

LabWindows™ /CVI™

Getting Started with LabWindows/CVI

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About This Manual

Getting Started with LabWindows/CVI is a hands-on introduction to the LabWindows™/CVI™ software package. This manual is intended for first-time LabWindows/CVI users. To use this manual effectively, you should be familiar with DOS, Microsoft Windows, and the C programming language.

Conventions

The following conventions appear in this manual:

» The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.

This symbol also leads you through the LabWindows/CVI Library Tree to a function panel. For example, **User Interface Library»Pop-up Panels»InstallPopup** directs you to expand the User Interface Library in the Library Tree, expand Pop-up Panels, and select InstallPopup.



This icon denotes a tip, which alerts you to advisory information.



This icon denotes a note, which alerts you to important information.

bold

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

italic

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

monospace

Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.

Related Documentation

The following documents contain information that you may find helpful as you read this manual:

- Harbison, Samuel P. and Guy L. Steele, Jr. *C: A Reference Manual*. Englewood Cliffs, NJ: Prentice-Hall, Inc. 1995.
- *LabWindows/CVI Help*
- *LabWindows/CVI Quick Reference*
- *LabWindows/CVI Instrument Driver Developers Guide*
- *LabWindows/CVI Release Notes*
- *NI-DAQmx Help*
- *DAQ Getting Started Guide*
- *DAQ Assistant Help*
- *Traditional NI-DAQ (Legacy) Function Reference Help*
- *NI-VISA Help*
- *NI-488.2 Help*

Introduction to LabWindows/CVI

This chapter contains an overview of the LabWindows/CVI software development system. It briefly describes the LabWindows/CVI environment, standard libraries, user interface development, and source code editing tools. These topics are discussed in greater detail in subsequent chapters. This chapter also includes an introduction to using hardware with LabWindows/CVI and suggestions for learning more about LabWindows/CVI.

LabWindows/CVI Program Development Overview

LabWindows/CVI is a software development environment for C programmers. LabWindows/CVI provides powerful function libraries and a comprehensive set of software tools for data acquisition, analysis, and presentation that you can use to interactively develop data acquisition and instrument control applications.

You can edit, compile, link, and debug ANSI C programs in the LabWindows/CVI development environment. Additionally, you can use compiled C object modules, dynamic link libraries (DLLs), C libraries, and instrument drivers in conjunction with ANSI C source files when you develop programs.

Typical LabWindows/CVI applications include the following elements:

- User interface
- Data acquisition
- Data analysis
- Program control

Figure 1-1 shows an outline of the relationship between these program elements. Program control elements receive input from the user interface, data acquisition, and data analysis elements. Each element has several sub-components.

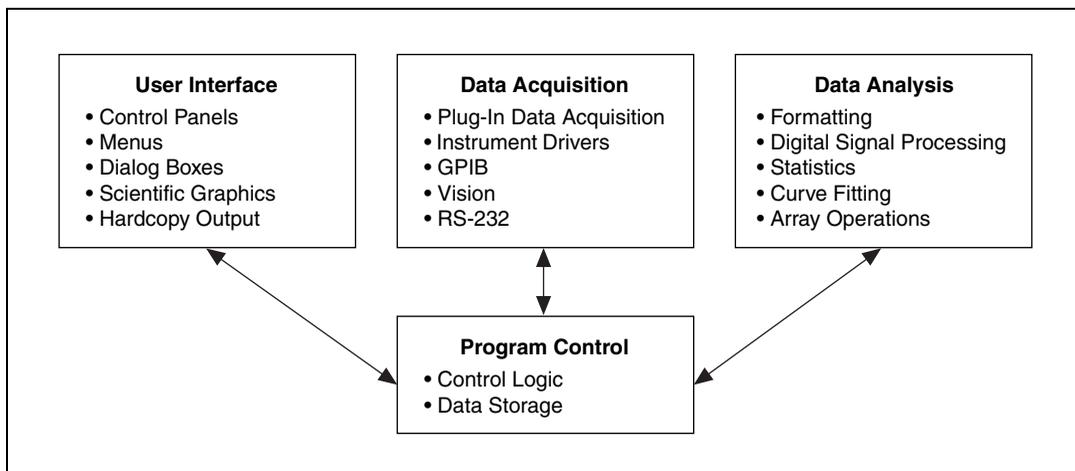


Figure 1-1. Relationship between Program Elements in LabWindows/CVI

Use LabWindows/CVI to create user interfaces that contain graphs, strip charts, and other controls. You also can create pull-down menus, display graphics, and prompt users for input with pop-up dialog boxes. You can use the User Interface Editor to create these items interactively, or you can use the User Interface Library to create them programmatically.

Use the user interface you create to control data acquisition from an instrument or from a plug-in data acquisition (DAQ) device. The user interface also can display the acquired data.

After you acquire data, you must analyze it. For example, you might want to perform formatting, scaling, signal processing, statistical analysis, and curve fitting. The LabWindows/CVI Formatting and I/O Library and Analysis Library (Base package) or Advanced Analysis Library (Full Development System) contain functions that perform these operations.

The program control portion of the program coordinates the user interface, data acquisition, and data analysis. Program control contains the control logic for managing the flow of program execution and user-defined support functions.

Use callback functions to help you control the flow of applications. Callback functions enable your program to execute code in response to user actions, timer ticks, and operating system events.

Organizing Application Components

Use projects and workspaces to organize files and manage application development in LabWindows/CVI. A project (.prj) file contains the files needed to run your application. A project must include one or more of the following files:

- source (.c) files
- object (.obj) files
- library (.lib) files

You may also include the following files in a project:

- header (.h) files
- user interface resource (.uir) files
- instrument driver function panel (.fip) files
- instrument driver program files

You can include one or more projects in a workspace. A workspace (.cws) file contains the settings that do not affect the way a project builds, such as breakpoints, window positions, tag information, and debugging levels. To edit the list of projects the current workspace contains, select **Edit»Workspace**.

LabWindows/CVI Environment

The LabWindows/CVI environment is structured around the Workspace window, which is shown in the following figure:

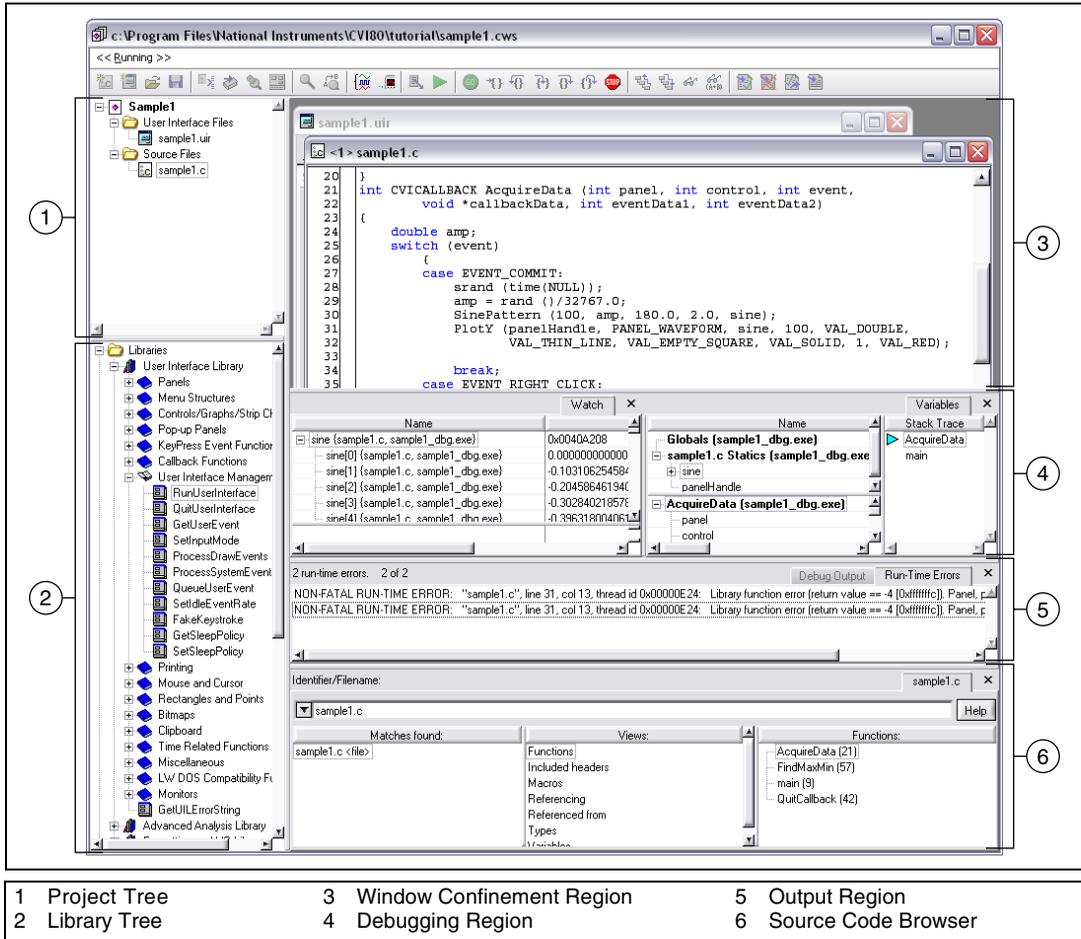


Figure 1-2. Workspace Window

The Workspace window contains the following areas:

- **Project Tree**—Contains the list of files in each project in the workspace. Right-click the different elements of the Project Tree to see the list of options available for files and folders.
- **Library Tree**—Contains a tree view of the functions in LabWindows/CVI libraries and instruments. You can arrange the library functions in alphabetical order, by function

name or function panel title, or in a flat list instead of a hierarchical class structure. Right-click the Library Tree and select **Find** to search for a specific function within the tree.

- **Window Confinement Region**—Contains open Source, User Interface Editor, Function Tree Editor, and function panel windows.
- **Debugging Region**—Contains the Variables, Watch, and Memory windows. Use these windows to view and edit variable values and program memory during debugging.
- **Output Region**—Contains the Build Errors, Run-Time Errors, Source Code Control Errors, Debug Output, and Find Results windows. These windows contain lists of errors, output, and search matches.
- **Source Code Browser**—Contains browse information for selected files, functions, variables, data types, and macros in a program.

Select **Window»Release Window** to move a window that is contained within the Window Confinement Region, Debugging Region, Output Region, or Source Code Browser outside of the Workspace window.



Note You cannot release the Project Tree or Library Tree from the Workspace window. However, you can select **Options»Environment** and then enable the **Auto hide Project and Library Trees** option to remove the Project and Library Trees from the Workspace window when they are not in focus.

The menus and toolbar buttons available within the LabWindows/CVI Workspace window differ depending on what window is active. To learn about what each menu item does, right-click the menu and select **Menu Help**. LabWindows/CVI launches the *LabWindows/CVI Help* topic that describes the items in the selected menu.

Standard Libraries

LabWindows/CVI provides a large set of built-in run-time libraries you can use to develop applications. You can browse the Library Tree or press <Ctrl-Shift-P> in a Source window to find a specific library function.

LabWindows/CVI includes the following standard libraries:

- **User Interface Library**—Functions for creating and controlling a graphical user interface.
- **Analysis Library (Base Package)/Advanced Analysis Library (Full Development System)**—Functions that operate on arrays to simulate and analyze large sets of numerical data quickly and efficiently.
- **Formatting and I/O Library**—Functions for inputting and outputting data to files and manipulating the format of data in a program.

- **Utility Library**—Functions that perform various operations, including using the system timer, managing disk files, launching another executable, and using multiple threads in a program.
- **ANSI C Library**—The ANSI C standard library functions.
- **VXI Library**—Functions for communicating with and controlling VXI devices.
- **GPIB/GPIB 488.2 Library**—Functions for communicating with and controlling devices on the General Purpose Interface Bus (GPIB).
- **RS-232 Library**—Functions for controlling multiple RS-232 ports using interrupt-driven I/O.
- **VISA Library**—Functions for controlling VXI, GPIB, serial, and other types of instruments.
- **TCP Support Library**—Functions that provide a platform-independent interface to the reliable, connection-oriented, byte-stream, network communication protocol.
- **Internet Library**—Functions that communicate with and receive files and commands from remote servers.
- **DDE Support Library**—Functions that you can use to create an interface with other Windows applications using the DDE standard.
- **ActiveX Library**—Functions that create and control ActiveX servers.
- **DIAdem Connectivity Library**—Functions that you can use to log test data in National Instruments DIAdem file format (.tdm).
- **.NET Library**—Functions that facilitate calling .NET assemblies.

