FIJI NATIONAL UNIVERSITY

Final Examination

College	Engineering, Science & Technollogy
School	Electrical & Electronics Engineering
Programme	Advanced Diploma in Electrical/Electronics Engineering
Semester	II
Year	2013
Unit Code	EEE612
Unit Title	Electronic Technology (Microcontroller)
Date of Examination	November 7
Time	9am
Venue	JNC
Duration	3 Hours *(extra 10 mins allowed to read the paper)*
Maximum Marks	100

Instructions

1. There are four (4) questions worth 25 marks each. Attempt all questions in the answer booklet.
2. Write your answers legibly in the answer booklet.
3. Write your student identification number on each page used.
4. A PIC16F877 block diagram and assembly instruction set is provided on the last page.

Question 1 *(25 Marks)*

(a) In your own words explain what a microprocessor is and what it does? (2)

(b) Draw a clearly labeled generalized microprocessor block diagram showing all the components. (3)

(c) What is the difference between a 16-Bit and a 32-Bit CPU? (1)

(d) What is the purpose of the following data transfer control lines in a microprocessor?

i. $M/\bar{IO}$ (2)

ii. $R/\bar{W}$ (2)

iii. $WRD/\bar{B}$ (2)

iv. AS (2)

v. DS (2)

vi. READY (1)

(e) What are the functions of the following registers in any CPU?

i. Program Counter (2)

ii. Instruction Register (2)

iii. Buffer Register (2)

(f) What are the two groups of signals generated by a control unit inside a CPU? (2)

Question 2 *(25 Marks)*

(a) Define the following:

i. PIC (1)

ii. RISC (1)

(b) What is the main difference between Microchip's mid-range and baseline architecture and give an example of each? (2)

(c) What is the maximum sink/source current on any pin in PIC16F877? (1)

(d) What feature of the PIC16F877 microcontroller allows users to easily download programs to the PIC for permanent storage until the next download? (1)

(e) Give two peripheral features of PIC16F877? (2)

(f) How many bidirectional ports and I/O pins does PIC16F877 have? (2)

(g) Identify the type of architecture used in PIC16F877 (Harvard or von Neumann), and give reasons for your answer? (2)

(h) Explain with an example the following addressing modes supported by PIC16F877 processor.

i. Immediate mode (2)

ii. Direct mode (2)

iii. Indirect mode (2)

(i) The following questions are related to your EEE612 Projects completed as part of the course.

i. What is the title of your project? (1)

ii. Name the most important component/part of your project? (1)

iii. With the aid of block diagrams, discuss the overall functionality your project? (5)

Question 3 *(25 Marks)*

(a) Identify the width (in Bits) of the following registers and busses in PIC16F877. *Refer to the block diagram given in appendix*

i. Program Counter (1)

ii. Instruction Register (1)

iii. Data Bus (1)

iv. Program Bus (1)

v. Stack (1)

vi. Direct Address Bus *(for data memory)* (1)

vii. W Register *(accumulator)* (1)

(b) Write a two instruction assembly code that will copy the data `0x2A` to the register `PORTA` in bank 0 of PIC16F877 data memory. (2)

(c) Write a simple 4-instruction assembly code that will make `PORTB` of PIC16F877 microcontroller an input port. (4)

(d) Write a simple 4-instruction assembly program which will act as a delay subroutine. The delay subroutine should create an exact $140\mu s$ delay on a PIC16F877 processor with clock speed 8MHz. (6)

(e) Assuming that you have a PIC16F877 porcessor with oscillator $F_{osc} = 20MHz$. Determine the number of instruction cycles and the time taken for the CPU to execute the following instructions. (6)

```
        movlw 0x05
        movwf 0x21
RPT     decfsz 0x21
        goto RPT
```

Question 4 *(25 Marks)*

(a) Write a C program for the CCS®C compiler to blink an LED connected to pin C0 of the PIC16F877 microcontroller as shown below. (Note: only write the main program) (4)

