Contents

Preface xiii
Acknowledgements xv

1 Introduction to Microcontrollers and Display Systems 1
  1.1 Microcontrollers and Microprocessors 2
  1.2 Evolution of the Microcontroller 3
  1.3 Parts of a Microcontroller 4
    1.3.1 Address 4
    1.3.2 ALU 5
    1.3.3 Analogue Comparator 5
    1.3.4 Analogue-to-Digital Converter 5
    1.3.5 Brown-out Detector 5
    1.3.6 Bus 5
    1.3.7 CAN 6
    1.3.8 CISC 6
    1.3.9 Clock 6
    1.3.10 CPU 6
    1.3.11 EEPROM 6
    1.3.12 EPROM 6
    1.3.13 Ethernet 7
    1.3.14 Flash Memory 7
    1.3.15 Harvard Architecture 7
    1.3.16 Idle Mode 7
    1.3.17 Interrupts 7
    1.3.18 LCD Drivers 8
    1.3.19 Pipelining 8
    1.3.20 Power-on Reset 8
    1.3.21 PROM 8
    1.3.22 RAM 8
    1.3.23 Real-time Clock 8
    1.3.24 Register 9
    1.3.25 Reset 9
    1.3.26 RISC 9
    1.3.27 ROM 9
3.2.13 Arrays 70
3.2.14 Pointers 73
3.2.15 Structures 76
3.2.16 Unions 80
3.2.17 Operators in mikroC Pro for PIC 80
3.2.18 The Flow of Control 90
3.3 Functions in mikroC Pro for PIC 101
  3.3.1 Function Prototypes 102
  3.3.2 void Functions 103
  3.3.3 Passing Parameters to Functions 104
  3.3.4 Passing Arrays to Functions 106
  3.3.5 Interrupt Processing 106
3.4 mikroC Pro for PIC Built-in Functions 108
3.5 mikroC Pro for PIC Libraries 109
  3.5.1 ANSI C Library 109
  3.5.2 Miscellaneous Library 111
3.6 Using the mikroC Pro for PIC Compiler 111
  3.6.1 mikroC Pro for PIC IDE 112
  3.6.2 Creating a New Source File 118
  3.6.3 Compiling the Source File 122
3.7 Using the mikroC Pro for PIC Simulator 123
  3.7.1 Setting a Break-Point 124
3.8 Other mikroC Pro for PIC Features 126
  3.8.1 View Statistics 126
  3.8.2 View Assembly 127
  3.8.3 ASCII Chart 127
  3.8.4 USART Terminal 127
  3.8.5 Seven Segment Editor 127
  3.8.6 Help 128
3.9 Summary 128
Exercises 129

4 PIC Microcontroller Development Tools – Including Display Development Tools 131
4.1 PIC Hardware Development Boards 132
  4.1.1 Super Bundle Development Kit 132
  4.1.2 PIC18 Explorer Board 132
  4.1.3 PIC18F4XX20 Starter Kit 134
  4.1.4 PICDEM 4 135
  4.1.5 PIC16F887 Development Kit 135
  4.1.6 FUTURLEC PIC18F4550 Development Board 137
  4.1.7 EasyPIC6 Development Board 137
  4.1.8 EasyPIC7 Development Board 139
4.2 PIC Microcontroller Display Development Tools 140
  4.2.1 Display Hardware Tools 140
  4.2.2 Display Software Tools 143
4.3 Using the In-Circuit Debugger with the EasyPIC7 Development Board 145
4.4 Summary 149
Exercises 149

5 Light Emitting Diodes (LEDs) 151
5.1 A Typical LED 151
5.2 LED Colours 153
5.3 LED Sizes 154
5.4 Bi-Colour LEDs 154
5.5 Tri-Colour LEDs 155
5.6 Flashing LEDs 155
5.7 Other LED Shapes 155
5.8 7-Segment LEDs 156
  5.8.1 Displaying Numbers 157
  5.8.2 Multi-digit 7-Segment Displays 159
5.9 Alphanumeric LEDs 159
5.10 mikroC Pro for PIC 7-Segment LED Editor 163
5.11 Summary 163
Exercises 164

