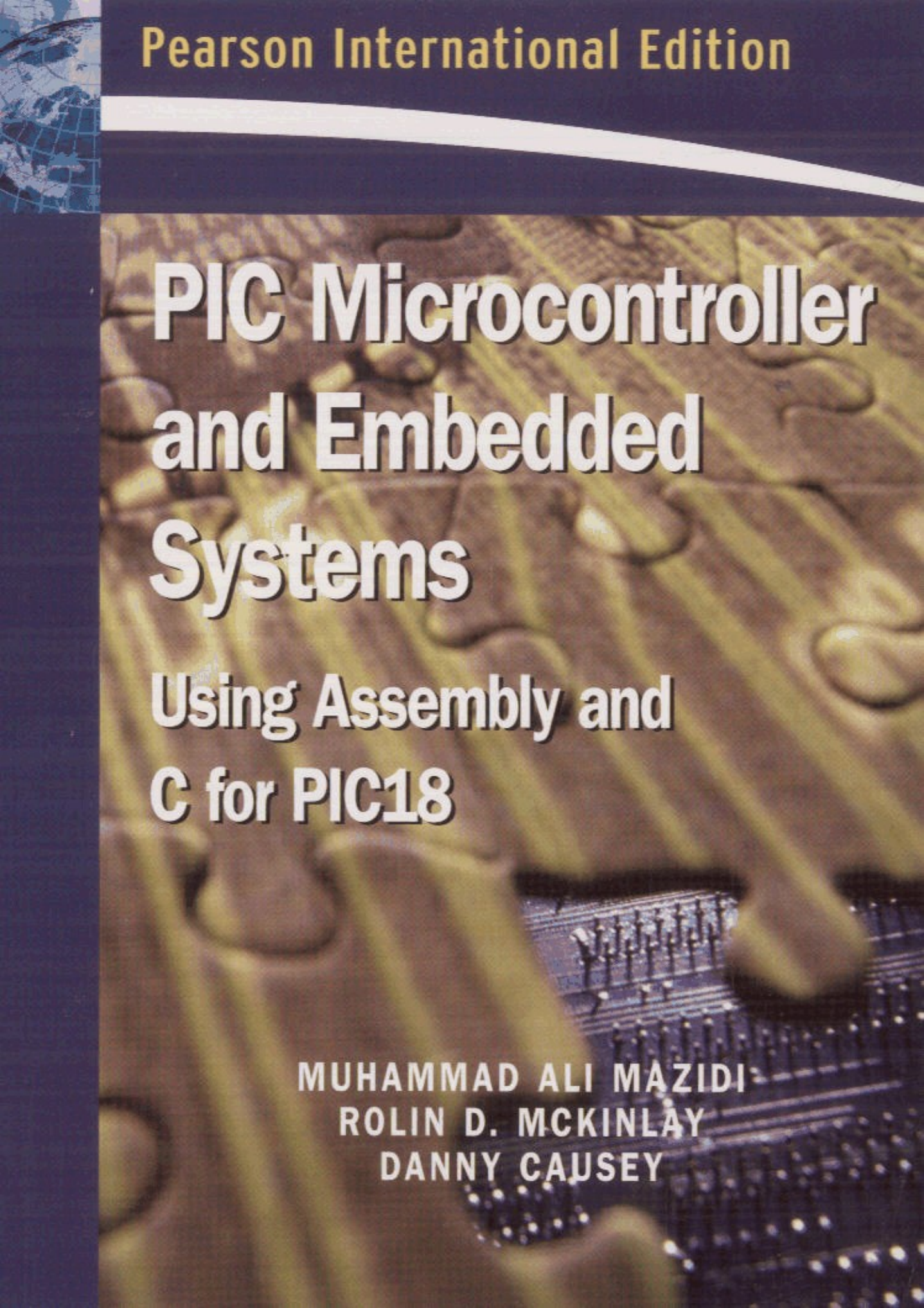




Pearson International Edition

PIC Microcontroller and Embedded Systems

**Using Assembly and
C for PIC18**

**MUHAMMAD ALI MAZIDI
ROLIN D. MCKINLAY
DANNY CAUSEY**

CONTENTS

CHAPTER 0: INTRODUCTION TO COMPUTING	1
SECTION 0.1: NUMBERING AND CODING SYSTEMS	2
SECTION 0.2: DIGITAL PRIMER	9
SECTION 0.3: INSIDE THE COMPUTER	13
 CHAPTER 1: THE PIC MICROCONTROLLERS: HISTORY AND FEATURES	 23
SECTION 1.1: MICROCONTROLLERS AND EMBEDDED PROCESSORS	24
SECTION 1.2: OVERVIEW OF THE PIC18 FAMILY	28
 CHAPTER 2: PIC ARCHITECTURE & ASSEMBLY LANGUAGE PROGRAMMING	 39
SECTION 2.1: THE WREG REGISTER IN THE PIC	40
SECTION 2.2: THE PIC FILE REGISTER	43
SECTION 2.3: USING INSTRUCTIONS WITH THE DEFAULT ACCESS BANK	48
SECTION 2.4: PIC STATUS REGISTER	57
SECTION 2.5: PIC DATA FORMAT AND DIRECTIVES	61
SECTION 2.6: INTRODUCTION TO PIC ASSEMBLY PROGRAMMING	67
SECTION 2.7: ASSEMBLING AND LINKING A PIC PROGRAM	70
SECTION 2.8: THE PROGRAM COUNTER AND PROGRAM ROM SPACE IN THE PIC	73
SECTION 2.9: RISC ARCHITECTURE IN THE PIC	84
SECTION 2.10: VIEWING REGISTER AND MEMORY WITH MPLAB SIMULATOR	87
 CHAPTER 3: BRANCH, CALL, AND TIME DELAY LOOP	 97
SECTION 3.1: BRANCH INSTRUCTIONS AND LOOPING	98
SECTION 3.2: CALL INSTRUCTIONS AND STACK	110
SECTION 3.3: PIC18 TIME DELAY AND INSTRUCTION PIPELINE	117
 CHAPTER 4: PIC I/O PORT PROGRAMMING	 129
SECTION 4.1: I/O PORT PROGRAMMING IN PIC18	130
SECTION 4.2: I/O BIT MANIPULATION PROGRAMMING	143