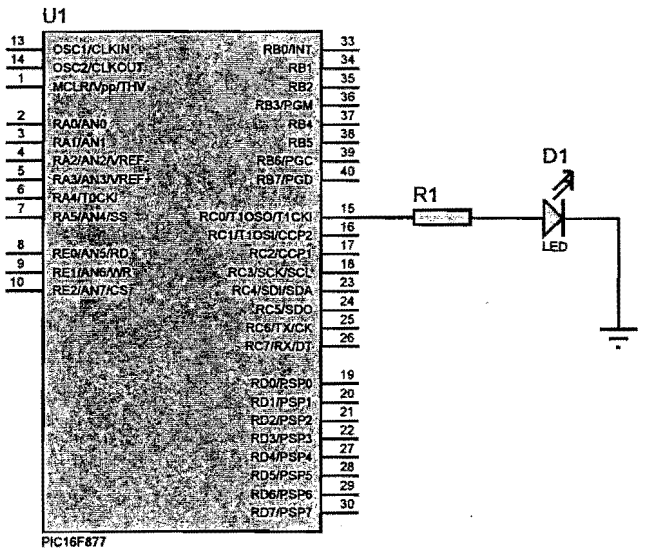

Figure 1: Schematic showing LED connection

(b) Determine the size of the LED protection resistor $R1$ shown in the schematic in part (a) above. Assume that the LED forward voltage is $2V$ with typical current of $16mA$. (2)

(c) Some students configured the ADC resolution in PIC16F877 to be 8-bits and ADC reference voltage as $5V$. They interfaced a $1k$ POT as shown below to PIN A0 of PIC16F877. They then adjusted the POT and read in a value of 0x2C using an ADC program. What analog voltage does this digital value correspond to? (2)

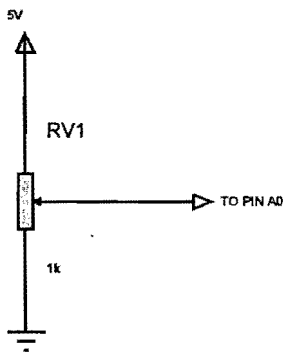

Figure 2: Schematic showing variable resistor connection

(d) PIC16F877 can only read analogue voltages from 0V to 5V. Design an effective circuit which could be interfaced at the input of PIC16F877 to allow an analog voltage from 0V to 14V. What is the name of the circuit? (Note: Show all necessary calculations and state all assumptions) (5)

(e) Using C programming some students configured the PIC16F877 timer 1 as follows: (2)

```
setup_timer_1 (T1_INTERNAL | T1_DIV_BY_1 ) ;
set_timer_1 ( 0 ) ;
```

Assuming that the device oscillator of PIC16F877 is 20MHz ($F_{osc} = 20MHz$), what time will it take timer 1 to overflow? (Note: Timer 1 is 16 Bits)

(f) How would the time change in the previous question if T1_DIV_BY_2 was used instead? (2)

(g) Which pins of PIC16F877 can be used to generate PWM signal? (2)

(h) When creating a program to generate PWM output, some students use the following line in their code to set up timer 2. (4)

```
setup_timer_2(T2_DIV_BY_16,200,1)
```

Calculate the frequency of the PWM signal generated assuming $F_{osc} = 20MHz$.

(i) Using the PWM frequency calculated in part (h) above some students wanted to generate a PWM signal with 20% duty cycle on PIN C2. They used the following line of C program to do this. (2)

```
set_pwm1_duty(PWM_value);
```

Determine the value of the variable `PWM_value` above which is a 10-Bit interger?

The End
Happy Holidays!

