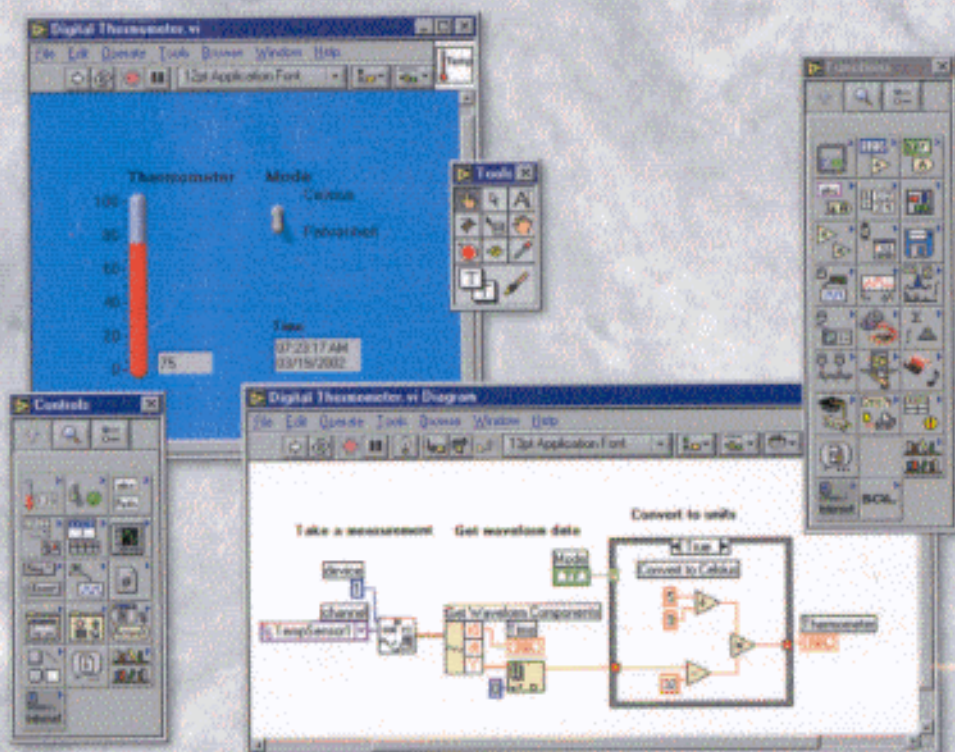




LabVIEW[®] FOR EVERYONE

SECOND EDITION



JEFFREY TRAVIS

Fundamentals



Introduction—What in the World Is LabVIEW?

3

- 1.1 What Exactly Is LabVIEW, and What Can It Do for Me? 3
 - 1.1.1 Dataflow and the Graphical Programming Language 5
 - 1.1.2 How Does LabVIEW Work? 6
- 1.2 Demonstration Examples 8
 - 1.2.1 Activity 1-1: Temperature System Demo 9
 - 1.2.2 Activity 1-2: Frequency Response Example 14

1.3	Wrap it Up!	16
1.4	Additional Activities	16

▼ 2

Virtual Instrumentation: Hooking Your Computer Up to the Real World

19

2.1	The Evolution of LabVIEW	19
2.2	What Is Data Acquisition?	21
2.3	What Is a GPIB?	24
2.4	Communication Using the Serial Port	26
2.5	Real-World Applications: Why We Analyze	27
2.6	A Little Bit about PXI and VXI	29
2.7	Connectivity	31
2.7.1	Internet Connectivity	31
2.7.2	Networking	32
2.7.3	ActiveX	33
2.7.4	DLLs and CINs	33
2.8	LabVIEW Add-on Toolkits	34
2.9	Wrap It Up!	35

▼ 3

The LabVIEW Environment: Building Your Own Workbench

37

3.1	Front Panels	37
3.1.1	Controls and Indicators	37

3.2	Block Diagrams	38
3.2.1	Terminals	39
3.2.2	Nodes	40
3.2.3	Wires	40
3.2.4	Dataflow Programming — Going with the Flow	41
3.3	The Icon and the Connector	41
3.3.1	Activity 3-1: Getting Started	42
3.4	Pull-Down Menus	49
3.5	Floating Palettes	52
3.5.1	Controls and Functions Palettes	52
3.5.2	The Thumbtack	55
3.5.3	Customizable Palettes	55
3.5.4	Tools Palette	55
3.6	The Toolbar	57
3.7	Pop-Up Menus	60
3.7.1	Pop-Up Menu Features to Keep in Mind	61
3.7.2	Pop-Up Features Described	62
3.8	Help!	65
3.8.1	The Context Help Window	65
3.9	A Word about SubVIs	67
3.10	Activity 3-2: Front Panel and Block Diagram Basics	68
3.11	Wrap It Up!	72

