

CSCE 236 Embedded Systems, Spring 2013

Exam 2

Thursday, April 11, 2013

Instructions: You will have the full class period to complete this test. **Make sure to show your work to ensure you receive partial credit if your final answer is incorrect.** This is a closed book quiz, no computers, textbooks, notes, etc. are allowed.

Name:

Problem 1. *Hex and bit operations (all references to bit locations are zero referenced). For each bit operation subproblem write a **single line** of C code to achieve the desired result.*

a) (5 pts.). *Set the lower 5 bits in the variable `var` to `0x7`.*

b) (5 pts.). *Clear the top three bits in the 32-bit variable `var`.*

c) (5 pts.). *What is the value (in hex) of the 8-bit variable after this operation `var = ((11<<2) | (3<<7))`?*

d) (5 pts.). *What is the value of `((0x70>>3) + 3)` in hex?*

e) (5 pts.). *Set the upper 3 bits in the 8-bit variable `var` to the lower 3 bits in the 32-bit variable `config`. (Remember to do this in a single line of code.)*

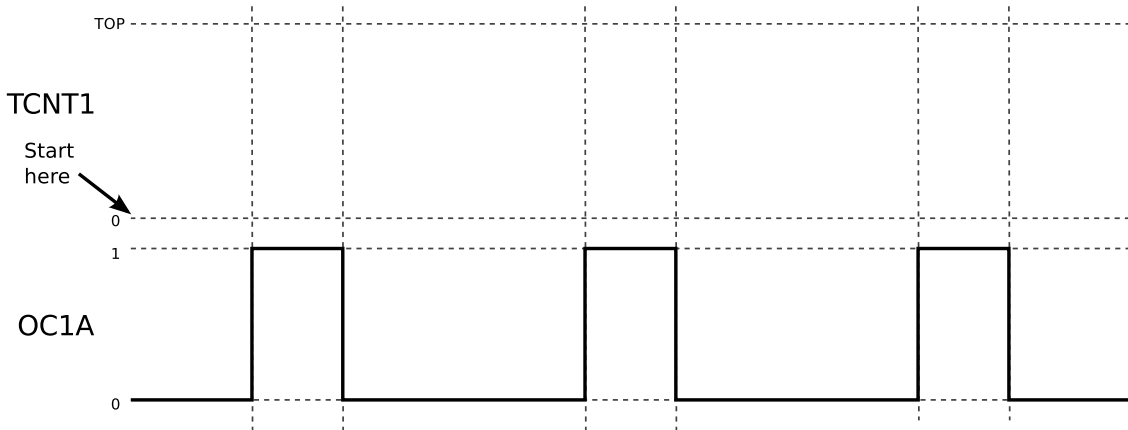
Problem 2. Timer/PWM

a) (5 pts.). What frequency will the interrupt be triggered on our Arduino with the following configuration (use the datasheet for this problem)? (You can leave the answer as a fraction.)

```
void setup(){
  TCCR1A = (1<<WGM10);
  TCCR1B = (1<<WGM12) | (1 << CS12) | (1 << CS10);
  TIMSK1 = (1 <<OCIE1A);
  OCR1A = 200;
}

SIGNAL(TIMER1_COMPA_vect){
  //Interrupt handler code goes here
}
```

b) (5 pts.). In the following figure, draw the clock, TCNT1, that will generate the lower square wave when it is configured in phase-correct PWM mode. Also draw the correct line in the upper part of the diagram to indicate the location of OCR1A. (Also make sure to read the next question before completing this one.)

