Exercise 0 - Open and Run a Virtual Instrument

Examine the **Signal Generation and Processing** VI and run it. Change the frequencies and types of the input signals and notice how the display on the graph changes. Change the Signal Processing Window and Filter options. After you have examined the VI and the different options you can change, stop the VI by pressing the Stop button.

     1. Select **Start»Programs»National Instruments»LabVIEW 7.0»LabVIEW** to launch LabVIEW. The **LabVIEW** dialog box appears.

     2. Select **Help»Find Examples.** The dialog box that appears lists and links to all available LabVIEW example VIs.

     3. On the Browse Tab, select browse according to task. Choose **Analyzing and Processing Signals**, then **Signal Processing**, then **Signal Generation and Processing.vi.**
     This will open the Signal Generation and Processing VI Front Panel.

Note You also can open the VI by clicking the **Open VI** button and navigating to labview\examples\apps\demos.llb\Signal Generation and Processing.vi.

Front Panel

4. Click the **Run** button on the toolbar, shown at left, to run this VI.
This VI determines the result of filtering and windowing a generated signal. This example also displays the power spectrum for the generated signal. The resulting signals are displayed in the graphs on the front panel, as shown in the following figure.
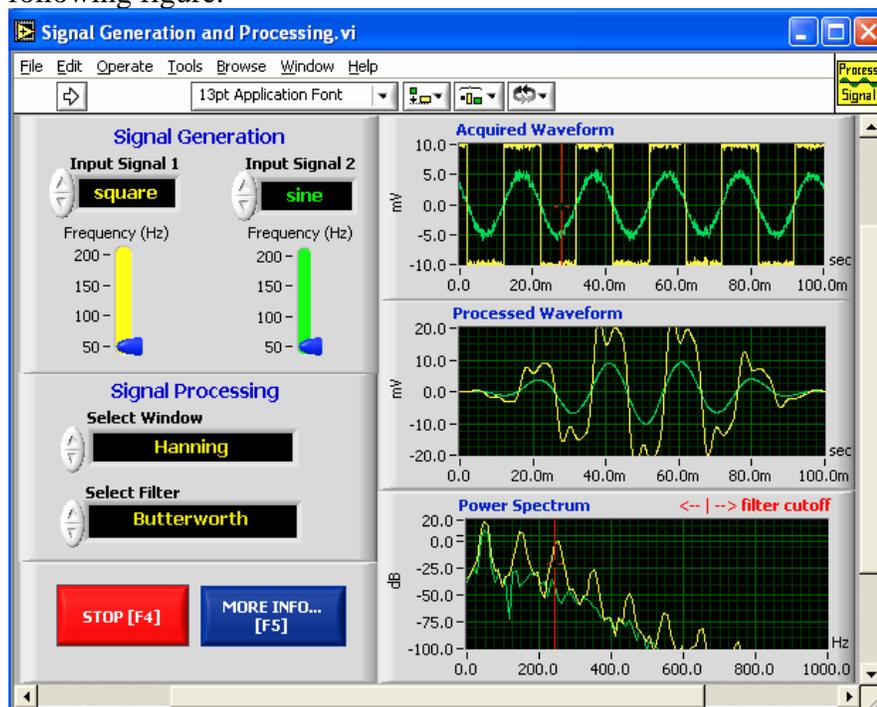
5. Use the Operating tool, shown at left, to change the Input Signal and the Signal Processing, use the increment or decrement arrows on the control, and drag the pointer to the desired Frequency.

6. Press the **More Info… button or [F5] to read more about the analysis functions.**

7. Press the **Stop** button or [F4] to stop the VI.

Block Diagram

8. Select **Window»Show Diagram** or press the <Ctrl-E> keys to display the block diagram for the Signal Generation and Processing VI.

(MacOS) Press the <Command-E> keys. **(Sun)** Press the <Meta-E> keys. **(Linux)** Press the <Alt-E> keys.

This block diagram contains several of the basic block diagram elements, including subVIs, functions, and structures, which you will learn about later in this course.

9. Select **Window»Show Panel** or press the <Ctrl-E> keys to return to the Front Panel.

10. Close the VI and do not save changes.

End of Exercise

Exercise 1 – Convert °C to °F

Build a VI

Complete the following steps to create a VI that takes a number representing degrees Celsius and converts it to a number representing degrees Fahrenheit.

In wiring illustrations, the arrow at the end of this mouse icon shows where to click and the number on the arrow indicates how many times to click.

Front Panel

1. Select **File»New** to open a new front panel.
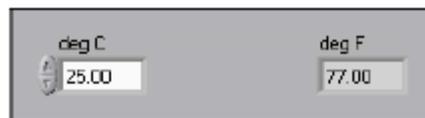
2. (Optional) Select **Window»Tile Left and Right** to display the front panel and block diagram side by side.
3. Create a numeric digital control. You will use this control to enter the value for degrees Centigrade.
   a. Select the digital control on the **Controls»Numeric Controls** palette. If the **Controls** palette is not visible, right-click an open area on the front panel to display it.
   b. Move the control to the front panel and click to place the control.
   c. Type deg C inside the label and click outside the label or click the **Enter** button on the toolbar. If you do not type the name immediately, LabVIEW uses a default label. You can edit a label at any time by using the Labeling tool.
4. Create a numeric digital indicator. You will use this indicator to display the value for degrees Fahrenheit.
   a. Select the digital indicator on the **Controls»Numeric Indicators** palette.
   b. Move the indicator to the front panel and click to place the indicator.
   c. Type deg F inside the label and click outside the label or click the **Enter** button.

   LabVIEW creates corresponding control and indicator terminals on the block diagram. The terminals represent the data type of the control or indicator. For example, a DBL terminal represents a double-precision, floating-point numeric control or indicator.
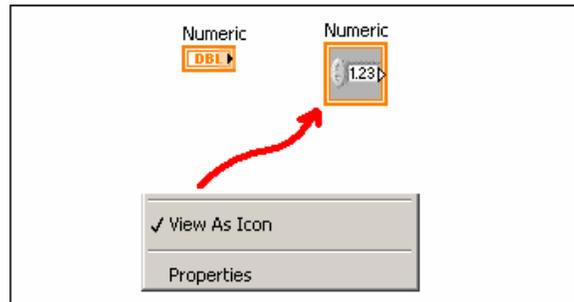
   Note Control terminals have a thicker border than indicator terminals.

