another device: hardware-timed scanning.
- From the program: software-timed scanning.

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Immediate Mode

Connect/Disconnect Channels

NI-SWITCH

1 - Open session to switch module and set topology.
2 - Connect specified channels.
3 - Wait for relay(s) to activate and debounce.
4 - Disconnect specified channels.
5 - Wait for relay(s) to activate and debounce.
6 - Close session to switch module.
7 - Display errors (if any).

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Immediate Mode

Connect/Disconnect Channels

NI-DAQmx

Steps:
1. Set topology.
2. Connect specified channels.
3. Wait for relay(s) to activate.
4. Disconnect specified channels.
5. Wait for relay(s) to activate.
6. Display errors (if any).

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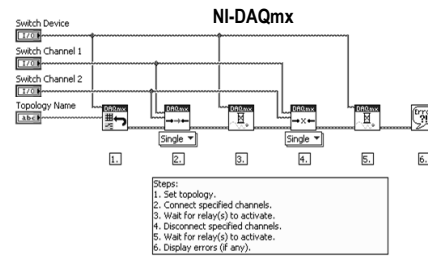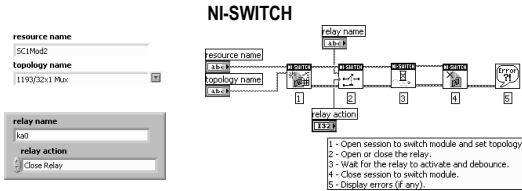
Immediate Mode

Relay Control

NI-SWITCH

1 - Open session to switch module and set topology.
2 - Open or close the relay.
3 - Wait for the relay to activate and debounce.
4 - Close session to switch module.
5 - Display errors (if any).

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Immediate Mode

Relay Control

NI-DAQmx

Steps:
1 - Reset the switch and set the topology.
2 - Open or close the relay.
3 - Wait for the relay to activate and debounce.
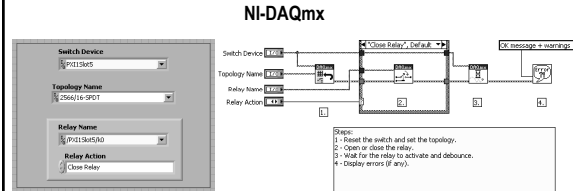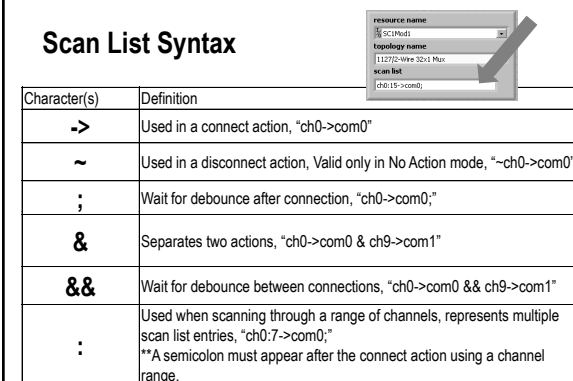4 - Display errors (if any).

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C. Scanning with Switches

- Switch connections are synchronized with an event of another device or with a software event (usually in the form of a trigger)
- Desired connection operations entered in a scan list downloaded to the memory of switch.
- The first entry in the scan list is executed when the scan is initiated, trigger settings determine how the switch advances through subsequent entries in the list

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Scan List Syntax

Character(s)	Definition
->	Used in a connect action, "ch0->com0"
~	Used in a disconnect action, Valid only in No Action mode, "~ch0->com0"
;	Wait for debounce after connection, "ch0->com0;"
&	Separates two actions, "ch0->com0 & ch9->com1"
&&	Wait for debounce between connections, "ch0->com0 && ch9->com1"
:	Used when scanning through a range of channels, represents multiple scan list entries, "ch0:7->com0;" **A semicolon must appear after the connect action using a channel range.

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Scan List Syntax: Scan Modes

Mode	Description
Break Before Make (default)	Connections from previous scan list entry are automatically disconnected before executing the current scan list entry. Disconnect actions (~) are not valid in this mode
No Action	Connections remain connected until they are explicitly disconnected by a disconnect action (~)
Break After Make	Currently not supported.

