Multisim™

Multisim For Educators
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When Multisim guides refer to a toolbar button, an image of the button appears in the left column.
Multisim guides use the convention Menu/Item to indicate menu commands. For example, “File/Open” means choose the Open command from the File menu.
Multisim guides use the convention of an arrow (▶) to indicate the start of procedural information.
Multisim guides use the construction CTRL-KEY and ALT-KEY to indicate when you need to hold down the “Ctrl” or “Alt” key on your keyboard and press another key.

The Multisim Documentation Set

The Multisim for Educators Guide describes the functions specific to Education edition of Multisim.
You should also refer to Getting Started with NI Circuit Design Suite.

User Guide

The User Guide describes Multisim and its many functions in detail. It is organized based on the stages of circuit design, and explains all aspects of Multisim, in detail.

Online Help

Multisim offers a full helpfile system to support your use of the product.
Choose Help/Multisim Help to display the helpfile that explains the Multisim program in detail, or choose Help/Component Reference to display the helpfile that contains details on the components families provided with Multisim. Both are compiled HTML helpfiles, offering a table of contents and index.
In addition, you can display context-sensitive help by pressing F1 from any command or window, or by clicking the Help button on any dialog box that offers it.
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Chapter 1
Educators’ Guide

Multisim is the schematic capture and simulation application of National Instruments Circuit Design Suite, a suite of EDA (Electronics Design Automation) tools that assists you in carrying out the major steps in the circuit design flow. Multisim is designed for schematic entry, simulation, and feeding to downstage steps, such as PCB layout.

In addition to the many features that have made Multisim a favorite with professional users, there are also a number of education-specific features that are outlined in this guide.

This chapter describes the tools that Multisim offers to let you exercise greater control over the program’s interface and functionality when sharing circuits with students, as well as to set certain aspects of a circuit’s behavior for instructional purposes.

Some of the features described in this chapter may not be available in your edition of Multisim. Refer to the release notes for a description of the features available in your edition.

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1.1 Circuit Creator’s Name

Multisim provides a feature by which the name of the creator of each circuit is stored with that circuit. Educators can take advantage of this feature to identify the student who, for example, created the circuit being submitted as the answer to an assignment (provided that the student uses his/her own copy of the program to create the circuit). The name appears on the Circuit Restrictions dialog box, which you can view as long as no passwords have been set — see “1.2.2 Setting Circuit Restrictions” on page 1-4 for more information.
1.2 Using Restrictions

Restrictions are useful in a number of ways:

• when you are designing circuits for demonstration purposes and want to limit the functionality available to students
• when you are sharing circuits with students and want:
  • to prevent them from being able to edit the circuit in any way
  • to limit the types of modifications they can make to a circuit
  • to limit the types of analyses they can perform on it
  • to limit the information they can see about certain parts of the circuit (for example, the value of a resistor you want them to calculate).

You can set global-level restrictions, which become default Multisim settings, or circuit-level restrictions, which affect only specific circuits.

To ensure that only you can set or modify restrictions, you use passwords which can protect both global and circuit restrictions. It is important that you set passwords immediately when using restrictions that you want to keep secure against any modification by students. The password for global restrictions is encrypted and stored in the Multisim program file. The password for circuit restrictions (for restricting only a particular circuit) is encrypted and stored in the circuit file.

1.2.1 Setting Global Restrictions

Use global restrictions to set the basic level of functionality of Multisim available to students in all circuits with which they will work. You can select a default path where circuits are to be saved, hide databases and the In Use List, and determine whether students may edit components or place instruments.

You can also hide complicated instruments and analysis options from the menus by using the simplified version. See “Simplified Version” on page 1-3.

Note Global restrictions are overridden by circuit restrictions if the circuit restrictions are saved with the circuit. See “1.2.2 Setting Circuit Restrictions” on page 1-4 for information.

1.2.1.1 General Global Restrictions

➢ To set general global restrictions:

1. Choose Options/Global restrictions. The Password dialog box appears.

Note The Password dialog also appears if you select Options/Circuit restrictions, if you have previously set a password by clicking Password from the Circuit restrictions dialog.
box. For details on the Circuit restrictions dialog box, see “1.2.2 Setting Circuit Restrictions” on page 1-4.

2. Enter the default password “Rodney” (this is case sensitive) and click OK.

The Global Restrictions dialog box appears.

Note You can, and should, change the default password. (See “1.2.3 Setting Passwords for Restrictions” on page 1-6 for more information).

3. Click the General tab and select from the following options:
   • Circuit Path — Sets the default path and location where students find and save files.
   • Disable database editing — Ensures that students cannot edit components in the database.
   • Disable Instruments toolbar — Makes instruments unavailable to be placed in the circuit.
   • Disable In-Use List toolbar — Hides the In Use List.
   • Disable Master DB component access — Hides the Multisim Master database and parts groups and families from the interface.
   • Disable User DB component access — Hides the “user” database and parts groups and families from the interface.
   • Disable Corporate DB component access — Hides the corporate database and parts groups and families from the interface.

4. Click OK. Your options are immediately set for all circuits, unless you have set circuit restrictions. (See “1.2.2 Setting Circuit Restrictions” on page 1-4.)

Simplified Version

The simplified version restricts students to only certain instruments and analyses. The simplified version can also be locked, preventing students from turning it off with Options/Simplified Version and having access to all analyses and instruments.

➢ To set up the simplified version:

1. Display the General tab of the Global Restrictions dialog box.

2. Set your options by enabling one of the following options:
   • Lock simplified — Disables the Options/Simplified Version menu option.
   • Simplified version — Changes the interface display by hiding the more complex functions and restricting the available instruments and analyses. If the simplified version is restricted, it will be greyed out in the Options menu.
   • Full version — Displays the full default interface without restrictions.

3. Click OK.

Your options are immediately set for all circuits, unless you have set circuit restrictions. (See “1.2.2 Setting Circuit Restrictions” on page 1-4.)
1.2.1.2 Global Analyses Restrictions

To set global analyses restrictions:

1. From the Global Restrictions dialog box, click the Analysis tab.
2. Enable the desired analyses by selecting their checkboxes and click OK. Only the analyses you check will be enabled in the Simulate/Analyses menu or when the student clicks the Grapher/Analyses List button in the Main toolbar.

Note: Refer to the Analysis chapter in the Multisim User Guide for more information on analyses.

These options are immediately set for all circuits, unless you have set circuit restrictions. (See “1.2.2 Setting Circuit Restrictions” on page 1-4.)

1.2.2 Setting Circuit Restrictions

Use circuit restrictions to set restrictions on individual circuits. Circuit restrictions override global restrictions. They are saved with your circuit and invoked each time the circuit is loaded. In addition to hiding databases and setting available analyses, you can set a schematic to be read-only (not editable by students), you can hide components’ values, faults and uses in analyses, and you can lock subcircuits to make them unavailable for opening by students.

Note: Remember that circuit restrictions only apply to the current circuit; when you create a new circuit, only the global restrictions will apply (see “1.2.1 Setting Global Restrictions” on page 1-2 for details). If you want circuit restrictions to apply to a new circuit, you will need to reset those restrictions each time you create a new circuit.

