Embedded Systems (0907333)
Homework 2

Every Problem 10 Points

Problem 1: Write an assembly program for the PIC 16P84A given the following specification:

- Port A is input port and Port B is output port.
- The microcontroller should continuously copy the least significant four bits from Port A to the most significant four bits of Port B, respectively.
- The least significant four bits of Port B should equal RA4.

Your program should include all needed port initialization.

```
;
      #include p16f84A.inc
;
      org   00
;Initialise
start bsf  status,rp0     ;select memory bank 1
      movlw B'00011111'
      movwf trisa         ;all port A bits input
      movlw 00
      movwf trisb         ;all port B bits output
      bcf   status,rp0    ;select bank 0
;
;The "main" program starts here
loop  swapf porta,0       ;move port A to W with swapping
      iorlw B'00001111'   ;preset three bits
      btfss porta,4       ;skip if RA4=1
      andlw B'11110000'   ;clear least significant 4 bits
      movwf portb         ;move W register to port B
      goto  loop
      end
```

Problem 2: How long does it take to execute the following subroutine on a PIC 16P84A running at an external clock of 800 kHz?

```
delay
      movlw  D'100'
      movwf  delcntr1
del1
      nop
      decfsz delcntr1,1
      goto   del1
      return
```

Internal frequency = 800 kHz / 4 = 200 kHz
Instruction cycle = 1 / 200 kHz = 5 µs
The loop takes 4 instruction cycles
Time = 100 * 4 * 5 µs = 2 ms

Problem 3: Write an assembly program for the PIC 16P84A given the following specification:

- Port A is an output port.
- The external interrupt is enabled on RB0.
- The main routine has two modes.
- Depending on the mode, the main routine increments or decrements the contents of the working register and outputs these contents to Port A.
- The interrupt handling subroutine toggles the mode of the main routine between the increment mode and the decrement mode.

Your program should include all needed port and interrupt initialization and ISR context saving.

```
;
      #include p16f84A.inc
;
flag equ   10              ;flag for mode: 0 inc, 1 dec
;
      org   00
      goto  start
;
      org   04
      goto  Int_Routine
;
start
      bsf   status,rp0     ;select bank 1
      movlw 01
      movwf trisb          ;bits 1-7 output, bit 0 input
      movlw 00
      movwf trisa          ;porta bits all output

      bcf   status,rp0     ;select bank 0
      bsf   intcon,inte    ;enable external interrupt
      bsf   intcon,gie     ;enable global int
;
wait
      btfss flag,0         ;skip if Bit 0 is 1
      addlw 01             ;increment
      btfsc flag,0         ;skip if Bit 0 is 0
      addlw B'11111111'    ;decrement
      movwf porta
      goto  wait
;
      org   0080
Int_Routine
      comf  flag,1         ;complement flag
      bcf   intcon,intf    ;clear INTF
      retfie
      end
```

Problem 4: Write an assembly program for the PIC 16P84A given the following specification:

- Port B is an output port.
- The main routine increments the contents of the working register and outputs these contents to Port B.
- After updating Port B, the microcontroller should enter the sleep mode.
- Timer 0 generates an interrupt every 512 instruction cycles, causing exit of the sleep mode for one more update.

Your program should include all needed port and interrupt initialization.

```
;
      #include p16f84A.inc
;
      org   00
      goto  start
;
      org   04
      goto  Int_Routine
;
start
      bsf   status,rp0     ;select bank 1
      movlw B'00000000'    ;set up T0 for internal input,
                          ;    +ve edge, prescale by 2
      movwf TMR0
      movwf trisb          ;portb bits all output

      bcf   status,rp0     ;select bank 0
      bsf   intcon,inte    ;enable external interrupt
      bsf   intcon,gie     ;enable global int
;
wait
      addlw 01             ;increment
      movwf portb
      sleep
      goto  wait
;
      org   0080
Int_Routine                ;assume it awakes at T0 interrupt
      bcf   intcon,t0if    ;clear T0IF
      retfie
      end
```

Problem 5: True or false problem: Circle **T** if the statement is always true and circle **F** if the statement is false. Also you need to correct the false statements.

T F Weak pull up resistors in I/O ports are used when the I/O port is configured as output.
False. Correction: Weak pull up resistors in I/O ports can be used when the I/O port is configured as input.

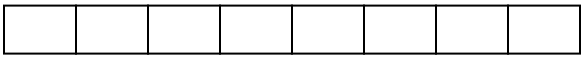
T F Decoupling capacitors are used to smooth the voltage supply of the microcontroller when the power supply is not able to do that at certain times.
True.

T F For an 8 bit timer with its input clock of 4 MHz, the maximum time that can be measured assuming no scaling is 64 micro seconds.
True.

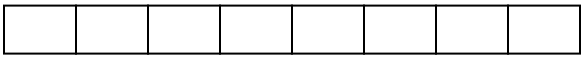
T F The WDT timeout depends on the external clock frequency.
False. Correction: The WDT timeout depends on its own RC clock.

Problem 6: Initialize the following two registers so that Timer 0 introduces a 100-second delay. Assume using an external 160-Hz crystal oscillator (show your calculations).