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Scan List Syntax: **NI-SWITCH versus DAQmx**

NI-Switch only allows one switch module to be programmed at a time; therefore, a device indicator is unnecessary

- ch0->com0; ch1->com0;

DAQmx Switch allows multiple modules to be programmed, and a device indicator must be included

- /Dev1/ch0->com0; /Dev1/ch1->com0;

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Scanning with Switches: Trigger Schemes

Recall that trigger settings determine how the switch advances through subsequent entries in the list.
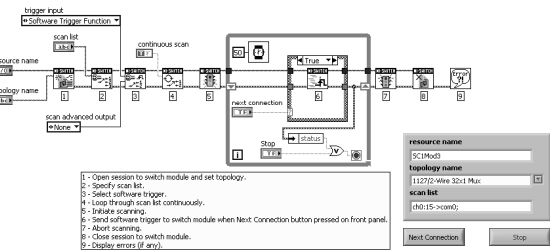
3 trigger schemes for scanning:
1. Software Scanning
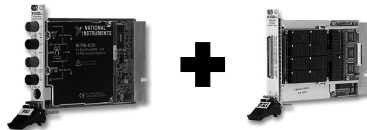2. Synchronous Scanning
3. Handshaking

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Software Scanning

1 - Open session to switch module and set topology.
2 - Specify scan list.
3 - Select software trigger.
4 - Loop through scan list continuously.
5 - Initiate scanning.
6 - Send software trigger to switch module when Next Connection button pressed on front panel.
7 - Abort scanning.
8 - Close session to switch module.
9 - Display errors (if any).

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Hardware Scanning: DMM and Switches

- Digital Multimeters (DMM) are often used with switches to extend the number of signals a DMM can be connected to
- DMMs are high performance, high precision devices, but only have one input channel
- Use switches to multiplex connections to multiple channels

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Hardware Scanning: DMM and Switches

Scanning on a switch is used when timing of a connection needs to be synchronized with hardware event (measurement completed on DMM)

Scanning can be performed with most switches
- **All** SCXI switches Except: 1160, 1161, 1163R, 1190, 1191
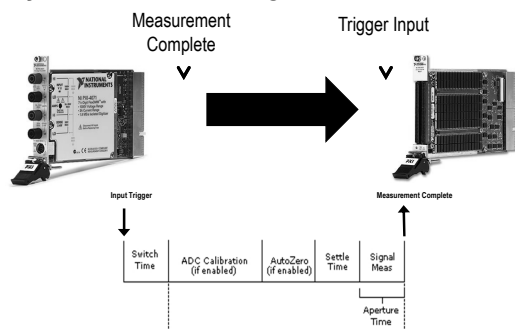- **All** PXI switches

Two types of hardware-timed scan options:
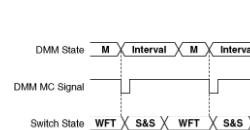- Synchronous Scanning
- Handshaking Scanning

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Synchronous Scanning

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Synchronous Scanning

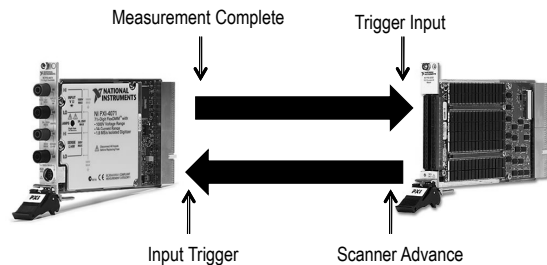Program the DMM interval time between measurements to allow time for the switch to activate and settle.

where:
M = measurement
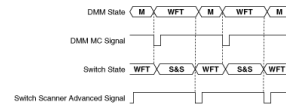**WFT** = wait for trigger
S&S = switch and settle

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Handshaking Scanning

Measurement Complete

Trigger Input

Input Trigger

Scanner Advance

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Handshaking Scanning

DMM State	M	WFT	M	WFT	M
DMM MC Signal					
Switch State	WFT	S&S	WFT	S&S	WFT
Switch Scanner Advanced Signal					

where:
M = **measurement**
WFT = **wait for trigger**
S&S = **switch and settle**

No longer need fixed intervals between measurements

Switching the switch and measurements on the DMM depend on triggers
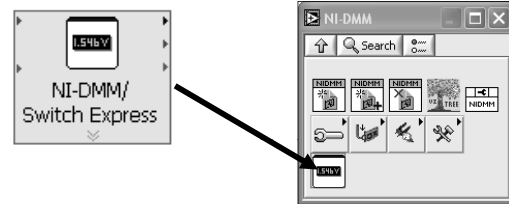
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Exercise 6-2: Software Scanning

GOAL

To build a VI in LabVIEW that will scan through a list of connections with each press of a front panel button

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D. DMM/Switch Express VI

- NI-DMM 2.5 introduced the NI-DMM/Switch Express VI which automatically handles the triggering and coding required for synchronous or handshaking scanning modes

- NI DMM/Switch Express VI can be used independently without switches to make normal DMM measurements

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DMM/Switch Express VI: Configuration Tab