To set general circuit restrictions:

1. Choose Options/Circuit Restrictions. If you have created a password, you will be prompted for it. (See “1.2.3 Setting Passwords for Restrictions” on page 1-6 for more information.) Enter your password in the Password dialog box, and click OK. The Circuit Restrictions dialog box appears.
2. Click the General tab and set the desired options by enabling the appropriate checkboxes. Select from the following options:
   - Schematic read-only — Prevents students from saving the circuit, and hides parts bins. Students will only be able to draw wires between instruments and an open pin on an existing connector. Also, they can only remove wires that are between an instrument and a connector.
   - Circuit description read-only — Prevents students from changing the contents of the Circuit Description box.
   - Hide component values — Marks the Values tab of components’ properties dialog boxes with an “X” and hides values. You may wish to provide false values using labels.
Using Restrictions

• **Hide component faults** — Marks the Faults tab of components’ properties dialog boxes with an “X”, and hides faults.
• **Lock subcircuits** — Prevents students from opening subcircuits and seeing their contents. Students must measure the input and output of a hidden subcircuit to determine its contents.
• **Disable Instruments toolbar** — Makes instruments unavailable to be placed on the circuit.
• **Disable In-Use List toolbar** — Disables the In-Use List for the current circuit.
• **Disable Multisim Master DB component access** — Hides the Multisim Master database and parts groups and families from the current circuit.
• **Disable User DB component access** — Hides the user database and parts groups and families from the current circuit.
• **Disable Corporate DB component access** — Hides the corporate database and parts groups and families from the interface.

**Note** The **Circuit Creator Name** is taken from the operating system.

3. Click **OK**. The options you select are immediately invoked in the circuit.

4. To have the restrictions apply each time the circuit is opened, choose **File/Save** to save the restrictions in the circuit file.

➢ To set circuit analyses restrictions:

1. From the **Circuit Restrictions** dialog box, click the **Analysis** tab.
2. Enable the desired analyses by selecting their checkboxes and click **OK**. Only the analyses you check will be enabled in the Simulate/Analyses menu or when the student clicks the Grapher/Analyses List button in the Main toolbar.

**Note** Refer to the Analysis chapter in the **Multisim User Guide** for more information on analyses.

3. To have these analyses apply each time the circuit is opened, choose **File/Save** to save the restrictions.

➢ To set circuit breadboard restrictions:

1. From the **Circuit Restrictions** dialog box, click the **Breadboard** tab.
2. Set the following as desired:
   • **Highlight Target Holes** — Disable if you do not wish to see where the targets for jumper wires are when placing them on the breadboard.
   • **Completion Feedback** — Disable if you do not wish components and wires on the schematic to change color as they are placed and wired on the breadboard.
3. Click **OK**.

**Note** For details on breadboarding, refer to Chapter 2, “Breadboarding”.
1.2.3 Setting Passwords for Restrictions

When using restrictions, you should create a password immediately to ensure that your settings are secure.

➢ To create/change a password:
1. For global restrictions, choose Options/Global restrictions. For circuit restrictions, choose Options/Circuit restrictions. Enter a password if prompted to do so.

   Note The default password for global restrictions is “Rodney” (this is case sensitive). Circuit restrictions do not have a default password.

2. From the restrictions dialog box that appears, click Password. The Change Password dialog box appears.
3. If you are choosing a password for the first time, leave the Old password field blank.
   If you are changing a password, enter the old password in the Old password field.
4. Enter your (new) password in the New password field.
5. Confirm your new password by entering it again in the Confirm password field.
6. Click OK to return to the dialog box, or Cancel to begin again.

Note If you want to change global or circuit restrictions, you will need to enter the respective password. Be sure to keep your passwords for both the Global restrictions and Circuit restrictions dialogs written down and in a safe place, as you will not be able to retrieve them from the program or circuit files, where they are stored in encrypted form.

Note A circuit password is not automatically transferred to a new circuit when you go to set circuit restrictions for it, so you will need to recreate the password every time you create circuit restrictions that you want to keep secure.

1.3 Link to Education Resources

Note This function is hidden when the simplified version option is selected. For details, see “Simplified Version” on page 1-3.

➢ To go to the Electronics Workbench Education website:
1. Click on the Educational Website button or select Tools/Education Webpage.
Chapter 2
Breadboarding

This chapter describes Multisim’s breadboarding feature. Some of the features described in this chapter may not be available in your edition of Multisim. Refer to the release notes for a description of the features available in your edition.

The following are described in this chapter.

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2.1 Breadboarding Overview

The Breadboarding feature provides a technical aid for educators who wish to illustrate breadboarding as a means of prototyping circuit designs. It also gives students exposure to the breadboarding process, and shows in 3D what the resulting breadboard will look like when completed.

2.2 Breadboard Settings

The default breadboard is shown in the screen capture below. If you wish to change the default settings, use the following procedure.

➢ To change the breadboard’s settings:
   1. Select Tools/Show Breadboard from the main Multisim menu. The Breadboard View displays. The default breadboard appears as shown below.
   
   ![Breadboard View](image)

   The default breadboard contains: one slat with two rows; one left strip; one right strip; one bottom strip; one top strip.
   
   2. Select Options/Breadboard Settings to display the Breadboard Settings dialog box.
   3. Enter the desired parameters for the breadboard and click OK. The view of the breadboard changes to reflect your changes.
2.3 3D Options

The 3D viewing options for the Breadboard View are set in the 3D Options tab of the Preferences dialog box.

➢ To change the 3D options:
   1. Select Options/Preferences and click on the 3D Options tab.
   2. Optionally, click on Background Color to display a standard Color dialog box where you can adjust the background color as desired.
   3. In the Info Box area:
      • Info Box — disable this checkbox if you do not wish to see the box at the top of the breadboard view that shows parts information.
      • Left — places parts information box at top-left.
      • Center — places parts information box at top-center.
      • Right — places parts information box at top-right.
   4. Disable the Show Target Holes checkbox if you do not wish to see where the targets for jumper wires are when placing them. (For details, see “2.5.1 Placing a Jumper” on page 2-7).
   5. Disable the Show Completion Feedback checkbox if you do not wish components and wires on the schematic to change color as they are placed and wired on the breadboard.
   6. In the 3D Performance box:
      • Move the slider as desired to improve graphic performance. More Details will result in a slower screen refresh rate.
      • Enable the User Defined checkbox and disable the 3D features that you do not wish to see.

Tip Disabling Show Breadboard Numbers will result in a much quicker refresh rate.

2.4 Placing Components on the Breadboard

➢ To place components on a breadboard:
   1. Create a schematic diagram of the desired circuit in the usual manner. (For details, on schematic capture, refer to the Multisim User Guide).
2. Select Tools/Show Breadboard from the main Multisim menu. The Breadboard View displays similar to the following example.

3. Click on a component in the Place Component Bar and drag it to the desired location on the breadboard. As the component passes over the breadboard, sockets change color as shown below.

Tip  Select CTRL-R to rotate a selected component 90 degrees clockwise or CTRL-SHIFT-R to rotate it 90 degrees counter-clockwise.
4. Release the mouse button to place the component. Notice that the colored (red and green) sockets on the breadboard no longer appear.

5. Return to the schematic view and note that the color of the placed component has changed as shown in the example below.

6. Continue placing the circuit's components on the breadboard. When all the components have been placed, the **Place Component Bar** collapses as shown below.
Breadboarding

Tip Where pins of components are connected on the schematic, you can place them in connected sockets on the breadboard as shown below. This technique can reduce the number of jumper wires required. For details on jumpers, see “2.5.1 Placing a Jumper” on page 2-7.

Appearance of 3D Components

The appearance of the 3D component is dependant on the footprint that is selected from the Select a Component browser during schematic capture in the Footprint manuf./Type list. Some virtual parts have a default 3D view that appears as a blue 3D rectangle or cube. “Real” parts that have pin pitch (spacing) that does not fit the pin pitch on the breadboard will also appear as 3D rectangles or cubes, with properly spaced pins. (See below).

Note Certain virtual components, including 3D parts also appear as 3D rectangles or cubes.

Note To view footprint information, hover the cursor over the desired component. For details, see “2.6 Viewing Component Information” on page 2-8.