User Interface Development

You can use LabWindows/CVI to develop graphical user interfaces (GUIs) that consist of panels, command buttons, pull-down menus, graphs, strip charts, knobs, gauges, and many other controls and indicators. You can use the User Interface Editor to build a GUI in LabWindows/CVI interactively. The User Interface Editor is a drag-and-drop editor that includes tools for designing, arranging, and customizing user interface objects.

You also can use the User Interface Library to create GUIs programmatically in LabWindows/CVI. The User Interface Library provides functions that you can use to add to, change, or build the entire GUI as the application runs.

To learn more about the available user interface elements and the functions that you can use to connect your interface to the rest of your program, refer to the *Using LabWindows/CVI» Developing a Graphical User Interface* and the *Library Reference» User Interface Library* sections of the *LabWindows/CVI Help*.

Generating a Program Shell with CodeBuilder

After you design a GUI in the User Interface Editor, you can use CodeBuilder to automatically generate a program shell based on the components in the GUI. CodeBuilder writes code for all control callback functions and creates a program skeleton that loads and displays GUI windows at program startup. CodeBuilder saves development time by automating many of the common coding tasks required for writing a Windows program. You use CodeBuilder in activities later in this tutorial.

Developing and Editing Source Code

Use the Source window in LabWindows/CVI to develop C source files for projects. LabWindows/CVI is compatible with the full ANSI C language specification. You can use any ANSI C language structures or standard library functions in the source code you develop in this window. LabWindows/CVI provides code generation tools that streamline source code development.

You can use the menu items in the Source window to edit files, debug code, compile files, and so on. You use Source window features in activities later in this tutorial. For more information about the Source window, refer to *Using LabWindows/CVI»Writing Source Code* in the *LabWindows/CVI Help*.

Instrument Control and Data Acquisition

You can use LabWindows/CVI to develop instrument control and data acquisition applications. LabWindows/CVI libraries provide functions for controlling GPIB, RS-232, serial, Ethernet, and National Instruments DAQ devices and modular instruments. LabWindows/CVI also provides interactive assistants you can use to generate code to communicate with different devices and to create and edit NI-DAQmx tasks.

Using the Instrument Control and Data Acquisition Libraries

LabWindows/CVI installs the GPIB/GPIB 488.2, VISA, and VXI libraries. However, LabWindows/CVI does not install the GPIB, VISA, or VXI drivers. Therefore, the GPIB/GPIB 488.2, VISA, and VXI libraries are listed in the Library Tree, but you must install the drivers to use the functions in an application. You can install these drivers from the NI Device Drivers CD. LabWindows/CVI does not install the NI-DAQmx, Traditional NI-DAQ, or IVI libraries or drivers. You also can install these libraries and drivers from the NI Device Drivers CD.

If you want to use instrument control and data acquisition libraries in LabWindows/CVI, you must make sure LabWindows/CVI is configured to load these libraries on startup. To do so, Select **Library»Customize** and check the libraries you want to use. All of the libraries are checked by default.

For a list of hardware library documentation resources, refer to the [Related Documentation](#) section of the [About This Manual](#) chapter.

Using the Instrument I/O Assistant

You can use the NI Instrument I/O Assistant to generate code to communicate with devices such as serial, Ethernet, and GPIB instruments without using an instrument driver. To launch the Instrument I/O Assistant from within the LabWindows/CVI environment, select **Tools»Create Instrument I/O Task**. For more information about using the Instrument I/O Assistant, refer to the *Using LabWindows/CVI»Wizards and Tools»Creating an Instrument I/O Task* section of the *LabWindows/CVI Help*.



Note You must install the NI Instrument I/O Assistant feature from the NI Device Drivers CD to use the Instrument I/O Assistant.

Using the DAQ Assistant

You can use the NI DAQ Assistant to configure measurement tasks, channels, and scales. You also can use the DAQ Assistant to generate NI-DAQmx code from a task. To launch the DAQ Assistant from within the LabWindows/CVI environment, select **Tools»Create/Edit DAQmx Tasks**. For more information about using the DAQ Assistant, refer to the *Using LabWindows/CVI»Data Acquisition»Taking an NI-DAQmx Measurement in LabWindows/CVI* section of the *LabWindows/CVI Help*.



Note You must install NI-DAQmx from the NI Device Drivers CD to use the DAQ Assistant.

Developing Instrument Drivers

If you plan to develop your own instrument driver, refer to the *LabWindows/CVI Instrument Driver Developers Guide*. This document provides information about developing and adding instrument drivers to LabWindows/CVI. It is intended for programmers who develop instrument drivers to control programmable instruments such as GPIB, PXI, and RS-232 instruments. Also refer to the *Using LabWindows/CVI»Instrument Drivers* section of the *LabWindows/CVI Help* for fundamental instrument driver information you must consider if you create or modify a driver.

Learning About LabWindows/CVI

Complete the exercises in the remaining chapters of this tutorial to learn how to build, debug, and deploy applications in LabWindows/CVI. The `tutorial\solution` folder includes completed tutorial exercises you can use for reference.

As you work through this tutorial, refer to the LabWindows/CVI documentation set for more information about the concepts presented in this manual. Use the *Guide to LabWindows/CVI Documentation* topic in the *LabWindows/CVI Help* to learn more about and access the documents in the LabWindows/CVI documentation set. To launch the *LabWindows/CVI Help*, select **Help»Contents**.

After you complete this tutorial, review the example programs included in the `\samples` folder of the LabWindows/CVI installation. These examples illustrate the LabWindows/CVI features and the concepts in this manual. You can use NI Example Finder to search for example programs included in the LabWindows/CVI installation and on ni.com. To launch NI Example Finder, select **Help»Find Examples**.

Building a Graphical User Interface

In the remaining chapters of this tutorial, you develop a project that consists of a GUI controlled by a C source file. In this chapter, you learn to design a user interface with the User Interface Editor.

User Interface Editor

The User Interface Editor is an interactive drag-and-drop editor for designing custom GUIs. You can select a number of different controls from the **Create** menu and position them on the panels you create. You can customize each control through a series of dialog boxes in which you set attributes for the control appearance, source code connection settings, and label appearance.

Source Code Connection

After you design a user interface in the User Interface Editor, you can write C source code to control the GUI. To connect elements on the user interface to the source code, you must assign a constant name to each panel, menu, and control on your user interface. Then, you can use those names in the C source code to differentiate the controls on the GUI. You also can assign a callback function to a control that is called automatically when you operate that control during program execution. Use the Edit dialog box for a control to associate a constant name and a callback function with that control in the User Interface Editor.

After you save a user interface as a `.uir` file, LabWindows/CVI automatically generates an include (`.h`) file that defines all the constants and callback functions you have assigned.

CodeBuilder

After you complete the `.uir` file, you can use CodeBuilder to create a source file that contains skeleton code for your GUI. CodeBuilder automatically includes in the source file the callback functions specified in your `.uir` file. For more information about CodeBuilder, refer to the *Using LabWindows/CVI»Developing a Graphical User Interface»Generating Code from the GUI* section of the *LabWindows/CVI Help*.

Sample Project

In the next several chapters of this tutorial, you build a sample program that acquires and displays a waveform on a GUI. The development process includes the following steps:

1. Create a user interface in the User Interface Editor (this chapter).
2. Generate a program shell source file using CodeBuilder (this chapter).
3. Add source code to generate and display a waveform (Chapter 3, *Using Function Panels and Libraries*).
4. Edit and debug the application (Chapter 4, *Editing and Debugging Tools*).
5. Develop a callback function to compute the maximum and minimum values of the waveform (Chapter 5, *Adding Analysis to Your Program*).
6. Create a distribution to deploy your application on another computer (Chapter 6, *Distributing Your Application*).

Setting Up

Launch LabWindows/CVI by selecting **Start»Programs»National Instruments»LabWindows CVI x.x»NI LabWindows CVI**. When you open LabWindows/CVI, you see an empty Workspace window.

Building a User Interface Resource (.uir) File

Complete the following steps to create the user interface for the sample project, as shown in Figure 2-1.

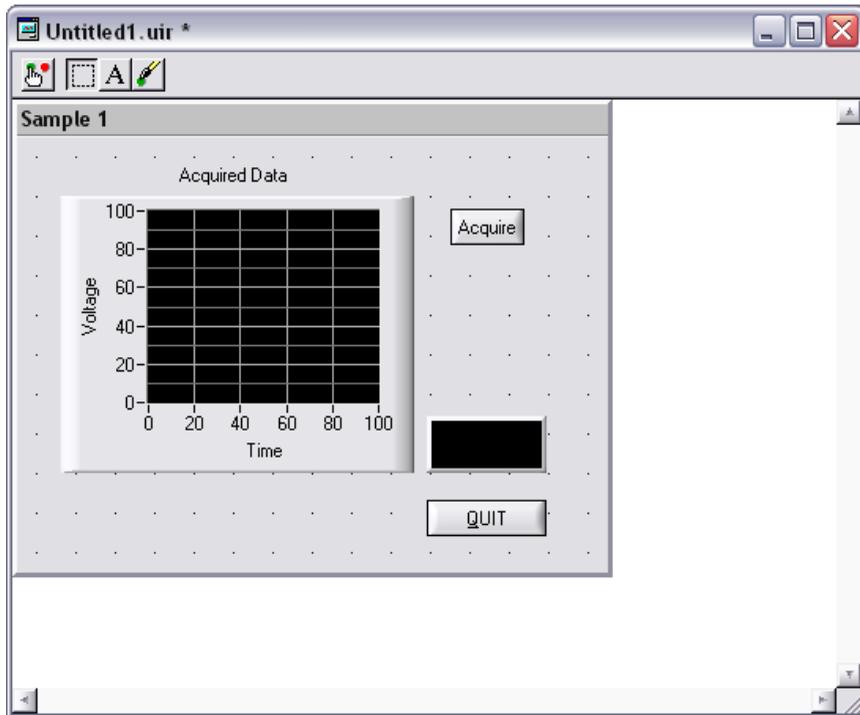


Figure 2-1. sample1.uir

Creating a .uir File

1. Select **File»New»User Interface (*.uir)** to create a new user interface resource file with a blank panel.
2. Double-click the panel to open the Edit Panel dialog box. In the Edit Panel dialog box, enter **Sample 1** as the **Panel Title**.
3. Click **OK** to close the dialog box.

Adding Command Buttons

1. Select **Create»Command Button»Square Command Button**. LabWindows/CVI places a button labeled **OK** on the panel.
2. To edit the button attributes, double-click the button or press <Enter>.

3. Assign a constant name to the button. The C source code uses this constant name to identify the button. LabWindows/CVI creates a default name for you, but you can assign your own constant name. Enter `ACQUIRE` as the **Constant Name**.
4. Assign a function name that the program calls when a user clicks the **Acquire** button. Enter `AcquireData` as the **Callback Function**. In Chapter 3, *Using Function Panels and Libraries*, you write the source code for the `AcquireData` function.
5. To change the label on the command button, enter `Acquire` in place of the existing characters, `__OK`, in **Label**. If you type a double underscore before any letter in **Label**, the letter is underlined on the user interface. The user can select the control by pressing `<Alt>` and the underlined letter, provided that no accessible menu bars contain a menu with the same underlined letter.
6. **(Optional)** Click the **...** button next to the **Label** control to customize the font for your button. Click **OK** in the Edit Label Attributes dialog box when you finish.
7. Click **OK** in the Edit Command Button dialog box.
8. To add the **QUIT** button, select **Create»Custom Controls»Quit Button**. Custom controls are frequently used control configurations. The **QUIT** button already has a callback function, `QuitCallback`, assigned. It is not necessary to modify the default settings for the **QUIT** button.

Adding a Graph Control

1. You also can add controls to a panel by right-clicking the panel and selecting the appropriate control. Right-click the Sample 1 panel and select **Graph»Graph**. LabWindows/CVI places a graph control labeled Untitled Control on the panel.
2. To size the panel, click and drag one of its corners. Use the commands in the **Edit** menu and the **Arrange** menu to cut, copy, paste, align, and space user interface controls in the editor so they appear as shown in Figure 2-1. You also can use the grid lines on the panel to align the controls.
3. Double-click the graph control to open the Edit Graph dialog box, which you can use to customize the graph attributes.
4. Enter `WAVEFORM` as the **Constant Name**.



Note Because the graph serves only as an indicator to display a waveform, the graph does not require a callback function. Callback functions are necessary only when the operation of the control initiates an action. Indicators generally do not require callback functions.

5. Enter `Acquired Data` as the **Label**.
6. Use the **Bottom X-axis** and **Left Y-axis** buttons to assign `Time` and `Voltage` labels to the x- and y-axes, respectively. Confirm that the Edit Graph dialog box looks as shown in Figure 2-2.

