Embedded Systems (CS [45]163)
Homework 3

April 9, 2010

This homework assignment is due on Thursday, April 15th at 5:00pm. Your work may be handed in electronically (use the **Homework 3** digital dropbox on D2L) or in hardcopy form (in person or under office door).

This assignment must be done individually: do not share/discuss your answers with others or look at the answers of others.

Question 1

Assume that *student_ID* is the number that corresponds to your student ID number.

1. (2pts) What is *student_ID % 2*? Call this *key1*

2. (2pts) What is *student_ID % 5*? Call this *key2*

Question 2

Assume timer/counter 0 (if key1 == 0) or 1 (if key1 == 1).

Assume a prescaler of 1 (if key2 == 0), 8 (key2 == 1), 64 (key2 == 2), 256 (key2 == 3) or 1024 (key2 == 4).

1. (5 pts) What is the interval between counts of the timer/counter (tocks)?

2. (5 pts) Assume that we have the overflow interrupt enabled. What is the frequency of interrupts?

Question 3

Suppose we want to produce a regular interrupt every $262ms$. Assume that we are using a 16 MHz crystal for our clock.

1. (5 pts) Which timer should we use?

2. (5 pts) Which prescaler should we use?

Question 4

1. (15pts) Suppose we want a function – called $myfunc()$ – to be executed once every $20.97s$. Assume a system clock of $16MHz$. What is the timer1 prescaler configuration and the code for the interrupt routine (the code does not need to be syntactically correct)? Also - show the code in your main function that configures the timer.

Question 5

Consider the following code:

```
ISR(TIMER0_OVF_vect) {
   static uint8_t counter = 0;
   static uint8_t phase = 0;

   if(counter == 0) {
      switch(phase) {
         case 0:
            PORTC |= 3;
            counter = 100;
            phase = 1;
            break;
         case 1:
            PORTC &= ~1;
            counter = 50;
            phase = 2;
            break;
         case 2:
            PORTC &= ~2;
            counter = 75;
            phase = 0;
            break;
       }
   }
   --counter;
};
```

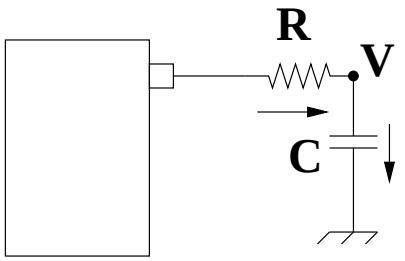
Somewhere in the main program:

```
// Initialization
timer0_config(TIMER0_PRE_8);
// Enable the timer interrupt
timer0_enable();
// Enable global interrupts
sei();

DDRC = 0x3;

while(1)
{
}
```

1. (15 pts) Explain in detail what the program does. You are welcome to provide a picture.

Question 6

Consider the following circuit that we discussed in class:



Assume that a PWM cycle starts at time $t = 0$ with the pin in a state of $5V$. At time t_1, the pin state changes to $0V$. At time t_2, the PWM cycle ends (and the new cycle begins).

1. (10 pts) Given an arbitrary $V(0)$, show the equation for $V(t)$ for $0 \leq t < t_1$. Hint: we derived this case in class.

2. (10 pts) Show the equation for $V(t)$ for $t_1 \leq t < t_2$ in terms of t_1, RC and $V(0)$. Hint: we derived this case in class (you just need to deal with the shift in time).

3. (10 pts) Assume that $V(t)$ has reached equilibrium for a given t_1 and t_2 (in other words: $V(t_2) = V(0)$. Derive an equation for $V(0)$ in terms of t_1, t_2 and RC. Hint: think about the simple cases to check.

4. (10 pts) **Graduate only**. Define V_{eq} to be this equilibrium voltage at the beginning of the PWM cycle. Show that if $V(0) < V_{eq}$, then $V(0) < V(t_2)$ (in other words, show that in a single cycle, V moves toward the equilibrium).

Question 7

How much time did you spend on this assignment?