2.5 Wiring Placed Components

By placing component pins that are connected on the schematic into sockets that are internally connected, much of the “wiring” can be done at the same time components are placed. However, in most circuits, it will also be necessary to place jumpers to complete the wiring of the placed components.
2.5.1 Placing a Jumper

To place a jumper wire:

1. Click on a socket connected to the pin where you wish to start the jumper and begin moving the cursor. Legitimate “target” pins display as shown below.

2. Click to place the jumper in the desired socket.

3. Return to the schematic view and note that the color of the wire connecting the two pins has changed to green to indicate a connection has been made.

**Note** If a net contains more than two connections, all must be connected before any of the wires in the net change color.
4. Continue placing jumpers until all schematic connections have been made.

**Tip** Run a Design Rules and Connectivity Check to see if there are any errors in your breadboard. Refer to “2.9 DRC and Connectivity Check” on page 2-12.

### 2.5.2 Changing Jumper Wire Color

- To change jumper wire color:
  1. Select **Edit/Breadboard Wire Color**.
  2. Select the desired color from the dialog box that appears.

  **Note** The color of previously placed wires is not affected. The new color will be applied to any subsequently placed wires.

### 2.6 Viewing Component Information

- To view information about a specific component:
  1. Hover the cursor over the component. The information box is populated as shown below.
Viewing Component Information

➢ To see pin information:
   1. Hover the cursor over the “metal” part of the desired pin. The information box now includes the pin name and the schematic net to which the pin should be connected.

Two-terminal Components

Two-terminal non-directional components like resistors have pin names (1 and 2) that will automatically swap if they are connected the “wrong way” according to the pin name that is on the schematic.

➢ To view the pin names for all devices on the schematic:
   1. Select Options/Sheet Properties and click the Circuit tab of the Sheet Properties dialog box.
   2. Click the Pin names checkbox until the checkmark is a solid black color and click OK to close the dialog.

In the above example, if Pin 1 is connected to a pin that should be receiving Pin 2, the pin names will automatically swap. (Pin 1 will become Pin 2 and vice versa).
2.7 Manipulating the Breadboard View

You can manipulate the view of the breadboard in a number of ways.

- To make the breadboard appear larger:
  1. Select View/Zoom in.

- To make the breadboard appear smaller:
  1. Select View/Zoom out.

  **Tip** Use your mouse’s center wheel to zoom in or out. (This must be set up in the General tab of the Preferences dialog box. For details, refer to the Multisim User Guide).

- To view the entire breadboard:
  1. Select View/Zoom Full.

- To rotate the breadboard 180 degrees:
  1. Select View/Rotate 180 Degrees
     
     **Or**
     
     Press SHIFT-R on your keyboard.

  **Tip** Rotate the breadboard in any direction by dragging the mouse from a blank area of the Breadboard View. You can also rotate the breadboard by using the arrow keys on your keyboard.

- To pan the breadboard:
  1. Hold down the SHIFT key on your keyboard and use any of the arrow keys.

  **Or**

  Press CTRL-SHIFT and drag the mouse.

  **Or**

  Hold down your mouse-wheel and drag the mouse.
2.8 Breadboard Netlist dialog box

To display a netlist for the placed components and jumpers:

1. Select Tools/Show Breadboard Netlist. The Breadboard Netlist dialog box appears.

2. Optionally, click Save to save the breadboard netlist as a .txt or .csv file.

*Note* These nets are breadboard connections, and are not necessarily numbered in correspondence to the schematic nets.
2.9 **DRC and Connectivity Check**

You can run a Design Rules and Connectivity Check to see if there are any errors in your breadboard.

➢ To run a DRC and Connectivity Check:

1. Select **Tools/DRC and Connectivity Check**. The results appear in the **Results** tab of the Spreadsheet View.

<table>
<thead>
<tr>
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<tr>
<td>— Design Rule Errors —</td>
</tr>
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<td>Design Rule Error: Pin 1 (B) of component U2 in net: &quot;Not Connected&quot; is connected to pin 3 (A) of component U3 in net 4</td>
</tr>
<tr>
<td>Design Rule Error: Pin 4 (A) of component U2 in net: &quot;Not Connected&quot; is connected to pin 10 (A) of component U3 in net 4</td>
</tr>
<tr>
<td>— 2 Design Rule Errors Found —</td>
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<tr>
<td>— Connectivity Errors —</td>
</tr>
<tr>
<td>Connectivity Error: For net VCC, Pin (VCC) of component U2 is not connected</td>
</tr>
<tr>
<td>Connectivity Error: For net VCC, Pin (VCC) of component U3 is not connected</td>
</tr>
<tr>
<td>— 2 Connectivity Errors Found —</td>
</tr>
</tbody>
</table>

**Design Rule Errors** — indicate connections that are on the breadboard that are not on the schematic.

**Connectivity Errors** — indicate component pins that are not connected to fully-completed schematic nets.
Chapter 3
Virtual NI ELVIS

This chapter describes the Multisim Virtual NI ELVIS feature.
Some of the features described in this chapter may not be available in your edition of Multisim. Refer to the release notes for a description of the features available in your edition.
The following are described in this chapter.

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3.1 Overview

Electronic Workbench’s Virtual NI ELVIS emulates much of the behavior of its real-world counter-part, the NI Educational Laboratory Virtual Instrumentation Suite (NI ELVIS). Planning, prototyping and testing of instructor’s projects can be carried out on the student’s PC before moving on to the real NI ELVIS workstation in the lab.
3.2 The Virtual NI ELVIS Schematic

A Virtual NI ELVIS schematic contains a number of unique items that correspond to elements of the real-world NI ELVIS workstation. The connection and control of these elements is described in this section.

To create a new Virtual NI ELVIS schematic:

1. Select File/New/NI ELVIS Schematic. When first opened, a Virtual NI ELVIS schematic appears as shown below.

   ![Virtual NI ELVIS Schematic Diagram](image)

   **Note** The Ground connector that appears at the bottom left of the diagram is the reference point for measurements taken during simulation, and should therefore not be removed.

2. Place and wire components in the Virtual NI ELVIS schematic in the same manner as other Multisim schematics. For details, refer to the *Multisim User Guide*.

The prototyping board rows found to the left and right of the main workspace correspond to rows in the real-world version of NI ELVIS and are labelled in the same manner. Rows that are shown with green labels are not enabled for simulation in Multisim. However, they can be used for schematic capture and viewing of the completed Virtual NI ELVIS schematic in the 3D view. Unlike other Multisim components, these rows cannot be moved to other places on the workspace.
Oscilloscope

The connections to Virtual NI ELVIS’s oscilloscope are found in the upper-left prototyping rows.

➢ To connect the oscilloscope:

1. Place wires from the points in your schematic that you wish to measure with the oscilloscope to any of the pins on the CH A+, CH A-, CH B+, CH B- or TRIGGER rows beside “Oscilloscope”. These rows correspond to the terminals of the oscilloscope.
   - CH A+ — positive input of channel A.
   - CH A- — negative input of channel A.
   - CH B+ — positive input of channel B.
   - CH B- — negative input of channel B.
   - TRIGGER — trigger input signal.

➢ To access the oscilloscope’s controls:

1. Double-click on the the word “Oscilloscope” in the upper-left prototyping rows. The instrument face for Multisim’s virtual oscilloscope displays.

2. Refer to the Multisim User Guide for details on the use of this instrument.
When a new Virtual NI ELVIS schematic is opened, the IV Analyzer is disabled, and the Ammeter is enabled as indicated above.

- To disable the Ammeter and enable the IV Analyzer, double-click where indicated on the Virtual NI ELVIS schematic.
- To disable the IV Analyzer and enable the Ammeter, double-click again.

