Islamic University of Gaza
Faculty of Engineering
Electrical Engineering Dept.

Microcontroller Lab.
Midterm Exam
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Time Allowed: ***1:30*** *hours*

Name: **ID:**

Question 1

(14 pts)

Answer the following questions:

1. **What is the main difference between a lab-top computer system and an microcontroller system?**
   - A lab-top computer is a standalone general purpose computer and its principle function is computational.
   - While a microcontroller system is a computer incorporated within a product to undertake control.

2. **Explain in few words the purpose of the address 0x0004 in the program memory of the PIC 16 series microcontrollers.**
   - This address is the interrupt vector. It is the address where interrupt service routines should start.

3. **What is the main difference between an assembler directive and an assembly instruction?**
   - Directives are used to aid the process of writing and transferring the program instructions (codes) to the target microcontroller/microprocessor. They only pass info to the assembler telling it what to do.
   - In contrast, the instructions perform the real task of the program and deal directly with the microcontroller/microprocessor hardware.

4. **What is the side effect of using the RETFIE to return from a normal subroutine in a PIC program?**
   - The RETFIE instruction enables the GIE bit in the INTCON register and this would enable all unmasked interrupts. Consequently, the system will be subject to unexpected interrupts if this issue is not taken into consideration during the program development.

5. **List the four sources of interrupts in the PIC16F84A microcontroller.**

   1) Timer-0 overflow 2) Alternation on RB (4 to 7) pins of PORTB

   3) External interrupt via RB0 4) EEPROM write completion

6. **What is the effect of executing the following instructions?**

```
movlw   b'11110000'
movwf   trisb
```

   - These instructions configure the lower 4 pins of PORTB as outputs and the remaining pins as inputs

7. **What is the binary content of the status register after executing this instruction?**

```
CLRF STATUS
```

   - This leaves the STATUS register as 000u u1uu , (where u = unchanged).

8. **Assume that the following code has just been executed.**

```
movlw 2f
addlw 55
```

a) Specify the condition of the following three status flags

   C: 0 DC: 1 Z: 0

b) The binary content of the working register is ____10000100_____

9. **What happens inside the microcontroller hardware when the instruction** `goto 0x34` **is executed?**

   1) Flush the current PC. 2) Load PC with 0x34.

10. If the INTCON register is set to A8H, then

a) Determine which interrupts are enabled?

- INTCON= 10101000, GIE=1, T0IE=1, RBIE=1
- So, the interrupt due to timer-0 overflow and due to alternation on RB (4 to 7) pins of PORTB are enabled.

b) An interrupt occurs, and the INTCON register is found to have changed to A9 H, which interrupt source has called?

INTCON= 10101001, RBIF=1

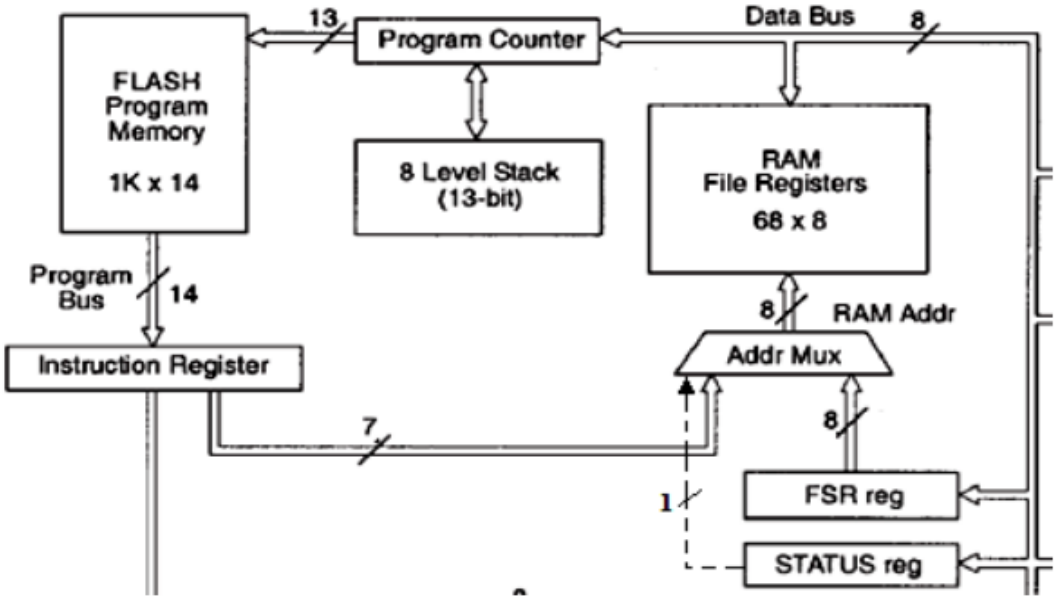
So, the interrupt due to alternation on RB(4 to 7) pins of PORTB has occurred.

c) Which bit must the designer change before the end of the ISR, and why?

- The designer need to change RBIF bit to zero to allow another interrupt occur after finishing the current interrupt.

Question 2 (4 pts)

The following figure shows part of the PIC1684A internal architecture. Study the figure and answer the following questions.



a) What is the purpose of the Stack block?

- The stack memory is used to store the program counter (address of next instruction) when interrupts occur or subroutines are called.

b) What is the size of each memory location in the Program Memory? Can you tell why?

