

Contents

Preface	xiii
About the Author	xviii
1. LABVIEW PROGRAM DEVELOPMENT	1
1.1 LabVIEW Programming Environment	1
1.2 Blank VI	2
1.3 Front-Panel Editing	3
1.4 Block-Diagram Editing	11
1.5 Program Execution	22
1.6 Pop-Up Menu and Data-Type Representation	24
1.7 Program Storage	27
1.8 Quick Drop	29
Do It Yourself	32
Use It!	34
Problems	36
2. THE WHILE LOOP AND WAVEFORM CHART	39
2.1 Programming Structures and Graphing Modes	39
2.2 While Loop Basics	40
2.3 Sine-Wave Plot Using a While Loop and Waveform Chart	42
2.4 LabVIEW Help Window	48
2.5 Front-Panel Editing	50
2.6 Waveform Chart Pop-Up Menu	53
2.7 Finishing the Program	56
2.8 Program Execution	57
2.9 Program Improvements	59
2.10 Data Types and Automatic Creation Feature	70
Do It Yourself	74
Use It!	75
Problems	77
3. THE FOR LOOP AND WAVEFORM GRAPH	83
3.1 For Loop Basics	83
3.2 Sine-Wave Plot Using a For Loop and Waveform Graph	84

3.3	Waveform Graph	85
3.4	Owned and Free Labels	86
3.5	Creation of Sine Wave Using a For Loop	87
3.6	Cloning Block-Diagram Icons	89
3.7	Auto-Indexing Feature	91
3.8	Running the VI	94
3.9	X-Axis Calibration of the Waveform Graph	94
3.10	Sine-Wave Plot Using a While Loop and Waveform Graph	100
3.11	Front-Panel Array Indicator	103
3.12	Debugging with the Probe Watch Window and Error List	108
	Do It Yourself	115
	Use It!	117
	Problems	119
4.	THE MATHSCRIPT NODE AND XY GRAPH	127
4.1	MathScript Node Basics	127
4.2	Quick MathScript Node Example: Sine-Wave Plot	130
4.3	Waveform Simulator Using a MathScript Node and XY Graph	137
4.4	Creating an XY Cluster	142
4.5	Running the VI	143
4.6	LabVIEW MathScript Window	144
4.7	Adding Shape Options Using an Enumerated Type Control	148
4.8	Finishing the Block Diagram	151
4.9	Running the VI	155
4.10	Control and Indicator Clusters	156
4.11	Creating an Icon Using the Icon Editor	163
4.12	Icon Design	163
4.13	Connector Assignment	168
	Do It Yourself	172
	Use It!	173
	Problems	174
5.	INTRODUCTION TO DATA ACQUISITION DEVICES USING MAX	179
5.1	Data Acquisition Hardware	179
5.2	Measurement & Automation Explorer (MAX)	181
5.3	Analog Input Modes	185
5.4	Range and Resolution	187
5.5	Sampling Frequency and the Aliasing Effect	187
5.6	Analog Input Operation Using MAX	189
5.7	Analog Output	193
5.8	Analog Output Operation Using MAX	193
5.9	Digital Input/Output	197
5.10	Digital Input/Output Operation Using Max	198

Do It Yourself	200
Use It!	202
Problems	204
DATA ACQUISITION USING DAQ ASSISTANT	206
6.1 Data Acquisition VIs	206
6.2 Simple Analog Input Operation on a DC Voltage	207
6.3 Digital Oscilloscope	218
6.4 DC Voltage Storage	228
6.5 Hardware-Timed Waveform Generator	234
6.6 Placing a Custom-Made VI on a Block Diagram	237
6.7 Completing and Executing Waveform Generator (Express)	240
Do It Yourself	242
Use It!	243
Problems	246
DATA FILES AND CHARACTER STRINGS	254
7.1 ASCII Text and Binary Data Files	254
7.2 Storing Data in a Spreadsheet-Formatted File	256
7.3 Storing a One-Dimensional Data Array	257
7.4 Transpose Option	260
7.5 Storing a Two-Dimensional Data Array	262
7.6 Controlling the Format of Stored Data	266
7.7 The Path Constant and Platform Portability	267
7.8 Fundamental File I/O VIs	269
7.9 Adding Text Labels to a Spreadsheet File	274
7.10 Backslash Codes	277
Do It Yourself	279
Use It!	282
Problems	284
SHIFT REGISTERS	292
8.1 Shift Register Basics	292
8.2 Quick Shift Register Example: Integer Sum	295
8.3 Noise and Signal Averaging	299
8.4 Noisy Sine VI	301
8.5 Moving Average of Four Traces	307
8.6 Modularity and Automatic SubVI Creation	316
8.7 Moving Average of Arbitrary Number of Traces	323
Do It Yourself	337
Use It!	337
Problems	340