**Note** When the IV Analyzer is enabled, there is a slight delay when simulation is started while a DC sweep is performed. If the Ammeter is enabled, there is no delay.
To connect the IV Analyzer:

1. Place wires from the component you wish to measure to the pins on the 3-WIRE, CURRENT HI and CURRENT LO rows. These rows correspond to the inputs of the IV Analyzer. See below for connections to specific component types.

To connect the Ammeter:

1. Place wires from the points in the circuit you wish to measure to the pins on the CURRENT HI and CURRENT LO rows.

CURRENT HI corresponds to the + terminal of the ammeter and CURRENT LO corresponds to the - terminal.

To access the controls for the enabled instrument:

1. Double-click just above the letters “DMM”. If you have enabled the IV Analyzer as described earlier, that instrument’s face appears. If you have enabled the Ammeter, an instrument containing the Ammeter function of a multimeter appears.

2. Refer to the *Multisim User Guide* for details on the use of these instruments.

To connect the Volt/Ohmmeter:

1. Place wires from the points in the circuit you wish to measure to the pins on the VOLTAGE HI and VOLTAGE LO rows.

VOLTAGE HI corresponds to the + terminal of the meter and VOLTAGE LO corresponds to the - terminal.
To access the controls for the Voltmeter and Ohmmeter:
1. Double-click just below the letters “DMM”. An instrument containing the Voltmeter and Ohmmeter functions of a multimeter appears.
2. Refer to the *Multisim User Guide* for details on the use of this instrument.

**Function Generator**

To connect the Function Generator:
1. Place wires from the pins on the FUNC OUT, SYNC OUT, AM IN and FM IN rows to the desired points in your schematic.
   - **FUNC OUT** — output signal.
   - **SYNC OUT** — outputs a TTL-compatible clock signal of the same frequency as the output waveform.
   - **AM IN** — a signal input here controls the amplitude of the signal at FUNC OUT.
   - **FM IN** — a signal input here controls the frequency of the signal at FUNC OUT and SYNC OUT.

To access the controls for the Function Generator:
1. Double-click on “Function Generator”. The properties dialog for the NI ELVIS Function Generator appears.
2. Click on the **Value** tab and enter the desired output parameters.
3. Click **OK** to close the Function Generator’s properties dialog box.

*Note* For details on the user-settable parameters, see “A.4.1 NI ELVIS Function Generator” on page A-24.

**Power Supplies**

The lower-left prototyping rows contain the following fixed DC Power Supplies:
- +15 V
- -15 V
- +5 V (also found in the lower-right prototyping rows).

Variable Power Supplies are also available:
- SUPPLY + (+12 V max)
- SUPPLY - (-12 V max).

To connect to any of the power supplies, place wires from the pin on the corresponding row to the desired point in the circuit.
To access the controls for the variable power supplies:
1. Double-click on “Variable Power Supplies”. The properties dialog box for the NI ELVIS power supply appears.
2. Click on the Value tab and enter the desired parameters.
3. Click OK to close the properties dialog box.

*Note* For details on the user-settable parameters, see “A.4.2 NI ELVIS Power Supply” on page A-25.

**LEDs**

Connections to the seven LEDs on the right side of the NI ELVIS schematic are found in the lower-right prototyping rows. During simulation, any of these LEDs that are correctly connected will light.

To connect to an LED:
1. Place a wire from one of the LED rows (LED 0 through LED 7) to the desired point in your schematic.
There are also three LEDs in the lower-left section of any Virtual NI ELVIS schematic.

During simulation, these LEDs will light whether or not connections have been made to their corresponding pins in the prototyping rows.

### 3.3 Placing Components on the Prototyping Board

Once you have completed the Virtual NI ELVIS schematic, you are ready to place the components on the 3D rendering of the prototyping board.

*Note* The controls that appear on the front of the 3D Virtual NI ELVIS are inactive. Interactive simulation of Virtual NI ELVIS is accomplished via the schematic view. For details on simulation, refer to the *Multisim User Guide* or the Multisim helpfile.
To place components on the 3D prototyping board:

1. Select **Tools/Show Breadboard** from the main Multisim menu.

   Hover the cursor over a component to see its description in this box.

2. Click on a component in the **Place Component Bar** and drag it to the desired location on the board. As the component passes over the board, sockets change color as indicated below:

   **Tip** Select CTRL-R to rotate a selected component 90 degrees clockwise or CTRL-SHIFT-R to rotate it 90 degrees counter-clockwise.

3. Release the mouse button to place the component. The colored (red and green) sockets on the board no longer appear.

**Note** 3D viewing options are set in the **Preferences** dialog box. For details, see “2.3 3D Options” on page 2-3. See also, “2.7 Manipulating the Breadboard View” on page 2-10 for useful viewing information.
Virtual NI ELVIS

4. Return to the schematic view and note that the color of the placed component has changed as shown in the example below.

5. Continue placing the circuit’s components on the board. When all the components have been placed, the Place Component Bar collapses.

*Tip* Where pins of components are connected on the schematic, you can place them in connected sockets as shown below. This technique can reduce the number of jumper wires required.

*Note* See also, “Appearance of 3D Components” on page 2-6.

3.4 Wiring Placed Components

By placing component pins that are connected on the schematic into sockets that are internally connected, much of the “wiring” can be done at the same time components are placed. However, in most circuits, it will also be necessary to place jumpers to complete the wiring of the placed components.

➢ To place a jumper wire:

1. Click on a socket connected to the pin where you wish to start the jumper and begin moving the cursor. Legitimate “target” pins (green) display as you move the cursor.
2. Click to place the jumper in the desired socket.
3. Return to the schematic view and note that the color of the wire connecting the two pins has changed to green to indicate a connection has been made.

\[\text{Green wire shows connection done in 3D view}\]

*Note*  If a net contains more than two connections, all must be connected before any of the wires in the net change color.

4. Continue placing jumpers until all schematic connections have been made.

*Tip*  Run a Design Rules and Connectivity Check to see if there are any errors in your board. Refer to “2.9 DRC and Connectivity Check” on page 2-12.

*Note*  See also “2.6 Viewing Component Information” on page 2-8 and “2.8 Breadboard Netlist dialog box” on page 2-11.
Chapter 4
Ladder Diagrams

This chapter describes the ladder diagram functionality that Multisim contains. Some of the features described in this chapter may not be available in your edition of Multisim. Refer to the release notes for a description of the features available in your edition. The following are described in this chapter.

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4.1 Overview

The Education edition of Multisim lets you capture and simulate Ladder Diagrams. These diagrams are electrically based, as opposed to the binary/digital representations employed by ladder logic. Diagrams of this type are used extensively for industrial motor control circuits.

Ladder Diagrams are able to drive output devices or take input data from regular schematics and embed the instructions on how input states affect output states in either the same schematic or separate hierarchical blocks or subcircuits that contain the Ladder Diagram.

Note Refer to the Multisim User Guide for a complete description of hierarchical blocks and subcircuits.
4.2 Creating a Ladder Diagram

This section describes the steps required to make a simple Ladder Diagram. The concepts described here should be understood before reviewing the more complex circuits found in this chapter.

This section describes how to build the Ladder Diagram that is reviewed in “4.3 AND Rungs and OR Rungs” on page 4-5.

Note For details on all ladder diagram components, refer to “A.2 Ladder Diagram Parts” on page A-8.