▼ 4

LabVIEW Foundations

75

4.1	Creating VIs — It's Your Turn Now!	75
-----	--	----

4.1.1	Placing Items on the Front Panel	75
4.1.2	Labeling Items	76
4.1.3	Changing Font, Style, Size, and Color of Text	79
4.1.4	Placing Items on the Block Diagram	79
4.1.5	Editing Techniques	80
4.2	Basic Controls and Indicators and the Fun Stuff They Do	88
4.2.1	Numeric Controls and Indicators	90
4.2.2	Booleans	94
4.2.3	Strings	96
4.2.4	Paths	97
4.2.5	Decorations	97
4.2.6	Custom Controls and Indicators	97
4.2.7	Summary of Basic Controls and Indicators	98
4.3	Wiring Up	98
4.3.1	Automatic Wiring	99
4.3.2	Wiring Complicated Objects	100
4.3.3	Bad Wires	100
4.3.4	Wiring Tips	101
4.3.5	Wire Stretching	102
4.3.6	Selecting and Deleting Wires	102
4.3.7	Moving Wires	102
4.3.8	Wiring to Off-Screen Areas	103
4.3.9	Adding Constants, Controls, and Indicators Automatically	103
4.4	Running Your VI	103
4.4.1	Activity 4-2: Building a Thermometer	104
4.5	Useful Tips	108

4.6	Wrap It Up!	112
4.7	Additional Activities	112

▼5

Yet More Foundations

115

5.1	Loading and Saving VIs	115
5.1.1	Save Options	116
5.1.2	Revert	117
5.1.3	Save and Load Dialogs	117
5.1.4	Filter Rings	118
5.2	VI Libraries	118
5.2.1	Reasons for Using VI Libraries	119
5.2.2	Reasons to Save VIs as Individual Files	119
5.2.3	How to Use VI Libraries	119
5.2.4	The Edit VI Library Dialog	120
5.2.5	The VI Library Manager	121
5.3	Debugging Techniques	121
5.3.1	Fixing a Broken VI	122
5.3.2	Warnings	122
5.3.3	Most Common Mistakes	123
5.3.4	Single-Stepping through a VI	123
5.3.5	Execution Highlighting	124
5.3.6	Using the Probe	125
5.3.7	Setting Breakpoints	127
5.3.8	Suspending Execution	127
5.3.9	Activity 5-1: Debugging Challenge	128

5.4	Creating SubVIs	130
5.4.1	Creating a SubVI from a VI	131
5.4.2	Creating a SubVI from a Block Diagram Selection	135
5.4.3	SubVI Help: Recommended, Required, and Optional Inputs	136
5.5	Documenting Your Work	137
5.5.1	Creating Descriptions and Tips for Individual Objects	137
5.5.2	Documenting VIs in the VI Properties	138
5.6	A Little about Printing	139
5.7	Activity 5-2: Creating SubVIs—Practice Makes Perfect	139
5.8	Wrap It Up!	142
5.9	Additional Activities	143

▼6

Controlling Program Execution with Structures 147

6.1	Two Loops	147
6.1.1	The For Loop	147
6.1.2	The While Loop	148
6.1.3	Placing Objects Inside Structures	149
6.1.4	Activity 6-1: Counting with Loops	151
6.2	Shift Registers	155
6.2.1	Activity 6-2: Shift Register Example	156
6.2.2	Why You Need Shift Registers	158
6.2.3	Initializing Shift Registers	159
6.3	Case Structures	160
6.3.1	Wiring Inputs and Outputs	161
6.3.2	Adding Cases	162

6.3.3	Dialog Boxes	162
6.3.4	Activity 6-3: Square Roots	163
6.3.5	The Select Function	165
6.4	Sequence Structures	166
6.4.1	Sequence Locals	167
6.4.2	Timing	168
6.4.3	Activity 6-4: Matching Numbers	169
6.5	The Formula Node	171
6.5.1	Activity 6-5: Formula Fun	173
6.6	Wrap It Up!	175
6.7	Additional Activities	176

7

LabVIEW's Composite Data:

Arrays and Clusters

181

7.1	What Are Arrays?	181
7.2	Creating Array Controls and Indicators	182
7.3	Using Auto-Indexing	184
7.4	Two-Dimensional Arrays	186
7.5	Activity 7-1: Building Arrays with Auto-Indexing	187
7.6	Functions for Manipulating Arrays	189
7.7	Activity 7-2: Array Acrobatics	192
7.8	Polymorphism	194
7.9	Activity 7-3: Polymorphism	196
7.10	Compound Arithmetic	197

