

LabVIEW

For Everyone

Graphical Programming
Made Easy and Fun



**JEFFREY TRAVIS
JIM KRING**

THIRD EDITION



LabVIEW **for** **Everyone**

Third Edition

LabVIEW for Everyone, Third Edition: Graphical Programming Made Easy and Fun

Table of Contents

Contents

About the Authors

Preface

Acknowledgments

1 What in the World Is LabVIEW?

What Exactly Is LabVIEW, and What Can It Do for Me?

Dataflow and the Graphical Programming Language

How Does LabVIEW Work?

Demonstration Examples

NI Example Finder

Examples on the CD

Activity 1-1: Temperature System Demo

Activity 1-2: Frequency Response Example

Wrap It Up!

Additional Activities

Activity 1-3: More Neat Examples

2 Virtual Instrumentation: Hooking Your Computer Up to the
Real World

Using LabVIEW in the Real World

The Evolution of LabVIEW

What Is Data Acquisition?

Table of Contents

What Is GPIB?

Communication Using the Serial Port

Real-World Applications: Why We Analyze

A Little Bit About PXI and VXI

Connectivity

- Internet Connectivity

- Networking

- ActiveX and .NET

- Shared Libraries, DLLs, and CINs

- Other Communication Mechanisms

LabVIEW Add-on Toolkits

LabVIEW Real-Time, FPGA, PDA, and Embedded

Wrap It Up!

3 The LabVIEW Environment

Front Panels

- Controls and Indicators

Block Diagrams

- Nodes

- Wires

- Dataflow ProgrammingGoing with the Flow

LabVIEW Projects

- Project Explorer Window

- Project Explorer Toolbars

- Adding Items to Your Project

- Project Folders

- Removing Items from a Project

- Building Applications, Installers, DLLs, Source Distributions, and Zip Files

- More Project Features

Table of Contents

SubVIs, the Icon, and the Connector

Activity 3-1: Getting Started

Alignment Grid

Pull-Down Menus

Floating Palettes

- Controls and Functions Palettes

- Customizing the Palettes

- Tools Palette

- Automatic Tool Selection

The Toolbar

Pop-Up Menus

- Pop-Up Menu Features to Keep in Mind

- Pop-Up Features Described

Help!

- The Context Help Window

- Online Help

Express VIs

Displaying SubVIs as Expandable Nodes

A Word About SubVIs

Activity 3-2: Front Panel and Block Diagram Basics

Wrap It Up!

4 LabVIEW Foundations

Creating VIs: It's Your Turn Now!

- Placing Items on the Front Panel

- Labeling Items

- Changing Font, Style, Size, and Color of Text

- Placing Items on the Block Diagram

- Editing Techniques

Table of Contents

Activity 4-1: Editing Practice

Basic Controls and Indicators and the Fun Stuff They Do

- Numeric Controls and Indicators
- Booleans
- Strings
- Paths
- Decorations
- Custom Controls and Indicators
- Summary of Basic Controls and Indicators

Wiring Up

- Automatic Wire Routing
- Automatic Wiring
- Wiring Complicated Objects
- Bad Wires
- Wiring Tips
- Wire Stretching
- Selecting and Deleting Wires
- Moving Wires
- Wiring to Off-Screen Areas
- Adding Constants, Controls, and Indicators Automatically

Running Your VI

- Activity 4-2: Building a Thermometer

Useful Tips

- Keyboard Shortcuts
- Examples
- Changing Tools
- Changing the Direction of a Wire
- Canceling a Wiring Operation
- Removing the Last Tack Point

Table of Contents

- Inserting an Object into Existing Wires
- Moving an Object Precisely
- Incrementing Digital Controls More Quickly
- Entering Items in a Ring Control
- Cloning an Object
- Moving an Object in Only One Direction
- Matching the Color
- Replacing Objects
- Making Space
- Configuring Your Preferences

Wrap It Up!

Additional Activities

- Activity 4-3: Comparison Practice
- Activity 4-4: Very Simple Calculator

5 Yet More Foundations

Loading and Saving VIs

- Save Options
- Revert
- LLBs
- Save and Load Dialogs
- Filter Rings

Debugging Techniques

- Fixing a Broken VI
- Warnings
- Most Common Mistakes
- Single-Stepping Through a VI
- Execution Highlighting
- Setting Breakpoints
- Suspending Execution

Table of Contents

Using the Probe

Activity 5-1: Debugging Challenge

Creating SubVIs

Creating a SubVI from a VI

Creating SubVIs from a Block Diagram Selection

SubVI Help: Recommended, Required, and Optional Inputs

Relink to SubVI: Changing Connector Panes of SubVIs

Documenting Your Work

Creating Descriptions and Tips for Individual Objects

Documenting VIs in the VI Properties

A Little About Printing

Activity 5-2: Creating SubVIs Practice Makes Perfect

Wrap It Up!