Circuit Notes:

• The relays (X1-X4) are normally open relays. When their controlling coils (M1 or M2) are energized they close. (The controlling coils are set in the Value tab of each relay’s properties dialog box. For details, see “A.2.4.4 Relay Contact NO” on page A-13).
• Both X1 AND X2 must be closed for the lamp in the AND rung (X5) to light up.
• Either X3 OR X4 must be closed for the lamp in the OR rung (X6) to light up.
• Coil M1 controls the relays with M1 as their reference. (X1 and X3).
• Coil M2 controls the relays with M2 as their reference. (X2 and X4).
• Use keys 1 and 2 on your keyboard to open and close switches J1 and J2, or hover your cursor over the desired switch and click on the button that pops up.
Creating a Ladder Diagram

➢ To add the diagram’s rungs:

1. Select Place/Ladder Rungs. The cursor appears with the rung’s left and right terminators attached.

➢ To add components to the rungs:

1. Select Place/Component, navigate to the Normally Open Relay Contact (RELAY_CONTACT_NO) click OK.

   **Note** This device is found in the Ladder Diagrams Group - Ladder Contacts Family.

2. Drop the relay contact directly onto the first rung.
3. Continue in this manner until all relay contacts have been placed. (X4 must be placed and then wired separately).

4. Place the lamps (Group - Indicators; Family - Lamp).

5. Place relay coils M1 and M2 on the third and fourth rungs (Group - Ladder Diagrams; Family - Ladder Relay Coils).

6. Place switches J1 and J2.
7. Double-click on each switch, select the Value tab, and change the key for J1 to 1 and the key for J2 to 2.

➢ To change the controlling device reference for X2 and X4:
   1. Double-click on X2 and click the Value tab.
   2. Enter M2 in the Controlling Device Reference field and click OK.
      Repeat for X4. The completed Ladder Diagram appears as shown below.

4.3 AND Rungs and OR Rungs

This section illustrates the difference between AND rungs and OR rungs that are found in Ladder Diagrams. The concepts described here should be understood before reviewing the more complex circuits found in this chapter.
To activate the lamp in the OR rung:
1. Select **Simulate/Run** to start simulation of the circuit.
2. Press 1 on your keyboard to close J1 (or hover your cursor over J1 and click the button that pops up). Lamp X6 lights as described below.

2. All relays with M1 as their reference are energized.
3. X6 lights because only X3 OR X4 need to be energized to complete the circuit.

If you press 2 on your keyboard (or hover your cursor over J2 and click the button that pops up), J2 closes which activates coil M2. X6 lights because X4 is energized.

To activate the lamp in the AND rung:
1. Select **Simulate/Run** to start simulation of the circuit.
2. Press 1 and 2 on your keyboard to close J1 and J2. Lamps X5 and X6 light as described below.

3. All relays with M1 and M2 as their references are energized.

4. X6 lights because X3 OR X4 is energized and the circuit is complete.

5. X5 lights because X1 AND X2 are energized and the circuit is complete.

4.4 Sample Circuits

4.4.1 Holding Tank

This section contains an example of a logic diagram that drives a circuit that fills and then empties a fluid holding tank.

For details on the user-settable parameters for the Holding Tank, Input Module and Output Module see “A.2 Ladder Diagram Parts” on page A-8.
Ladder Diagrams

To activate this circuit:

1. Select **Simulate/Run** to begin simulation.
2. Press P on your keyboard to activate the Power temporary switch (or hover your cursor over the Power switch and click the button that pops up). This sends 5 V to pin IN4 of Input Module U2 (**Input Module Base Address** = 100) which in turn energizes Input

The Ladder Diagram is contained in a separate Hierarchical Block called HoldingTankLogic. For details on hierarchical blocks, refer to the Multisim User Guide.
Contact X1 in the Power Lock-up Rung of the ladder diagram. Relay Coil M1 is energized, causing all Relay Contacts with Relay Device Reference = M1 to energize.

To run the holding tank circuit:
1. Activate the circuit as described above.
2. Press R on your keyboard (or hover your cursor over the Run switch and click the button that pops up) to activate the Run temporary switch.

**Tip** Select Window/Tile Vertical to view the ladder diagram and the circuit at the same time. Observe the interaction between the ladder diagram and the circuit as the simulation proceeds.
3. As the simulation proceeds, the tank begins to fill.

4. When the level of the fluid in the tank gets to the **Set Point**, fluid stops being pumped.
5. After a delay of five seconds, the tank begins to empty.

6. When the tank is empty, the flow stops.
To turn off the power at any point in the simulation:

1. Press K on your keyboard (or hover your cursor over the Kill switch and click the button that pops up) to activate the Kill temporary switch. This sends 5 V to pin IN3 of Input Module U2 (Input Module Base Address = 100) which in turn energizes Input Contact X2 (the contact opens). The continuity in the Power Lock-up Rung is broken and Relay Coil M1 is de-energized, which in turn switches off all Relay Contacts with Relay Device Reference = M1.

When you press K, X20 is also temporarily energized, which in turn temporarily energizes Output Coil Y2, which sends a pulse to pin Out3 of Output Module U3. This is wired to the Stop pin of the holding tank, so the tank stops filling or emptying (depending on which is currently occuring).

4.4.2 Conveyor Belt

This section contains an example of a Ladder Diagram that drives a conveyor belt.

For details on the user-settable parameters for the Conveyor Belt, Input Module and Output Module, see “A.2 Ladder Diagram Parts” on page A-8.
To activate this circuit:

1. Select **Simulate/Run** to begin simulation.
2. Press P on your keyboard (or hover your cursor over the Power switch and click the button that pops up) to activate the Power temporary switch. This sends 5 V to pin IN2 of Input Module U4 (**Input Module Base Address** = 101) which in turn energizes Input Contact X1.

The Ladder Diagram is contained in a separate Hierarchical Block called ConveyorLogic. For details on hierarchical blocks, refer to the Multisim User Guide.
To run the conveyor belt:

1. Activate the circuit as described earlier.
2. Press R on your keyboard (or hover your cursor over the Run switch and click the button that pops up) to activate the Run temporary switch.

**Tip**  Select Window/Tile Vertical to view the ladder diagram and the circuit at the same time. Observe the interaction between the ladder diagram and the circuit as the simulation proceeds.
3. As the simulation proceeds, the box moves along the conveyor belt to Position Sensor 2 (PS2). The box stops moving and balls begin dropping from the hopper into the box.

4. When five balls have dropped into the box (counted by Count sensor and C1), the hopper stops dropping balls.
5. The conveyor continues moving and stops when the box gets to Position Sensor 3 (PS3).

➢ To turn off the power at any point in the simulation:

1. Press K on your keyboard (or hover your cursor over the Kill switch and click the button that pops up) to activate the Kill temporary switch. This sends 5 V to pin IN3 of Input Module U4 (Input Module Base Address = 101) which in turn energizes Input Contact X3 (the contact opens). The continuity in the Power Lock-up Rung is broken and Relay Coil M1 is de-energized, which in turn switches off all Relay Contacts with Relay Device Reference = M1.

When you press K, X19 is also temporarily energized, which in turn temporarily energizes Output Coil Y2, which sends a pulse to pin Out3 of Output Module U2. This is wired to the Stop pin of the conveyor belt, so the belt stops.
4.4.3 Traffic Light

The ladder diagram in this section runs two traffic lights.

To run the traffic lights:

1. Select **Simulate/Run**.
2. Press P on your keyboard (or hover your cursor over the Power switch and click the button that pops up) to activate the Power momentary switch.
**Tip**  Select **Window/Tile Vertical** to view the ladder diagram and the circuit at the same time. Observe the interaction between the ladder diagram and the circuit as the simulation proceeds.

3. The red and green lights in traffic lights U1 and U3 light as shown below.

4. After 15 seconds, the green lights turn amber.
5. After 5 more seconds, the amber lights turn red and the red lights turn green.

6. After 15 seconds, the green lights turn amber.
7. After 5 more seconds, the amber lights turn red and the red lights turn green.

8. The cycle continues in this way until you stop the simulation, or press K (or hover your cursor over the Kill switch and click the button that pops up) to activate the Kill momentary switch.
Appendix A - Education Edition Parts

This appendix contains a description of the parts that are unique to the Education edition of Multisim.