6 Liquid Crystal Displays (LCDs) and mikroC Pro for PIC LCD Functions 165
6.1 HD44780 Controller 165
6.2 Displaying User Defined Data 168
6.3 DDRAM Addresses 169
6.4 Display Timing and Control 171
  6.4.1 Clear Display 172
  6.4.2 Return Cursor to Home 172
  6.4.3 Cursor Move Direction 172
  6.4.4 Display ON/OFF 172
  6.4.5 Cursor and Display Shift 173
  6.4.6 Function Set 173
  6.4.7 Set CGRAM Address 173
  6.4.8 Set DDRAM Address 173
  6.4.9 Read Busy Flag 174
  6.4.10 Write Data to CGRAM or DDRAM 174
  6.4.11 Read Data from CGRAM or DDRAM 174
6.5 LCD Initialisation 174
  6.5.1 8-bit Mode Initialisation 175
  6.5.2 4-bit Mode Initialisation 175
6.6 Example LCD Display Setup Program 177
6.7 mikroC Pro for PIC LCD Functions 180
  6.7.1 Lcd_Init 180
  6.7.2 Lcd_Out 181
  6.7.3 Lcd_Out_Cp 181
  6.7.4 Lcd_Chr 181
9 LED Based Projects

9.1 PROJECT 9.1 – Flashing LED
9.2 PROJECT 9.2 – Binary Counting Up LEDs
9.3 PROJECT 9.3 – Rotating LEDs
9.4 PROJECT 9.4 – Wheel of Lucky Day
9.5 PROJECT 9.5 – Random Flashing LEDs
9.6 PROJECT 9.6 – LED Dice
9.7 PROJECT 9.7 – Connecting more than one LED to a Port Pin
9.8 PROJECT 9.8 – Changing the Brightness of LEDs
9.9 PROJECT 9.9 – LED Candle
9.10 Summary

Exercises

10 7-Segment LED Display Based Projects

10.1 PROJECT 10.1 – Single Digit Up Counting 7-Segment LED Display
10.2 PROJECT 10.2 – Display a Number on 2-Digit 7-Segment LED Display
10.3 PROJECT 10.3 – Display Lottery Numbers on 2-Digit 7-Segment LED Display
10.4 PROJECT 10.4 – Event Counter Using 4-Digit 7-Segment LED Display
10.5 PROJECT 10.5 – External Interrupt Based Event Counter Using 4-Digit 7-Segment LED Display with Serial Driver
10.6 Summary

Exercises

11 Text Based LCD Projects

11.1 PROJECT 11.1 – Displaying Text on LCD
11.2 PROJECT 11.2 – Moving Text on LCD
11.3 PROJECT 11.3 – Counting with the LCD
11.4 PROJECT 11.4 – Creating Custom Fonts on the LCD
11.5 PROJECT 11.5 – LCD Dice
11.6 PROJECT 11.6 – Digital Voltmeter
11.7 PROJECT 11.7 – Temperature and Pressure Display
11.8 PROJECT 11.8 – The High/Low Game
11.9 Summary

Exercises
## 12 Graphics LCD Projects

12.1 PROJECT 12.1 – Creating and Displaying a Bitmap Image 347
12.2 PROJECT 12.2 – Moving Ball Animation 355
12.3 PROJECT 12.3 – GLCD Dice 357
12.4 PROJECT 12.4 – GLCD X-Y Plotting 372
12.5 PROJECT 12.5 – Plotting Temperature Variation on the GLCD 374
12.6 PROJECT 12.6 – Temperature and Relative Humidity Measurement 385
12.7 Operation of the SHT11 386
12.8 Acknowledgement 389
12.9 Summary 400
   Exercises 400

## 13 Touch Screen Graphics LCD Projects

13.1 PROJECT 13.1 – Touch Screen LED ON-OFF 401
13.2 PROJECT 13.2 – LED Flashing with Variable Rate 410
13.3 Summary 418
   Exercises 418

## 14 Using the Visual GLCD Software in GLCD Projects

14.1 PROJECT 14.1 – Toggle LED 420
14.2 PROJECT 14.2 – Toggle more than One LED 425
14.3 PROJECT 14.3 – Mini Electronic Organ 426
14.4 PROJECT 14.4 – Using the SmartGLCD 430
14.5 PROJECT 14.5 – Decimal to Hexadecimal Converter using the SmartGLCD 444
14.6 Summary 452
   Exercises 452

## 15 Using the Visual TFT Software in Graphics Projects

15.1 PROJECT 15.1 – Countdown Timer 454
15.2 PROJECT 15.2 – Electronic Book 462
15.3 PROJECT 15.3 – Picture Show 467
15.4 Summary 472
   Exercises 472

## Bibliography

## Index