Additional Activities

Activity 5-3: Find the Average

Activity 5-4: Divide by Zero (Who Says You Can't?)

6 Controlling Program Execution with Structures

Two Loops

The For Loop

The While Loop

Placing Objects Inside Structures

Activity 6-1: Counting the Loops

Shift Registers

Activity 6-2: Shift Register Example

Why You Need Shift Registers

Initializing Shift Registers

The Feedback Node

Converting Tunnels to Shift Registers (and Vice Versa)

Table of Contents

The Case Structure

Wiring Inputs and Outputs

Adding Cases

Dialogs

Activity 6-3: Square Roots

The Select Function

The Sequence Structure Flat or Stacked

Stacked Sequence Structures and Sequence Locals Are Evil

Timing

Activity 6-4: Matching Numbers

Express Timing Functions

The Timed Structures

The Timed Loop

The Timed Sequence

The Timed Structure VIs

The Formula Node

Activity 6-5: Formula Fun

The Expression Node

The While Loop + Case Structure Combination

The Main Loop

Handling Multiple Work Items in a While Loop

Adding Efficiency: Wait on Front Panel Activity

Wrap It Up!

Additional Activities

Activity 6-6: Equations

Activity 6-7: Calculator

Activity 6-8: Combination For/While Loop Challenge

Activity 6-9: Dialog Display

Table of Contents

7 LabVIEW's Composite Data: Arrays and Clusters

What Are Arrays?

Creating Array Controls and Indicators

Array Scrollbars

Using Auto-Indexing

Using Auto-Indexing to Set the For Loop Count

Two-Dimensional Arrays

Creating Two-Dimensional Arrays

Activity 7-1: Building Arrays with Auto-Indexing

Functions for Manipulating Arrays

Activity 7-2: Array Acrobatics

Polymorphism

Activity 7-3: Polymorphism

Compound Arithmetic

A Word About Boolean Arithmetic

All About Clusters

Creating Cluster Controls and Indicators

Cluster Order

Using Clusters to Pass Data to and from SubVIs

Replacing a Cluster Element

Unbundling Your Clusters

Activity 7-4: Cluster Practice

Bundling and Unbundling by Name

Activity 7-5: More Fun with Clusters

Interchangeable Arrays and Clusters

Comparison Function Modes for Arrays and Clusters

Error Clusters and Error-Handling Functions

Error Cluster Datatype

Table of Contents

Propagating Errors: Error Dataflow

Generating and Reacting to Errors in SubVIs

Handling Errors in SubVIs

Generating Errors in SubVIs

Giving Up: Displaying Error Messages to the User

Extra Tips for Error Handling

Wrap It Up!

Additional Activities

Activity 7-6: Reversing the Order Challenge

Activity 7-7: Taking a Subset

Activity 7-8: Dice! Challenge

Activity 7-9: Multiplying Array Elements

8 LabVIEW's Exciting Visual Displays: Charts and Graphs

Waveform Charts

Chart Update Modes

Single-Plot Charts

Wiring a Multiple-Plot Chart

Single-Plot Versus Multi-Plot Data Types: A Trick for Remembering

Show the Digital Display?

The X Scrollbar

Clearing the Chart

Stacked and Overlaid Plots

Multiple Y Scales

Chart History Length

Activity 8-1: Temperature Monitor

Graphs

Single-Plot Waveform Graphs

Multiple-Plot Waveform Graphs

Table of Contents

Activity 8-2: Graphing a Sine on a Waveform Graph

XY Graphs

Showing Optional Planes in an XY Graph

Chart and Graph Components

Playing with the Scales

The Plot Legend

Activity 8-3: Using an XY Graph to Plot a Circle

Using the Graph Palette

Graph Cursors

Graph Annotations

Activity 8-4: Temperature Analysis

Intensity Charts and GraphsColor as a Third Dimension

Activity 8-5: The Intensity Graph

3D Graphs

Time Stamps, Waveforms, and Dynamic Data

Time Stamp

Waveforms

Waveform Functions

Activity 8-6: Generate and Plot a Waveform

Digital Data

Digital Waveform Graphs

Dynamic Data

Mixed Signal Graphs

Exporting Images of Charts and Graphs

Wrap It Up!