Block Diagram

5. Display the block diagram by clicking it or by selecting **Window»Show Diagram**.
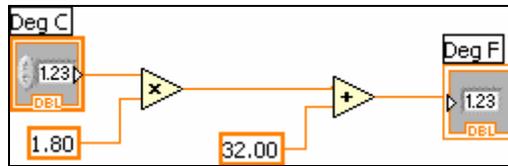
Note: Block Diagram terminals can be viewed as icons or as terminals. To change the way LabVIEW displays these objects right click on a terminal and select **View As Icon**.

6. Select the Multiply and Add functions on the **Functions»Numeric** palette and place them on the block diagram. If the **Functions** palette is not visible, right-click an open area on the block diagram to display it.
7. Select the numeric constant on the **Functions»Numeric** palette and place two of them on the block diagram. When you first place the numeric constant, it is highlighted so you can type a value.
8. Type `1.8` in one constant and `32.0` in the other.
   If you moved the constants before you typed a value, use the Labeling tool to enter the values.
9. Use the Wiring tool to wire the icons as shown in the previous block diagram.

    To wire from one terminal to another, use the Wiring tool to click the first terminal, move the tool to the second terminal, and click the second terminal, as shown in the following illustration. You can start wiring at either terminal.
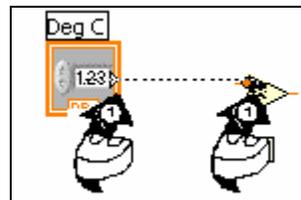
You can bend a wire by clicking to tack the wire down and moving the cursor in a perpendicular direction. Press the spacebar to toggle the wire direction.

To identify terminals on the nodes, right-click the Multiply and Add functions and select **Visible Items»Terminals** from the shortcut menu to display the connector pane. Return to the icons after wiring by right-clicking the functions and selecting **Visible Items»**

Terminals from the shortcut menu to remove the checkmark.

When you move the Wiring tool over a terminal, the terminal area blinks, indicating that clicking will connect the wire to that terminal and a tip strip appears, listing the name of the terminal.

To cancel a wire you started, press the <Esc> key, right-click, or click the source terminal.

10. Display the front panel by clicking it or by selecting **Window»Show Panel**.
11. Save the VI because you will use this VI later in the course.
   a. Select **File»Save**.
   b. Navigate to `c:\exercises\LV Intro`.

Note Save all the VIs you edit in this course in `c:\exercises\LV Intro`.

   c. Type `Convert C to F.vi` in the dialog box.
   d. Click the **Save** button.
12. Enter a number in the digital control and run the VI.
   a. Use the Operating tool or the Labeling tool to double-click the digital control and type a new number.
   b. Click the **Run** button to run the VI.
   c. Try several different numbers and run the VI again.
13. Select **File»Close** to close the Convert C to F VI.

End of Exercise

Exercise 2a – Create a SubVI

Front Panel

1. Select **File»Open** and navigate to `c:\exercises\LV Intro` to open the Convert C to F VI.
    If you closed all open VIs, click the **Open…** button on the **LabVIEW** dialog box.

Tip Click the arrow next to **Open…** button on the **LabVIEW** dialog box to open recently opened files, such as `Convert C to F.vi`.

The following front panel appears.
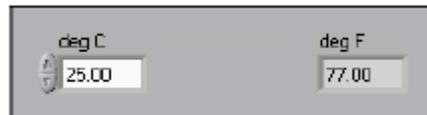
2. Right-click the icon in the upper right corner of the front panel and select **Edit Icon** from the shortcut menu. The **Icon Editor** dialog box appears.
3. Double-click the Select tool on the left side of the **Icon Editor d**ialog box to select the default icon.
4. Press the <Delete> key to remove the default icon.
5. Double-click the Rectangle tool to redraw the border.
6. Create the following icon.
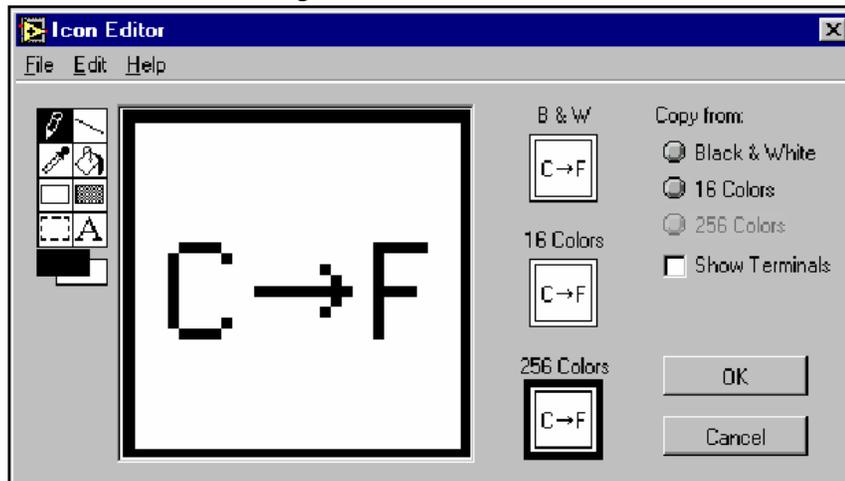
   a. Use the Text tool to click the editing area.
   b. Type `C` and `F`.
   c. Double-click the Text tool and change the font to **Small Fonts**.
   d. Use the Pencil tool to create the arrow.

Note To draw horizontal or vertical straight lines, press the <Shift> key while you use the Pencil tool to drag the cursor.

   e. Use the Select tool and the arrow keys to move the text and arrow you created.
   f. Select the **B&W** icon and select **256 Colors** in the **Copy from** field to create a black and white icon, which LabVIEW uses for printing unless you have a color printer.

g. When the icon is complete, click the **OK** button to close the **Icon Editor** dialog box. The icon appears in the upper right corner of the front panel and block diagram.

7. Right-click the icon on the front panel and select **Show Connector** from the shortcut menu to define the connector pane terminal pattern.
LabVIEW selects a connector pane pattern based on the number of controls and indicators on the front panel. For example, this front panel has two terminals, **deg C** and **deg F**, so LabVIEW selects a connector pane pattern with two terminals.

