EEC 417/517 Embedded Systems, Spring 2018

Lab 3:
Program Branching, Lookup Tables, Timers, Interrupts

Name:

Give brief answers to the following questions. You can edit this document and insert your answers after each question,

Due dates:
MW – Wed, Feb 21, beginning of class
TTH – Tue, Feb 20, beginning of class

1. (1 pt) There is a discrepancy between one of the labels in Figure 7-1 on page 55 of the datasheet and the register bit table for Register 7-1 on the same page. What is the discrepancy? Which is correct, the figure or the register bit table? (Hint: the correctness can be determined looking in the P16F877_inc_copy.txt file.) Moral of the story: data sheets can have errors.

   Ans.
   T2OUTPS3 → TOUTPS3
   The right once which is in the header file and REGISTER 7-1 is correct.

2. (1 pt) Which register is copied to W with the instruction `movf   PIR1, W` if:

   PIR1 = 0x0c = 0000 1100
   a) STATUS = 0x00 →STATUS: 0000 0000 → W = 00 000 1100 → 0x0c → PIR1
   b) STATUS = 0x20 →STATUS: 0010 0000 → W = 01 000 1100 → 0x8c → PIE1
   c) STATUS = 0x40 →STATUS: 0100 0000 → W = 10 000 1100 → 0x10c → EEDATA
   d) STATUS = 0x60 →STATUS: 0110 0000 → W = 11 000 1100 → 0x18c → EECON1

   Ans.

3. (1 pt) What is value of the W register (in hex) after the following instruction:
   `movlw  D'381'` ? What warning number and message does the assembler generate when it assembles this instruction?

   Ans.
   Argument out of range, Least significant bit used
   D'381' = 10 (STATUS) + 111 1101(W)
   W = 111 1101
   STATUS = 0x40

4. (1 pt) Suppose PORTC = 0011 1100 and STATUS<C> = 1. What will be the contents of PORTC and STATUS<C> after the instruction `rrf   PORTC, F`?

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Ans.

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Details on page:
Bank 0											
00h[(3)]	INDF	Addressing this location uses contents of FSR to address data memory (not a physical register)								0000 0000	27
01h	TMR0	Timer0 Module Register								xxxx xxxx	47
02h[(3)]	PCL	Program Counter (PC) Least Significant Byte								0000 0000	26
03h[(3)]	STATUS	IRP	RP1	RP0	$\overline{TO}$	$\overline{PD}$	Z	DC	C	0001 1xxx	18

PORTC = 0001 1110
STATUS<C> = 0

5. (1 pt) In the `lab03_LookupTable.asm` code, the following line occurs at the beginning of the code:

   ```
   list p = 16f877
   ```

   Why can we use the "=" symbol even though it is not one of the PIC's instructions? (Hint: See Table 3.4 in the MPASM User Guide.)

   Ans.
   since = means set equal to and 16f877 is set into the p and it is one of the legal actions this is a directive rather an instruction thus this symbol is allowed

6. (1 pt) Build the `lab03_LookupTable.asm` code. Under the Edit/Properties menu, make sure the following dialog is set as shown below..
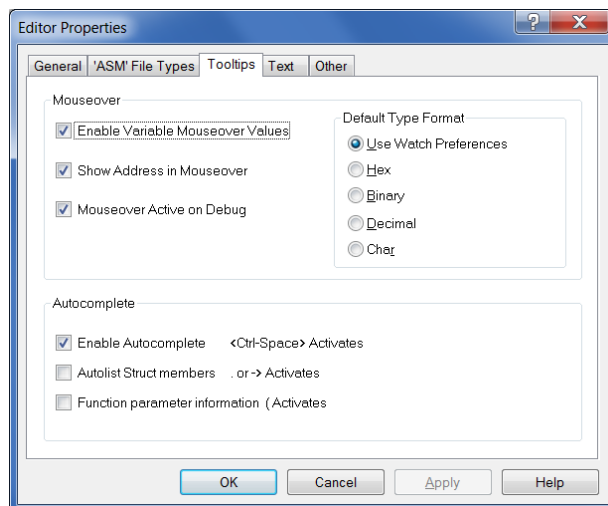
   a) Note that `TableSize` is set equal to 4. Mouseover `TableSize`. What message do you see?

   Ans.
   Addr = 0x004   TableSize = 0x90

b) Open the File Registers dialog and notice that `TableSize` is not listed. In which register is 0x90 being stored? Why?

Ans.
FSR
The reason that the value is stored in FSR is that table Size is used with EQU directive and the number 4

7. (2 pts) In the Instruction Summary the instruction `decf` is listed with two arguments:

```
decf f, d
```

If the destination bit is omitted, the code will still compile. In the `lab03_LookupTable.asm` code, insert the instructions below after the `INIT` label, build the code, and program the chip. Step the program until the two instructions are executed. Mouseover `TableSize` and compare the value of `TableSize` with the value of W in the status bar at the bottom of the window.

```
movlw 0x5

decf TableSize
```

a) What values are in `TableSize` and the W register (in hex)? What is the default destination, F or W?

Ans. `TableSize` = 0x90 → 0x8F
W = 0xC4 → 0x05
Default = F

b) Now include the W destination bit in the `decf` instruction and repeat Part (a). What values are in `TableSize` and the W register?

Ans. `TableSize` = 0x90 → 0x90
W = 0xC4 → 0x05 → 0x8F

8. (1 pt) Suppose the instruction `movlw TRISA` were added to the `lab03_LookupTable.asm` code immediately following the `INIT` label.

a) What would the W register contain (in hex) after the instruction executes and why?