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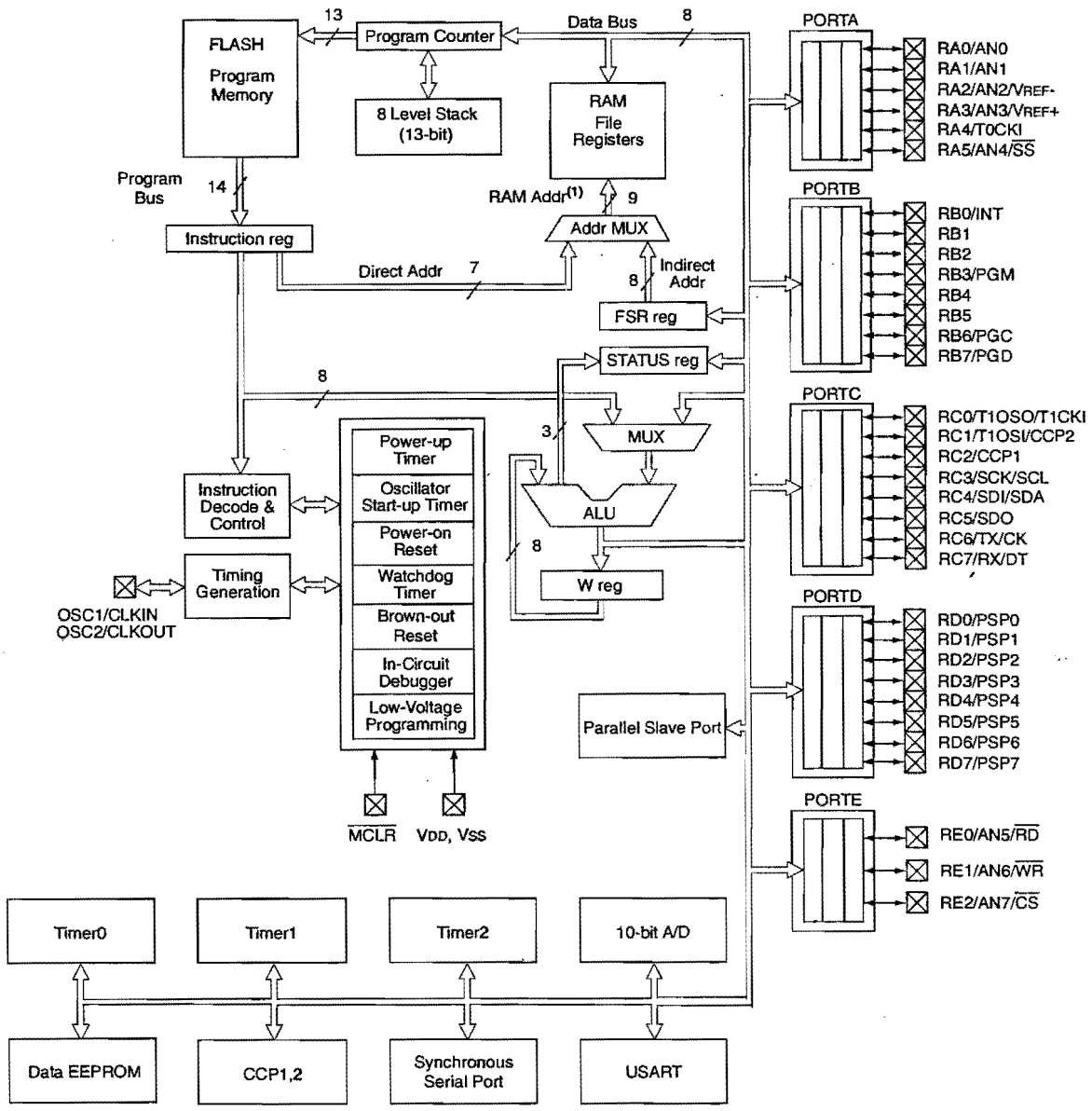
FIGURE 1-2: PIC16F874 AND PIC16F877 BLOCK DIAGRAM

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes



Note 1: Higher order bits are from the STATUS register.

