

## Table of Contents

<b>Microprocessor Design Trainer</b> .....	1
1 Microprocessor Design Trainer.....	5
1.1 Microprocessor Design Trainer Hardware.....	5
1.2 System Requirements.....	6
1.3 Quartus Development Software Installation.....	6
1.4 Driver Installation .....	9
1.5 Testing the Microprocessor Design Trainer Board.....	11
2 Microprocessor Circuits .....	14
2.1 Datapath .....	14
2.2 Control Unit .....	15
3 Datapath Design .....	16
3.1 Register Transfer Level.....	16
3.2 Problem Specification.....	17
3.3 Selecting Registers.....	20
3.4 Selecting Functional Units.....	20
3.5 Data Transfer Methods .....	21
3.5.1 Multiple Sources .....	21
3.5.2 Multiple Destinations.....	22
3.5.3 Tri-state Bus.....	22
3.6 Generating Status Signals .....	23
3.7 Control Words.....	24
3.8 Examples of Datapath Design.....	24
3.8.1 Example 1: Datapath for a simple IF-THEN-ELSE problem.....	24
3.8.2 Example 2: Datapath for the counting from 1 to 10 problem .....	26
4 Control Unit Design .....	28
4.1 The State Diagram .....	28
4.2 Examples of Control Unit Design.....	29
4.2.1 Example 3: Control unit for a simple IF-THEN-ELSE problem.....	29
4.2.2 Example 4: Control unit for the counting from 1 to 10 problem .....	33
5 Microprocessor Design .....	38
5.1 Examples of Microprocessor Design .....	38
5.1.1 Example 5: Microprocessor for the two-statement problem.....	38
5.1.2 Example 6: Microprocessor for the counting from 1 to 10 problem .....	39
6 Labs.....	41
6.1 Lab 1: Quartus Development Software.....	42
6.1.1 Starting Quartus II.....	42
6.1.2 Creating a New Project .....	43
6.1.3 Using the Block Editor.....	45
6.1.4 Managing Files in a Project .....	50
6.1.5 Creating and Using a Logic Symbol.....	51
6.1.6 Experiments .....	53
6.2 Lab 2: Implementing a Circuit in Hardware .....	55
6.2.1 Analysis and Synthesis .....	55
6.2.2 Mapping the I/O Signals to the FPGA Pins.....	55
6.2.3 Full Compilation .....	57
6.2.4 Programming the FPGA .....	58
6.2.5 Testing the Circuit in Hardware.....	58
6.2.6 Experiments .....	59
6.3 Lab 3: Counting from 1 to 10 .....	60
6.3.1 Experiments .....	62
6.4 Lab 4: Countdown from Input n .....	64
6.4.1 Experiments .....	67
6.5 Lab 5: Count and Sum .....	69

6.5.1	Experiments .....	73
6.6	Lab 6: Greatest Common Divisor .....	74
6.6.1	Experiments .....	80
6.7	Lab 7: Summing Input Numbers.....	81
6.7.1	Experiments .....	86
6.8	Lab 8: Finding the Largest Number.....	87
6.8.1	Experiments .....	91
6.9	Lab 9: Hi-Lo Number Guessing Game.....	93
6.9.1	Experiments .....	98
6.10	Lab 10: The EC-1 General-Purpose Microprocessor.....	100
6.10.1	Instruction Set .....	100
6.10.2	Datapath .....	101
6.10.3	Control Unit .....	102
6.10.4	EC-1 Microprocessor Circuit.....	106
6.10.5	Sample Program.....	107
6.10.6	Hardware Implementation .....	109
6.10.7	Experiments .....	109
6.11	Lab 11: The EC-2 General-Purpose Microprocessor.....	113
6.11.1	Instruction Set .....	113
6.11.2	Datapath .....	114
6.11.3	Control Unit .....	115
6.11.4	EC-2 Microprocessor Circuit.....	118
6.11.5	Sample Program.....	119
6.11.6	Hardware Implementation .....	121
6.11.7	Experiments .....	122
7	Appendix A – FPGA Pin Mappings.....	124