8. Assign the terminals to the digital control and digital indicator.
   a. Select **Help»Show Context Help** to display the **Context Help** window. View each connection in the **Context Help** window as you make it.
   b. Click the left terminal in the connector pane. The tool automatically changes to the Wiring tool, and the terminal turns black.
   c. Click the **deg C** control. The left terminal turns orange, and a marquee highlights the control.
   d. Click an open area of the front panel. The marquee disappears, and the terminal changes to the data type color of the control to indicate that you connected the terminal.
   e. Click the right terminal in the connector pane and click the **deg F** indicator. The right terminal turns orange.
   f. Click an open area on the front panel. Both terminals are orange.
   g. Move the cursor over the connector pane. The **Context Help** window shows that both terminals are connected to floating-point values.

9. Select **File»Save** to save the VI because you will use this VI later in the course.

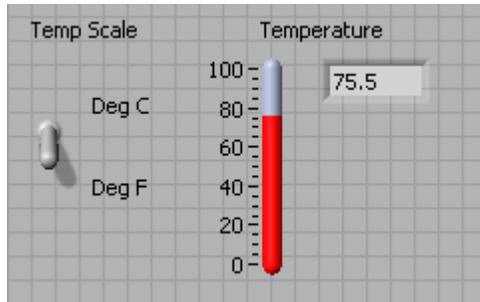10. Select **File»Close** to close the Convert C to F VI.

End of Exercise

Exercise 2b - Data Acquisition

To complete this exercise, you will need the IC temperature sensor available on either the BNC-2120, SCB-68, or DAQ Signal Accessory.

Front Panel

1. Select **File»New** to open a new front panel.
2. Create the thermometer indicator, as shown on the following front panel.

   a. Select the thermometer on the **Controls»Numeric Indicators** palette and place it on the front panel.
   b. Type `Temperature` inside the label and click outside the label or click the **Enter** button on the toolbar.
   c. Right-click the thermometer and select **Visible Items»Digital Display** from the shortcut menu to display the digital display for the thermometer.

3. Create the vertical switch control.
   a. Select the vertical toggle switch on the **Controls»Buttons** palette.
   b. Type `Temp Scale` inside the label and click outside the label or click the **Enter** button.
   c. Use the Labeling tool to place a free label, `deg C`, next to the TRUE position of the switch, as shown in the previous front panel.
   d. Place a free label, `deg F`, next to the FALSE position of the switch.

Block Diagram

4. Select **Window»Show Diagram** to display the block diagram.
5. Build the following block diagram.
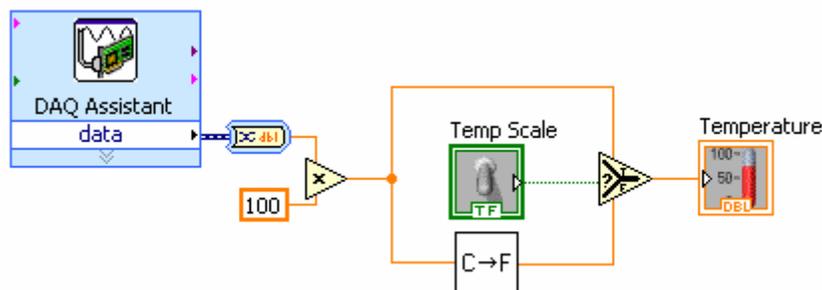
a. Place the DAQ Assistant Express VI located on the **Functions»Input** palette. Make the following configurations in the DAQ Assistant configuration wizard.
   i. Select **Analog Input** as the measurement type.
   ii. Select **Voltage**.
   iii. Select **ai0** as the channel from your data acquisition device.
   iv. In the Task Timing section, select **Acquire 1 sample.**

b. Place the Convert from Dynamic Data function located on the **Functions»Signal Manipulation and select Single Scalar as the Resulting data type.**

c. Place the Multiply function located on the **Functions»Numeric** palette. This function multiplies the voltage that the AI Sample Channel VI returns by `100.0` to obtain the Celsius temperature.

d. Select **Functions»Select a VI**; navigate to the Convert C to F VI, which you built in Exercise 2a, and place the VI on the block diagram. This VI converts the Celsius readings to Fahrenheit.

e. Place the Select function located on the **Functions»Comparison** palette. This function returns either the Fahrenheit (FALSE) or Celsius (TRUE) temperature value, depending on the value of **Temp Scale**.

f. Right-click the **y** terminal of the Multiply function, select **Create»Constant**, type `100`, and press the <Enter> key to create another numeric constant.

g. Use the Positioning tool to place the icons as shown in the previous block diagram and use the Wiring tool to wire them together.

Tip To identify terminals on the nodes, right-click the icon and select **Visible Items»Terminal** from the shortcut menu to display the connector pane.

6. Display the front panel by clicking it or by selecting **Window»Show Panel**.
7. Click the **Continuous Run** button, shown at left, to run the VI continuously.
8. Put your finger on the temperature sensor and notice the temperature increase.
9. Click the **Continuous Run** button again to stop the VI.
10. Create the following icon, so you can use the Temperature VI as a subVI.
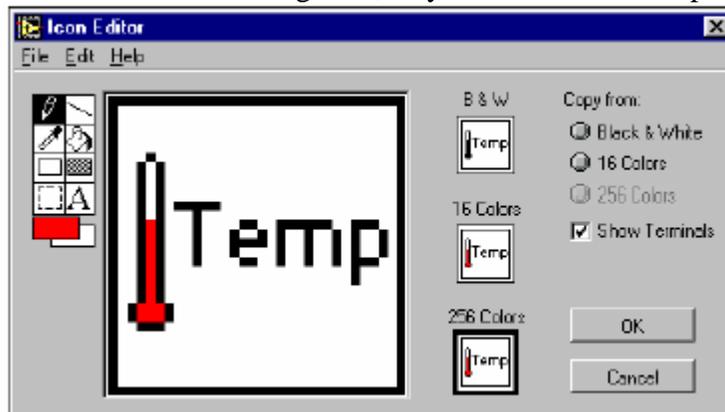
a. Right-click the icon in the upper right corner of the front panel and select **Edit Icon** from the shortcut menu. The **Icon Editor** dialog box appears.

b. Double-click the Select tool on the left side of the **Icon Editor** dialog box to select the default icon.

c. Press the <Delete> key to remove the default icon.

d. Double-click the Rectangle tool to redraw the border.

e. Use the Pencil tool to draw an icon that represents the thermometer.

f. Use the Foreground and Fill tools to color the thermometer red.

Note To draw horizontal or vertical straight lines, press the <Shift> key while you use the Pencil tool to drag the cursor.

a. Double-click the Text tool, shown at left, and change the font to **Small Fonts**.

b. Select the **B&W** icon and select **256 Colors** in the **Copy from** field to create a black and white icon, which LabVIEW uses for printing unless you have a color printer.

c. When the icon is complete, click the **OK** button. The icon appears in the upper right corner of the front panel.