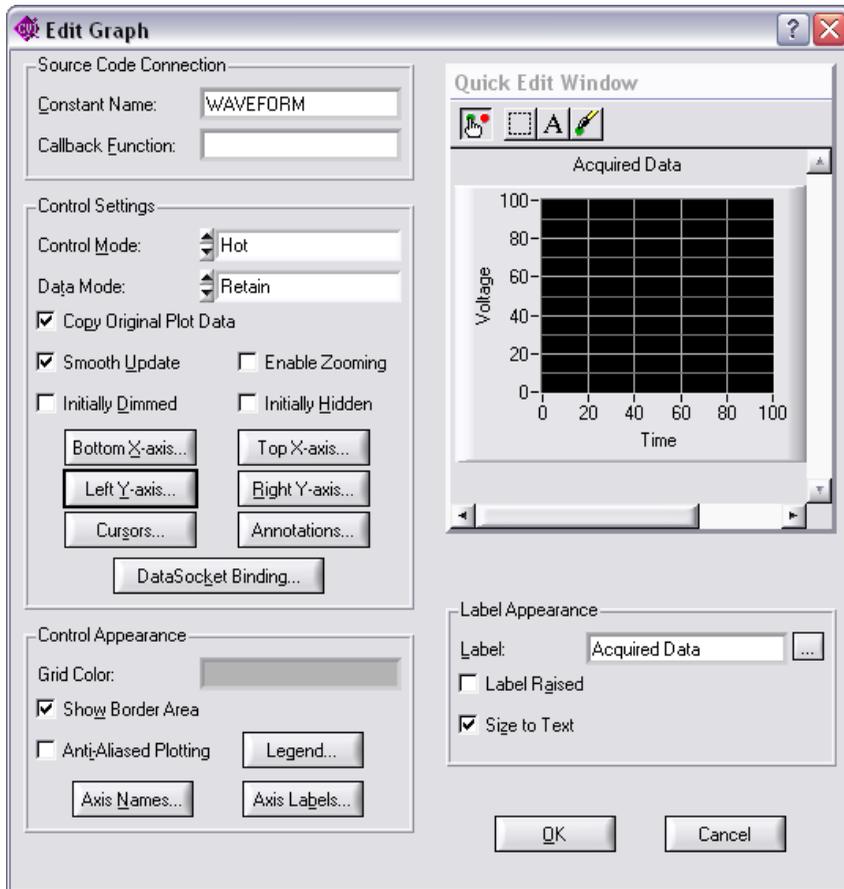


Figure 2-2. Edit Graph Dialog Box

7. After you set the graph attributes, click **OK** in the Edit Graph dialog box.
8. Verify that the completed user interface looks like the one shown in Figure 2-1.

Saving the Project Files

1. Select **File»Save Untitled.uir As**, browse to the <CVI>\tutorial directory, and enter `sample1.uir` as the filename for the user interface. Then click **Save**.
2. Select **View»Preview User Interface Header File** to display the header file that LabWindows/CVI automatically created and saved when you saved the `.uir` file.
3. Close the header file.
4. Select **File»Save Untitled.prj As**, browse to the <CVI>\tutorial directory, and enter `sample1.prj` as the filename for the project. Then click **Save**.

5. You must add the `.uir` file to the project. Select **Edit»Add Files to Project»User Interface (*.uir)**. In the Add Files to Project dialog box, select `sample1.uir` and click **Add**. Then click **OK** to exit the dialog box. Notice that LabWindows/CVI now displays `sample1.uir` in the Project Tree.
6. Now save the workspace by selecting **File»Save Workspace**.

Generating the Program Shell with CodeBuilder

Now that you have built a GUI in the User Interface Editor, use the CodeBuilder feature to automatically generate a program shell for your GUI.

1. Before you use CodeBuilder, you must specify the events to which your program must respond. Select **Code»Preferences»Default Control Events**. In the Control Callback Events dialog box, shown in Figure 2-3, the `EVENT_COMMIT` and `EVENT_TIMER_TICK` callback events are checked.



Note LabWindows/CVI generates the `EVENT_TIMER_TICK` event for timer control callback functions only.

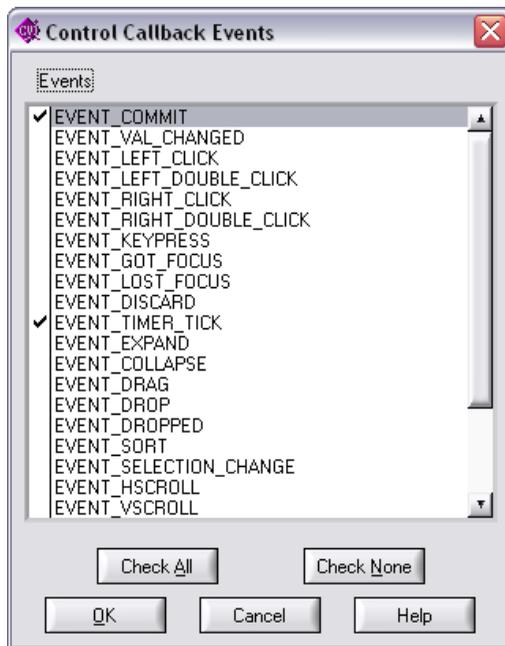


Figure 2-3. Control Callback Events Dialog Box

2. In Chapter 7, *Additional Exercises*, you develop code to display help when a user right-clicks a GUI control. To establish this functionality, you now must place a checkmark beside `EVENT_RIGHT_CLICK` in the list. Click **OK** to save your settings.
The callback functions in your program now can respond to the following two events:
 - `EVENT_COMMIT`—A commit event (click or <Enter>) that generates data and plots it on the graph
 - `EVENT_RIGHT_CLICK`—A right-click event that displays help
3. Select **Code»Generate»All Code** to open the Generate All Code dialog box. You must specify several options in this dialog box.
4. In the Target Files section, select **Add to Current Project**.
5. You must decide which panels to display at program startup. In this case, only one user interface panel exists. Select this item so that the program displays this panel at startup.



Note For this exercise, the panel variable name must be `panelHandle`. Enter the correct name as the **Panel Variable Name**, if necessary.

6. The Program Termination section lists the callback functions in the `.uir` file. Select a function from this list that causes the program to terminate execution. In this case, verify that the **QuitCallback** function is selected. Verify that the Generate All Code dialog box matches the one shown in Figure 2-4.

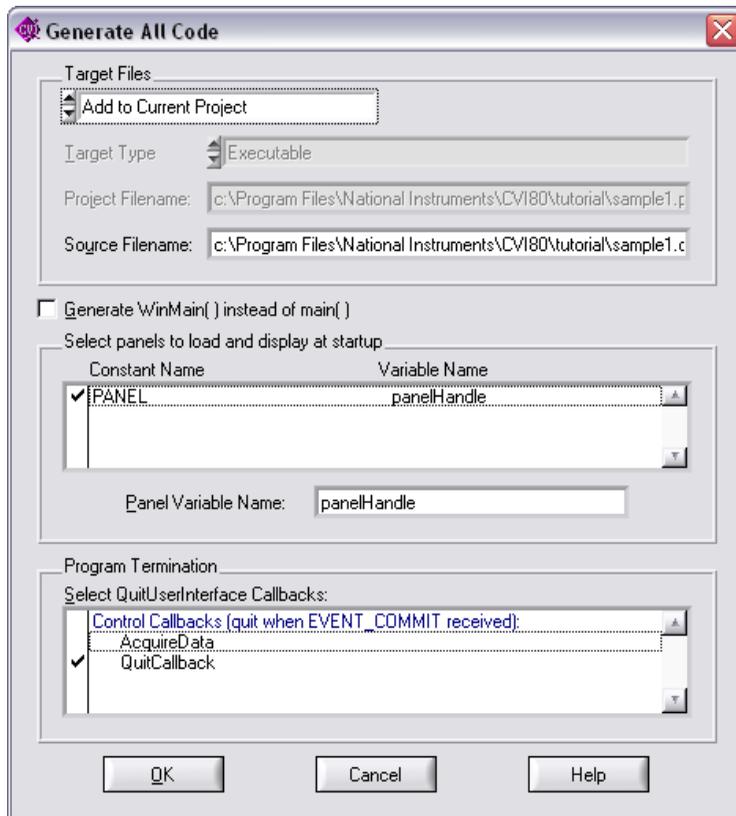


Figure 2-4. Generate All Code Dialog Box

7. Click **OK**. CodeBuilder builds the source code for `sample1.prj`. LabWindows/CVI creates a new source file and adds it to the project.

Analyzing the Source Code

The source code that you generated for the Sample 1 program is skeleton code. You must add code to this skeleton that determines how the program responds when it generates events. The program you generated consists of three functions. The functions in the `sample1.c` code are good examples of the functions you may write in the future for your own LabWindows/CVI programs.

main Function

Completing the `main` function is the first step you must take when you build your own applications. The `main` function is shown in the following code:

```

int main (int argc, char *argv[])
{
    if (InitCVIRTE (0, argv, 0) == 0)
        return -1; /* out of memory */
    if ((panelHandle = LoadPanel (0, "sample1.uir", PANEL)) < 0)
        return -1;
    DisplayPanel (panelHandle);
    RunUserInterface ();
    DiscardPanel (panelHandle);
    return 0;
}

```

To allow users to operate the user interface that you created, your program must perform the following steps:

- `LoadPanel` loads the panel from the `.uir` file into memory.
- `DisplayPanel` displays the panel on the screen.
- `RunUserInterface` activates LabWindows/CVI to begin sending events from the user interface to the C program you are developing. This function does not return until the program calls `QuitUserInterface`.

When you no longer need the user interface, call `DiscardPanel` to remove the panel from memory and from the screen.

AcquireData Function

The `AcquireData` function automatically executes whenever you click **Acquire** on the user interface. You add to this function later in this chapter so you can plot the array on the graph control that you created on the user interface. The `AcquireData` function is shown in the following code:

```

int CVICALLBACK AcquireData (int panel, int control, int event,
    void *callbackData, int eventData1, int eventData2)
{
    switch (event) {
        case EVENT_COMMIT:

            break;

        case EVENT_RIGHT_CLICK:

            break;

    }
    return 0;
}

```

QuitCallback Function

The `QuitCallback` function automatically executes whenever you click **QUIT** on the user interface. This function disables the user interface from sending event information to the callback function and causes the `RunUserInterface` call in the main function to return. The `QuitCallback` function is shown in the following code:

```
int CVICALLBACK QuitCallback (int panel, int control, int event,
    void *callbackData, int eventData1, int eventData2)
{
    switch (event) {
        case EVENT_COMMIT:
            QuitUserInterface (0);
            break;
        case EVENT_RIGHT_CLICK:

            break;
    }
    return 0;
}
```

Running the Generated Code

The code you generated using CodeBuilder is syntactically and programmatically correct code that compiles and runs before you add to it. Select **Run»Debug sample1_dbg.exe** to run the generated code. The program displays the user interface panel and exits when you press the **QUIT** button.

Using Function Panels and Libraries

In this chapter of the tutorial, you use LabWindows/CVI function panels to generate code. You then use this code to plot an array on the graph control on the user interface that you built in Chapter 2, *Building a Graphical User Interface*.

Function Panel Fundamentals

A function panel is a graphical view of a library function in LabWindows/CVI. Function panels serve several important purposes in LabWindows/CVI.

- With function panels, you can execute each LabWindows/CVI function interactively before incorporating it into the program. With this feature, you can experiment with the parameter values until you are satisfied with the operation of the function.
- Function panels provide help that discusses the purpose of each function in the LabWindows/CVI libraries and of each parameter in the function call.
- Function panels generate code automatically so that you can insert the function call syntax into your program source code.

Accessing Function Panels

The Library Tree includes function panels for all of the libraries in LabWindows/CVI. You can search quickly through the hierarchy of the library to find the right function. To find a particular function, right-click the Library Tree, select **Find**, and enter the name of the function.

Function Panel Controls

The controls on the function panel represent parameters. Enter values in the controls to specify parameter values. There are eight types of controls, and these controls are explained as you encounter them in the examples that follow. Some controls contain a ... button next to them. These controls provide additional dialog boxes to help you select input for parameters.

Function Panel Help

You can access help for functions and parameters from function panels. Table 3-1 lists methods for accessing the help information.

Table 3-1. Displaying Function Panel Help

Type of Help	How to View Help
Function Help	Select Help»Function . <i>or</i> Right-click anywhere on the background of the function panel.
Parameter Help	Place the cursor in the control, then select Help»Control . <i>or</i> Right-click the control. <i>or</i> Press <F1> from the control.
Combined Help	Select Help»Online Function Help . <i>or</i> Press <Ctrl-Shift-F1>.



