E. Waveform and XY Graphs

VIs with graphs usually collect the data in an array and then plot the data to the graph. The following illustration shows the elements of a graph.

The graphs located on the Controls►Graph palette include the waveform graph and XY graph. The waveform graph plots only single-valued functions, as in $y = f(x)$, with points evenly distributed along the x-axis, such as acquired time-varying waveforms. XY graphs display any set of points, evenly sampled or not.

Resize the plot legend to display multiple plots. Use multiple plots to save space on the front panel and to make comparisons between plots. XY and waveform graphs automatically adapt to multiple plots.

### Single-Plot Waveform Graphs

The waveform graph accepts a single array of values and interprets the data as points on the graph and increments the $x$ index by one starting at $x = 0$. The graph also accepts a cluster of an initial $x$ value, a $\Delta x$, and an array of $y$ data. Refer to the Waveform Graph VI in the examples\general\graphs\gengraph.llb for examples of the data types that single-plot waveform graphs accept.
**Multiple-Plot Waveform Graphs**

A multiplot waveform graph accepts a 2D array of values, where each row of the array is a single plot. The graph interprets the data as points on the graph and increments the x index by one, starting at $x = 0$. Wire a 2D array data type to the graph, right-click the graph, and select **Transpose Array** from the shortcut menu to handle each column of the array as a plot. Refer to the (Y) Multi Plot 1 graph in the Waveform Graph VI in the examples\general\graphs\gengraph.llb for an example of a graph that accepts this data type.

A multiplot waveform graph also accepts a cluster of an x value, a $\Delta x$ value, and a 2D array of y data. The graph interprets the y data as points on the graph and increments the x index by $\Delta x$, starting at $x = 0$. Refer to the (X0, dX, Y) Multi Plot 3 graph in the Waveform Graph VI in the examples\general\graphs\gengraph.llb for an example of a graph that accepts this data type.

A multiplot waveform graph accepts a cluster of an initial x value, a $\Delta x$ value, and an array that contains clusters. Each cluster contains a point array that contains the y data. You use the Bundle function to bundle the arrays into clusters, and you use the Build Array function to build the resulting clusters into an array. You also can use the Build Cluster Array, which creates arrays of clusters that contain inputs you specify. Refer to the (X0, dX, Y) Multi Plot 2 graph in the Waveform Graph VI in the examples\general\graphs\gengraph.llb for an example of a graph that accepts this data type.

**XY Graphs**

The XY graph is a general-purpose, Cartesian graphing object that plots multivalued functions, such as circular shapes or waveforms with a varying timebase.

**Single-Plot XY Graphs**

The single-plot XY graph accepts a cluster that contains an x array and a y array. The XY graph also accepts an array of points, where a point is a cluster that contains an x value and a y value. Refer to the XY Graph VI in the examples\general\graph\gengraph.llb for an example of single-plot XY graph data types.
Multiplot XY Graphs

The multiplot XY graph accepts an array of plots, where a plot is a cluster that contains an x array and a y array. The multiplot XY graph also accepts an array of clusters of plots, where a plot is an array of points. A point is a cluster that contains an x value and a y value. Refer to the XY Graph VI in the examples\general\graph\gengraph.llb for an example of multiplot XY graph data types.
Lesson 5  Arrays, Graphs, and Clusters

Exercise 5-2  Graph Waveform Array VI

Objective:  To create an array by auto-indexing a For Loop and to plot the array on a waveform graph.

Complete the following steps to build a VI that generates and plots an array on a waveform graph and modify the VI to graph multiple plots.

Front Panel

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

   a. Place an array located on the Controls»Array & Cluster palette.
   b. Label the array Waveform Array.
   c. Place a digital indicator located on the Controls»Numeric palette in the array shell.
   d. Place a waveform graph located on the Controls»Graph palette.

Block Diagram

2. Build the following block diagram.
**Tip** When you wire data to charts and graphs, use the **Context Help** window to determine how to wire them, including whether to use a Build Array or Bundle function, the order of the input terminals, and so on. In general, use a waveform chart for single scalar points, a waveform graph for an array of y values, and an XY graph for an array of x values and an array of y values. For example, if you move the cursor over a waveform graph terminal on the block diagram, the following information appears in the **Context Help** window. Select **Help» Find Examples** and **Fundamentals»Graphs and Charts** to access the example Waveform Graph VI. Refer to Lesson 8, *Data Acquisition and Waveforms*, for more information about the waveform data type.