11. Select **File»Save** to save the VI. Choose a location on your hard drive and save the VI as Thermometer.vi.

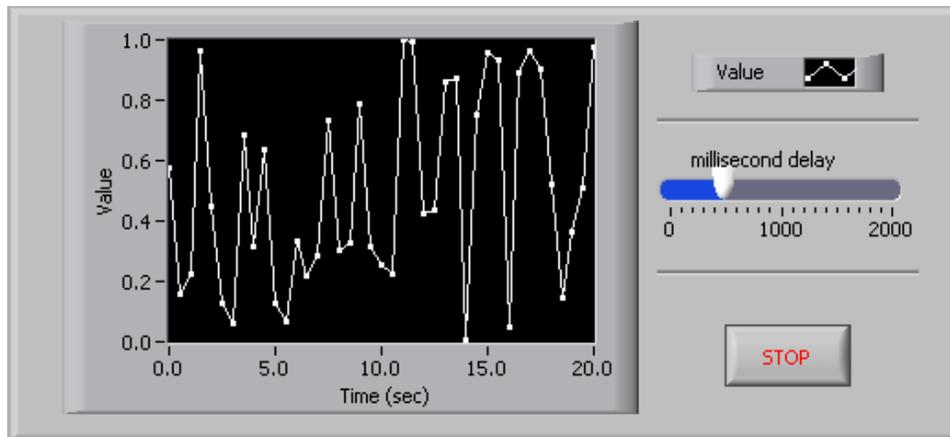12. Select **File»Close** to close the VI.

End of Exercise

Exercise 3 – Using Loops

Use a while loop and a waveform chart to build a VI that demonstrates software timing.

Front Panel

1. Open a new VI.
2. Build the following front panel.

    a. Select the horizontal pointer slide on the **Controls»Numeric Controls** palette and place it on the front panel. You will use the slide to change the software timing.

    b. Type `millisecond delay` inside the label and click outside the label or click the **Enter** button on the toolbar, shown at left.

    c. Place a Stop Button from the **Controls»Buttons palette.**

    d. Select a waveform chart on the **Controls»Graph Indicators** palette and place it on the front panel. The waveform chart will display the data in real time.

    e. Type `Value History` inside the label and click outside the label or click the **Enter** button.

    f. The waveform chart legend labels the plot `Plot 0`. Use the Labeling tool to triple-click `Plot 0` in the chart legend, type `Value`, and click outside the label or click the **Enter** button to relabel the legend.

    g. The random number generator generates numbers between 0 and 1, in a classroom setting you could replace this with a data acquisition VI. Use the Labeling tool to double-click `10.0` in the y-axis, type `1`, and click outside the label or click the **Enter** button to rescale the chart.

    h. Change `-10.0` in the y-axis to `0`.

    i. Label the y-axis `Value` and the x-axis `Time (sec)`.

Block Diagram

3. Select **Window»Show Diagram** to display the block diagram.

4. Enclose the two terminals in a While Loop, as shown in the following block diagram.
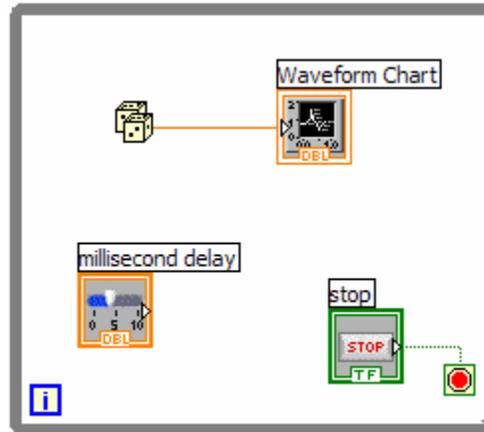
a. Select the While Loop on the **Functions»Execution Control** palette.
b. Click and drag a selection rectangle around the two terminals.
c. Use the Positioning tool to resize the loop, if necessary.

5. Select the Random Number (0-1) on the **Functions»Arithmetic and Comparison»Numeric** palette. Alternatively you could use a VI that is gathering data from an external sensor.
6. Wire the block diagram objects as shown in the previous block diagram.
7. Save the VI as `Use a Loop.vi` because you will use this VI later in the course.
8. Display the front panel by clicking it or by selecting **Window»Show Panel**.
9. Run the VI.
   The section of the block diagram within the While Loop border executes until the specified condition is TRUE. For example, while the STOP button is not pressed, the VI returns a new number and displays it on the waveform chart.
10. Click the STOP button to stop the acquisition. The condition is FALSE, and the loop stops executing.
11. Format and customize the X and Y scales of the waveform chart.
    a. Right-click the chart and select **Properties** from the shortcut menu. The following dialog box appears.
    b. Click the **Scale tab** and select different styles for the y-axis. You also can select different mapping modes, grid options, scaling factors, and formats and precisions. Notice that these will update interactively on the waveform chart
    c. Select the options you desire and click the **OK** button.
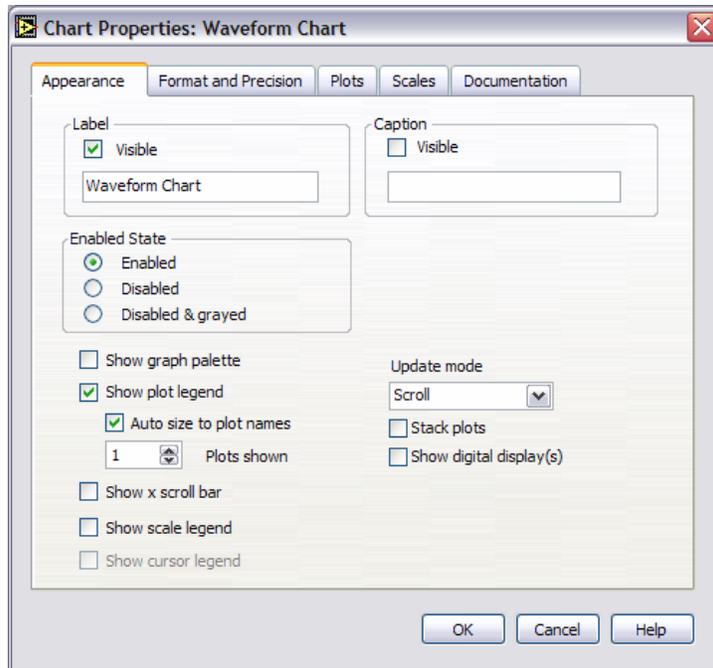
12. Right-click the waveform chart and select **Data Operations»Clear Chart** from the shortcut menu to clear the display buffer and reset the waveform chart. If the VI is running, you can select **Clear Chart** from the shortcut menu.