Note A function must be documented in the *LabWindows/CVI Help* to have combined help available through its function panel.

Setting Up

If you did not proceed directly from Chapter 2, *Building a Graphical User Interface*, go back and do so now.

Generating an Array of Data

In this exercise, you complete the source code for `sample1.c` so the program generates an array with a sinusoidal pattern and plots the array on the graph control. Most of the action takes place in the `AcquireData` function. When a user clicks **Acquire**, the program generates a random number using the ANSI C `srand` and `rand` functions and then uses that number as the amplitude for the sine pattern.

1. Open `sample1.c`, if it is not already open.
2. On the line following `case EVENT_COMMIT:` in the `AcquireData` function, enter the following lines of code to generate the random numbers.

```
srand (time(NULL));
amp = rand ()/32767.0;
```

3. Position the cursor on the line following `amp = rand ()/32767.0`.
4. Right-click the Library Tree, select **Find**, enter `SinePattern` for **Find What**, and click **Find Next** to locate the Sine Pattern function panel. Double-click the function panel to open it.



Note If LabWindows/CVI cannot find a match, right-click the Library Tree and select **Show Function Names**. Then repeat step 4.

5. Select **Code»Set Target File**. Select `sample1.c` and click **OK**.
6. Enter `100` in the **Number of Elements** control.
7. Enter `amp` in the **Amplitude** control. Select **Code»Declare Variable** and enable the **Add declaration to current block in target file “sample1.c”** option. Click **OK**.
8. Enter `180.0` in the **Phase (Degrees)** control.
9. Enter `2.0` in the **Number of Cycles** control.
10. Enter `sine` in the **Sine Pattern** control. Select **Code»Declare Variable**.
11. In the Declare Variable dialog box, enter `100` as the **Number of Elements** and enable the **Add declaration to top of target file “sample1.c”** option. Click **OK**.
12. Select **Code»Insert Function Call**. LabWindows/CVI pastes the `SinePattern` function from the function panel into the `sample1.c` source code at the position of the text cursor.



Tip In the Source window, you can place your cursor anywhere in a LabWindows/CVI library function call and then select **View»Recall Function Panel** to open the function panel for the selected function. When you recall a function panel, the controls automatically reflect the state of the function call in the Source window.

Building the PlotY Function Call Syntax

Complete the following steps to generate a line of code that plots the random data array on the graph control.

1. Position the cursor in the Source window on the line following the `SinePattern` function call within the `AcquireData` function.
2. Type `PlotY` and then press <Ctrl-P> to open the Plot Y function panel.
3. In the **Panel Handle** control, select **Code»Select Variable**. The dialog box contains a list of variable names used in your program. Choose `panelHandle` from the list and click **OK**.

If `panelHandle` is not listed, enable the **Show Project Variables** option and click **Build The Project**. During the compile process, LabWindows/CVI recognizes that the

- program is missing the `ansi_c.h` and `analysis.h` include statements. Click **Yes** to add these include files in your program.
- For the **Control ID** control, you must specify the constant name assigned to the graph control. While the cursor is in **Control ID**, press <Enter> to open a dialog box with a complete list of the constant names in the `.uir` files in the workspace. In the User Interface Resource Files section, select `\sample1.uir`. Select **PANEL_WAVEFORM** from the list of constants and click **OK**.
 - Type `sine` in the **Y Array** control. This name indicates which array in memory the program displays on the graph.
 - Type `100` in the **Number of Points** control. This number indicates the number of elements in the array to plot. Leave the default values for the other controls. When the Plot Y function panel matches the one in Figure 3-1, proceed to the next step.

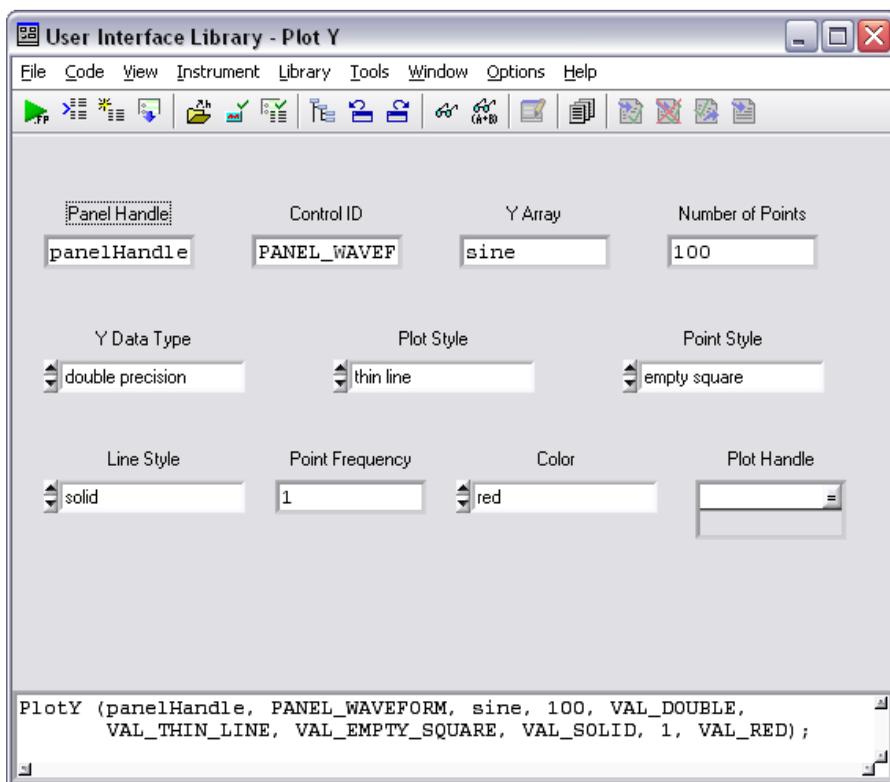


Figure 3-1. Completed Plot Y Function Panel

7. Select **Code»Insert Function Call** to paste the `PlotY` function call into the source code. LabWindows/CVI displays a message that states text is selected on the current line. Click **Replace** to replace the `PlotY` you typed with the complete function call.

8. Confirm that the `AcquireData` function matches the following source code:

```
int CVICALLBACK AcquireData (int panel, int control, int event,
void *callbackData, int eventData1, int eventData2)
{
    double amp;
    switch (event) {
        case EVENT_COMMIT:
            srand (time(NULL));
            amp = rand ()/32767.0;
            SinePattern (100, amp, 180.0, 2.0, sine);
            PlotY (panelHandle, PANEL_WAVEFORM, sine, 100, VAL_DOUBLE,
                VAL_THIN_LINE, VAL_EMPTY_SQUARE, VAL_SOLID, 1, VAL_RED);
            break;
        case EVENT_RIGHT_CLICK:

            break;
    }
    return 0;
}
```

9. Save the source file.

Running the Completed Project

You now have a completed project, saved as `sample1.prj`. Select **Run»Debug `sample1_dbg.exe`** to execute the code. If prompted, click **Yes** to add `ansi_c.h` and `analysis.h` to the top of the file. When you run your program, the following actions take place:

1. LabWindows/CVI compiles the source code from `sample1.c` and links with the appropriate libraries in LabWindows/CVI.
2. When the program starts, LabWindows/CVI launches the user interface, ready for keyboard or mouse input.
3. When you click **Acquire**, LabWindows/CVI passes the event to the `AcquireData` callback function.
4. The `AcquireData` function generates an array of data and plots it on the graph control on the user interface.
5. When you click **QUIT**, LabWindows/CVI passes the event to the `QuitCallback` function, which halts the program.

Editing and Debugging Tools

In this chapter, you become acquainted with the following tools available for editing and debugging in the interactive LabWindows/CVI environment.

- Source window
- Step modes of execution
- Breakpoints
- Variables window
- Array Display window
- Memory Display window
- String Display window
- Watch window
- Graphical Array View

Setting Up

This chapter uses the project you developed in Chapter 3, *Using Function Panels and Libraries*. If you did not proceed directly from Chapter 3, go back and do so now.

Editing Tools

The LabWindows/CVI Source window has a number of quick editing features that are helpful when you work with source files. Complete the following steps to view some of the editing features available in LabWindows/CVI.

1. Open `sample1.c` if it is not already open. Select **View»Line Numbers** to display a column to the left of the window that shows line numbers.
2. The programs you develop in LabWindows/CVI often refer to other files, such as header files or user interface files. To view these additional files quickly, place the cursor on the filename in the source code and select **File»Open Quoted Text**, press <Ctrl-U>, or right-click the filename and select **Open Quoted Text**.

Place the cursor on the `userint.h` filename in `sample1.c` and press <Ctrl-U>.

LabWindows/CVI opens the `userint.h` header file in a separate Source window. Scroll through and then close the header file.

- If you want to view a portion of your source code while you make changes to another area of the source code in the same file, you can split the window into top and bottom halves called *subwindows*, as shown in Figure 4-1.

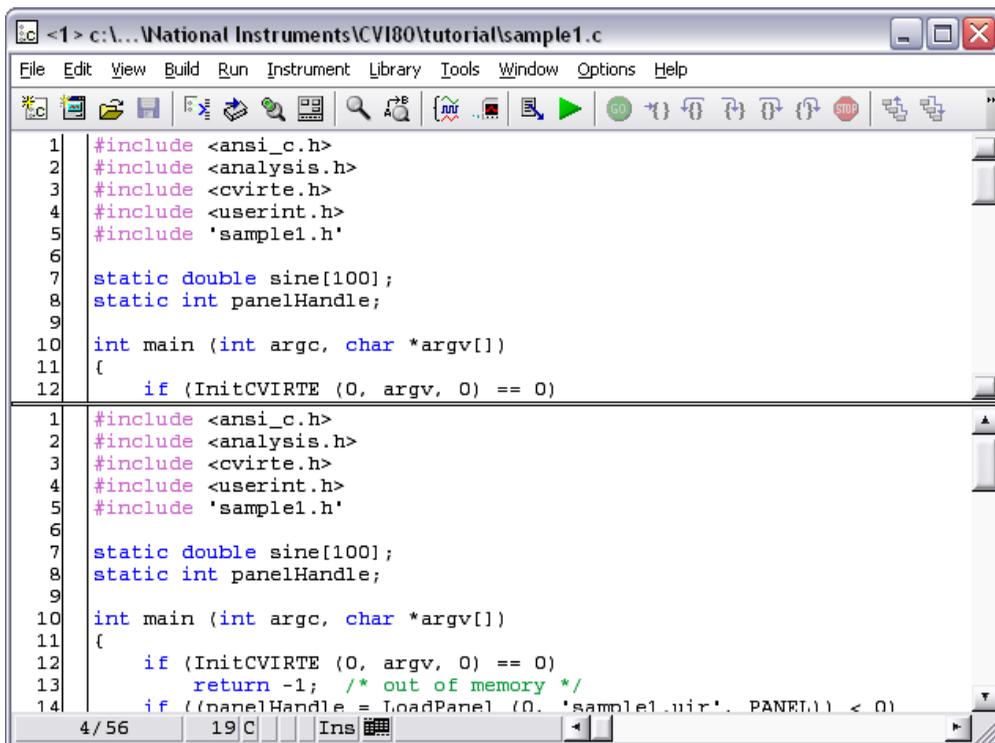


Figure 4-1. Split Source Window

To split the window, click and drag the double line at the top of the Source window to the middle of the screen.

Notice how each half of the window scrolls independently to display different areas of the same file simultaneously. Type text on line 6. Notice that the text you typed appears in both halves of the window.

- If you make editing mistakes while entering or editing source code in the Source window, LabWindows/CVI has an **Undo** feature you can use to reverse any mistakes. The default configuration of LabWindows/CVI allows up to 100 undo operations, and you can undo up to 1,000 operations. Select **Edit>Undo**. The text you entered on line 6 of the source code disappears.
- Drag the dividing line between the two subwindows back to the top to make a single window again.

6. You can use two different methods to quickly move to a particular line of code in your source file. If you know the line number you want to view, select **View»Line** and enter the line number.
7. You also can set tags on particular lines to highlight lines of code to which you can jump quickly. Place the cursor on line 3. Select **View»Toggle Tag**. A green square appears in the left-hand column of the Source window.

Move the cursor to line 12 of the Source window and add another tag. Select **View»Next Tag**, and the cursor jumps to the next tagged line in your source code. You also can press the <F2> key to jump between tags. Select **View»Clear Tags**, make sure all of the tags are checked, and then click **OK** to remove the tags from the source file.

8. You also can navigate through the Source window by finding specific text in the code. Select **Edit»Find** to open the Find dialog box, in which you enter the text you want to locate and specify various searching preferences. Enter `panelhandle` in the **Find What** control and leave the remaining controls set to their default values. Then click **Find Next**. LabWindows/CVI highlights the first match in the text and displays a list of all matches in the Find Results window. You can click an entry in the Find Results window to locate the corresponding text in the Source window.

