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 262 ms. 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:

```c
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:

```c
// 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?