Additional Activities

Activity 8-7: Temperature Limit

Activity 8-8: Max/Min Temperature Limit

Table of Contents

Activity 8-9: Plotting Random Arrays

9 Exploring Strings and File I/O

More About Strings

Choose Your Own Display Type

Single Line Strings

Updating While You Type

The Scrollbar

Tables

Listboxes

Using String Functions

Activity 9-1: String Construction

Parsing Functions

Match Pattern and Regular Expressions

Activity 9-2: More String Parsing

File Input/Output

How They Work

Express Writing and Reading of Measurement Files

Writing and Reading Spreadsheet Files

Activity 9-3: Writing to a Spreadsheet File

Activity 9-4: Reading from the Spreadsheet File

More Writing and Reading of Files

Activity 9-5: Reading a Text File

Activity 9-6: Writing and Reading Binary Files

Wrap It Up!

Additional Activities

Activity 9-7: Temperatures and Time Stamps

Activity 9-8: Spreadsheet Exercise

10 Signal Measurement and Generation: Data Acquisition

Table of Contents

DAQ and Other Data Acquisition Acronyms

How to Connect Your Computer to the Real World

Signals 101

- Timing Is Everything

- Signal Classification

- Signal Conditioning

- Finding a Common Ground

- Measuring Differences

- Sampling, Aliasing, and Mr. Nyquist

- In Conclusion

Selecting and Configuring DAQ Measurement Hardware

- Choosing Your Hardware

- Activity 10-2: Measurement System Analysis

- Installing DAQ Device Driver Software

- Measurement & Automation Explorer (MAX)

- NI-DAQmx

- Configuring NI-DAQmx Devices in MAX

- Configuring Data Acquisition

Wrap It Up!

Solutions to Activities

11 Data Acquisition in LabVIEW

Understanding Analog and Digital I/O

- Using the DAQ Assistant

- Activity 11-1: Analog Input

- Analog I/O Terms and Definitions

- Digital I/O Terms and Definitions

NI-DAQmx Tasks

- Creating NI-DAQmx Tasks in MAX

- Referencing MAX DAQmx Tasks in LabVIEW

Table of Contents

Generating Code from MAX DAQmx Tasks

Using NI-DAQmx Tasks in LabVIEW

Advanced Data Acquisition

DAQmx Timing and DAQmx Trigger

Multichannel Acquisition

Continuous Data Acquisition

Activity 11-7: Continuous Acquisition

Streaming Data to a File

Activity 11-8: Streaming Data to File

Counting Frequency and Events

Wrap It Up!

12 Instrument Control in LabVIEW

Instrumentation Acronyms

Connecting Your Computer to Instruments

Using a GPIB Controller

Getting Ready for Serial Communications

Ethernet-Enabled Instruments

SCPI, the Language of Instruments

VISA: Your Passport to Instrument Communication

VISA Resource Strings

Configuring Your VISA Resources in MAX

Instrument Control in LabVIEW

Using the Instrument I/O Assistant

Instrument Drivers

Find Instrument Drivers from LabVIEW

VISA Functions

Advanced VISA Functions

Bus/Interface Specific VISA Functions

Table of Contents

VISA GPIB Versus Traditional GPIB Functions

VISA Serial Functions

VISA USB Functions

Create Your Own Instrument Driver: The Instrument Driver
Wizard

Wrap It Up!

13 Advanced LabVIEW Structures and Functions

Local, Global, and Shared Variables

Local Variables

Activity 13-1: Using Local Variables

Activity 13-2: Fun with Locals

Activity 13-3: More Fun with Locals

Global Variables

Shared Variables

Property Nodes

Another Example

Activity 13-4: Using Property Nodes with Charts

Invoke Nodes

Activity 13-5: Using Invoke Nodes to Export an Image from a Graph

Event-Driven Programming: The Event Structure

The Timeout Event

Editing Events Handled by Event Structure Cases

Using the Event Structure

Event Smorgasbord

Activity 13-6: Playing with Events

Stopping While Loops That Contain Event Structures

Activity 13-7: Using the Event Structure to Read Data Value Changes

Advanced Concepts: Event Data Node and Event Filter Nodes

Table of Contents

Advanced Concepts: Notify Events Versus Filter Events

Advanced Concepts: Dynamic Events and User Events

Type Definitions

Activity 13-8: Creating a Typedef

The State Machine and Queued Message Handler

The Standard State Machine

Activity 13-9: Using the Standard State Machine

The Queued Message Handler

Messaging and Synchronization

Queues

Notifiers

Semaphores: Locking and Unlocking Shared Resources

Rendezvous

Occurrences

First Call?