Select **Edit»Quick Search** and type `disc`. When you use the **Quick Search** command, LabWindows/CVI performs an incremental search. Notice that LabWindows/CVI finds matches of the letters you have typed. The selection changes as you type more letters.

Step Mode Execution

Step mode execution is a useful run-time tool for debugging programs. To step through `sample1.c`, complete the following steps:

1. Select **Run»Break on»First Statement** to stop execution at the first statement in the source code.
2. Select **Run»Debug sample1_dbg.exe** to begin program execution. After the program compiles, the `main` function line in the program is highlighted in the Source window, indicating that program execution is currently suspended.
3. To execute the highlighted line, select **Run»Step Into**.



Tip To avoid accessing the **Run** menu each time you perform step mode execution, use the shortcut key combinations listed in Table 4-1. You also can click the icons in the toolbar to execute these commands.

Table 4-1. Quick Keys for Step Mode Execution

Command	Shortcut Key Combination	Toolbar Icon	Description
Continue	<F5>		Causes the program to continue operation until it completes or reaches a breakpoint
Go to Cursor	<F7>		Continues program execution until the program reaches the location of the cursor
Set Next Statement	<Ctrl-Shift-F7>		Changes the next statement to execute
Step Into	<F8>		Single-steps through the code of the function call being executed
Step Over	<F10>		Executes a function call without single-stepping through the function code itself
Finish Function	<Ctrl-F10>		Resumes execution through the end of the current function and breakpoints on the next statement
Terminate Execution	<Ctrl-F12>		Halts execution of the program during step mode

- To find the definition of the `SinePattern` function, place the cursor on the function in `sample1.c` and select **Edit>Go to Definition**. Alternatively, you can right-click the function and select **Go to Definition**.

The **Go to Definition** command immediately finds the definition of the function, even when the function resides in a different source or header file. However, the target source file must have been compiled in the project. You also can use this command to find variable declarations.

In this case, LabWindows/CVI opens `analysis.h` and highlights the `SinePattern` function declaration. When you finish viewing `analysis.h`, select **Edit>Go Back** to return to your previous source code location.



Tip Many of the commands in this exercise also are available in the Source window context menu. You can right-click within the Source window to view the available commands.

5. Use **Step Into** to begin stepping through the program. Notice that when the `main` function is executed, the highlighting moves to the function and traces the instructions inside the function. Continue to step through the program until the `DisplayPanel(panelHandle);` statement is highlighted.
6. You can select the next statement to execute with the **Run»Set Next Statement** command. Place the cursor on the line with the call to `DiscardPanel(panelHandle);`. Select **Run»Set Next Statement**. The highlighting moves to that line. Press <F5> to continue program execution. Notice that the program exits without having run the user interface because the program execution skipped over the `RunUserInterface` function call.

Breakpoints

Breakpoints are another run-time tool that you can use to debug programs in LabWindows/CVI. A breakpoint is a location in a program at which LabWindows/CVI suspends execution of your program. You can invoke a breakpoint in LabWindows/CVI in the following ways:

- **Fixed Breakpoint**—Insert a breakpoint at a particular location in the Source window. You can turn breakpoints on or off even while your program is executing.
- **Instant Breakpoint**—When an application is running, press <Ctrl-F12> while a window is active in the LabWindows/CVI environment.
- **Breakpoint on Library Errors**—Select **Run»Break on»Library Errors** to cause LabWindows/CVI to pause at a particular location when a library function returns an error.
- **Conditional Breakpoint**—Cause LabWindows/CVI to pause at a particular location when a user-specified condition becomes true.
- **Programmatic Breakpoint**—In your code, call the `Breakpoint` function.
- **Watch Expression Breakpoint**—Cause LabWindows/CVI to pause when the value of a watch expression changes.

Fixed Breakpoints

To insert a breakpoint at a specific location in your source code, click in the left column of the Source window on the line on which you want to suspend execution. Complete the following steps to insert a breakpoint inside the `AcquireData` function.

1. Stop program execution by selecting **Run»Terminate Execution**, if necessary.
2. Disable **Run»Break on»First Statement**. The checkmark next to the **First Statement** menu item disappears.

3. In the Source window, click to the left of the line that contains the following statement:

```
SinePattern (100, amp, 180.0, 2.0, sine);
```

A red diamond, which represents a breakpoint, appears beside that line as shown in Figure 4-2.

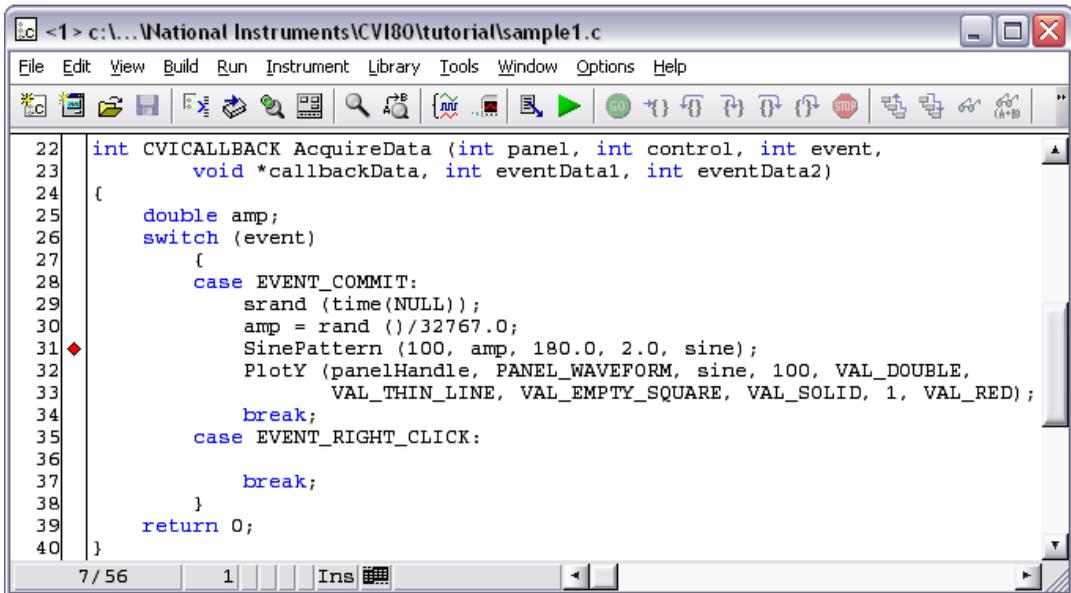


Figure 4-2. Breakpoint beside a Line of Code



Note You do not need to suspend or terminate execution to insert a breakpoint. If you insert a breakpoint while the program is running, LabWindows/CVI suspends the program when it reaches that line of code.

4. Begin execution of the program by selecting **Run»Debug sample1_dbg.exe**. Click **Acquire** to generate a commit event for `AcquireData`. When LabWindows/CVI encounters the breakpoint during execution, it suspends program execution and highlights the line where you inserted the breakpoint.
5. Press <F5> to continue execution. Program execution continues until the next breakpoint or until completion. You can single-step through the code at that point by selecting **Run»Step Over** or **Run»Step Into**.
6. Stop the program at a breakpoint by pressing <Ctrl-F12> or by selecting **Run»Terminate Execution**.
7. To remove the breakpoint from the program, click the red diamond.

Conditional Breakpoints

Use conditional breakpoints to halt program execution only when the specified condition is true. Complete the following steps to use conditional breakpoints in your program.

1. Select **Run»Breakpoints** to open the Breakpoints dialog box.
2. In the Breakpoints dialog box, click **Add/Edit Item** to open the Edit Breakpoint dialog box.
3. In the Edit Breakpoint dialog box, enter 32 for **Line**, and enter `amp > 0` as the **Condition**. Leave the default values for the remaining controls and click **Add**.
4. Click **OK** to exit the Breakpoints dialog box. LabWindows/CVI displays a yellow square to the left of line 32 to indicate the conditional breakpoint.
5. Select **Run»Debug sample1_dbg.exe** to begin program execution. Click **Acquire** to run the code in the commit event case for `AcquireData`. LabWindows/CVI halts execution at line 32 because the breakpoint condition was met. Hover the mouse cursor over `amp` to verify its value is greater than 0.
6. Select **Run»Terminate Execution** to stop the program.
7. Right-click the conditional breakpoint icon to the left of line 32 and select **Breakpoints** to open the Breakpoints dialog box.
8. Click **Add/Edit Item** to open the Edit Breakpoint dialog box. Replace the **Condition** text with `amp < 0` and click **Replace**. Then click **OK** to exit the Breakpoints dialog box.
9. Repeat step 5. Notice that LabWindows/CVI does not halt execution at line 32 because the breakpoint condition is no longer true.
10. Click <Ctrl-F12> twice to stop the program. To remove the breakpoint, select **Run»Breakpoints**, ensure the breakpoint is highlighted, and click **Delete Item**. Then click **OK** to exit the dialog box.

For more information about breakpoints, refer to *breakpoints* in the *LabWindows/CVI Help* index.

Displaying and Editing Data

Step mode execution and breakpoints are useful tools for high-level testing. However, you often need to look beyond your source code to test your programs. The LabWindows/CVI interactive environment provides the following displays for viewing and editing the data for your program.

- Variables window
- Array Display window
- Memory Display window
- String Display window

- Watch window
- Tooltips
- Graphical Array View

Variables Window

The Variables window shows all variables currently declared in the LabWindows/CVI interactive program. To view the Variables window, select **Window»Variables**.

The Variables window lists the name, value, and type of currently active variables. LabWindows/CVI displays variables in categories according to how they are defined, such as global or local. The Stack Trace section shows the current call stack of functions. To view variables that are active elsewhere in the call stack, double-click the corresponding function in the Stack Trace.

You can view the Variables window at any time to inspect variable values. This feature is especially useful when you step through a program during execution. Complete the following steps to step through the program and view the Variables window at different points in the execution of the program.

1. Select **Run»Break on»First Statement**.
2. Select **Run»Debug sample1_dbg.exe**, or press <Shift-F5>, to run the program. When the program begins execution, LabWindows/CVI highlights the `main` function in the Source window.
3. Select **Window»Variables** to view the Variables window, shown in Figure 4-3.

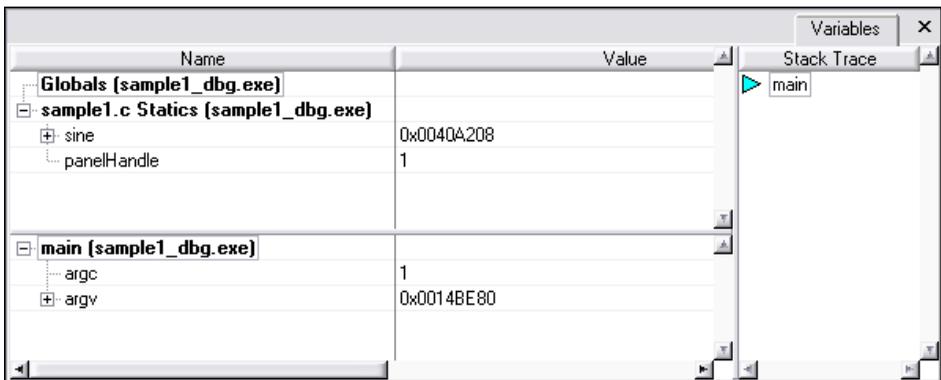


Figure 4-3. Variables Window during Execution of main



Note The values you see for your project might differ from the values shown in Figure 4-3.

4. Insert a breakpoint on the line with the following code:

```
SinePattern (100, amp, 180.0, 2.0, sine);
```
5. Press <F5> to continue program execution. Click **Acquire**. LabWindows/CVI halts program execution on the statement with the breakpoint. In the Variables window, LabWindows/CVI now lists `AcquireData` in the Stack Trace section. The Variables window shows the variables that are declared locally to that function.
6. Leave the program suspended and continue to the next section, *Editing Variables*.

Editing Variables

In addition to displaying variables, you can use the Variables window to edit the contents of a variable. Complete the following steps to use the Variables window for this purpose.

1. Make sure the `sample1.c` program is still suspended on the following line:

```
SinePattern (100, amp, 180.0, 2.0, sine);
```
2. Highlight the `amp` variable in the Source window and select **Run»View Variable Value**. LabWindows/CVI highlights the `amp` variable in the Variables window.
3. From the Variables window, press <Enter> to edit the value of `amp`. Enter `.2` in the value column and press <Enter>.
4. In the Source window, select **Run»Continue**. Notice that the sine pattern amplitude is now `.2`. The change you made using the Variables window took effect immediately in the execution of the program.