CHAPTER 5: ARITHMETIC, LOGIC INSTRUCTIONS, AND PROGRAMS	155
SECTION 5.1: ARITHMETIC INSTRUCTIONS	156
SECTION 5.2: SIGNED NUMBER CONCEPTS AND ARITHMETIC OPERATIONS	166
SECTION 5.3: LOGIC AND COMPARE INSTRUCTIONS	171
SECTION 5.4: ROTATE INSTRUCTION AND DATA SERIALIZATION	179
SECTION 5.5: BCD AND ASCII CONVERSION	184
 CHAPTER 6: BANK SWITCHING, TABLE PROCESSING, MACROS, AND MODULES	 193
SECTION 6.1: IMMEDIATE AND DIRECT ADDRESSING MODES	194
SECTION 6.2: REGISTER INDIRECT ADDRESSING MODE	199
SECTION 6.3: LOOK-UP TABLE AND TABLE PROCESSING	205
SECTION 6.4: BIT-ADDRESSABILITY OF DATA RAM	214
SECTION 6.5: BANK SWITCHING IN THE PIC18	219
SECTION 6.6: CHECK SUM AND ASCII SUBROUTINES	227
SECTION 6.7: MACROS AND MODULES	234
 CHAPTER 7: PIC PROGRAMMING IN C	 251
SECTION 7.1: DATA TYPES AND TIME DELAYS IN C	252
SECTION 7.2: I/O PROGRAMMING IN C	259
SECTION 7.3: LOGIC OPERATIONS IN C	267
SECTION 7.5: DATA SERIALIZATION IN C	277
SECTION 7.6: PROGRAM ROM ALLOCATION IN C18	280
SECTION 7.7: DATA RAM ALLOCATION IN C18	286
 CHAPTER 8: PIC18F HARDWARE CONNECTION AND ROM LOADERS	 299
SECTION 8.1: PIC18F458/452 PIN CONNECTION	300
SECTION 8.2: PIC18 CONFIGURATION REGISTERS	304
SECTION 8.3: EXPLAINING THE INTEL HEX FILE FOR PIC18	316
SECTION 8.4: PIC18 TRAINER DESIGN AND LOADING	323
 CHAPTER 9: PIC18 TIMER PROGRAMMING IN ASSEMBLY AND C	 335
SECTION 9.1: PROGRAMMING TIMERS 0 AND 1	336
SECTION 9.2: COUNTER PROGRAMMING	355
SECTION 9.3: PROGRAMMING TIMERS 0 AND 1 IN C	362
SECTION 9.4: PROGRAMMING TIMERS 2 AND 3	373

