



Chapter 1 : PIC Architecture and Embedded C		1-1 to 1-51
1.1	Introduction	1-1
1.2	Comparison of CISC and RISC Processors	1-1
1.3	Harvard and Von Neumann Architectures	1-2
1.3.1	Harvard Architecture of PIC Microcontroller	1-2
1.4	Features of PIC Family of Microcontrollers : Overview of PIC Microcontroller Family 12FXX, 16FXX and 18FXX	1-2
1.4.1	PIC Microcontroller Features	1-3
1.5	Comparison of Features of PIC10, PIC12, PIC16, PIC18 Families	1-4
1.6	PIC18F458 Features	1-5
1.7	Pin Diagram of PIC18F458	1-7
1.8	Architecture of PIC18F458 (Block Diagram).....	1-7
1.8.1	Program Memory	1-8
1.8.2	31 Level Stack	1-8
1.8.3	Data RAM.....	1-9
1.8.4	Arithmetic and Logic Unit (ALU).....	1-9
1.8.5	CPU Registers	1-9
1.8.5(A)	Working Register (WREG).....	1-9
1.8.5(B)	Status Register.....	1-9
1.8.5(C)	Program Counter and PCLATH.....	1-10
1.8.5(D)	Stack.....	1-10
1.8.5(E)	INDF and FSR	1-11
1.8.6	8 × 8 Multiply Unit	1-11
1.8.7	Five I/O (Ports A, B, C, D, E)	1-11
1.8.8	Four Timers (Timer0 to Timer3).....	1-11
1.8.8(A)	Applications of Timer in PIC18F.....	1-12



1.8.9	Analog to Digital Convertor (ADC).....	1-12
1.8.10	Analog Comparator	1-12
1.8.11	Master Synchronous Serial Port (MSSP).....	1-13
1.8.11(A)	Serial Peripheral Interface (SPI) Mode.....	1-13
1.8.11(B)	I2C (Inter Integrated Circuit) Mode	1-13
1.8.12	USART Ports.....	1-13
1.8.13	Interrupt and its Handling in PIC18F	1-13
1.9	Oscillator Configurations.....	1-14
1.9.1	HS, HS4, XT or LP Oscillator	1-15
1.9.2	RC Oscillator Mode	1-16
1.9.3	EC and ECIO Oscillator Modes.....	1-16
1.9.4	Instruction Cycle.....	1-16
1.10	PIC18 RESET	1-17
1.10.1	Power-on Reset (POR).....	1-18
1.10.2	MCLR.....	1-18
1.10.3	Power-up Timer (PWRT)	1-18
1.10.4	Oscillator Start-up Timer (OST)	1-18
1.10.5	PLL Lock Time-out.....	1-18
1.10.6	Brown-Out Reset (BOR).....	1-18
1.10.7	Time-Out Sequence	1-19
1.10.8	Reset at Supply Voltage Drop below the Permissible (Brown-out Reset)	1-19
1.10.9	Watchdog Timer	1-19
1.11	Program and Data Memory Organization	1-20
1.11.1	Data Memory	1-20
1.11.1(A)	Bank Select Register (BSR).....	1-21



1.11.2	Program Memory Organization.....	1-21
1.12	Pipelining	1-22
1.13	Power-Down Mode (Sleep)	1-23
1.13.1	Wake-Up from Sleep	1-24
1.14	Addressing Modes for PIC18 Microcontroller	1-24
1.14.1	Register Direct.....	1-24
1.14.2	Immediate Mode.....	1-25
1.14.3	Inherent Mode	1-25
1.14.4	Indirect Mode	1-26
1.14.5	Bit-Direct Addressing Mode.....	1-27
1.15	Instruction Set.....	1-28
1.16	Embedded C Concepts.....	1-31
1.16.1	Comparison between Object Oriented and Procedural Language	1-31
1.16.2	Advantages of High Level based Embedded Software Development.....	1-31
1.17	Programming in Embedded C (From Embedded System and Real-time Perspective).....	1-32
1.17.1	Use of Modifiers	1-32
1.17.2	Interrupt Service Routines (ISR)	1-33
1.17.3	Macros.....	1-33
1.17.4	Tokens of C	1-34
1.17.4(A)	Character Set of C	1-34
1.17.4(B)	Keywords	1-34
1.17.4(C)	Identifiers.....	1-35
1.17.4(D)	Scalar Data Types in C.....	1-35
1.17.4(E)	Constants and Variables.....	1-36
1.18	Operators.....	1-36
1.18.1	Unary Operators	1-36



1.18.2	Binary Operators	1-38
1.18.3	Ternary Operators	1-39
1.18.4	Assignment Operators and Statements	1-40
1.18.5	Selection Operators	1-40
1.18.6	Decision Making and Branching Statement	1-41
1.18.6(A)	if-else Selective Statement	1-41
1.18.6(B)	switch-case Statement	1-41
1.18.7	Looping Statements	1-42
1.19	C- Control Structures for Iteration	1-42
1.19.1	for Loop	1-42
1.19.1(A)	while and do-while Loops	1-43
1.19.2	Arrays and Pointers	1-45
1.19.3	Function in C	1-46
1.20	Exam Pack (Review and University Questions)	1-49

Chapter 2 : Port and Timer 0 Programming**2-1 to 2-30**

2.1	Timers / Counters	2-1
2.2	Prescaling of PIC Timers3	2-1
2.3	Timer 0	2-1
2.3.1	Timer 0 Block Diagram	2-1
2.3.2	Timer 0 Registers	2-3
2.3.3	T0CON (Timer 0 Control) Register	2-3
2.4	Timer 1	2-4
2.4.1	Timer 1 Block Diagram	2-4
2.4.2	Timer 1 Registers	2-6
2.4.3	Timer 1 Control Register (T1CON)	2-6