Array Display Window

Another useful data display in the LabWindows/CVI interactive program is the Array Display window. The Array Display window shows the contents of an array of data. You can use the Array Display window to edit array elements in the same way that you edited variables using the Variables window.

1. Click **Acquire** to put the program in breakpoint mode again.
2. Right-click `sine` in the Variables window and select **View»Array Display** to view the array values as shown in Figure 4-4.

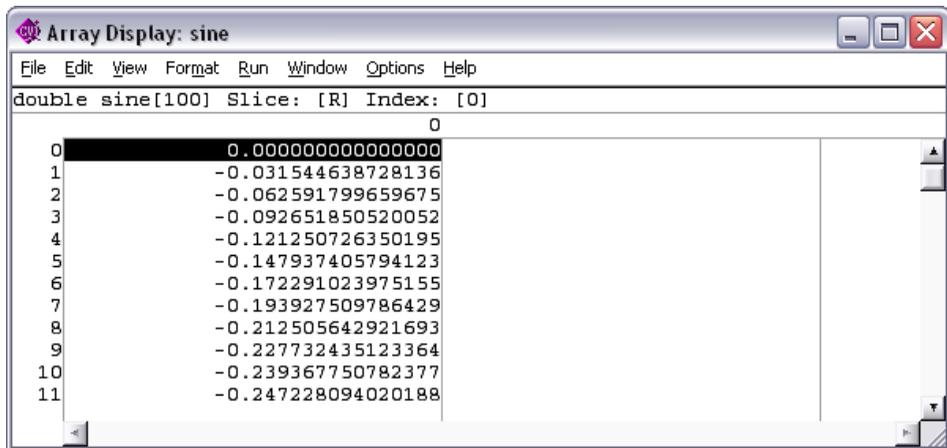


Figure 4-4. Array Display Window



Note The actual values in your array might differ from the values shown in Figure 4-4.

The Array Display window shows the values of array elements in tabular format. In Figure 4-4, the `sine` array is a one-dimensional array, so the display consists of one column of numbers. The numbers in the column on the left side of the display indicate the index number. The first element is zero.

Take a moment to view the display. You can edit individual elements in the array just as you edited variables in the Variables window.

3. Close the Array Display window.

Memory Display Window

You can use the Memory Display window to view and edit the memory of the program you are debugging. Use the Memory Display window as follows:

1. With your program still suspended, select **Window»Memory** to display the Memory Display window.
2. Click the **Variables** tab to return to the Variables window.
3. Click the `sine` variable in the Variables window and drag it to the **Memory** tab. LabWindows/CVI displays the `sine` array memory in the Memory Display window.

To edit the program memory, right-click in the Memory Display window and select **Edit Mode**. When the Memory Display window is in edit mode, double-click a value to edit it.

4. When you are finished, click <Ctrl-F12> to terminate program execution.

String Display Window

Another useful data display is the String Display window. You can select a string variable from the Variables window to launch the String Display window. The String Display window is similar to the Array Display window except that you use the String Display window to view and edit elements of a string. Operations in the String Display window are similar to the operations you performed in the Array Display window. For more information about the String Display window, refer to *Using LabWindows/CVI»Debugging Tools»Using the Array and String Display Windows* in the *LabWindows/CVI Help*.

Watch Window

The Watch window is a powerful debugging tool because you can view values of variables changing dynamically as your program executes. You also can use the Watch window to view expression values and set conditional breakpoints when variable or expression values change. Complete the following steps to use the Watch window to view variables during program execution.

1. With `sample1.prj` still loaded as the current project, ensure that **Run»Break on»First Statement** is enabled. Click the breakpoint on the `SinePattern` line of code to remove it.
2. Select **Run»Debug sample1_dbg.exe**, or press <Shift-F5>, to start program execution. Execution breaks with the `main` function highlighted.
3. In the Variables window, right-click the `sine` variable and select **Add Watch Expression** to add the `sine` variable to the Watch window. LabWindows/CVI displays the Add/Edit Watch Expression dialog box.
4. Enable the **Break when value changes** option so that the dialog box matches the one shown in Figure 4-5. Then click **Add** to close the dialog box. LabWindows/CVI displays the `sine` variable within the Watch window. Expand the `sine` variable within the Watch window to view the individual elements within the array.

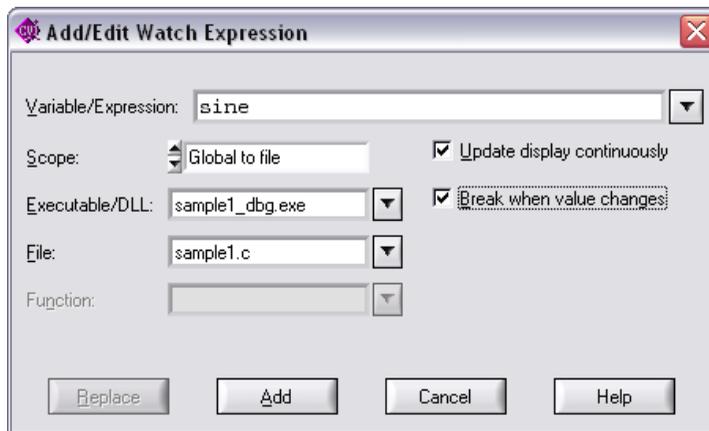


Figure 4-5. Add/Edit Watch Expression Dialog Box

5. Select **Run»Continue** to continue program execution. Click **Acquire** on the user interface. Program execution breaks after the call to `SinePattern` because the `sine` variable values have changed. Expand the `sine` variable again to view the updated element values. After viewing the new variable values, select **Run»Continue** to continue program execution and then click **QUIT** on the user interface to exit the program. Remove the watch expression by clicking the `sine` variable in the Watch window and pressing <Delete>.

Tooltips

You also can use the following method to edit variables:

1. Disable the **Break on»First Statement** option and set a breakpoint on the line of code that includes the `SinePattern` function call. Then, select **Run»Debug sample1_dbg.exe**.
2. Click **Acquire** on the user interface. Program execution breaks on the `SinePattern` statement.
3. Position the mouse cursor on the `amp` variable in the `SinePattern` statement.
4. The variable value appears in a tooltip. Highlight the current value and enter `3.0`.
5. Select **Run»Continue** to complete program execution. Notice the amplitude of the graphed sine pattern is the value you specified in the tooltip, not the amplitude calculated in the program. Click **QUIT** on the user interface to exit the program.

Graphical Array View

The Graphical Array View shows the values of arrays in a graph view. This display is available for 1D and 2D arrays during debugging. To open the Graphical Array View, complete the following steps:

1. Clear the existing breakpoint. Then, set a breakpoint on the line of code that includes the call to `PlotY`.
2. Select **Run»Debug sample1_dbg.exe** and click **Acquire** on the user interface.
3. In the Variables window, highlight the `sine` variable and select **View»Graphical Array View** to view the `sine` values in a graph. You also can right-click the variable name in the Source window and select **Graphical Array View**. The Graphical Array View displays the value of the array on a graph.
4. Select **Run»Continue** to complete program execution. Then click **QUIT** on the user interface to exit the program.

Adding Analysis to Your Program

In Chapter 3, *Using Function Panels and Libraries*, you generated code to plot the sine pattern array on the graph control. The plotting function that you generated was placed in a callback function triggered by clicking the **Acquire** button. In this chapter, you add analysis code that computes the maximum and minimum values of the random array you generate. To do this, you write a callback function that finds the maximum and minimum values of the array and displays them in numeric indicators on the user interface.

Setting Up

This chapter builds on the concepts that you learned in Chapter 3, *Using Function Panels and Libraries*. If you did not complete the exercise in Chapter 3, go back and do so now.

1. Remove all breakpoints and close all windows except the Workspace window.
2. Run `sample1.prj` to verify the operation of the program. Click **QUIT** to terminate the execution.

Modifying the User Interface

Complete the following steps to modify the existing user interface:

1. Open `sample1.c`. Place the cursor at the end of the file. CodeBuilder uses that location for the new callback function that it generates later in this chapter.
2. Without closing the `sample1.c` source code, open `sample1.uir`. Your goal is to modify the `.uir` to match the user interface shown in Figure 5-1.

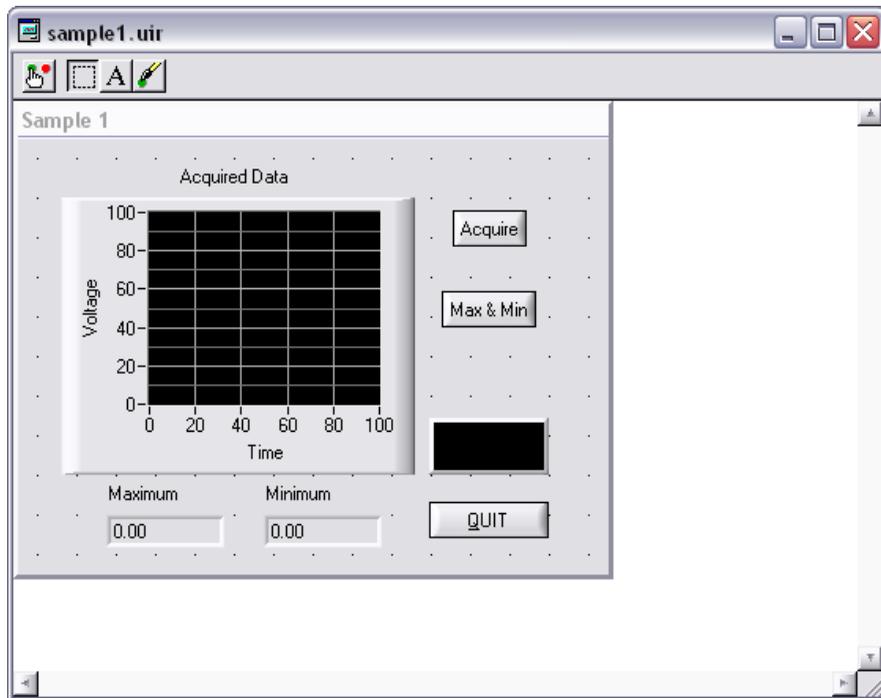


Figure 5-1. Sample User Interface

3. Add a command button to the panel.
4. Double-click the new command button to open the Edit Command Button dialog box. Enter the following information in the dialog box and click **OK**.

Control	Value
Constant Name	MAXMIN
Callback Function	FindMaxMin
Label	Max & Min

5. You can use CodeBuilder to add code to your program shell for an individual control callback function. Right-click the **Max & Min** command button and select **Generate Control Callback**.

The lightning bolt cursor appears while CodeBuilder generates code in the `sample1.c` source file. When you finish updating the user interface for Sample 1, you will add code to the `FindMaxMin` callback function to compute and display the maximum and minimum values of the array.

- In the User Interface Editor, select **Create»Numeric»Numeric**.
- Double-click the numeric control to open the Edit Numeric dialog box. Enter the following information in the dialog box and click **OK**.

Control	Value
Constant Name	MAX
Control Mode	Indicator
Label	Maximum

- Add a second numeric control to the panel.
- Double-click the numeric control to open the Edit Numeric dialog box. Enter the following information in the dialog box and click **OK**.

Control	Value
Constant Name	MIN
Control Mode	Indicator
Label	Minimum

- Position the new controls on the user interface to match those shown in Figure 5-1.



Tip You can use the **Arrange»Alignment** command to position controls on the panel.

- Save the modified `.uir` file.

Writing the Callback Function

Now that you have modified the `.uir` file and generated the shell for the callback function for the **Max & Min** command button, you must complete the `FindMaxMin` function in the source file, as follows:

- To quickly locate the `FindMaxMin` callback function in your source file, right-click the **Max & Min** button in the User Interface Editor and select **View Control Callback**. LabWindows/CVI displays the `sample1.c` source file with the `FindMaxMin` callback function highlighted.
- Position the cursor on the blank line just after the `case EVENT_COMMIT:` statement.
- In addition to function panels, LabWindows/CVI provides source code completion options within the Source window. You can use the **Edit»Show Completions** option to view a list of potential matches for functions or variables you are typing. Type `Max` and

then press <Ctrl-Space> to view the drop-down list of matches. Select **MaxMin1D** from the list.

4. Type an open parenthesis after the function name to display the function prototype. If you do not see the prototype after you type the parenthesis, select **Edit>Show Prototype**.

The prototype provides many of the same features as a function panel. As you type, LabWindows/CVI highlights the appropriate parameter name in the prototype tooltip. When you press <F1>, LabWindows/CVI displays help for the highlighted item.