A.1 3D Virtual Parts

This family contains a number of 3D parts. These components function normally when the circuit is simulated, but appear like the real component on the circuit schematic. The 3D virtual components are found in the Basic group in the 3D Rated Virtual family.

A.1.1 3D 555 Timer

The 555 timer is an IC chip that is commonly used as an astable multivibrator, a monostable multivibrator or a voltage-controlled oscillator. The 555 timer consists basically of two comparators, a resistive voltage divider, a flip-flop and a discharge transistor. It is a two-state device whose output voltage level can be either high or low. The state of the output can be controlled by proper input signals and time-delay elements connected externally to the 555 timer.

Note Refer to the Component Reference Guide for a more detailed discussion of the 555 timer.
A.1.2 3D BJT

A bipolar junction transistor, or BJT, is a current-based valve used for controlling electronic current. BJTs are operated in three different modes, depending on which element is common to input and output: common base, common emitter or common collector. The three modes have different input and output impedances and different current gains, offering individual advantages to a designer.

Note Refer to the Component Reference Guide for a more detailed discussion of BJTs.

A.1.3 3D Capacitors

A capacitor stores electrical energy in the form of an electrostatic field. Capacitors are widely used to filter or remove AC signals from a variety of circuits. In a DC circuit, they can be used to block the flow of direct current while allowing AC signals to pass.

Note Refer to the Component Reference Guide for a more detailed discussion of capacitors.
A.1.4 3D 74LS160N Counter

This synchronous, presettable decade counter features an internal carry look-ahead for fast counting.

*Note* Refer to the Component Reference Guide for a more detailed discussion of the 74LS160N counter.

A.1.5 3D Diode

Diodes allow current to flow in only one direction and can therefore be used as simple solid-state switches in AC circuits, being either open (not conducting) or closed (conducting). Terminal A is called the anode and terminal K is called the cathode.

*Note* Refer to the Component Reference Guide for a more detailed discussion of diodes.
A.1.6 3D Inductor

An inductor stores energy in an electromagnetic field created by changes in current through it. Its ability to oppose a change in current flow is called inductance, $L$, and is measured in Henries.

*Note* Refer to the *Component Reference Guide* for a more detailed discussion of inductors.

A.1.7 3D LED

This diode emits visible light when forward current through it, $I_d$, exceeds the turn-on current, $I_{on}$. The electrical model of the LED is the same as the diode model.

*Note* Refer to the *Component Reference Guide* for a more detailed discussion of LEDs.
A.1.8 3D MOSFET

A MOSFET is a Metal-Oxide-Semiconductor FET. This transistor is a type of FET that uses an induced electrical field to control current through the device. Either negative or positive gate voltages can be applied to control the current.

Note Refer to the Component Reference Guide for a more detailed discussion of MOSFETs.

A.1.9 3D DC Motor

The component is a universal model of an ideal DC motor which can be used to model the behavior of a DC motor excited in parallel, in series or separately.

Note Refer to the Component Reference Guide for a more detailed discussion of DC motors.

A.1.10 3D Opamp
An ideal operational amplifier (Opamp) is an amplifier with infinite gain, infinite input impedance and zero output impedance. With the application of negative feedback, Opamps can be used to implement functions such as addition, subtraction, differentiation, integration, averaging and amplification.

**Note** Refer to the *Component Reference Guide* for a more detailed discussion of opamps.

### A.1.11 3D Potentiometer

This component acts much like a regular resistor, except that you can adjust its resistance.

**Note** Refer to the *Component Reference Guide* for a more detailed discussion of potentiometers.

### A.1.12 3D AND Gate

This device contains four independent 2-input AND gates.

**Note** Refer to the *Component Reference Guide* for a more detailed discussion of the 74LS08 Quad AND gate.
A.1.13 3D Resistor

Resistors come in a variety of sizes, depending on the power they can safely dissipate. A resistor's resistance, $R$, is measured in ohms.

*Note* Refer to the *Component Reference Guide* for a more detailed discussion of resistors.

A.1.14 3D Shift Register

This serial shift-register shifts the data in the direction of QA toward QH when clocked. To load the data at the 8-inputs into the device, apply a low level at the shift/load input. This register is equipped with a complementary output at the eighth bit.

*Note* Refer to the *Component Reference Guide* for a more detailed discussion of the 74LS165N shift register.

A.1.15 3D Switch

This component is a SPST (single-pole, single-throw) switch.

*Note* Refer to the *Component Reference Guide* for a more detailed discussion of switches.
A.1.16 3D Components Toolbar

Some of the more commonly-used 3D components can be placed using the 3D Components toolbar.

- To display the 3D Components toolbar, click the Show 3D Family button in the Virtual toolbar (refer to the Multisim User Guide for Virtual toolbar information).

The buttons (from left to right) in the 3D Components toolbar place the following virtual components: NPN transistor; PNP transistor; 100 uF capacitor; 10 pF capacitor; 100 pF capacitor; 74LS160N counter; Diode; 1 uH inductor; 1 uH inductor; Red LED; Yellow LED; Green LED; MOSFET; DC motor; 741 OPAMP; Potentiometer; Quad AND gate; 1.1 k Resistor; Shift Register 74LS165N; Switch.

A.2 Ladder Diagram Parts

A.2.1 Ladder Rungs

A.2.1.1 L1 and L2

L1 is a Rung Starter and L2 is a Rung Terminator. Continuity between L1 and L2 is required to activate/energize devices placed between them.
A.2.2 Ladder I/O Modules

A.2.2.1 Input Module

This device is an input module for ladder diagrams and is available in various input voltages. It is used to bring external stimulus into a ladder diagram.

➢ To set the Input Module’s base address:
  1. Double-click on the module and select the Value tab.
  2. Enter the desired value in the Input Module Base Address field. The default value is 100, as shown in the above diagram.

A.2.2.2 Output Module

This device is an output module for ladder diagrams and is available in various output voltages. It allows external circuit elements to be manipulated by the logic contained in a ladder diagram.

➢ To set the Output Module’s base address:
  1. Double-click on the module and select the Value tab.
  2. Enter the desired value in the Output Module Base Address field. The default value is 200, as shown in the above diagram.
A.2.3 Ladder Relay Coils

A.2.3.1 Relay Coil

This device is a relay coil for ladder diagrams. When this coil is energized, corresponding contact(s) which reference this device will change their state. (For example, a normally open contact will close).

➢ To set the coil reference for this device:
   1. Double-click on the relay coil and select the Value tab.
   2. Enter the desired value in the Coil Reference field.

A.2.3.2 Negated Relay Coil

This device is a negated relay coil for ladder diagrams.

➢ To set the coil reference for this device:
   1. Double-click on the relay coil and select the Value tab.
   2. Enter the desired value in the Coil Reference field.

A.2.3.3 Set Coil

This device is a latch relay coil for ladder diagrams (requires a reset coil to operate).

➢ To set the coil reference for this device:
   1. Double-click on the relay coil and select the Value tab.
   2. Enter the desired value in the Coil Reference field.
A.2.3.4 Reset Coil

This device is an unlatch relay coil for ladder diagrams, used to reset timers, counters and set coils.

➢ To set the target device for this coil:
  1. Double-click on the set coil and select the **Value** tab.
  2. Enter the desired value in the **Target Device Reference** field.

A.2.3.5 Pulsed Relay Coil

This device is a positive pulse relay coil, which produces a positive pulse of user-definable duration.

➢ To set the parameters for this coil:
  1. Double-click on the positive pulse relay coil and select the **Value** tab.
  2. Enter the desired values in the **Coil Reference** and **Pulse Duration** fields.

A.2.4 Ladder Contacts

A.2.4.1 Input Contact NC

This device is a normally closed input contact for ladder diagrams. It responds to the status at the specified input on the referenced input module.