9.	THE CASE STRUCTURE	348
9.1	Case Structure Basics	348
9.2	Quick Case Structure Example: Runtime Options Using Property Nodes	351
9.3	State Machine Architecture: Guessing Game	363
9.4	State Machine Architecture: Express VI-Based Digital Oscilloscope	377
	Do It Yourself	386
	Use It!	387
	Problems	389
10.	DATA DEPENDENCY AND THE SEQUENCE STRUCTURE	396
10.1	Data Dependency and Sequence Structure Basics	396
10.2	Event Timer Using a Sequence Structure	400
10.3	Event Timer Using Data Dependency	407
10.4	Highlight Execution	411
	Do It Yourself	413
	Use It!	414
	Problems	417
11.	ANALYSIS VIs: CURVE FITTING	425
11.1	Thermistor Resistance-Temperature Data File	425
11.2	Temperature Measurement Using Thermistors	428
11.3	The Linear Least-Squares Method	431
11.4	Inputting Data to a VI Using a Front-Panel Array Control	433
11.5	Inputting Data to a VI by Reading from a Computer File	436
11.6	Slicing Up a Multidimensional Array	439
11.7	Running the VI	443
11.8	Curve Fitting Using the Linear Least-Squares Method	444
11.9	Residual Plot	452
11.10	Curve Fitting Using the Nonlinear Least-Squares Method	454
	Do It Yourself	457
	Use It!	460
	Problems	462
12.	ANALYSIS VIs: FAST FOURIER TRANSFORM	470
12.1	Quick Fast Fourier Transform Example	470
12.2	The Fourier Transform	480
12.3	Discrete Sampling and the Nyquist Frequency	481
12.4	The Discrete Fourier Transform	482
12.5	The Fast Fourier Transform	484
12.6	Frequency Calculator VI	485

12.7	FFT of Sinusoids	488
12.8	Applying the FFT to Various Sinusoidal Inputs	491
12.9	Magnitude of the Complex-Amplitude	494
12.10	Observing Leakage	500
12.11	Windowing	503
12.12	Estimating Frequency and Amplitude	509
12.13	Aliasing	513
	Do It Yourself	514
	Use It!	515
	Problems	519
13.	DATA ACQUISITION AND GENERATION USING DAQmx VIs	525
13.1	DAQmx VI Basics	525
13.2	Simple Analog Input Operation on a DC Voltage	527
13.3	Digital Oscilloscope	533
13.4	Express VI Automatic Code Generation	540
13.5	Limitations of Express VIs	541
13.6	Improving Digital Oscilloscope Using State Machine Architecture	543
13.7	Analog Output Operations	556
13.8	Waveform Generator	557
	Do It Yourself	560
	Use It!	561
	Problems	565
14	CONTROL OF STAND-ALONE INSTRUMENTS	574
14.1	Instrument Control Using VISA VIs	574
14.2	The VISA Session	575
14.3	The IEEE 488.2 Standard	579
14.4	Common Commands	579
14.5	Status Reporting	580
14.6	Device-Specific Commands	584
14.7	Specific Hardware Used in This Chapter	586
14.8	Measurement & Automation Explorer (MAX)	587
14.9	Simple VISA-Based Query Operation	594
14.10	Message Termination	598
14.11	Getting and Setting Communication Properties Using a Property Node	599
14.12	Performing a Measurement over the Interface Bus	603
14.13	Synchronization Methods	608
14.14	Measurement VI Based on the Serial Poll Method	616
14.15	Measurement VI Based on the Service Request Method	622
14.16	Creating an Instrument Driver	628

14.17	Using the Instrument Driver to Write an Application Program Do It Yourself Use It! Problems	642 647 648 651
APPENDIX A.	FORMULA NODE PROGRAMMING FOR CHAPTER 4	653
A.1	Formula Node Basics	653
A.2	Quick Formula Node Example: Sine-Wave Plot (Section 4.2)	654
A.3	Formula Node-Based Waveform Simulator (Sections 4.3–4.4)	658
A.4	Formula Node-Based Waveform Simulator (Section 4.8)	659
A.5	Formula Node-Based Waveform Simulator (Section 4.10)	660
APPENDIX B.	MATHEMATICS OF LEAKAGE AND WINDOWING	661
B.1	Analytic Description of Leakage	661
B.2	Description of Leakage Using the Convolution Theorem	665
APPENDIX C.	PID TEMPERATURE CONTROL PROJECT	670
C.1	Project Description	670
C.2	Voltage-Controlled Bidirectional Current Driver for Thermoelectric Device	670
C.3	PID Temperature Control Algorithm	672
C.4	PID Temperature Control System	675
C.5	Construction of Temperature Control System	676
INDEX		684