TMR0 Register



OPTION Register



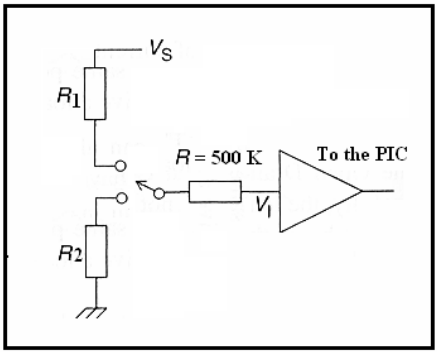
OPTION REGISTER (ADDRESS 81h)

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

Internal Frequency = 160/4= 40 Hz
Tc= 1/40 s
100 / (1/40) = 4000
250 * 16 = 4000 **or** **125 * 32 = 4000**
So we load TMR0 with 256- 250 = 6 **or** **256 – 125 = 131**
and use Prescaler of 16 **or** **32**

TMR0 = (00000110)$_b$ or (10000011)$_b$
OPTION_REG = (xx0x0011)$_b$ or (xx0x0100)$_b$

Problem 7: The circuit shown to the right is connected at V_I to PIC16F84A's PORTA input. What are the constrains on R_1 and R_2 resistor values?



Given that Vs = 5V, Maximum VIH = 5.5V, Minimum VIH = 2.4V, Maximum VlL = 0.8V, Minimum VIL = 0V, and I =1μA.

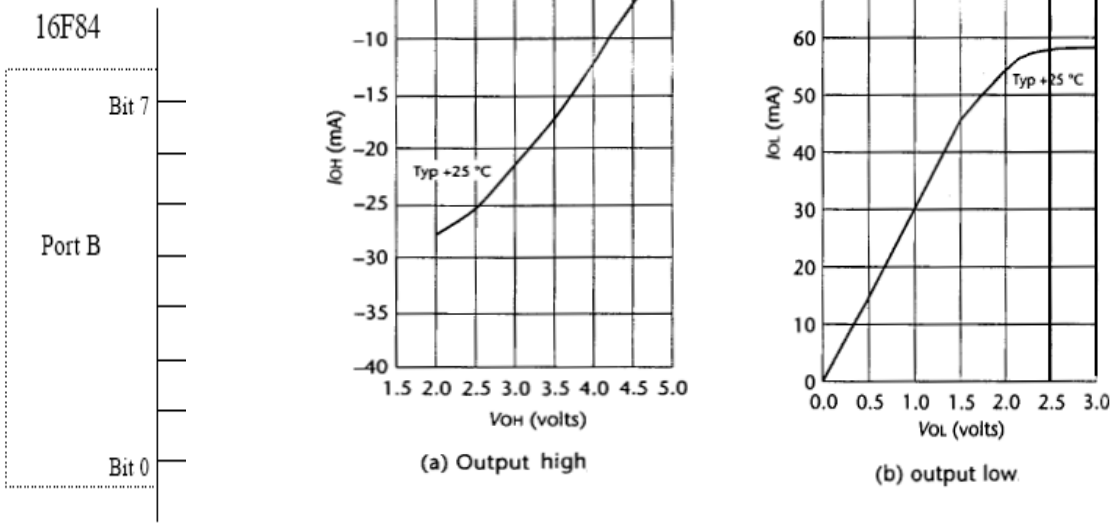
a)
1μ A * (0.5 M Ω + R2 M Ω) ≤ 0.8 V
0.5 + R2 ≤ 0.8
R2 ≤ 0.3 M Ω .

b)
5 – 2.4 = 2.6
1μ A * (0.5 M Ω + R1 M Ω) ≤ 2.6 V
0.5 + R1 ≤ 2.4
R1 ≤ 2.1 M Ω .

Problem 8: Four bits of Port B of a 16F84 are to be used to drive four LEDs, and the rest four bits are to be used to receive inputs from four push button switches. For the input bits, the interrupt on change option is to be used. The microcontroller power supply is 5V. Each LED requires 15mA when "ON" with forward voltage of 1.9V. Two LEDs should be "ON" when their associated port bits are at logic 1, and two should be "ON" when their associated port bits are at logic 0.

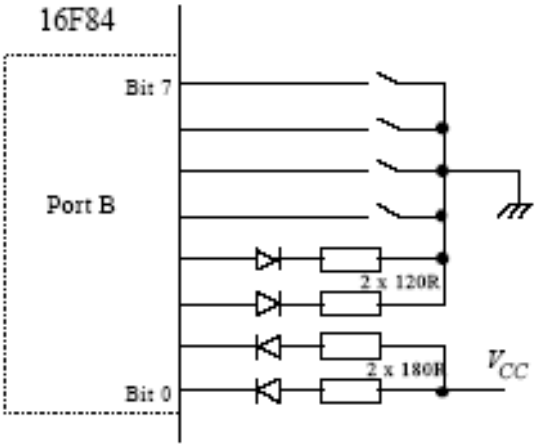
a) Show, using the diagram below to the left, how the switches and the LEDs may be connected?
b) Use the following output characteristics to calculate the values of any resistor needed.

c) Specify the contents of SFRs involved in this process.



Solutions:

a)



Bit allocation is shown. Push button inputs are connected to higher bits of Port B, as these have the interrupt on change facility. Pull-up resistors are not needed, as internal pull-ups will be used. LED locations are arbitrary in lower 4 port bits.

b) For the LEDs driven from logic 1: From the given characteristics figure we can see that for 15mA of output current, the output voltage is around 3.7V. Therefore,

$$R_s = \{(3.7 - 1.9)/0.015\} = 120\Omega$$

For the LEDs driven from logic 0: From the given characteristics figure we can see that for 15mA current sink, the output voltage is around 0.5V. Therefore,

$$R_s = \{(5.0 - 1.9 - 0.5)/0.015\} = 173\Omega$$

The nearest preferred value is 180 Ohm.

c) Relevant SFR bits are:

- Msb of OPTION, set to 0 to enable internal pull-ups
- TRISB is set to 11110000, i.e. upper 4 bits input, lower 4 output
- To enable interrupt on change, bits 7 and 3 of INTCON are set.