➢ To set the parameters for this device:
  1. Double-click on the input contact and select the **Value** tab.
  2. Enter the address of the input module associated with this contact (see “A.2.2.1 Input Module” on page A-9) in the **Input Module Base Address** field.
3. Enter the number of the input on the input module which will control this input contact in the **Input Number** field.

![Diagram](
3. Enter the number of the input on the input module which will control this input contact in the **Input Number** field.

**A.2.4.2 Input Contact NO**

This device is a normally open input contact for ladder diagrams. It responds to the status at the specified input on the referenced input module.

➢ To set the parameters for this device:

1. Double-click on the input contact and select the **Value** tab.
2. Enter the address of the input module associated with this contact (see “A.2.2.1 Input Module” on page A-9) in the **Input Module Base Address** field.
3. Enter the number of the input on the input module which will control this input contact in the **Input Number** field.

![Diagram](

**A.2.4.3 Relay Contact NC**

This device is a normally closed relay contact for ladder diagrams. This contact will open when the controlling device (coil, counter or timer) is energized.

➢ To set the parameters for this device:

1. Double-click on the NC contact and select the **Value** tab.
2. Enter the desired value in the **Controlling Device Reference** field.
A.2.4.4 Relay Contact NO

This device is a normally open relay contact for ladder diagrams.

➢ To set the parameters for this device:
   1. Double-click on the relay contact and select the Value tab.
   2. Enter the desired value in the Controlling Device Reference field.

A.2.5 Ladder Counters

A.2.5.1 Count Off

This device is a count OFF counter with preset, for ladder diagrams. The contact associated with this device will be energized at simulation start. The contact will be de-energized when the counter “Set Value” is reached.

This device does not retain its count out state and will automatically reset after count out occurs on the next action.

➢ To set the parameters for this device:
   1. Double-click on the counter and select the Value tab.
   2. Enter the following parameters:
      • Set Value — the counter’s count out value.
      • Preset Value — the count starting point.
      • Counter Reference — set to the device’s RefDes by default. You can enter any other identifying string.
A.2.5.2 Count Off Hold

This device is a count OFF and hold counter with preset, for ladder diagrams. The contact associated with this device will be energized at simulation start. The contact will be de-energized when the counter “Set Value” is reached.

Once the count out state is reached, the counter status is held until simulation is restarted.

➢ To set the parameters for this device:

1. Double-click on the counter and select the Value tab.
2. Enter the following parameters:
   • **Set Value** — the counter’s count out value.
   • **Preset Value** — the count starting point.
   • **Counter Reference** — set to the device’s RefDes by default. You can enter any other identifying string.

A.2.5.3 Count Off Reset

This device is a count OFF and hold until reset counter with preset, for ladder diagrams. The contact associated with this device will be energized at simulation start. The contact will be de-energized when the counter “Set Value” is reached.

You can reset this counter using a reset coil at any time during simulation, regardless of the current counter state.

➢ To set the parameters for this device:

1. Double-click on the counter and select the Value tab.
2. Enter the following parameters:
   • **Set Value** — the counter’s count out value.
   • **Preset Value** — the count starting point.
   • **Counter Reference** — set to the device’s RefDes by default. You can enter any other identifying string.
A.2.5.4 Count Off Up Down

This device is a resettable up/down count OFF and hold until reset counter with preset, for ladder diagrams. This bi-directional counter increments the count via the “U” input, and decrements the count via the “D” input.

To set the parameters for this device:
1. Double-click on the counter and select the Value tab.
2. Enter the following parameters:
   - Set Value — the counter’s count out value.
   - Preset Value — the count starting point.
   - Counter Reference — set to the device’s RefDes by default. You can enter any other identifying string.

A.2.5.5 Count On

This device is a count ON counter with preset, for ladder diagrams. The contact associated with this device will be de-energized at simulation start. The contact will be re-energized when the counter “Set Value” is reached.

This device does not retain its count out state and will automatically reset after count out occurs on the next action.

To set the parameters for this device:
1. Double-click on the counter and select the Value tab.
2. Enter the following parameters:
   - Set Value — the counter’s count out value.
   - Preset Value — the count starting point.
   - Counter Reference — set to the device’s RefDes by default. You can enter any other identifying string.
A.2.5.6 Count On Hold

This device is a count ON and hold counter with preset, for ladder diagrams. The contact associated with this device will be de-energized at simulation start. The contact will be energized when the counter “Set Value” is reached.

Once the count out state is reached, the counter status is held until simulation is restarted.

➢ To set the parameters for this device:
1. Double-click on the counter and select the Value tab.
2. Enter the following parameters:
   • Set Value — the counter’s count out value.
   • Preset Value — the count starting point.
   • Counter Reference — set to the device’s RefDes by default. You can enter any other identifying string.

A.2.5.7 Count On Reset

This device is a count ON and hold until reset counter with preset, for ladder diagrams. The contact associated with this device will be de-energized at simulation start. The contact will be energized when the counter “Set Value” is reached.

You can reset this counter using a reset coil at any time during simulation, regardless of the current counter state.

➢ To set the parameters for this device:
1. Double-click on the counter and select the Value tab.
2. Enter the following parameters:
   • Set Value — the counter’s count out value.
   • Preset Value — the count starting point.
   • Counter Reference — set to the device’s RefDes by default. You can enter any other identifying string.
A.2.5.8 Count On Up Down

This device is a resettable up/down count ON and hold until reset counter with preset, for ladder diagrams. This bi-directional counter increments the count via the “U” input, and decrements the count via the “D” input.

➢ To set the parameters for this device:
1. Double-click on the counter and select the Value tab.
2. Enter the following parameters:
   • Set Value — the counter’s count out value.
   • Preset Value — the count starting point.
   • Counter Reference — set to the device’s RefDes by default. You can enter any other identifying string.

A.2.6 Ladder Timers

A.2.6.1 Timer TOFF

This device is a TOFF timer for ladder diagrams. The associated contact is energized at the start of simulation, and is de-energized when this device “times out”. Any interruption in continuity on the rung in which this timer is located causes the time value to be reset to zero. (This occurs whether or not the timer has timed out).

➢ To set the parameters for this device:
1. Double-click on the timer and select the Value tab.
2. Enter the following parameters:
   • Delay Time — the timer’s time out value.
   • Timer Reference — set to the device’s RefDes by default. You can enter any other identifying string.
A.2.6.2 Timer TON

This device is a TON timer for ladder diagrams. The associated contact is de-energized at the start of simulation, and is energized when this device "times out". Any interruption in continuity on the rung in which this timer is located causes the time value to be reset to zero. (This occurs whether or not the timer has timed out).

➢ To set the parameters for this device:

1. Double-click on the timer and select the Value tab.
2. Enter the following parameters:
   - **Delay Time** — the timer’s time out value.
   - **Timer Reference** — set to the device’s RefDes by default. You can enter any other identifying string.

A.2.6.3 Timer TON Retention

This device is a TON timer with retention capabilities, for ladder diagrams. Once continuity is established, the timer starts. If continuity is broken, the timer retains the accumulated time and will continue from this time when continuity is re-established, until time out. Once timed out, the timer will reset if continuity is broken, and will start accumulated time at zero.

➢ To set the parameters for this device:

1. Double-click on the timer and select the Value tab.
2. Enter the following parameters:
   - **Delay Time** — the timer’s time out value.
   - **Timer Reference** — set to the device’s RefDes by default. You can enter any other identifying string.
A.2.6.4 Timer TON Retention Reset

This device is a TON timer with retention and reset capabilities, for ladder diagrams. Once continuity is established, the timer starts. If continuity is broken, the timer retains the accumulated time and will continue from this time when continuity is re-established, until time out. Once timed out, the timer will reset automatically if continuity is removed. This device can be reset by a reset coil at any time before time out.