TABLE 13-2: PIC16F87X INSTRUCTION SET

Mnemonic, Operands		Description	Cycles	14-Bit Opcode MSb			LSb	Status Affected	Notes
BYTE-ORIENTED FILE REGISTER OPERATIONS									
ADDWF	f, d	Add W and f	1	00	0111	dfff	ffff	C,DC,Z	1,2
ANDWF	f, d	AND W with f	1	00	0101	dfff	ffff	Z	1,2
CLRF	f	Clear f	1	00	0001	lfff	ffff	Z	2
CLRW	-	Clear W	1	00	0001	0xxx	xxxx	Z	
COMF	f, d	Complement f	1	00	1001	dfff	ffff	Z	1,2
DECF	f, d	Decrement f	1	00	0011	dfff	ffff	Z	1,2
DECFSZ	f, d	Decrement f, Skip if 0	1(2)	00	1011	dfff	ffff		1,2,3
INCF	f, d	Increment f	1	00	1010	dfff	ffff	Z	1,2
INCFSZ	f, d	Increment f, Skip if 0	1(2)	00	1111	dfff	ffff		1,2,3
IORWF	f, d	Inclusive OR W with f	1	00	0100	dfff	ffff	Z	1,2
MOVF	f, d	Move f	1	00	1000	dfff	ffff	Z	1,2
MOVWF	f	Move W to f	1	00	0000	lfff	ffff		
NOP	-	No Operation	1	00	0000	0xx0	0000		
RLF	f, d	Rotate Left f through Carry	1	00	1101	dfff	ffff	C	1,2
RRF	f, d	Rotate Right f through Carry	1	00	1100	dfff	ffff	C	1,2
SUBWF	f, d	Subtract W from f	1	00	0010	dfff	ffff	C,DC,Z	1,2
SWAPF	f, d	Swap nibbles in f	1	00	1110	dfff	ffff		1,2
XORWF	f, d	Exclusive OR W with f	1	00	0110	dfff	ffff	Z	1,2
BIT-ORIENTED FILE REGISTER OPERATIONS									
BCF	f, b	Bit Clear f	1	01	00bb	bfff	ffff		1,2
BSF	f, b	Bit Set f	1	01	01bb	bfff	ffff		1,2
BTFSC	f, b	Bit Test f, Skip if Clear	1 (2)	01	10bb	bfff	ffff		3
BTFSS	f, b	Bit Test f, Skip if Set	1 (2)	01	11bb	bfff	ffff		3
LITERAL AND CONTROL OPERATIONS									
ADDLW	k	Add literal and W	1	11	111x	kkkk	kkkk	C,DC,Z	
ANDLW	k	AND literal with W	1	11	1001	kkkk	kkkk	Z	
CALL	k	Call subroutine	2	10	0kkk	kkkk	kkkk		
CLRWDT	-	Clear Watchdog Timer	1	00	0000	0110	0100	$\overline{TO}$,$\overline{PD}$	
GOTO	k	Go to address	2	10	1kkk	kkkk	kkkk		
IORLW	k	Inclusive OR literal with W	1	11	1000	kkkk	kkkk	Z	
MOVLW	k	Move literal to W	1	11	00xx	kkkk	kkkk		
RETFIE	-	Return from interrupt	2	00	0000	0000	1001		
RETLW	k	Return with literal in W	2	11	01xx	kkkk	kkkk		
RETURN	-	Return from Subroutine	2	00	0000	0000	1000		
SLEEP	-	Go into standby mode	1	00	0000	0110	0011	$\overline{TO}$,$\overline{PD}$	
SUBLW	k	Subtract W from literal	1	11	110x	kkkk	kkkk	C,DC,Z	
XORLW	k	Exclusive OR literal with W	1	11	1010	kkkk	kkkk	Z	

Note 1: When an I/O register is modified as a function of itself (e.g., `MOVF PORTB, 1`), the value used will be that value present on the pins themselves. For example, if the data latch is '1' for a pin configured as input and is driven low by an external device, the data will be written back with a '0'.

2: If this instruction is executed on the TMR0 register (and, where applicable, d = 1), the prescaler will be cleared if assigned to the Timer0 module.

3: If Program Counter (PC) is modified, or a conditional test is true, the instruction requires two cycles. The second cycle is executed as a `NOP`.

Note: Additional information on the mid-range instruction set is available in the PICmicro™ Mid-Range MCU Family Reference Manual (DS33023).