Adding Timing

When this VI runs, the While Loop executes as quickly as possible. Complete the following steps to take data at certain intervals, such as once every half-second, as shown in the following block diagram.
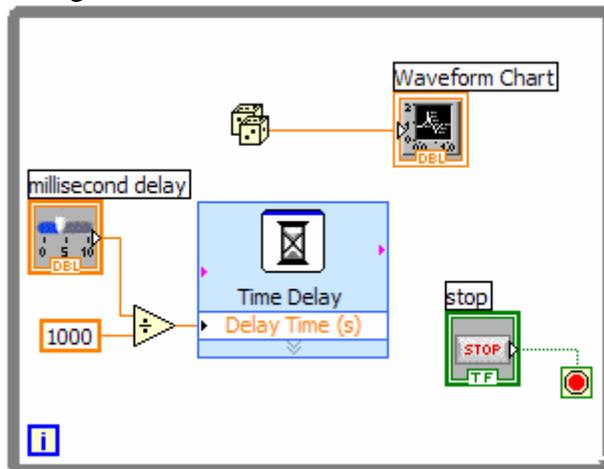
a. Place the Time Delay Express VI located on the **Functions»Execution Control** palette. In the dialog box that appears, insert 0.5. This function would make sure that each iteration occurs every half-second (500 ms).

      b. Divide the millisecond delay by 1000 to get time in seconds. Connect the output of the divide function to the Delay Time (s) input of the Time Delay Express VI. This will allow you to adjust the speed of the execution from the pointer slide on the front panel.

13. Save the VI, because you will use this VI later in the course.
14. Run the VI.
15. Try different values for the millisecond delay and run the VI again. Notice how this effects the speed of the number generation and display.
16. Close the VI.

End of Exercise

Exercise 4 - Analyzing and Logging Data

Complete the following steps to build a VI that measures temperature every 0.25 s for 10s. During the acquisition, the VI displays the measurements in real time on a waveform chart. After the acquisition is complete, the VI plots the data on a graph and calculates the minimum, maximum, and average temperatures. The VI displays the best fit of the temperature graph.
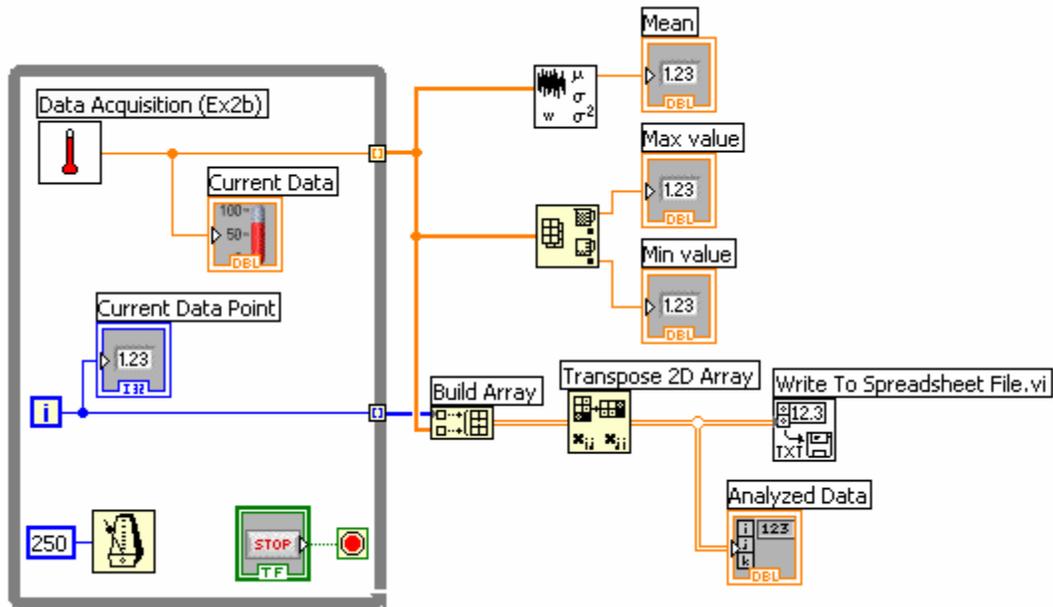
Front Panel

1. Open a new VI and build the following front panel using the following tips.
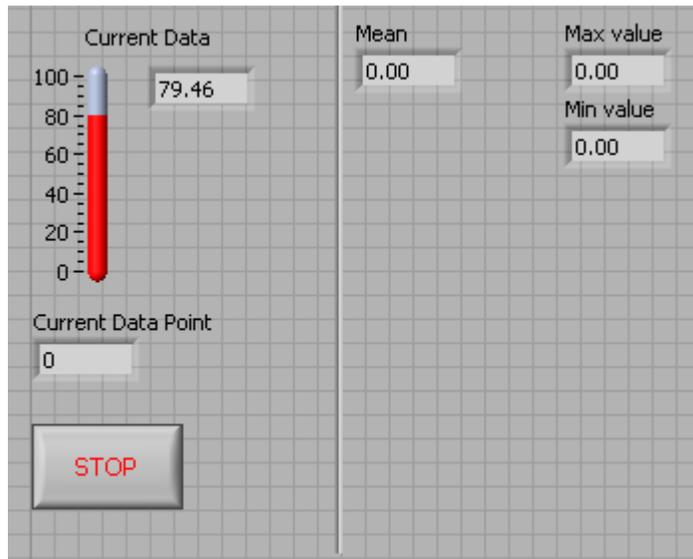
Do not create the **Mean**, **Max**, and **Min** indicators yet. Create them on the Block Diagram by right clicking on the functions and choosing Create Indicator. Then position them on the Front Panel.