![Context Help Window](image)

a. Select **Functions»Select a VI**, navigate to c:\exercises\LVBasicsI, double-click the Thermometer VI, which you built in Exercise 3-2, and place the VI on the block diagram. This VI returns one point of simulated temperature data during each For Loop iteration.

b. Place a For Loop located on the **Functions»Structures** palette. Each For Loop iteration generates a temperature value and stores it in the tunnel. Create a constant of 100 for the count terminal.

3. Save the VI as **Graph Waveform Array.vi**.

4. Display the front panel and run the VI. The VI plots the auto-indexed waveform array on the waveform graph.

5. Enter the index of any element in the **Waveform Array** index display to view the value of that element. If you enter a number greater than the array size of 100, the display dims.

6. Use the Positioning tool to resize **Waveform Array** to view more than one element. The indicator displays elements in ascending index order, beginning with the index you entered.
Lesson 5  Arrays, Graphs, and Clusters

7. Display the block diagram.

In this block diagram, you use the default value of the initial \( x \) and \( \Delta x \) value for the waveform. In cases where the initial \( x \) and \( \Delta x \) value are a specific value, use the Bundle function to specify an initial \( x \) and \( \Delta x \) value for a waveform array.

8. Build the following block diagram.

![Diagram](image)

a. Place the Bundle function located on the **Functions»Cluster** palette. This function assembles the plot elements into a single cluster. The elements include the initial \( x \) value (20), the \( \Delta x \) value (0.5), and the \( y \) array of waveform data.

b. Place two numeric constants located on the **Functions»Numeric** palette for the initial \( x \) value and \( \Delta x \) value.

c. Label the \( \Delta x \) constant by typing \( \Delta x \). Use the Labeling tool to select the \( \Delta \) and select the **Symbol** font from the **Text Settings** pull-down menu on the toolbar. \( \Delta \) converts to the delta symbol (\( \Delta \)).

9. Display the front panel.

10. Save and run the VI.

The graph displays the same 100 points of data with a starting value of 20 and a \( \Delta x \) of 0.5 for each point on the \( x \)-axis. In a timed test, this graph would correspond to 50 seconds worth of data starting at 20 seconds.

11. Right-click the waveform graph and select **Visible Items»Graph Palette** from the shortcut menu to display the graph palette. Click the **Zoom** button to see the data on the graph in more detail.

12. Right-click the graph and select **Visible Items»Scale Legend** from the shortcut menu to display the scale legend.

13. Display the block diagram.

14. Change \( x_0 \) and \( \Delta x \) to 0 and 1, respectively.
15. Display the front panel and change the scale formatting, as shown in the following front panel.

**Note** Change the initial \( x \) and \( \Delta x \) values in only one location, either the Bundle function or X Scale»Formatting.

![Waveform Graph and X Scale Formatting](image.png)

a. Right-click the waveform graph and select X Scale»Formatting from the shortcut menu.

b. Change Format to Time & Date.

c. Make sure HH:MM:SS is selected.

d. Change the Scaling Factors to an \( X_0 \) of 7:30:00.00 AM 01/15/2000 and a \( \Delta X \) of 0:10:00.00.

e. Click the OK button to apply the changes.

   If the \( x \)-axis text is not visible, use the Positioning tool to decrease the size of the inner display (black area) of the graph.

f. Save and run the VI.
Multiple-Plot Graphs

Complete the following steps to create a multiple-plot waveform graph by building a 2D array of the data type normally passed to a single-plot graph.

16. Build the following block diagram.

![Block Diagram Image]

a. Place the Sine function located on the Functions » Numeric » Trigonometric palette. Use this function to build an array of points that represents one cycle of a sine wave.

b. Place the Build Array function located on the Functions » Array palette. This function creates the data structure to plot two arrays on a waveform graph.

c. Place the pi constant located on the Functions » Numeric » Additional Numeric Constants palette.

d. Place the Numeric functions and create the numeric constants, as shown in the previous block diagram.