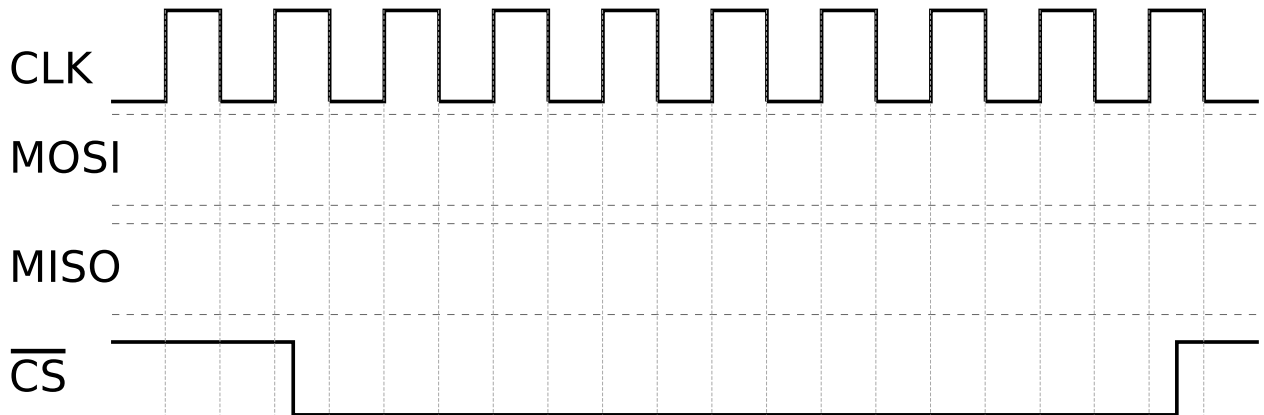


c) (5 pts.). For the previous figure, what are the proper mode bit settings (COM1A0 and COM1A1) to generate the signal from the timer register you drew?

d) (5pts). If a PWM signal was 500Hz in Phase Correct Mode, what would the frequency be if you switched to Fast PWM mode without changing other settings?

Problem 3. Communication

a) (5 pts.). In the following figure, draw the proper signal for sending the from the master to the slave the value 0x61 on the rising edge and from the slave to the master the value 0xCD on the falling edge.



b) (5pts). What is one advantage and one disadvantage of differential signaling when communicating (e.g. like RS435)?

c) (5 pts.). In I²C, describe how arbitration works when there are two masters. What is unique at the physical layer that enables multiple masters with I²C?

Problem 4. *Interrupt Example Code.* For this problem, refer to the following code. This code monitors two of the external interrupts connected to two different buttons. The goal of the code is to turn on one of the LEDs if the counter is less than zero, the other when the counter is greater than zero, and to have both off when counter is zero. Note that during the SIGNALs interrupts are disabled.

```
00: int32_t counter = 0;
01:
02: SIGNAL(INT0_vect){
03:   counter++
04: }
05:
06: SIGNAL(INT1_vect){
07:   counter--;
08: }
09:
10: void loop(){
11:   if(counter < 0){
12:     //Red on
13:     digitalWrite(LED_RED,HIGH);
14:   }else if(counter > 0){
15:     //Green on
16:     digitalWrite(LED_GREEN,HIGH);
17:   }else if(counter == 0){
18:     //Both off
19:     digitalWrite(LED_RED,LOW);
20:     digitalWrite(LED_GREEN,LOW);
21:   }
22: }
```

a) (5 pts.). *This code does not work properly. Describe how this code could end up with both LEDs on (at least until the buttons are pressed again). Refer to line numbers to help in your explanation.*

b) (5 pts.). *How can you fix this code by modifying the main loop?*

c) (5pts.). *Describe one benefit and one drawback of using interrupts in your code.*

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

Problem 5. *Analog to Digital Converters*

a) (5 pts.). *If a 12-bit ADC, with a 5.0V reference reports a value of 990, what is the voltage being read on the pin? (You can leave the answer as a fraction.)*

b) (5 pts.). *Write the Arduino C code to read the analog value on pin A1 and add it to the analog value read from A3. Store the result in a variable `sum`. What is the smallest `uintX_t` type needed to store this result?*

Problem 6. *Embedded Operating Systems*

a) (4 pts.). *What is the difference between a non-cooperative multi-tasking operating system and a cooperative multi-tasking operating system?*

b) (4 pts.). *What does it mean when an OS has a fully preemptive scheduler? What is one advantage and one disadvantage of a fully preemptive scheduler?*