Block Diagram

2. Build the following block diagram.

a. Select **Functions»All Functions»Select a VI…** and choose Thermometer.vi (from previous exercise).
b. Place the Wait Until Next ms Multiple function located on the **Functions»All Functions »Time & Dialog** palette and create a constant of 250. Much like the Time Delay Express VI, this function causes the For Loop to execute every 0.25 s (250 ms).
c. Place the Array Max & Min function located on the **Functions»All Functions »Array** palette. This function returns the maximum and minimum temperature.
d. Place the Mean VI located on the **Functions»All Functions» Mathematics»Probability and Statistics** palette. This VI returns the average of the temperature measurements.
e. Right-click the output terminals of the Array Max & Min function and Mean VI and select **Create»Indicator** from the shortcut menu to create the **Max**, **Min**, and **Mean** indicators.
f. Place the Build Array function located on the **Functions»Array** palette. This function creates an array of data points and values.
g. Place the Transpose 2D Array function located on the F**unctions»Array** palette. This transposes the array so it will appear as columns in the file.
h. Place the Write To Spreadsheet File function located on **Functions»File I/O** palette. This will save the data to a spreadsheet file.

3. Save the VI as Temperature Logger.vi.
4. Display the front panel and run the VI.
5. After pressing STOP a dialog box will appear. Enter the name of the file to save the spreadsheet.
6. Open the spreadsheet file to make sure the file was properly created by using Notepad or by creating a VI to read the file as follows.
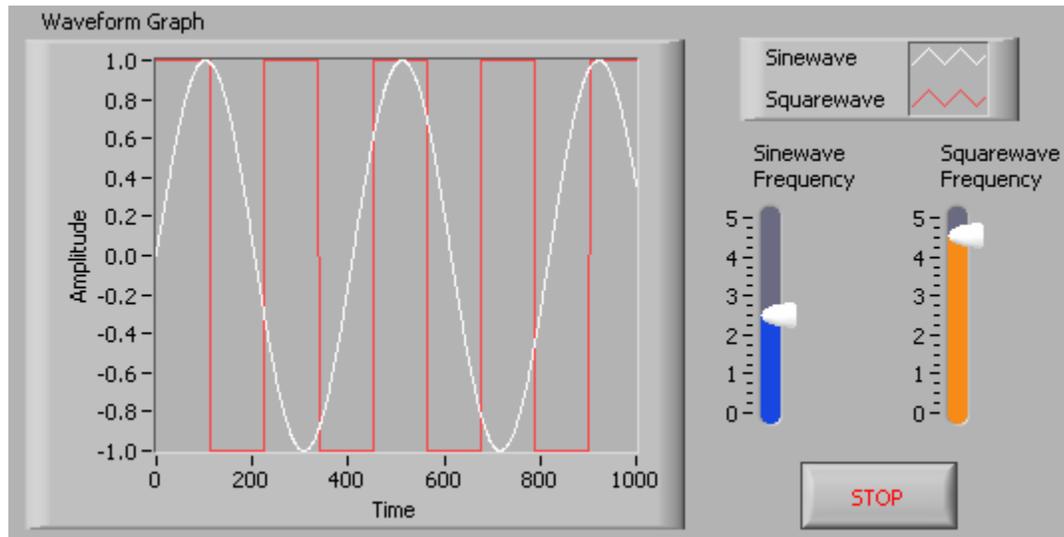
7. Run the VI
8. Save and close both of the VIs.

End of Exercise

Exercise 5 - Using Waveform Graphs

Front Panel

1. Open a new VI and build the following front panel using the following tips.

a. Create a waveform graph indicator from the **Controls»Graph Indicators** palette. Use the position/size/select tool to move the plot legend to the side, and expand it to display two plots. Use the labeling tool to change the plot names and the properties page to choose different colors for your plots.

b. Place a Stop button on the front panel.

c. Place two vertical pointer slides from the **Controls»Numeric Controls** palette. Use the properties page again to change the slide fill color.

Block Diagram

2. Build the following block diagram.
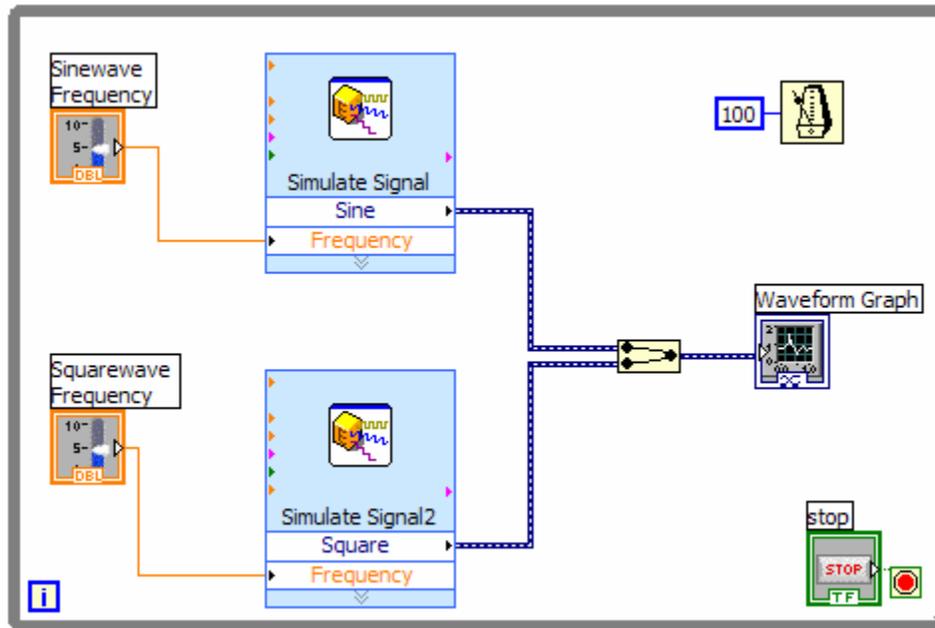
     a. Place a While Loop from **Functions»Execution Control** palette.

     b. Place a **Wait Until Next ms Multiple** from **Functions»All Functions »Time & Dialog and create a constant with a value of 100.**

     c. **Place two Simulate Signal Express VIs from the Functions»Input and leave the Signal type as Sine for the first Simulate Signal VI and change the Signal Type to Square for the second VI. Wire both of the outputs into the waveform graph. A Merge Signals function will automatically be inserted.**

     d. **Expand the Simulate Signal Express VIs to show another Input/Output. By default, error out should appear. Change this to Frequency by clicking on error out and choosing Frequency.**

3. Save the VI as `Multiplot Graph.vi.`

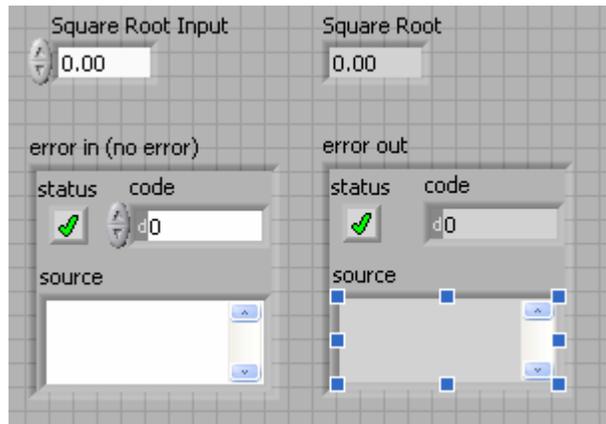4. Display the front panel and run the VI.