➢ To set the parameters for this device:
   1. Double-click on the timer and select the Value tab.
   2. Enter the following parameters:
      • Delay Time — the timer’s time out value.
      • Timer Reference — set to the device’s RefDes by default. You can enter any other identifying string.

A.2.6.5 Timer TON Retention Hold Reset

This device is a TON timer with retention, hold and reset capabilities, for ladder diagrams. Once continuity is established, the timer starts. If continuity is broken, the timer retains the accumulated time and will continue from this time when continuity is re-established, until time out. Once timed out, the timer will not reset automatically when continuity is removed. This device can be reset by a reset coil at any time.

➢ To set the parameters for this device:
   1. Double-click on the timer and select the Value tab.
   2. Enter the following parameters:
      • Delay Time — the timer’s time out value.
      • Timer Reference — set to the device’s RefDes by default. You can enter any other identifying string.
A.2.7 Ladder Output Coils

A.2.7.1 Output Coil

This device is an output coil for ladder diagrams.

➢ To set the parameters for this device:
  1. Double-click on the output coil and select the Value tab.
  2. Enter the address for the output module associated with this device in the Output Module Base Address field.
  3. Enter the number of the output on the output module that this device will drive in the Output Number field.

A.2.7.2 Output Coil Negated

This device is a negated output coil for ladder diagrams.

➢ To set the parameters for this device:
  1. Double-click on the output coil and select the Value tab.
  2. Enter the address for the output module associated with this device in the Output Module Base Address field.
  3. Enter the number of the output on the output module that this device will drive in the Output Number field.
A.3 Miscellaneous Peripherals

A.3.1 Holding Tank

This device is a liquid holding tank for use in ladder diagrams.

To set the parameters for this device:

1. Double-click on the relay coil and select the Value tab.
2. Set the following parameters as desired:
   - Tank Volume (litres) — capacity of the tank in litres.
   - Level Detector Set Point (litres) — the level of the SP (set point) marker (see above screen capture).
   - Maximum Pump Flow Rate (litres/second) — the maximum speed at which the liquid is pumped into the holding tank. If the Flow pin of the holding tank (see above screen capture) is unconnected, the liquid only flows at this speed.
   - Flow Rate Full Scale Voltage — if the Flow pin of the holding tank is connected, this is the voltage required at the Flow pin to make the liquid move at the maximum speed set in the Maximum Pump Flow Rate field. For example, if you enter 5 V in this field, and then apply 5 V to the Flow pin, the liquid will flow at 1 litre/second if the value in the Maximum Pump Flow Rate field is 1. If you apply 2.5 V to the Flow pin, the liquid will flow at half that speed (0.5 litre/second).
   - Sensor Full Scale Voltage — the sensor voltage that equates to a full tank. As the tank fills, the voltage shown in the Sensor field of the holding tank (see above screen capture) increases.

Note For an example of this component in a complete circuit, refer to “4.4.1 Holding Tank” on page 4-7.
A.3.2  Conveyor Belt

This device is a conveyor belt for use in ladder diagrams.

➢ To set the parameters for this device:

1. Double-click on the relay coil and select the Value tab.
2. Set the following parameters as desired:

   • **Belt Length (meters)** — the length of the conveyor belt in meters.
   • **Max. Belt Speed (meters/sec)** — the maximum speed the belt moves. If the Speed pin of the conveyor belt (see above screen capture) is unconnected, the belt only moves at this speed.
   • **Speed Control Full Scale Voltage** — if the Speed pin of the conveyor belt is connected, this is the voltage required at the Speed pin to make the belt move at the maximum speed set in the Max. Belt Speed field. For example, if you enter 5 V in this field, and then apply 5 V to the Speed pin, the belt will move at 0.5 meters/second if the value in the Max. Belt Speed field is 0.5. If you apply 2.5 V to the Speed pin, the belt will move at half that speed (0.25 meters per second).
   • **Sensor 1 Position (meters)** — the position of Sensor 1 from the left edge of the belt.
   • **Sensor 2 Position (meters)** — the position of Sensor 2 from the left edge of the belt.
   • **Sensor 3 Position (meters)** — the position of Sensor 3 from the left edge of the belt. Do not set greater than the Belt Length value.

*Note* For an example of this component in a complete circuit, see “4.4.2 Conveyor Belt” on page 4-12.
A.3.3 Traffic Light

This component has no parameters that need to be set up in the Value tab.

**Note** For an example of this component in a complete circuit, see “4.4.3 Traffic Light” on page 4-17.

A.3.4 Single Traffic Light

This device is similar to the double traffic light (see “A.3.3 Traffic Light” on page A-23) except that it contains a single bank of lights.
A.4 Virtual NI ELVIS Components

Virtual NI ELVIS components are special devices that are only accessible from special rows on the Virtual NI ELVIS prototyping schematic.

A.4.1 NI ELVIS Function Generator

This component emulates the behavior of a function generator, and is accessed from the left row of the Virtual NI ELVIS prototyping schematic.

To set the parameters for the function generator:

1. Double-click on “Function Generator” in the Virtual NI ELVIS schematic. The properties dialog for the NI ELVIS Function Generator appears.

2. Click on the Value tab and set the following parameters as desired:
   - **Waveform** — choose 1 for a sine wave; 2 for a triangle wave; 3 for a square wave.
   - **Frequency** — the frequency and unit of measure of the function generator output.
   - **Amplitude** — the peak voltage and its unit of measure.
   - **Voltage Offset** — controls the DC level about which the alternating signal varies. An offset of 0 positions the waveform along the oscilloscope's x-axis (provided its Y POS setting is 0). A positive value shifts the DC level upward, while a negative value shifts it downward. Offset uses the units set for Amplitude.
   - **Duty Cycle** — the ratio of on-period to off-period. A sine wave is not affected by this setting.

**Note** See also, “3.2 The Virtual NI ELVIS Schematic” on page 3-2.
A.4.2 NI ELVIS Power Supply

This component is accessed from the left row of the Virtual NI ELVIS prototyping schematic.

To set the parameters for this device:

1. Double-click on “Variable Power Supplies”. The properties dialog box for the NI ELVIS power supply appears.
2. Click on the Value tab and set the following parameters as desired:
   - **Positive Supply Control Key** — select a key to press on the keyboard to increase or decrease the output of the positive variable power supply by the amount set in the Increment Value field. Maximum output is +12 VDC.
   - **Negative Supply Control Key** — select a key to press on the keyboard to increase or decrease the output of the negative variable power supply by the amount set in the Increment Value field. Maximum output is -12 VDC.
   - **Increment Value** — the size of steps by which the power supply’s output is increased or decreased as the control key is pressed on the keyboard.

*Note* See also, “3.2 The Virtual NI ELVIS Schematic” on page 3-2.
Appendix B - Support and Services

B.1 Technical Support and Professional Services

Visit the following sections of the National Instruments web site at ni.com for technical support and professional services:

- **Support** — online technical support resources at ni.com/support include the following:
  - **Self-Help Resources** — For answers and solutions, visit the award-winning National Instruments web site 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.
  - **Free Technical Support** — All registered users receive free Basic Service, which includes access to hundreds of Application Engineers worldwide in the NI Discussion Forums at ni.com/forums. National Instruments Application Engineers make sure every question receives an answer. For information about other technical support options in your area, visit ni.com/services or contact your local office at ni.com/contact.
  - **Training and Certification** — Visit ni.com/training for self-paced training, eLearning, virtual classrooms, interactive CDs, and Certification program information. You also can register for instructor-led, hands-on courses at locations around the world.
  - **System Integration** — If you have time constraints, limited in-house technical resources, or other project challenges, National Instruments Alliance Partner members can help. 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 in the front of this manual. You can also 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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