CHAPTER 10: PIC18 SERIAL PORT PROGRAMMING IN ASSEMBLY AND C	387
SECTION 10.1: BASICS OF SERIAL COMMUNICATION	388
SECTION 10.2: PIC18 CONNECTION TO RS232	395
SECTION 10.3: PIC18 SERIAL PORT PROGRAMMING IN ASSEMBLY	397
SECTION 10.4: PIC18 SERIAL PORT PROGRAMMING IN C	414
CHAPTER 11: INTERRUPT PROGRAMMING IN ASSEMBLY AND C	423
SECTION 11.1: PIC18 INTERRUPTS	424
SECTION 11.2: PROGRAMMING TIMER INTERRUPTS	429
SECTION 11.3: PROGRAMMING EXTERNAL HARDWARE INTERRUPTS	439
SECTION 11.4: PROGRAMMING THE SERIAL COMMUNICATION INTERRUPTS	445
SECTION 11.5: PORTB-CHANGE INTERRUPT	449
SECTION 11.6: INTERRUPT PRIORITY IN THE PIC18	454
CHAPTER 12: LCD AND KEYBOARD INTERFACING	473
SECTION 12.1: LCD INTERFACING	474
SECTION 12.2: KEYBOARD INTERFACING	487
CHAPTER 13: ADC, DAC, AND SENSOR INTERFACING	499
SECTION 13.1: ADC CHARACTERISTICS	500
SECTION 13.2: ADC PROGRAMMING IN THE PIC18	505
SECTION 13.3: DAC INTERFACING	516
SECTION 13.4: SENSOR INTERFACING AND SIGNAL CONDITIONING	521
CHAPTER 14: USING FLASH AND EEPROM MEMORIES FOR DATA STORAGE	529
SECTION 14.1: SEMICONDUCTOR MEMORY	530
SECTION 14.2: ERASING AND WRITING TO FLASH IN THE PIC18F	539
SECTION 14.3: READING AND WRITING TO DATA EEPROM IN THE PIC18	555
CHAPTER 15: CCP AND ECCP PROGRAMMING	569
SECTION 15.1: STANDARD AND ENHANCED CCP MODULES	570
SECTION 15.2: COMPARE MODE PROGRAMMING	573
SECTION 15.3: CAPTURE MODE PROGRAMMING	579
SECTION 15.4: PWM PROGRAMMING	586
SECTION 15.5: ECCP PROGRAMMING	592

CHAPTER 16: SPI PROTOCOL AND DS1306 RTC INTERFACING	603
SECTION 16.1: SPI BUS PROTOCOL	604
SECTION 16.2: DS1306 RTC INTERFACING AND PROGRAMMING	608
SECTION 16.3: DS1306 RTC PROGRAMMING IN C	619
SECTION 16.4: ALARM AND INTERRUPT FEATURES OF THE DS1306	622
 CHAPTER 17: MOTOR CONTROL: RELAY, PWM, DC, AND STEPPER MOTORS	 635
SECTION 17.1: RELAYS AND OPTOISOLATORS	636
SECTION 17.2: STEPPER MOTOR INTERFACING	642
SECTION 17.3: DC MOTOR INTERFACING AND PWM	651
SECTION 17.4: PWM MOTOR CONTROL WITH CCP	663
SECTION 17.5: DC MOTOR CONTROL WITH ECCP	665
 APPENDIX A: PIC18 INSTRUCTIONS: FORMAT AND DESCRIPTION	 673
 APPENDIX B: BASICS OF WIRE WRAPPING	 721
 APPENDIX C: IC TECHNOLOGY AND SYSTEM DESIGN ISSUES	 725
 APPENDIX D: FLOWCHARTS AND PSEUDOCODE	 745
 APPENDIX E: PIC18 PRIMER FOR x86 AND 8051 PROGRAMMERS	 750
 APPENDIX F: ASCII CODES	 752
 APPENDIX G: ASSEMBLERS, DEVELOPMENT RESOURCES, AND SUPPLIERS	 754
 APPENDIX H: DATA SHEETS	 756
 INDEX	 807