5. Save and close the VI.

End of Exercise

Exercise 6 - Error Clusters & Handling

Front Panel

1. Open a new VI and build the following front panel using the following tips.

    a. Create a numeric control and change the Label to Square Root Input. Create a numeric indicator for Square Root.

    b. Place Error In 3D.ctl from **Controls»All Controls»Arrays & Clusters.**

    c. Place Error Out 3D.ctl from **Controls» All Controls»Arrays & Clusters.**

Block Diagram

2. Build the following block diagram.
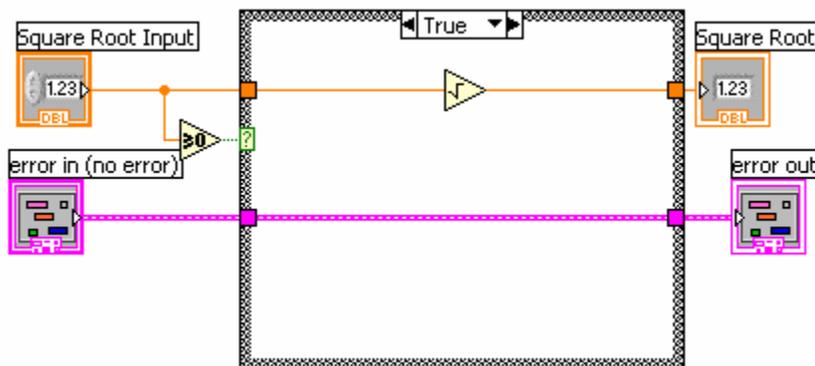
    a. Place a Case Structure from **Functions»Execution Control** palette.

    b. Place a **Greater or Equal to 0?** from the **Functions»Arithmetic and Comparison»Comparison palette and wire it to the condition terminal of the case structure.**

In the True Case:
>
> c. Place the Square Root function from **Functions»Arithmetic and Comparison»Numeric palette.**

In the False Case:
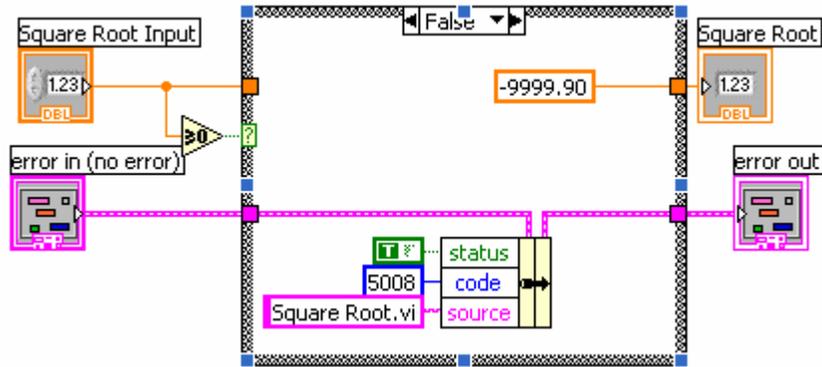
> d. Create a numeric constant from **Functions»Arithmetic and Comparison»Numeric palette and type -9999.90.**
> e. **Place the Bundle By Name from Functions»All Functions»Arrays & Clusters palette. Wire from Error in to the center terminal of Bundle by Name to make status show up. Create constants. Wire from the Error Out indicator to the output of Bundle By name.**

3. Save the VI as `Square Root.vi`.
4. Display the front panel and run the VI.
5. Save and close the VI.

## End of Exercise

Exercise 7 - Simple State Machine

Create a VI using state machine architecture that simulates a simple test sequence. The VI will have an initial state, where it will display a pop-up message indicating that it is starting the test. Then it will proceed to the next case and then to the final state where it will ask the user whether to start over or end the test.

Front Panel

Rather than start from scratch, we will use a VI template to create our state machine.

1. From the initial LabVIEW screen click on **New…**, and choose Standard State Machine, which is located under the **VI from Template » Frameworks » Design Patterns** heading.
2. Examine the template, and then save it in another directory before you begin working on it.

Block Diagram
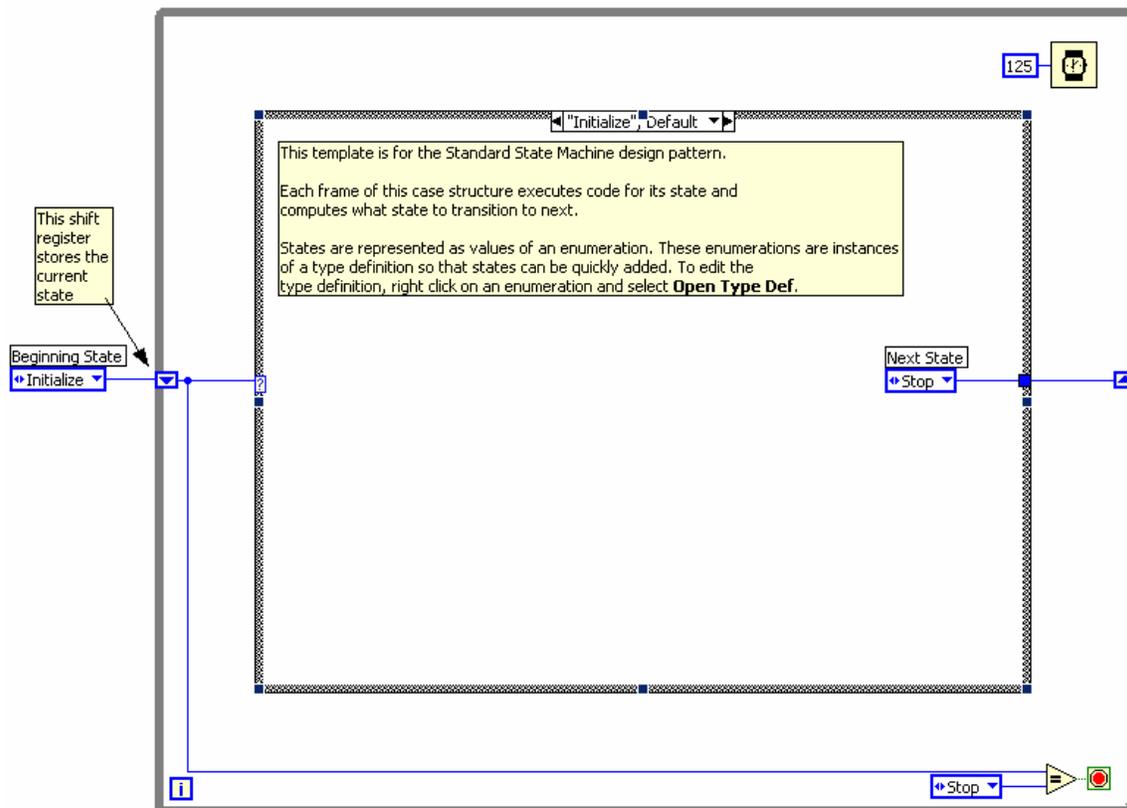
3. Right click on the enum constant labeled Next State and select Open Type Def.