7.11	All about Clusters	199
7.12	Creating Cluster Controls and Indicators	200
7.13	Cluster Order	201
7.14	Using Clusters to Pass Data to and from SubVIs	202
7.15	Bundling Your Data	202
7.16	Replacing a Cluster Element	203
7.17	Unbundling Your Clusters	203
7.18	Activity 7-4: Cluster Practice	204
7.19	Bundling and Unbundling by Name	206
7.20	Activity 7-5: More Fun with Clusters	208
7.21	Interchangeable Arrays and Clusters	209
7.22	Wrap It Up!	210
7.23	Additional Activities	212

8

LabVIEW's Exciting Visual Displays: Charts and Graphs **215**

8.1	Waveform Charts	215
8.1.1	Chart Update Modes	216
8.1.2	Single-Plot Charts	217
8.1.3	Wiring a Multiple-Plot Chart	217
8.1.4	Show the Digital Display?	218
8.1.5	The Scrollbar	218
8.1.6	Clearing the Chart	218
8.1.7	Stacked and Overlaid Plots	218

8.1.8	Multiple X and Y Scales	219
8.1.9	Chart History Length	219
8.2	Activity 8-1: Temperature Monitor	220
8.3	Graphs	224
8.3.1	Single-Plot Waveform Graphs	225
8.3.2	Multiple-Plot Waveform Graphs	226
8.4	Activity 8-2: Graphing a Sine on a Waveform Graph	227
8.5	XY Graphs	231
8.6	Chart and Graph Components	232
8.6.1	Playing with the Scales	233
8.6.2	The Plot Legend	236
8.6.3	Activity 8-3: Using an XY Graph to Plot a Circle	238
8.6.4	Using the Graph Palette	239
8.6.5	Graph Cursors	240
8.7	Activity 8-4: Temperature Analysis	242
8.8	Intensity Charts and Graphs — Color as a Third Dimension	245
8.8.1	Activity 8-5: The Intensity Graph	246
8.8.2	3D Graphs	248
8.8.3	Digital Waveform Graphs	251
8.9	Waveforms	252
8.9.1	Waveforms versus Arrays	253
8.9.2	Waveform Functions	254
8.9.3	Activity 8-6: Generate and Plot a Waveform	257
8.10	Wrap It Up!	259
8.11	Additional Activities	260

9

Exploring Strings and File I/O

263

9.1	More about Strings	263
9.1.1	Choose Your Own Display Type	263
9.1.2	Single-Line Strings	265
9.1.3	Updating While You Type	265
9.1.4	The Scrollbar	266
9.1.5	Tables	266
9.1.6	Listboxes	267
9.2	Using String Functions	267
9.3	Activity 9-1: String Construction	270
9.4	Parsing Functions	271
9.5	Activity 9-2: More String Parsing	273
9.6	File Input/Output	275
9.6.1	How They Work	275
9.7	Activity 9-3: Writing to a Spreadsheet File	277
9.8	Activity 9-4: Reading from the Spreadsheet File	278
9.9	Wrap It Up!	279
9.10	Additional Activities	280

Advanced Topics

Introduction to the Advanced Section	283
--	-----

▼10

Getting Data into and out of Your Computer: Data Acquisition and Instrument Control

285

10.1	Acronyms Unlimited	285
10.2	How to Connect Your Computer to the Real World	287
10.3	Signals 101	289
10.3.1	Timing Is Everything	290
10.3.2	Signal Classification	290
10.3.3	Signal Conditioning	298
10.3.4	Finding a Common Ground	302
10.3.5	Measuring Differences	304
10.3.6	Sampling, Aliasing, and Mr. Nyquist	309
10.3.7	In Conclusion	312
10.4	Selecting and Configuring DAQ Measurement Hardware	313
10.4.1	Choosing Your Hardware	313
10.5	Activity 10-2: Measurement System Analysis	316
10.6	Installing the Boards	317
10.6.1	Analog I/O Settings	318
10.6.2	Measurement and Automation Explorer (MAX)	319
10.6.3	DAQ Boards under MacOS and Linux	326
10.7	Using a GPIB Board	326
10.8	Getting Ready for Serial Communications	328
10.9	Wrap It Up!	330
10.10	Solutions to Activities	331

