ECE 331 Digital System Design Student:_____

Fall 2007 Nathalia Peixoto

HOMEWORK 10 – due **Tuesday**, November 20th at **≤6pm**

1) Feedback (3pts) – to be completed after you finish.

- F1. If you worked on it with classmates and your solutions might be TOO similar, write their names here:_____
- F2. How long did it take you to work on the homework (don't count the reading assignment!)
  1h 2h 4h infinite hours
- F3. Do you have suggestions on how to improve it? (ideas for new problems?) Let us know here (and/or use your own homework sheets):

2) Three-flops

If we cross-couple three-input NANDs with feedback as in figure 1 below (notice it's only one IC that I'm using!), we achieve a 3-flop.

(a) Write out the eight lines of a truth table for inputs A, B, and C and outputs Y1, Y2, and Y3. (14 pts)

(b) What are the three stable states? (4pts)

(c) What are the not-allowed inputs (which lines would be considered not-allowed)? (4 pts)

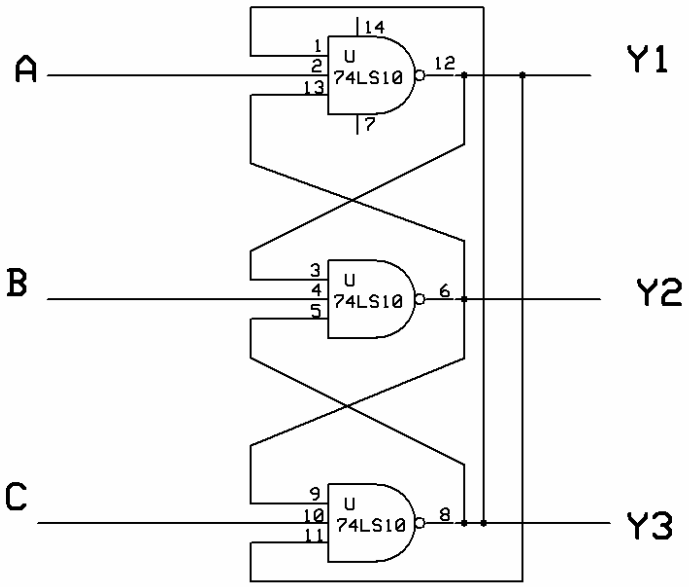

Figure 1. Circuit schematic for problem 2.

3) T flip-flops

(a) You haven't heard of T flip-flops yet (in class). The book covers it in pages 394-396. They are a simplification of D flip-flops. T is for *toggle*, and gives the idea behind it: if you set T to 1, during the next rising clock signal, the output (Q) will toggle (either from 0 to 1, or from 1 to 0). The output will remain constant it T=0. Analyze the following circuit: (in particular, write the sequence of outputs over time. Is this a counter?) (10 pts)

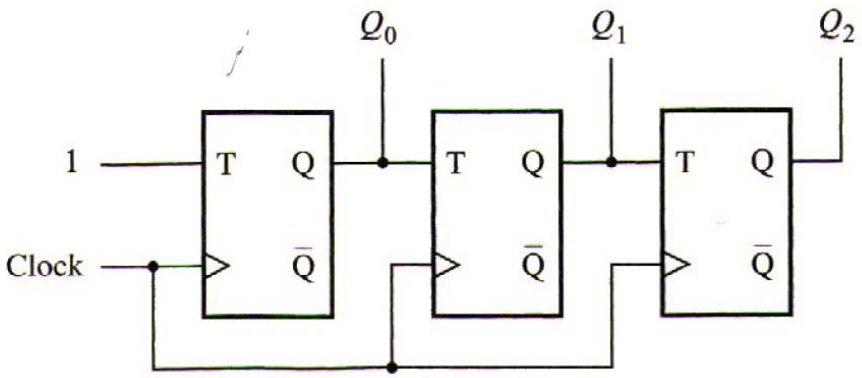

Figure 2. Toggle flip-flops in action. The input to the first (left most) flip-flop is 1.

(b) Implement the circuit from Figure 2 using one SN74LS174. Indicate pin numbers too (look up the datasheet, hook up power and CLR' lines to appropriate voltage level). You may need logic gates to fully execute the T circuit above. That is allowed (adding logic gates to your circuit). (15 pts)

4) D master-slave (10 pts).

A circuit you designed for a PIC microcontroller is run at 1MHz. It contains a D master-slave flip-flop. Given that the input D may change at any moment, how long will you have to wait (the worst case scenario) to see the output change? Assume a 50% duty cycle on your clock line.

5) Controlling the temperature of a microwave with RS latches. (35 pts)

Your parents own a microwave with a thermometer. The thermometer has a simple circuitry[1] associated to it which has two outputs: TH goes to 1 when the temperature goes higher than a threshold "THh", and TL is set to 1 when the temperature falls below "THl". THh is obviously higher than THl.

Your task is to design a controller for this oven. The controller should turn the oven on when the temperature falls below THl, turn the oven off when the temperature is above THh. When the temperature is between THl and THh, leave the oven in the condition it was in before those were last reached. Implement the controller using RS latch(es).

TIP: if you don't know where to start: draw sample waveforms of TH and TL, and then draw the output of your system (what is the desired output of your controller?). If you are still lost, first go through the drill problems from the "extra homework 10) – available on the website under "links". Enough practice with the RS latches will make this problem straightforward.

5) Extra-(ECE280!)-credit. You may only receive either 0 or 10 for this problem. No other points are given. This homework maxes out at 100 points.

We are trying to implement debouncing for a two-button switch (S1) by hardware. The circuit below is our first attempt. What is the output for this circuit without and with the capacitor? (R=100kOHms, C=1μF). R4 is connected to Vcc (5V). I am expecting two waveforms over time, one without the capacitor, the other with the capacitor.

[1] You can also try to design that simple circuit, but do not add it to the answers of this homework at this point.

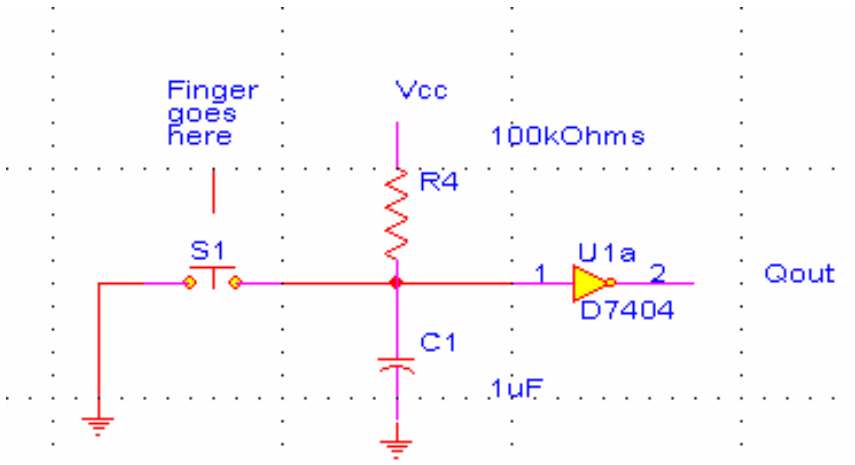

Figure 3. Debouncing by hardware: circuit idea.