Ans.
0x85 = 1000 0101
Since it only copies the 8 LSBs into W register and TRISA is B 1000 1001

b) If the instruction `movf TRISA, W` were added to the code immediately following the `INIT` label, what would the W register contain (in hex) after the instruction executes and why?

Ans.
W = 0 since this is not a valid arithmetic
The w register contains 0. Value of TRISA and PORTA are identical for movlw instruction. Since bank 0 is selected the value of PORTA is selected and the content of PORTA is copied into W

9. (1 pt) In the `lab03_LookupTable.asm` code, insert the following `dt` directive after the `INIT` label and build the code:

```
dt 10, 20, 30
```

Open the Program Memory dialog. What code did the `dt` directive produce?

Ans.
It generates three instructions retlw 0x10, retlw 0x20, retlw 0x30,

10. (1 pt) What is the opcode for the instruction `movlw 0xE5` ? Give your answer in binary and hex. For the binary, separate into nibbles for easier reading. (Hint: See the instruction description for `movlw`.)

Ans.
Binary: 11 00xx 1110 0101
Hex: 0x30E5

11. (1 pt) What is wrong with the syntax of the instruction `incf PORTC, 2`?

Ans.
2 is not valid. It can be either 0 or 1

12. (1 pt) What are the contents of the W register (in hex and binary) and STATUS<Z> after the instructions in the following code?

```
movlw  0xD8
xorlw  0xFF
```

Ans.

0xD8 = 1101 1000   xor   1111 1111 →result 0010 0111
    W = 0010 0111   hex:27 → W!=0 → Z=0
    Z = 0

13. (1 pt) What are the contents of the Count and W registers (in binary) and STATUS<Z> after the instructions in the following instructions?

```
movlw   0xD8                    W=1101    1000
movwf   Count                count=101    1000
comf    Count, W
```

Ans.

Count = 1101   1000
   W = 0010   0111
   Z = 0 since W != 0

14. (1 pt) What are the contents of the W register (in binary) and STATUS<Z> after the following instructions execute?

```
movlw   D'100'                   0110 0100
andlw   0x88                     1000 1000
```

Ans.
W = 0000 0000
Z = 1 since W=0

15. (1 pt) What instruction will be executed after the `btfsc` instruction in the following code? What are the values of W and STATUS<Z> after the following code executes?

```
movlw   0x81
addlw   0x7F
btfsc   STATUS, Z
goto    label_A
goto    label_B
```

Ans.
the result of addlw is 256 which is over the limit so it overflows to 0 and Z bit is set
since Z=1 next instruction is executed whick is Label_A

16. (1 pt) Suppose Bank 2 is selected.

a) What are the contents of W (in hex) after the following instruction? (Hint: see the PIC16F877.inc on the resources folder.)

```
movlw   EEDATA
```

Ans.
EEDATA is H'010C' which is 0000 0001 0000 1100. Only the first 8 bit on the right side would move to W which is 0000 1100 or 0x0c

b) Suppose Bank 3 is selected. What are the contents of W (in hex) for the same instruction?

Ans.
It should technically get the data from the location of EEDATA in bank 3 which is EECON1. Thus the result should be the default value of EECON1 which is 1000 1100. However, when I run the program and run it in the debugger, the default value of EEDATA is moved to W which is 0000 1100

17. (1 pt) Suppose the oscillator frequency is 8 MHz, PR2 = 117, and T2CON = 0101 0011. What is the time (in milliseconds) between Timer2 interrupts?

Ans.
Frequency = 8 MHz → Tosc = 1/8MHz = 0.125 us
T2CON = 0101 0011
- T2CKPS1:T2CKPS0 = 11   → Prescalar = 16
- TOUTPS3:TOUTPS0 = 1010 → Postscalar = 11
Timer2 interrupt = (Prescaler) (PR2 + 1) (Postscaler) (4 Tosc) =
         = (16) (117+1) (11) (4 x 0.125 us)
         = (16) (117+1) (11) (0.5 us) = 10.384 ms

18. (1 pt) Suppose W = 5, and program memory address 0x008E executes an `addwf PCL, F` instruction. What program memory address (in hex) will execute next?

Ans+
PCL = PCL + W + 1 = 0x008E + 0x5 + 0x1 = 0x94

19. (1 pt) In the lab03_Timer2.asm project, put a breakpoint in the interrupt service routine. Notice that the program never reaches the breakpoint.

We have apparently not set up the Timer2 interrupt correctly in lab03_Timer2.asm. Note that the INIT routine attempts to set T2CON = 0000 1101. Add T2CON to a watch window and step through the INIT routine to see if everything is working. Is T2CON being set to 0000 1101? Why not? What register is getting set to 0000 1101 instead of T2CON?

Ans.

The program is in bank0 while T2CON is in bank1. Thus PR2 is changed instead of T2CON. To resolve, bank should be changed before moving the WREG to T2CON

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20. (5 pts) Demonstrate the Watch window with the incorrect value of T2CON to the instructor or TA as described in the previous problem. Fix the error in the lab03_Timer2.asm program by adding one instruction. Demonstrate a correctly working lab03_Timer2.asm program and explain what you did.

Student Name:_____

Instructor or TA: _____ Date:_____

21. (10 pts) Create a new MPASM project called lab03_LookupTable_2.asm using the lab03_LookupTable.asm program. Modify the program so that the LEDs continually repeat the following sequence of blinks: 7, 5, 3, 1, 0, 2, 4, 6. Explain the modified code to the instructor or TA and demonstrate this program.

Instructor or TA: _____ Date:_____