11

DAQ and Instrument Control in LabVIEW

335

11.1	Definitions, Drivers, and Devices	335
11.1.1	Buffers	336
11.1.2	Triggering	337
11.2	Analog I/O	338
11.2.1	Quick and Dirty Analog I/O: The Top Tier	341
11.2.2	Activity 11-1: Analog Input	344
11.2.3	Activity 11-2: More Analog Input	345
11.2.4	Better Analog I/O: The Middle Tier	347
11.2.5	Activity 11-3: Buffered DAQ	352
11.2.6	Activity 11-4: More Fun with DAQ	353
11.2.7	Nerd-Level Analog I/O	354
11.2.8	Activity 11-5: Continuous Acquisition	354
11.2.9	Activity 11-6: Triggering	358
11.2.10	Activity 11-7: Streaming to Disk	360
11.3	Digital I/O	361
11.3.1	Quick and Dirty Digital I/O: The Top Tier	363
11.3.2	Activity 11-8: Digital Output	365
11.4	Instrument Control in LabVIEW: VISA, GPIB, and Serial	365
11.4.1	VISA	366
11.4.2	GPIB	368
11.4.3	Serial Communications	369
11.4.4	Instrument Drivers	370
11.5	Wrap It Up!	372

▼12

Advanced LabVIEW Functions and Structures 375

12.1	Local and Global Variables	375
12.1.1	Local Variables	376
12.1.2	Global Variables	384
12.2	Property Nodes	390
12.3	Other LabVIEW Goodies	400
12.3.1	Dialogs	401
12.3.2	Saying “NO” Harshly.	402
12.3.3	Sound.	403
12.4	Calling Code from Other Languages	404
12.4.1	Using CINs.	405
12.5	Fitting Square Pegs into Round Holes: Advanced Conversions and Typecasting.	407
12.6	Wrap It Up!	412

▼13

Advanced LabVIEW Features 415

13.1	Options, Options	415
13.2	Configuring Your VI	417
13.2.1	SubVI Node Setup Options.	418
13.2.2	Activity 13-1: Using SubVIs	418
13.2.3	VI Properties Options.	420
13.2.4	Window Appearance	421
13.2.5	Execution.	423

13.3	The VI Server	425
13.3.1	Mechanisms for Accessing the VI Server	427
13.3.2	Keyboard Navigation	433
13.4	Radices and Units	436
13.4.1	Radices	436
13.4.2	Units	437
13.5	Automatically Creating a SubVI from a Section of the Block Diagram	440
13.6	A Few More Utilities in LabVIEW	442
13.6.1	The Hierarchy Window	442
13.6.2	Searching for Objects in the Virtual Haystack	443
13.7	Wrap It Up!	445

▼14

Connectivity in LabVIEW

447

14.1	LabVIEW, Networking, and the Internet	447
14.1.1	The Internet and the Client–Server Model	448
14.1.2	Choosing a Technical Solution with LabVIEW	449
14.2	An Overview of How the Web Works	450
14.2.1	Anatomy of a URL	450
14.2.2	URL Encoding	452
14.2.3	Web Browsers, Web Servers, and HTTP	453
14.3	Publishing and Controlling VIs on the Web	454
14.3.1	Configuring LabVIEW's Built-in Web Server	455
14.3.2	Publishing to HTML with LabVIEW's Web Server	456
14.4	Sharing Data over the Network: DataSocket	459
14.4.1	DataSocket VIs	464

14.5	Connectivity to Other Programs and Devices	469
14.5.1	TCP/IP	469
14.5.2	UDP	472
14.5.3	ActiveX	473
14.5.4	Apple Events and PPC	480
14.6	Enterprise Connectivity—The Big Picture	482
14.7	Wrap It Up!	484

▼15

Advanced File I/O, Printing, and Reports **487**

15.1	Advanced File I/O	487
15.1.1	Giving Directions to Find Your File	488
15.1.2	The Three-Step Process	489
15.1.3	Writing and Reading Text Files	492
15.1.4	Writing and Reading Datalog Files	497
15.1.5	Writing and Reading Binary Files	501
15.1.6	Working with Waveform Data in Files	508
15.2	Putting It in Writing: Printing with LabVIEW	509
15.3	Reports from LabVIEW	511
15.4	Wrap It Up!	512

▼16

The Art of LabVIEW Programming **515**

16.1	Why Worry about the Graphical Interface Appearance	515
16.2	Arranging, Decorating, Grouping, and Locking	516

16.3	Vive l'Art: Importing Pictures	518
16.4	Custom Controls and Indicators	520
16.5	Adding Online Help	524
16.6	Pointers and Recommendations for a "Wow!" Graphical Interface	527
16.7	How Do You Do That in LabVIEW?	531
16.8	Memory, Performance, and All That	538
	16.8.1 Curing Amnesia and Slothfulness	538
	16.8.2 The Declaration of Independence	540
16.9	Programming with Style	541
	16.9.1 Modularize and Test Your VIs	542
	16.9.2 Document as You Go Along	542
	16.9.3 One More Time: Dataflow!	543
16.10	Wrap It Up!	544
16.11	Concluding Remarks	545

Appendix

Resources for LabVIEW	547
-----------------------------	-----

Glossary

553

Index

571