- 14 bits, since the PIC 16 instructions are 14 bits.

c) What is the purpose of the 1-bit dashed wire?

- It is the RP0 bit which is used for bank selection in direct addressing.

d) Explain why the Program Counter is connected to the Data Bus?

- In some cases the ALU may execute instructions that modify the program counter, such ADDWF PCL, F

Question 3

(3 pts)

Write the initialization code needed for the PIC 16F84A to set Timer TMR0 (at address 01h) to generate an interrupt after 20 external pulses. The Registers INTCON (at address 0bh) and OPTION_REG (at address 81h) are shown below. You need to write the code needed to initialize the three registers properly.

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-x
GIE	EEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF
bit 7							bit 0

R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
RBPU	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0
bit 7							bit 0

bit 7 **RBPU**: PORTB Pull-up Enable bit
1 = PORTB pull-ups are disabled
0 = PORTB pull-ups are enabled by individual port latch values

bit 6 **INTEDG**: Interrupt Edge Select bit
1 = Interrupt on rising edge of RB0/INT pin
0 = Interrupt on falling edge of RB0/INT pin

bit 5 **T0CS**: TMR0 Clock Source Select bit
1 = Transition on RA4/T0CKI pin
0 = Internal instruction cycle clock (CLKOUT)

bit 4 **T0SE**: TMR0 Source Edge Select bit
1 = Increment on high-to-low transition on RA4/T0CKI pin
0 = Increment on low-to-high transition on RA4/T0CKI pin

bit 3 **PSA**: Prescaler Assignment bit
1 = Prescaler is assigned to the WDT
0 = Prescaler is assigned to the Timer0 module

bit 2-0 **PS2:PS0**: Prescaler Rate Select bits

Bit Value	TMR0 Rate	WDT Rate
000	1 : 2	1 : 1
001	1 : 4	1 : 2
010	1 : 8	1 : 4
011	1 : 16	1 : 8
100	1 : 32	1 : 16
101	1 : 64	1 : 32
110	1 : 128	1 : 64
111	1 : 256	1 : 128

One possible solution

- TMR0 = 256 – 20 = 236 (to overflow after 20 pulses)
- OPTION_REG = B'xx1x 1xxx' (select external clock and assign prescaler to WDT)
- INTCON = B'1x1xOOxx' (GIE =1, T0IE = 1, T0IF = 0)

```
Movlw D'236'

movwf TMRO

bsf STATUS, RPO

movlw 0x28

movwf OPTION_REG

bsf INTCON, TOIE

bsf INTCON, GIE
```

Question 4

(3 pts)

Three microcontrollers (A, B & C) have maximum clock speeds 10MHz, 20MHz, 24MHz respectively. Microcontroller A divides its clock by 4 to give one machine cycle, microcontroller B by 8, and microcontroller C by 12. Microcontrollers A & C take 2 machine cycles to perform an instruction, while microcontroller B takes three cycles. Place the microcontrollers in order of the speed in which they can perform that instruction?

- Cycle time= #clock divisions / fosc
- Time for one instruction = #cycles needed to perform one istruction* one cycle time

Microcontroller A:

Tcycle= 4/10M=0.4 usec

Tinstruction =2* Tcycle =2*0.4u=0.8 usec

Microcontroller B:

Tcycle= 8/20M=0.4 usec

Tinstruction =3* Tcycle =3*0.4u=1.4 usec

Microcontroller C:

Tcycle= 12/20M=0.6 usec

Tinstruction =2* Tcycle =2*0.6u=1.2 usec

Microcontroller A execute the instruction in the least time compared with microcontrollers C and B then it is the fastest one. A is faster than C, and C is faster than B.

Question 5

(2 pts)

How long does it take to execute the following instructions on a PIC 16F84A running at a clock of 8 MHz?

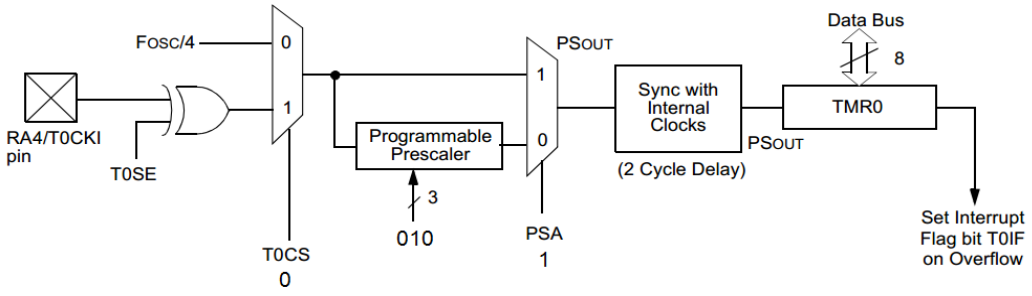
```
goto L2

L1   movwf var1

btfss var1,0

L2 sublw 10
```

- TIME = #cycles * 4 / Fosc = (2+1) * 0.5 usec = 1.5 usec
- The answer is __1.5___ usec

Question 6

(2 pts)

Every how many instruction cycles the following circuit generate an interrupt signal?



__256____

Question 7

(2 pts)

Outline the procedures of installing a program in the PIC microcontroller during your project design?

GOOD LUCK

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