# Lab 7:

**SPI Mode, 7-Segment LED Displays, Shift Registers, Setup, Keypad Scanning, Finite Arithmetic, Watchdog Timer**

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

**Due dates:**

**MW – Wed, Mar 28, beginning of class  
TTH – Tue, Mar 27, beginning of class**

**Circle one: MW or TTH**

1. (1 pt) Derive the value of 2.56 V as seen in lab07, Slide 34. Show work.  
     
   **Ans.**Parallel resistors (10K and 470) = 10000\*470/(10000+470) 448 ohm

Voltage = 470/(470+448) = 2.559 ~ 2.56v

1. (1 pt) How many 4-bit binary number systems can be defined to represent the decimal integers {0, 1, 2, 3, … , 15 }? Hint: Use the Multiplication Principle from counting theory. There are 16 ways we can assign a 4-bit symbol to decimal 0. Next, there are 15 ways we can assign the remaining 4-bit symbols to decimal 1. And so on  
     
   **Ans. DONE**  
   2^4 = 16 different way to represent 1 of the 16 numbers, thus:

16\*15\*…\*2\*1 = 16! = 2.092279e+13

1. (1 pt) Look up the logic diagram in the Fairchild Semiconductor datasheet for the DM74LS164 shift register. What are the 8 output devices in the diagram called? What is the function of the active-low CLEAR pin ?  
     
   **Ans.**

OUTPUTS are Qa, Qb, Qc, Qd, Qe, Qf, Qg, Qh and they are the 8 bit output parallel registers.

Active Low CLEAR means that regardless of input values, the output vaues will be all Low (zero)

active-low CLEAR pin clears all the 8 registers and get them ready to be occupied in the next set

1. (1 pt) When you run lab07\_SPI, and then halt and reset the PIC, one of the LED segments remains lit. Why? How can you turn it off?  
     
   **Ans. DONE**  
   The reason is that once PIC is halted the data in the shift register is not cleared and whatever last 8-bit data was in the shift register iw will show up in the display. In order to clear the data on the display, shift register has to be cleared in the beginning of the program. To clear the shift register, the mater clear has to be used.
2. (1 pt) Recall from the lecture slides that we can display the digit 0 on the 7-segment LED display using the binary code 1100 000, the digit 1 using the binary code 1111 1001, etc. Complete the following table showing how we can display the given characters on the LED display.

|  |  |  |
| --- | --- | --- |
| **Digit** | **Binary** | **Hex** |
| 0 | 1100 0000 | 0xC0 |
| 1 | 1111 1001 | 0xF9 |
| 2 | 1010 0100 | 0xA4 |
| 3 | 1011 0000 | 0xB0 |
| 4 | 1001 1001 | 0x99 |
| 5 | 1001 0010 | 0x92 |
| 6 | 1000 0010 | 0x82 |
| 7 | 1111 1000 | 0xF8 |
| 8 | 1000 0000 | 0x80 |
| 9 | 1001 0000 | 0x90 |

1. (1 pt) What does the acronym MSSP stand for? What does SPI stand for?  
     
   **Ans.**

MSSP: Master Synchronous Serial Port

SPI: Serial Peripheral Interface Bus

1. (2 pts) Suppose that your oscillator frequency is 4 MHz and SSPCON = 0010 0001.
2. Does the SPI clock idle high or low?
3. Is the SPI configured as Master or Slave?
4. What is the SPI clock frequency?
5. How long does each SPI bit value appear on the SDO pin? (Hint: See Figure 9-2 in data sheet)

**Ans. DONE**SSPCON = 0010 0001

bit SSPM3:SSPM0: 0001 = SPI Master mode, clock = FOSC/16

bit 4 CKP = 0 = Idle state for clock is a low level

bit 5 SSPEN = 1= Enables serial port

bit 6 SSPOV = 0 = No overflow

bit 7 WCOL = 0 = No collision

1. Idle state for clock is a low level
2. SPI Master mode
3. FOSC/16 = 4MHz/16 = 250 kHz
4. Each bit remains for the period of SPI which is: 1/250kHz = 4us DONE
5. (1 pt) What is the mechanical operation life for each key on a Grayhill 96 Series keypad?   
     
   **Ans.**

1,000,000 operations per key

1. (1 pt) In lab07, which bit (bit number and mnemonic) in which register must be set to what value in order to transmit a data bit on the falling edge of SCK?  
     
   **Ans.** **DONE**  
   SSPSTAT: < CKE > bit 6

For CKP = 1—> 1 = Data transmitted on falling edge of SCK

1. (2 pts) What is the 8-bit result (hex), the value of STATUS<DC>, and the value of STATUS<C> after the following operations?  
     
   (a) 0x50 + D’200’  
   (b) 0x50 − D’200’  
     
   **Ans. DONE**  
   (a) 0x50 + D’200’ = 0x50 + 0xC8 = 0101 0000 + 1100 1000= 0x118 = **1** 0001 1000

Carry bit = 1 —> STATUS<C> = 1 so the 8-bit result **is not valid**

0000 + 1000 = 1000 🡪 STATUS<DC>0

(b) 0x50 − D’200’ = 0x50 - 0xC8 = 101 0000 + TsC(1100 1000) =

101 0000 + 0011 1000 = 1000 1000 —>

STATUS<C> = 0, 8-bit result **is not valid**

0000 + 1000 = 1000 🡪 STATUS<DC> = 0

1. (2 pts) **DONE**  
   a) What is the two’s complement **representation** of 4 in a 4-bit number system?  
   b) What is the two’s complement of 4 in a 4-bit number system?   
   b) What is the two’s complement **representation** of 4 in a 3-bit number system?   
   d) What is the two’s complement of 4 in a 3-bit number system?   
     
   (Hint: Draw the table for the number systems as in the PPTs)

**Ans.**  
(a) 4 = 0100

(b) 4 = 0100 —>Two’s complement: 1011+1 = 1100

(c) there is no representation

(d) 4 = 100 —>Two’s complement: 011+1 = 100

1. (1 pt) Which bit (bit-number and mnemonic) in which register must be set to what value in order to disable the watchdog timer?  
    **Ans.**

CONFIGURATION WORD

bit 2 WDTE: Watchdog Timer Enable bit

1 = WDT enabled

0 = WDT disabled

1. (1 pt) Which bit (bit-number and mnemonic) in which register indicates that the watchdog timer has timed out?   
     
   **Ans.**   
   TO bit in the STATUS register will be cleared upon a Watchdog Timer time-out.
2. (4 pts) Demonstrate that lab07\_spi.asm is working to the instructor or TA. Explain what the Interrupt Service Routine does.  
     
   **Name** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
     
   **Instructor/TA signature** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **Date**\_\_\_\_\_\_\_\_\_\_\_\_\_
3. (8 pts) Create a new project called lab07\_keypad\_mod. Modify the lab07\_keypad.asm program so that when one of the numeric keys {0, 1, ... , 9} is pressed, the corresponding digit is displayed on the LED display. The digit should remain displayed after you release the key until you press another key. The \* and # keys should clear the display. Demonstrate and explain your program to the instructor or TA.

**Instructor/TA signature** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **Date**\_\_\_\_\_\_\_\_\_\_\_\_\_