MaxMin1D finds the maximum and minimum values of an array. Enter the following values for the parameters:

Parameter	Value
InputArray	sine
NumberofElements	100
MaximumValue	&max
MaximumIndex	&max_index
MinimumValue	&min
MinimumIndex	&min_index

5. Before you proceed, you must declare the `max`, `max_index`, `min`, and `min_index` variables. Place the cursor over the `max` variable name to highlight it in the prototype tooltip, and press <Ctrl-D>. LabWindows/CVI inserts a copy of the `max` variable declaration at the top of the code block that contains your current position.
6. Repeat step 6 for the `max_index`, `min`, and `min_index` variables.
7. Enter a new line after the call to `MaxMin1D` and type `SetCtrlVal (` to display the function prototype for `SetCtrlVal`. If LabWindows/CVI does not display the prototype, press <Ctrl-Shift-Space> to view the tooltip.
8. The `SetCtrlVal` function sets the value of a control on your user interface. Enter `panelHandle` for the **PanelHandle** parameter. Then enter a comma to highlight the **ControlID** parameter in the prototype.
9. When **ControlID** is the highlighted parameter in the function prototype, LabWindows/CVI displays a `...` button next to the parameter name. This button indicates that LabWindows/CVI provides an input selection dialog box or list of constant values for the current parameter.
Click this button or press <Ctrl-Shift-Enter> to launch the Select UIR Constant dialog box. Select `\sample1.uir` in the **User Interface Resource Files** list and select **PANEL_MAX** from the list of constants. Then click **OK**.
10. Enter `max` for the value parameter, which is indicated by a `...` in the function prototype.

11. Immediately following the first instance of the function, include another instance of `SetCtrlVal` with the following parameter values to set the value of the **Minimum** control on the user interface.

Parameter	Value
PanelHandle	panelHandle
ControlID	PANEL_MIN
Value (...)	min

12. Confirm that the source code matches the following code:

```
int CVICALLBACK FindMaxMin (int panel, int control, int event, void
*callbackData, int eventData1, int eventData2)
{
    int min_index;
    double min;
    int max_index;
    double max;
    switch (event)
    {
        case EVENT_COMMIT:
            MaxMin (sine, 100, &max, &max_index, &min, &min_index);
            SetCtrlVal (panelHandle, PANEL_MAX, max);
            SetCtrlVal (panelHandle, PANEL_MIN, min);
            break;
        case EVENT_RIGHT_CLICK:

            break;
    }
    return 0;
}
```

Running the Program

You have now successfully written the callback function. During program execution, the `FindMaxMin` function is called when the program is running and you click **Max & Min**. When you click **Max & Min**, three separate events occur.

- First, clicking the left mouse button generates an `EVENT_LEFT_CLICK` event.
- Next, releasing the left mouse button generates an `EVENT_COMMIT` event. You wrote the function so that it finds the minimum and maximum values and displays them only when your program receives the `EVENT_COMMIT` event.

- Finally, the button gets the input focus, and an `EVENT_GOT_FOCUS` event is generated. For more practice with user interface events, complete [Exercise 4: Adding User Interface Events](#) of Chapter 7, [Additional Exercises](#).
1. Save the file.
 2. Run the project.
 3. Close the file before moving on to Chapter 6, [Distributing Your Application](#).

Distributing Your Application

This chapter describes how to distribute an application you create in LabWindows/CVI. You can use the LabWindows/CVI distribution creation and management features to develop and edit multiple distributions for an application. This tutorial includes steps for creating a basic Windows Installer (.msi). For more advanced information about distributing applications, refer to the *Using LabWindows/CVI»Managing Projects»Building a Project»Distributing Applications»Step-by-Step Guide to Creating and Editing an Installer* in the *LabWindows/CVI Help*.

Setting Up

In this chapter, you build a distribution for the project you created in previous chapters. If you did not complete the tutorial exercises in Chapter 2 through Chapter 5, go back and do so now.

Creating a New Distribution

Complete the following steps to create a new distribution for your application.

1. Select **Build»Distributions»Manage Distributions** to open the Manage Distributions dialog box. The dialog box lists the distributions available for the current workspace.
2. Click **New** to launch the New Distribution dialog box. By default, **Windows Installer (.msi)** is selected as the **Type**. Enter `Sample Distribution` as the **Name**. Verify that `<CVI>\tutorial\Sample1.cds` is specified as the **Settings file**. Then click **OK**.

Editing the Distribution

When you create a new distribution, LabWindows/CVI launches the Edit Installer dialog box. The dialog box contains tabs in which you can specify various distribution components and features. Complete the following steps to verify and edit the distribution settings for your application.

1. In the **General** tab, verify that `<CVI>\tutorial\cvidistkit.Sample Distribution` is specified as the **Output Directory**. LabWindows/CVI builds the installer in this location.
2. Verify that the **Auto-increment** option is enabled. This option ensures that LabWindows/CVI increments the version number each time you build the installer.



Note National Instruments recommends you install an upgrade installer—an installer that has a higher version number than the previous installer—every time you install an application to a location where another version of that application might be installed. Upgrade installers uninstall the previous version of the application before installing the updated version.

3. Click the **Files** tab. By default, LabWindows/CVI adds the project output (`sample1.exe`) and dependencies to the installation. These files are listed in the **Installation Files & Directories** section of the dialog box.



Note Notice that Sample1 Output (`sample1.exe`) is listed in red text. Red text indicates that LabWindows/CVI cannot locate the file on your computer. In this case, you must build the executable for LabWindows/CVI to include it in the installer. It is not necessary to exit the Edit Installer dialog box and build the executable. LabWindows/CVI builds the target automatically when it builds the distribution, as it does in step 9.

4. Click the **Shortcuts** tab. Notice that, by default, LabWindows/CVI includes a shortcut for `sample1.exe` in the `[Start>Programs]\Sample Distribution` directory.
5. Click the **Drivers & Components** tab. Notice that LabWindows/CVI includes the full LabWindows/CVI Run-Time Engine in the installer.
6. Click **Check Module Dependencies** to ensure that any merge modules on which the selected drivers and components depend are included in the installer. The LED on the button glows green to indicate that there are no missing dependencies.
7. **(Optional)** Click the **Registry Keys** and **Advanced** tabs to view the available options. For this application, it is not necessary to modify any of the settings in either of these tabs.
8. When you finish viewing and verifying the Edit Installer dialog box settings, click **OK** to exit the dialog box. Then click **OK** to exit the Manage Distributions dialog box.
9. Select **Build>Distributions>Build Sample Distribution**. Click **Yes** in the message box LabWindows/CVI displays to prompt you to build the project. In some cases, LabWindows/CVI prompts you to insert an NI product installation CD during the build. During the build process, LabWindows/CVI launches a dialog box that displays the build status. When LabWindows/CVI finishes building the installer, click **Close**. You are now ready to deploy the application to the target computer.

Deploying the Application to a Target Computer

Once you create the installer, you can deploy it to a target computer. Complete the following steps to copy the installer files and run the installer on the target computer.

1. In the previous steps, you built an installer that generated the files in the `<CVI>\tutorial\cvidistkit.Sample Distribution` folder. This folder contains one or more `Volume` folders, the number of which depends on the size of the installer and the distribution media size. In this exercise, there is only one folder, `Volume1`.
2. Copy the `Volume1` folder and its contents to the target computer. For this exercise, the target computer can be your development computer.
3. Double-click `setup.exe` to launch the installer for your application.
4. The installer displays a series of panels in which a user specifies the installation preferences. When the installer finishes updating the target system, click **Finish**.
5. To uninstall the application, use the **Add or Remove Programs** option in the Windows Control Panel. If you also want to uninstall the LabWindows/CVI Run-Time Engine and any other National Instruments software that was included in the installer, select **National Instruments Software** from the list of currently installed programs, and then click **Remove**. Select the NI products you want to remove and click **Remove**.

Additional Exercises

This chapter provides additional exercises that build on the concepts you have used throughout this tutorial. Each exercise adds to the code that you develop in the preceding exercise.

You can access the solutions to all the exercises in this chapter in `\tutorial\solution`. If you have trouble completing one of the exercises but would like to continue to the next topic, use the solution from the previous exercise.

Base Project

All of the exercises in this chapter build on the sample project that you completed in Chapter 5, *Adding Analysis to Your Program*. If you did not complete the sample project, go back and do so now. If you have trouble successfully completing the Chapter 5 exercise, start with `sample1.prj` from the `solution` directory.

The Sample 1 project generates a waveform and displays it on a graph control when you click the **Acquire** button. After you display the data, you can find and display the maximum and minimum values of the data points by clicking the **Max & Min** button. The project uses the `SinePattern` function to generate the data. The user interface for the project is shown in Figure 7-1.

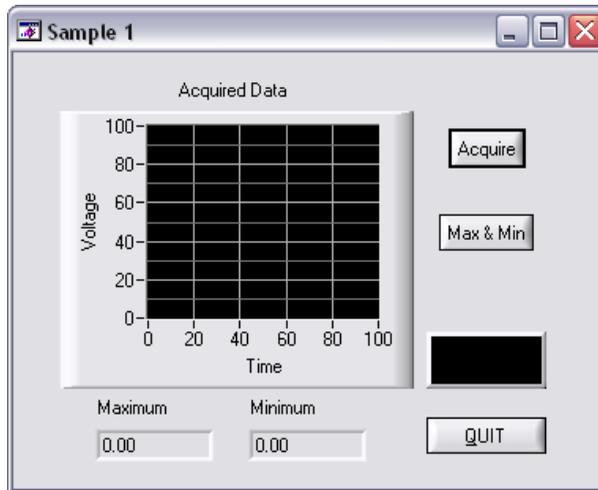


Figure 7-1. Sample User Interface

Exercise 1: Setting User Interface Attributes Programmatically

Each control on the `.uir` files that you create has a number of control attributes that you can set to customize the look and feel of the control. When you build a user interface, you set the control attributes in the Edit dialog boxes for the controls. For example, you can set the font, size, and color of the text for a label in the User Interface Editor. Text font, size, and color are user interface control attributes.

Use `GetCtrlAttribute` and `SetCtrlAttribute` to get and set attributes of a control during program execution in a method similar to the one you used to set the value of a control. You can build a customized GUI in the User Interface Editor and dynamically change the look and feel of the controls at run time.

Hundreds of attributes are defined in the User Interface Library as constants, such as `ATTR_LABEL_BGCOLOR` for setting the background color of the label on a control. You can use these constants in the `GetCtrlAttribute` and `SetCtrlAttribute` functions.

Assignment

In this exercise, use `SetCtrlAttribute` to change the operation of a command button on the user interface. Because the **Max & Min** command button does not operate correctly until you acquire the data, you can disable the **Max & Min** button until a user clicks the **Acquire** button. Use `SetCtrlAttribute` to enable the **Max & Min** button when a user clicks the **Acquire** button.



Tip To ensure multiple plots do not accumulate on the graph control, add a line of code to delete any existing plots before you call `PlotY`.

Hints

- Start by disabling (dimming) the **Max & Min** command button in the User Interface Editor.
- Use `SetCtrlAttribute` from the User Interface Library to enable the **Max & Min** button.
- The attribute that you need to set is the *dimmed* attribute.

Solution: `exer1.prj`

Exercise 2: Storing the Waveform on Disk

Users often acquire large amounts of data and want to save it on disk for future analysis or comparison. LabWindows/CVI provides a selection of functions from the ANSI C Library for reading from and writing to data files. If you are already familiar with ANSI C, you know these functions as the `stdio` library. In addition to the `stdio` library, LabWindows/CVI has its own set of file I/O functions in the Formatting and I/O Library.



Tip When you must store very large data sets, National Instruments recommends that you use the DIAdem Connectivity Library, which is optimized for handling large amounts of data.

Assignment

Use the file I/O functions in the ANSI C Library to save the `sine` array to a text file. Write the program so that the file is overwritten each time you acquire the data. Do not append data to the file as you acquire it.

Hints

- Remember that you must first open a file before you can write to it.
- Open the file as a text file so you can view the contents in any text editor later.
- Open the file with the Create/Open flag and not the Append flag so that the file is overwritten each time.
- Use the `fprintf` function in a loop to write the data to disk.
- Use the Utility Library `GetProjectDir` and `MakePathname` functions to create the pathname for the file.

Solution: `exer2.prj`

Exercise 3: Using Pop-Up Panels

The User Interface Library has a set of predefined panels called pop-up panels. Pop-up panels provide a quick and easy way to display information on the screen without developing a complete `.uir` file. You can use pop-up panels to prompt the user for input, confirm a selection, or display a message.

One of the most useful pop-up panels is the File Select Popup. With the File Select Popup, you can use a File Load or File Save dialog box, shown in Figure 7-2, to prompt the user to select or input a filename whenever your program must write to or read from a file.