2.5	Timer 2	2-7
2.5.1	Timer 2 Block Diagram.....	2-8
2.5.2	Timer 2 Registers and TMR2IF Flag.....	2-8
2.5.3	Timer 2 Control Register (T2CON).....	2-9
2.6	Timer 3	2-9
2.6.1	Timer 3 Block Diagram.....	2-10
2.6.2	Timer 3 Control Register (T3CON).....	2-11
2.7	Programming the PIC18 Timers	2-12
2.8	I/O Port Programming.....	2-20
2.9	Port A.....	2-20
2.10	Port B.....	2-22
2.11	Port C.....	2-22
2.12	Port D	2-23
2.13	Port E.....	2-24
2.14	Simple Programs for I/O Ports.....	2-24
2.15	Display	2-26
2.15.1	LED Displays	2-26
2.15.2	Seven Segment Display (SSD)	2-28
2.16	Exam Pack (Review and University Questions).....	2-29

Chapter 3 : CCP Module and its Applications**3-1 to 3-14**

3.1	CCP Module in PIC18 Microcontroller	3-1
3.2	Timers Required for CCP Applications	3-1
3.3	CCP Registers.....	3-1
3.3.1	CCP1CON Control Register	3-1
3.4	Generating of Waveform using Compare Mode of CCP Module.....	3-2



3.4.1	Programming the CCP Module in Compare Mode.....	3-3
3.5	Capture Mode.....	3-4
3.6	PWM Mode.....	3-6
3.6.1	Period of PWM.....	3-6
3.6.2	Duty Cycle of PWM	3-7
3.6.3	Steps for Programming the CCP Module for PWM Generation.....	3-7
3.7	Speed Control of DC Motor using PWM Mode of CCP Module.....	3-9
3.7.1	Interfacing DC Motor using L293 H-Bridge and Opto-isolator	3-10
3.8	Exam Pack (Review and University Questions)	3-13

Chapter 4 : Interrupt Structure and its Programming**4-1 to 4-8**

4.1	Interrupts Vs Polling.....	4-1
4.2	Interrupt Service Routine (ISR)	4-1
4.3	Steps in Executing an Interrupt.....	4-2
4.4	PIC18 Interrupt Structure	4-3
4.4.1	Timer Flag Interrupts	4-3
4.4.1(A)	PIR Registers	4-3
4.4.1(B)	Interrupt Control Register	4-3
4.5	PIC18 Interrupt Programming in C Using C18 Compiler	4-5
4.6	Hardware Interrupts	4-6
4.7	Serial Port Interrupts	4-7
4.8	Setting the Interrupt Priority	4-7
4.9	Interrupt inside an Interrupt / Nested Interrupt.....	4-8
4.10	Exam Pack (Review and University Questions)	4-8

Chapter 5 : ADC Structure and LCD Interfacing**5-1 to 5-34**

5.1	PIC18F458 ADC.....	5-1
5.1.1	ADCON0 Register.....	5-1
5.1.2	ADCON1 Register	5-2



5.1.3	A/D Conversion Time.....	5-3
5.2	A/D Acquisition Requirements.....	5-5
5.3	Selecting the A/D Conversion Clock.....	5-6
5.4	Configuring Analog Port Pins	5-6
5.5	Use of the ECCP Trigger.....	5-7
5.5.1	A/D Result Registers.....	5-8
5.5.2	A/D Programming using Interrupts.....	5-9
5.6	Temperature Sensor LM35.....	5-11
5.7	Interfacing of PIC18F458 8 Bit Model LCD (16 × 2)	5-18
5.7.1	Initialization of LCD.....	5-19
5.7.2	Interfacing LCD Module with PIC18F458.....	5-20
5.8	Exam Pack (Review and University Questions)	5-33

Chapter 6 : Serial Communication and its Protocols**6-1 to 6-23**

6.1	Introduction to Serial Communication	6-1
6.1.1	Parallel vs Serial Interface	6-1
6.1.2	Types of Communication Systems	6-1
6.1.3	Baud Rate	6-2
6.2	RS 232 Standard Signals used in RS 232	6-2
6.3	PIC18 Connection to RS232	6-3
6.4	Interfacing Serial Port and USART.....	6-3
6.4.1	SPBRG Register.....	6-3
6.4.2	Sampling	6-3
6.4.3	RCSTA (Receive Status and Control Register)	6-5
6.5	USART Asynchronous Mode	6-6
6.6	UART Asynchronous Transmitter	6-7



6.6.1	Setting Up Asynchronous Transmission	6-8
6.7	UART Asynchronous Receiver	6-8
6.7.1	Setting Up Asynchronous Reception without Address Detect Mode.....	6-9
6.7.2	Setting Up Asynchronous Reception with Address Detect.....	6-9
6.8	Programming the PIC18 to Transfer Data Serially	6-10
6.9	Programming the PIC18 to Receive Data Serially	6-10
6.10	SPI (Serial Peripheral Interface).....	6-10
6.10.1	PIC18F SPI Bus.....	6-11
6.10.2	Registers	6-12
6.11	I ² C Bus.....	6-14
6.11.1	Comparison between RS232, RS485, I ² C.....	6-15
6.12	I ² C Mode.....	6-15
6.12.1	Registers	6-16
6.12.2	Operation.....	6-18
6.12.3	Slave Mode.....	6-18
6.12.3(A)	Addressing.....	6-19
6.12.3(B)	Reception.....	6-19
6.12.3(C)	Transmission	6-20
6.12.4	Master Mode	6-20
6.12.5	Baud Rate Generator	6-21
6.13	Comparison of SPI and I ² C	6-22
6.14	Exam Pack (Review and University Questions)	6-22