4. On the front panel of the StateMachinesStates.ctl Type Def VI, right click on the States enum control and choose **Edit Items**.
5. Add two more states. Call them "State 1" and "State 2"
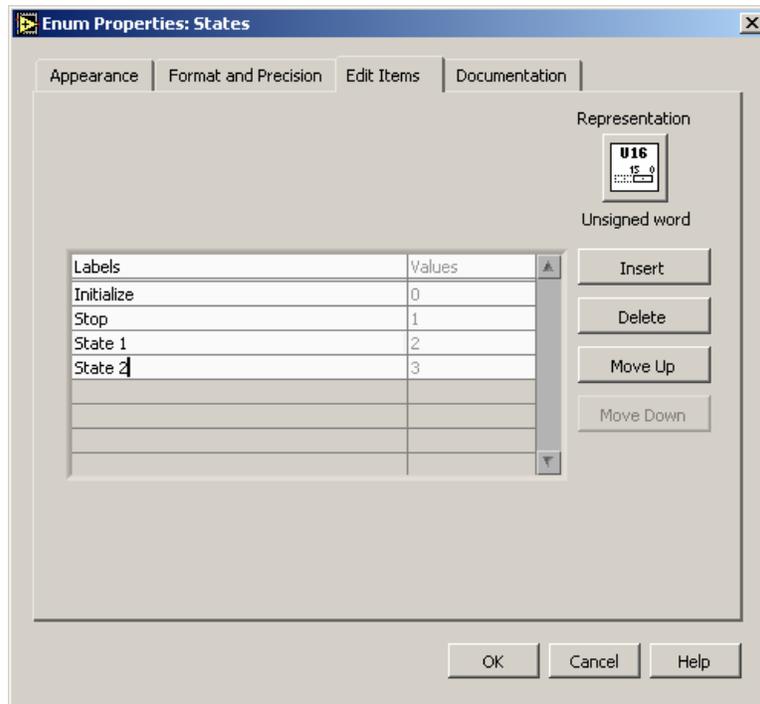
6. Close the State Machines.ctl Type Def Front panel and save the control with the default name when prompted.
7. Right click on the Case Selector Label of the case structure and choose Duplicate case. Do this one additional time so that there are four cases: Initialize, State 1, State 2, and Stop.
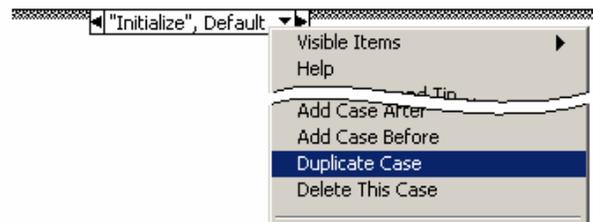

8. Change the value connected to the Wait function to 2000.
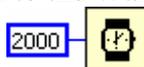
9. Right click on the shift register on the left side of the while loop and create an indicator. Change it's name to "Current State".
10. In the "Initialize", Default case place a One Button Dialog function and wire a string constant into the **Message** input. Type "Now beginning test…" into the string constant.

Now beginning test...
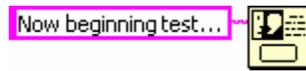
11. Change the enum constant labled Next State to "State 1".
12. Change to the next state in the case structure ("State 1") and change the enum constant labled Next State to "State 2".
13. Change to the next state ("State2") and add the following code.
    a. Place a Select function and connect two enum constants
    (Tip: Copy the enum constants from one of the previous cases)
    b. Place a Two Button Dialog and wire create the constants as illustrated below.
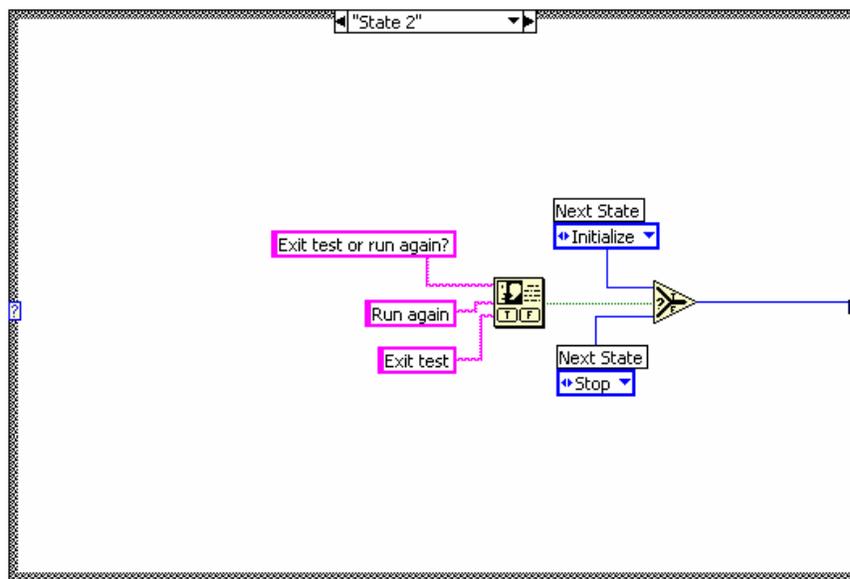
14. Run the VI.
15. Save and close the VI.

End of Exercise