17. Display the front panel.

18. Save and run the VI. The two waveforms plot on the same waveform graph.

19. Display the block diagram.

20. Right-click the wire to Waveform Array, select Custom Probe » Graph from the shortcut menu, and select a waveform graph to place a graph probe on the wire.

21. Display the front panel and run the VI. The probe shows only the data array. The sine wave is not present because you did not place the probe on the wire to which the sine wave is bundled.

22. Close the Probe window.
23. Zoom in on a portion of the graph.
   a. Click the **Zoom** button on the graph palette, shown at left, to display the following pull-down menu.
   ![Zoom Menu]
   b. Select **Zoom by X Rectangle**, as shown.
   c. Click and drag a selection rectangle on the graph. When you release the mouse button, the graph display zooms in on the selected area.
   d. You also can select **Zoom by Y Rectangle** or **Zoom by Selected Area**. Experiment with these options.
   e. Select **Undo Zoom** from the lower left corner of the pull-down menu to undo a zoom or click the x-axis single fit button and the y-axis single fit button on the scale legend, shown at left.

24. Use the Panning tool, shown at left, to click and drag the graph display. Click the x-axis and y-axis single fit buttons again to restore the display to its original position.

25. Use the Cursor Movement tool, shown at left, to return the cursor to standard mode.

26. Save and close the VI.

**End of Exercise 5-2**
Exercise 5-3  Temperature Analysis VI

Objective:  To graph and analyze data.

Complete the following steps to build a VI that measures temperature every 0.25 s for 10 s. 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.

   - Set the point style of the waveform chart plot to a small x.
   - Hide the plot legend of the waveform chart.
   - Right-click the waveform chart, select X Scale»Formatting from the shortcut menu, and change ΔX to 0.25 and Digits of Precision to 2.
   - Use the Positioning tool to resize the plot legend of the waveform graph.
   - Use the Labeling tool to rename Plot 0 to Temp and Plot 1 to Fitted.

   ![Temp Chart and Temp Graph with Mean, Max, and Min values shown.](image)
• Set the point style of the waveform graph Temp plot to a small square.
• Do not create the Mean, Max, and Min indicators yet.

**Block Diagram**

2. Build the following block diagram.

![Block Diagram Image]

a. Select Functions»Select a VI, navigate to c:\exercises\LVBasicsI, double-click the Thermometer VI, which you built in Exercise 3-2, and place the VI on the block diagram. This VI returns one point of simulated temperature data.

b. Place the Wait Until Next ms Multiple function located on the Functions»Time & Dialog palette and create a constant of 250. 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»Array palette. This function returns the maximum and minimum temperature.

d. Place the Mean VI located on the 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 General Polynomial Fit VI located on the Functions»Mathematics»Curve Fitting palette. This VI returns an array that is a polynomial fit to the temperature array.
g. Place the Bundle function located on the **Functions**»**Cluster** palette. Press the `<Ctrl>` key while you drag the function to copy it. This function assembles the plot elements into a single cluster. The elements include the initial x value (0), the Δx value (0.25), and the y array of temperature data. The Δx value of 0.25 is required so that the VI plots the temperature array points every 0.25 s on the waveform graph.

h. Place the Build Array function located on the **Functions**»**Array** palette. This function creates an array of clusters from the temperature cluster and the best fit cluster.

3. Save the VI as **Temperature Analysis.vi**.

4. Display the front panel and run the VI.

The graph displays both the temperature data and best fit curve of the temperature waveform.

5. Try different values for the polynomial order constant on the block diagram and run the VI again.

6. Change the appearance of plots by modifying the plot styles and fill styles.
   
a. Right-click the **Temp** plot display in the plot legend and select **Common Plots**»**Scatter Plot** from the shortcut menu, the top middle option.

b. Right-click the **Fitted** plot display in the plot legend, select **Bar Plots** from the shortcut menu, and select the second option in the middle row. The waveform graph should appear similar to the following waveform graph.

7. Save and close the VI.

**End of Exercise 5-3**