Structures for Disabling Code

The Diagram Disable Structure

The Conditional Disable Structure

Halting VI and Application Execution

Cool GUI Stuff: Look What I Can Do!

System Controls and Colors

Drag and Drop

Tree Control

Activity 13-11: Capturing Mouse Events on a Tree Control

Tab Control

Subpanels

Splitter Bars

Scrollbars

Graphics and Sound

Table of Contents

Wrap It Up!

14 Advanced LabVIEW Data Concepts

A Word About Polymorphic VIs

Advanced File I/O: Text Files, Binary Files, and Configuration Files

Opening and Closing File References

Advanced File Functions

End of File

Activity 14-1: Reading a Text File

Activity 14-2: Writing and Reading Binary Files

Configuration (INI) Files

Opening and Closing Configuration Files

Writing and Reading Key Values

Activity 14-3: Storing Data in a Configuration File

Additional Configuration File Operations

Calling Code from Other Languages

Using the Call Library Function Node to Call DLLs

Activity 14-4: Calling a DLL in LabVIEW

Fitting Square Pegs into Round Holes: Advanced Conversions
and Typecasting

You Can Be Anything: Variants

Using Variants: Creating Generic Software Components

ActiveX and the Variant Data Type

Wrap It Up!

Additional Activities

Activity 14-5: Read Text File by Page

15 Advanced LabVIEW Features

Exploring Your Options: The LabVIEW Options Dialog

Configuring Your VI

Table of Contents

SubVI Node Setup Options (Are Evil)

Activity 15-1: Using SubVIs

VI Properties Options

Reentrant Execution

Keyboard Navigation

The VI Server

Enabling Remote Access to the VI Server

Properties and Methods, By Reference

Déjà Vu: Property Nodes and Invoke Nodes

Application References

VI References

Control References

Activity 15-9: Building an Emergency Abort Utility

Final Thoughts on VI Server

Radices and Units

Radices

Units

Automatically Creating a SubVI from a Section of the Block Diagram

A Few More Utilities in LabVIEW

Custom Probes

The VI Hierarchy Window

Searching for Objects in the Virtual Haystack

Replacing Search Result Items

Find VIs on Disk

More Tools

Wrap It Up!

16 Connectivity in LabVIEW

Your VIs on the Web: The LabVIEW Web Server

Configuring LabVIEW's Built-in Web Server

Table of Contents

Publishing to HTML with LabVIEW's Web Server

Emailing Data from LabVIEW

Remote Panels

Self-Describing Data: XML

Sharing Data over the Network: Shared Variables

Shared Variables in LabVIEW Projects

Binding Controls and Indicators to Shared Variables

Programmatically Accessing Shared Variables Using DataSocket

Talking to Other Programs and Objects

.NET and ActiveX

AppleEvents

Pipes

Talking to Other Computers: Network VIs

TCP/IP

UDP

Databases

Report Generation

Express Report

Easy Text Report

Advanced Report Generation

Wrap It Up!

17 The Art of LabVIEW Programming

Why Worry About the Graphical Interface Appearance?

Arranging, Decorating, Resizing, Grouping, and Locking

Vive l'art: Importing Pictures

Custom Controls and Indicators

Adding Online Help

Pointers and Recommendations for a Wow! Graphical

Table of Contents

Interface

How Do You Do That in LabVIEW?

Memory, Performance, and All That

Curing Amnesia and Slothfulness

The Declaration of (Platform) Independence

Programming with Style

Modularize and Test Your VIs

Document as You Go Along

One More Time: Dataflow!

Wrap It Up!

Concluding Remarks

Appendix A: CD Contents

Appendix B: Add-on Toolkits for LabVIEW

Appendix C: Open Source Tools for LabVIEW: OpenG

Appendix D: LabVIEW Object-Oriented Programming

Appendix E: Resources for LabVIEW

Appendix F: LabVIEW Certification Exams

Glossary

A

B

C

D

E

F

G

H

Table of Contents

I

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Index