CSCE 236 Embedded Systems, Fall 2017
Homework 5

Started: Tuesday, November 7th, 2017
Due: Friday, November 17th, 2017 (5pm)

Instructions: This homework is an individual assignment, collaboration is not allowed. Show your work and describe your reasoning to get partial credit if your solution is incorrect. Unless otherwise specified, assume problems refer to the Arduino board we are using. This assignment is out of 100 points, but is equally weighted with other homework assignments.

Name:

Problem 1. *(5 pts) (To be completed at end of assignment) Approximately how much time did the total assignment take? Which problem took longest and how much time did it take? List any resources you used to complete this assignment (e.g. websites, datasheets, office hours, discussions with others, etc.). Be specific and if you did not use any other resources include the statement "I did not use outside resources for this assignment."*

Problem 2. *Interrupts*

a). *(5 pts) Give the C code to configure the registers to generate an interrupt from* `Timer0`*. Also give function definition for the interrupt handler for this interrupt.*

b). *(5 pts) What are the steps that occur to switch from executing the main code to executing an interrupt handler code when an interrupt occurs?*

c). *(5 pts) On the Arduino, how do you disable all interrupts? How do you enable them?*

d). *(5 pts) On the Arduino,* `timer0` *is configured to generate an interrupt every millisecond to enable counting how many milliseconds have elapsed since startup (using the* `millis()` *function). If global interrupts are disabled for 0.5ms every other millisecond will the time reported by* `millis()` *be accurate? Explain your answer for full credit.*

e). *(5 pts) If an interrupt requires 10 clock cycles to enter the interrupt handler, 30 clock cycles for the code to execute, and 8 to return to the prior code execution, then what is the maximum frequency that this interrupt can be handled if the processor is running at 16MHz?*

f). *(5 pts) Describe two benefits of using interrupts in your code.*

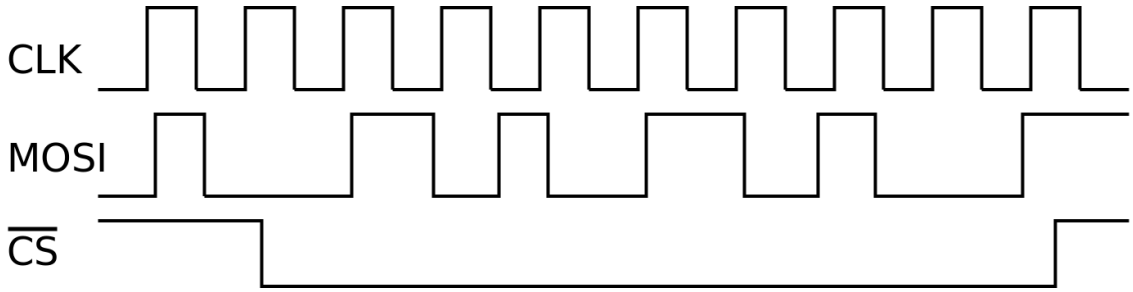
g). *(5 pts) Describe two problems and their causes that can occur when using interrupts in your code.*

h). *(10 pts) What problem could occur with the below code? Describe one approach to fix it. Assume the serial port with RX interrupts is already configured properly and all the queue operations are functions that do what their name suggests correctly.*

```
QUEUE uart0RxQueue;

ISR(USART_RX_vect){
  char t;
  if(!(UCSR0A & (1<<RXC0))) return;
  if(QUEUE_ISFULL(uart0RxQueue)) t = DEQUEUE(uart0RxQueue);
  ENQUEUE(uart0RxQueue,UDR0);
}

int8_t uartReceiveByte(char *c){
   if(QUEUE_ISEMPTY(uart0RxQueue)) return 0;
   *c = DEQUEUE(uart0RxQueue);
   return 1;
}

loop(){
 char c;
 if(uartReceiveByte(&c) == 1){
   uartSendByte(c);
 }
}
```

Problem 3. *Communication*

a). *(5 pts) What are two advantages of parallel communication over serial communication methods?*



b). *(5 pts) In the above signal, what is the data stream (bit values) processed by the slave device if it is configured for data to be valid on the rising edge? What about for falling edge? Note that the $\overline{CS}$ ("not CS") line means the device is active low, in other words it is selected when the line is low.*

c). *(5 pts) Describe how SPI supports multiple slave devices.*

d). *(5 pts) What is the fastest UART baud rate that could be generated on an Arduino with a 12MHz clock speed when in asynchronous normal mode? What about in double speed mode?*

e). *(5 pts) How many* **bytes** *could be sent per second with a baud rate of 115200 when configured as:*

```
//Use double speed here
UCSR0A = (1<<U2X0);
//Enable tx and rx
UCSR0B = (1<<RXEN0)|(1<<TXEN0);
//Set frame format to 6 data, 2 stop bits, Even Parity
UCSR0C = (1<<UCSZ00) | (1 << USBS0) | (1 << UPM01);
```

f). *(5 pts) On an Arduino with a clock speed of 15MHz, what value does the serial port* `UBRR0` *register need to be set to in order to communicate with a baud rate of 28800 when in normal speed mode? What is the error associated with this setting?*

g). *(5 pts) What does open-drain mean and why is it needed in* I^2C*? Are both* `SCL` *and* `SDA` *open-drain?*

h). *(5 pts) In* I^2C*, how does the master tell the slave if it wants to write or read?*

i). *(10 pts) In* I^2C*, describe how arbitration works when there are multiple masters?*

Do not forget to fill in the amount of time you spent on this assignment and resources you used in Question 1.