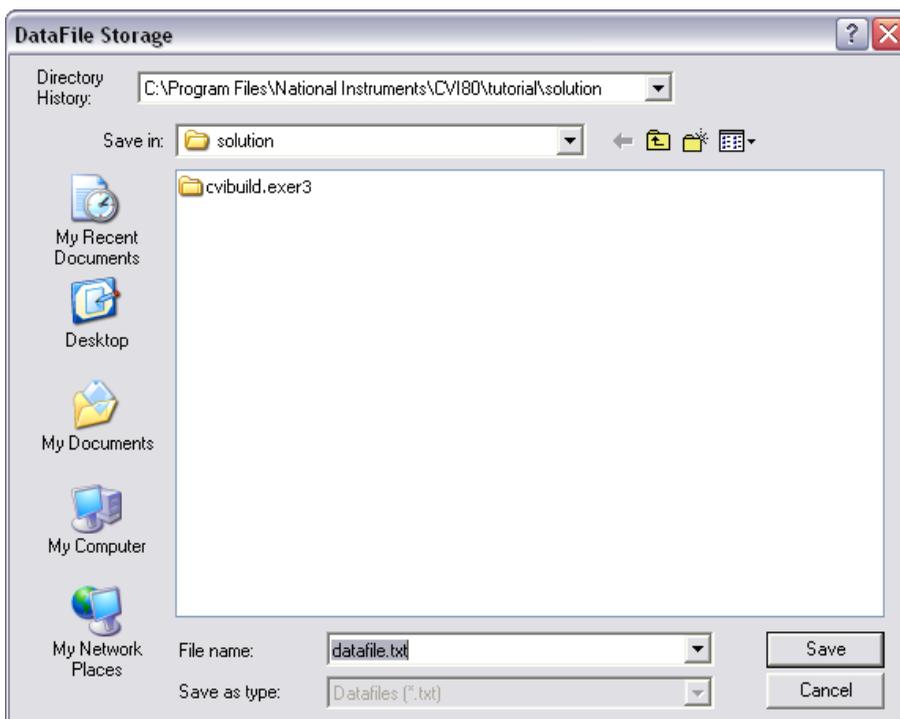


Figure 7-2. File Select Popup

Assignment

Add a **Save** button to the `.uir` file so that the data in the array is saved only after the user clicks the **Save** button. When the user clicks the **Save** button, your program should launch a dialog box in which the user can define the drive, directory, and filename of the data file. When you finish, the `.uir` file should look similar to the one shown in Figure 7-3.

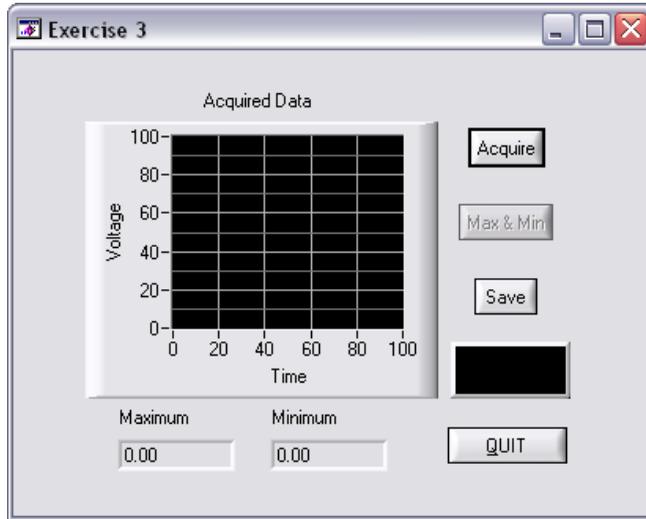


Figure 7-3. Completed User Interface

Hints

- When you create the **Save** button, assign a callback function to it.
- You must move the source code that you developed in Exercise 2 for writing the array to disk into the callback function.
- Before you write the data to disk, prompt the user for a filename with the `FileSelectPopup` function from the User Interface Library.

Solution: `exer3.prj`

Exercise 4: Adding User Interface Events

Throughout this tutorial, you have been developing an event-driven program. When you place a control on a `.uir` file, you are defining a region of the screen that can generate events during program execution. Your C source files are written to respond to these events in callback functions.

So far, you have written functions that respond only to the `EVENT_COMMIT` event from the user interface. An `EVENT_COMMIT` event occurs whenever the end user commits on a control, which usually happens when that user releases the left mouse button after clicking a control.

User interface controls can generate many different types of events. For example, an event can be a left-click or a right-click. Or, an event can be a left double-click. Events in LabWindows/CVI can be more than just mouse clicks. An event can be the press of a key

or a move or size operation performed on a panel. Each time one of these events occurs, the callback function associated with the user interface called executes.



To view the events that each user action generates, click the icon shown at left, which puts the User Interface Editor into operate mode. When the User Interface Editor is in operate mode, LabWindows/CVI displays events under the User Interface Editor menu bar as you operate the user interface controls. Refer to the *Events Overview* topic in the *LabWindows/CVI Help* for a list of the events you can generate from a GUI.

When the callback function is called, the event type is passed through the event parameter to the callback function. Performing one simple operation on the user interface, such as clicking a command button, can call the callback function for that button three times.

The first time, the callback function is called to process the `EVENT_LEFT_CLICK` event. The second time, it is called to process the `EVENT_COMMIT` event. The third time, the callback function is called to process the `EVENT_GOT_FOCUS` event if the button did not have the input focus before you clicked it. For this reason, all of the callback functions you have worked on check the event type first and execute only when the event is an `EVENT_COMMIT`. Therefore, the operations in the callback functions happen only once with each event click, rather than three times.

Assignment

Many times, the person operating a LabWindows/CVI program is not the person who developed the program. The GUI might be very easy to use, but usually it is preferable to add help for the controls on `.uir` panels to assist the operator. Modify `exer4.prj` to display a short description for each command button when the user right-clicks the button.

Hints

- Use `MessagePopup` to display the help.
- Remember that the event type is passed to each callback function in the event parameter.
- The event that you must respond to is `EVENT_RIGHT_CLICK`.



Tip If you want to add pop-up documentation to controls, use `SetCtrlToolTipAttribute`. You can find this function by expanding the Library Tree to **Programmer's Toolbox**»**User Interface Utilities**»**SetCtrlToolTipAttribute**.

Solution: `exer4.prj`

Exercise 5: Timed Events

You have developed an event-driven program that responds to events generated by mouse clicks or keypresses from the user. With the LabWindows/CVI timer control, you can generate events at specified time intervals to trigger program actions without requiring an action from the user.

You can include timer controls in your program by creating them in the User Interface Editor. The timer control is visible only at design time in the User Interface Editor. At run time, the timer control does not appear. You can specify a constant name, callback function, and timer event interval in the Edit Timer dialog box. LabWindows/CVI automatically calls the specified timer callback function with an event of type `EVENT_TIMER_TICK` each time the specified time interval elapses. The interval value is specified in seconds with a resolution of 1 millisecond between timer events.

Assignment

Add a thermometer control to the user interface and use a timer control to generate a random number and display it on the thermometer once each second.

Hints

- Set the timer interval to 1.
- Use CodeBuilder to generate the shell for the timer control callback function.
- Use `SetCtrlVal` to display the random number on the thermometer.

Solution: `exer5.prj`



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Glossary

A

active window	The window affected by keyboard input at a given moment. The title of an active window appears highlighted.
API	Application programming interface.
Array Display window	A window for viewing and editing numeric arrays.

B

binary control	A function panel control that resembles a physical on/off switch and can produce one of two values depending on the position of the switch.
breakpoint	An interruption in the execution of a program. Also, a function in code that causes an interruption in the execution of a program.

C

checkbox	A dialog box item that allows you to toggle between two possible execution options.
click	A mouse-specific term; to quickly press and release the mouse button.
CodeBuilder	The LabWindows/CVI feature that creates code based on a <code>.uir</code> file to connect a GUI to the rest of a program. You can compile and run this code as soon as it is generated.
command button	A user interface item that, when selected, executes a command associated with the item.
control	Function panel: An input or output device that appears on a function panel for specifying function parameters and displaying function results. User interface: An object on a panel that displays information or accepts input from a user.

cursor The flashing rectangle that shows where you can enter text on the screen. There is also a rectangular mouse cursor, or pointer, that shows the position of the mouse.

D

Debugging Region An area of the Workspace window that contains the Variables, Watch, and Memory windows.

default command The action that takes place when <Enter> is pressed and no command is specifically selected. Default command buttons in dialog boxes have an outline around them.

dialog box A prompt mechanism in which you specify additional information needed to complete a command.

DLL Dynamic link library.

double-click A mouse-specific term; to click the mouse button twice in rapid succession.

F

.fcp file A file that contains information about the function tree and function panels of an instrument driver.

function panel A user interface to the LabWindows/CVI libraries that allows interactive execution of library functions and is capable of generating code for inclusion in a program.

function tree The hierarchical structure in which the functions in instrument drivers and LabWindows/CVI libraries are grouped.

G

global control A function panel control that displays the value of a global variable within a function.

GPIB General Purpose Interface Bus.

Graphical Array View A window in which you can view the values of arrays in a graph.

GUI Graphical user interface.

H

highlight To make a LabWindows/CVI screen item ready for input.

I

input control A function panel control in which a value or variable name is entered from the keyboard.

instrument driver A group of several subprograms related to a specific instrument that reside on disk in a special language-independent format. An instrument driver is used to generate and execute code interactively through menus, dialog boxes, and function panels.

Interactive Execution window A LabWindows/CVI work area in which sections of code can be executed without creating an entire program.

L

Library Tree An area in the Workspace window that contains a tree view of the LabWindows/CVI libraries and instruments.

list box A dialog box item that displays a list of possible choices for completing a command.

M

menu An area accessible from the menu bar that displays a subset of the possible menu items.

mouse cursor A mouse-specific term; the rectangular block on the screen that shows the current mouse position.

O

- output control A function panel control that displays the results of a function.
- Output Region An area of the Workspace window in which LabWindows/CVI displays errors, output, and search matches.

P

- point A mouse-specific term; to move the mouse until the pointer rests on the item you want to click on.
- pointer A mouse-specific term; the rectangular block on the screen that shows the current mouse position.
- project A list of files, usually including a source file, user interface resource file, and header file, that your application uses.
- Project Tree An area of the Workspace window that contains the lists of projects and files in the current workspace.

R

- return value control A function panel control that displays a function result returned as a return value rather than as a formal parameter.
- ring control A control that displays a list of options one option at a time. Ring controls appear on function panels and in dialog boxes.

S

- select To choose the item that the next executed action will affect by moving the input focus (highlight) to a particular item or area.
- shortcut key commands A combination of keystrokes that automatically executes a command.
- slide control A function panel control that resembles a physical slide switch and inserts a value in a function call that depends on the position of the cross-bar on the switch.
- Source Code Browser A cross-reference tool that lists browse information for selected files, functions, variables, data types, and macros.

Source window	A LabWindows/CVI work area in which you edit and execute complete programs. The file extension <code>.c</code> designates a file that appears in this window.
standard libraries	The LabWindows/CVI ActiveX, Advanced Analysis (or Analysis), DDE Support, DIAdem Connectivity, Formatting and I/O, GPIB/GPIB-488.2, Internet, .NET, RS-232, TCP Support, User Interface, Utility, VISA, and VXI libraries and the ANSI C Library.
step mode	A program execution mode in which a program is manually executed one instruction at a time. Each instruction in the program is highlighted as it is executed.
String Display window	A mechanism for viewing and editing string variables and arrays.
subwindow	A Source window, split into two scrollable editing areas for the same file.

T

text box	A dialog box item in which the user enters text from the keyboard to complete a command.
timer control	A user interface control that schedules the periodic execution of a callback function. A typical use of this control might be to update a graph every second.
tooltip	A small, yellow box that displays variable and expression values or function prototypes in a Source window.

U

User Interface Editor	A graphical drag-and-drop editor for designing user interfaces for programs.
User Interface Library	A set of functions for controlling the interface programmatically.

V

Variables window	A display that shows the values of variables currently defined in LabWindows/CVI.
VXI	VME eXtensions for Instrumentation (bus).

W

window	A working area that supports operations related to a specific task in the development and execution processes.
Window Confinement Region	An area of the Workspace window that contains open Source, User Interface Editor, and Function Tree Editor windows, and function panels.
workspace	A file that contains settings that do not affect the way a project builds, such as breakpoints, window position, tag information, and debugging levels. A workspace can contain one or more projects.
Workspace window	The main work area in LabWindows/CVI; contains the Project Tree, Library Tree, Window Confinement Region, Debugging Region, Output Region, and Source Code Browser.

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