Configuration tab specifies which DMM device to use and the desired measurement configuration
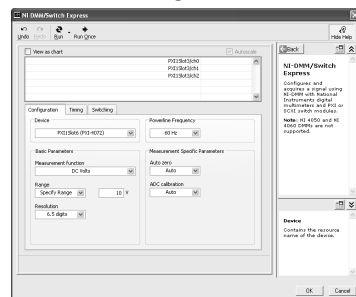
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DMM/Switch Express VI: Timing Tab

Timing tab configures the timing of measurements:

- 1 Sample
- N Samples
- Continuous

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DMM/Switch Express VI: Switching Tab

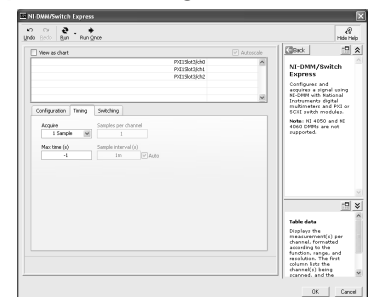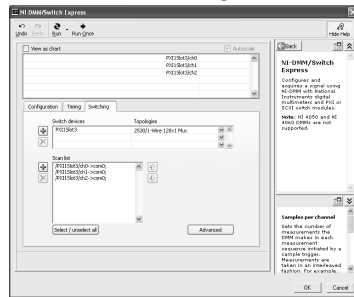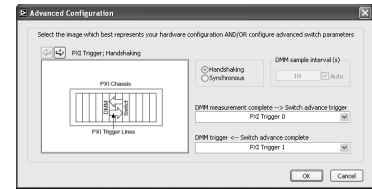Switching tab configures which switch and channels to use in scanning mode with the DMM

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DMM/Switch Express VI: Advanced Configuration

Advanced window configures what Scanning Mode to use as well as the trigger lines

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Summary—Quiz

1. Which of the following APIs can you use to program NI switches?

   a) NI-Switches

   b) NI-DAQmx»Switches

   c) Switch Executive

   d) All of the above

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Summary—Quiz Answer

1. Which of the following APIs can you use to program NI switches?

   a) NI-Switches

   b) NI-DAQmx»Switches

   c) Switch Executive

   d) All of the above

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Summary – Quiz

2. Match each API to its advantage:

NI-Switch	a.	Save multiple configurations
NI-DAQmx»Switch	b.	IVI Compliance
Switch Executive	c.	Easier multi-module scanning and some Linux support

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Summary – Quiz Answers

2. Match each API to its advantage:

NI-Switch	b.	IVI Compliance
NI-DAQmx»Switch	c.	Easier multi-module scanning and some Linux support
Switch Executive	a.	IVI Compliance

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Summary—Quiz

3. Which of the following are modes that you can use to
    program NI Switches?
    a) Immediate Mode
    b) Execution Mode
    c) Scanning Mode

Summary—Quiz Answer

3. Which of the following are modes that you can use to
    program NI Switches?
    a) Immediate Mode
    b) Execution Mode
    c) Scanning Mode

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• Alliance Program: ni.com/alliance
• Publications: ni.com/devzone/reference/books/
• Practice!

**Please help us improve by
completing the course survey.**
THANK YOU!

B

Additional Information and Resources

This appendix contains additional information about National Instruments technical support options and LabVIEW Modular Instruments—Switches (Online) resources.

National Instruments Technical Support Options

Visit the following sections of the award-winning National Instruments Web site at `ni.com` for technical support and professional services:

- **Support**—Technical support at `ni.com/support` includes the following resources:

  - **Self-Help Technical Resources**—For answers and solutions, visit `ni.com/support` for software drivers and updates, a searchable KnowledgeBase, product manuals, step-by-step troubleshooting wizards, thousands of example programs, tutorials, application notes, instrument drivers, and so on. Registered users also receive access to the NI Discussion Forums at `ni.com/forums`. NI Applications Engineers make sure every question submitted online receives an answer.

  - **Standard Service Program Membership**—This program entitles members to direct access to NI Applications Engineers via phone and email for one-to-one technical support as well as exclusive access to on demand training modules via the Services Resource Center. NI offers complementary membership for a full year after purchase, after which you may renew to continue your benefits.

    For information about other technical support options in your area, visit `ni.com/services` or contact your local office at `ni.com/contact`.

- **System Integration**—If you have time constraints, limited in-house technical resources, or other project challenges, National Instruments Alliance Partner members can help. The NI Alliance Partners joins system integrators, consultants, and hardware vendors to provide comprehensive service and expertise to customers. The program ensures qualified, specialized assistance for application and system development. To learn more, call your local NI office or visit `ni.com/alliance`.

If you searched `ni.com` and could not find the answers you need, contact your local office or NI corporate headquarters. Phone numbers for our

worldwide offices are listed at the front of this manual. You also can visit the Worldwide Offices section of `ni.com/niglobal` to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

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