cs281: Introduction to Computer Systems

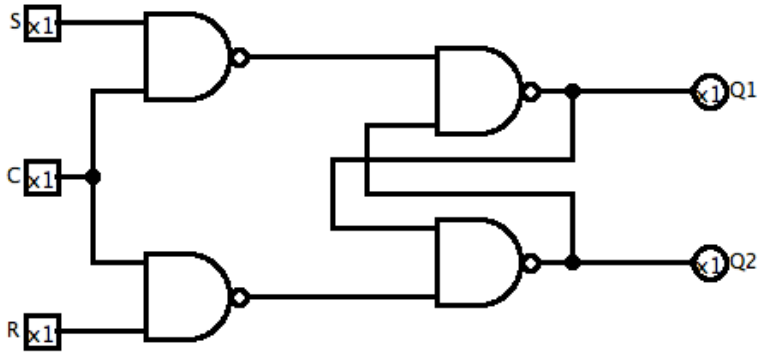
Lab 6: Mystery Circuits

In this lab, you will experiment with three circuits that are given to you, and identify their behavior. You will use Logisim for the first circuit (Mystery1), and will use the breadboard for Mystery2 and Mystery3.

1 Mystery1

Implement the following circuit from Figure 1, using input pins for S, C, and R, and output pins for $Q1$ and $Q2$

Figure 1: Mystery Circuit 1



In analyzing the input to output behavior below, I'll give you the hint that the C input is used as a "clock" that limits the *action* to occur when the C bit goes from 0 to 1. So in the instructions that follow, you will set up S and R in a configuration while C is 0, and then change C to 1. You should also then check and see what happens when you cycle the C bit through more 0-1 and 1-0 transitions.

1. Before you begin testing against the various input combination, note and write down what is different about this circuit from those you have designed in the past.

2. Begin by just randomly setting values for S, C, and R and see if you can make the circuit reach an unstable state. What combination and/or sequence caused the unstable situation?

3. Recover form the unstable state by:

   (a) Reset the simulation.

   (b) Enable simulation.

   (c) Set R to 1,

   (d) Set C to 1,

   (e) Set all to 0.

4. Write down a truth table based on S and R and with output columns $Q1$ and $Q2$. Enter the 0, 0 entry output values.

5. Now start with $S = 1$ and $R = 0$ and rise the clock C. What are the outputs $Q1$ and $Q2$? Write down your observations on your truth table.

6. Next set $S = 0$ and $R = 0$ and rise the clock. What are the outputs $Q1$ and $Q2$?

7. Next set $S = 0$ and $R = 1$ and rise the clock. What are the outputs $Q1$ and $Q2$?

8. Next set S and R back to 0 and rise the clock. What are the outputs $Q1$ and $Q2$? Is this consistent with your earlier experiment?

9. Experiment further with the input values of S and R. What can you say about the outputs $Q1$ and $Q2$ based on the inputs and the *history* of their values?

10. Is this a combinational circuit? Justify your answer. (Hint: Think about the definition of what it means to be combinational.)

11. Assume that we begin with a current value of 1 for $Q1$, and $S = R = C = 0$. Using the circuit picture start by labeling the 0/1 values on each line segment. Next, follow the sequence of events that occur when R is set to 1 and C goes to 1. Working from left to right and top to bottom, label each line segment with the values on each of the wires, crossing out values that must change.

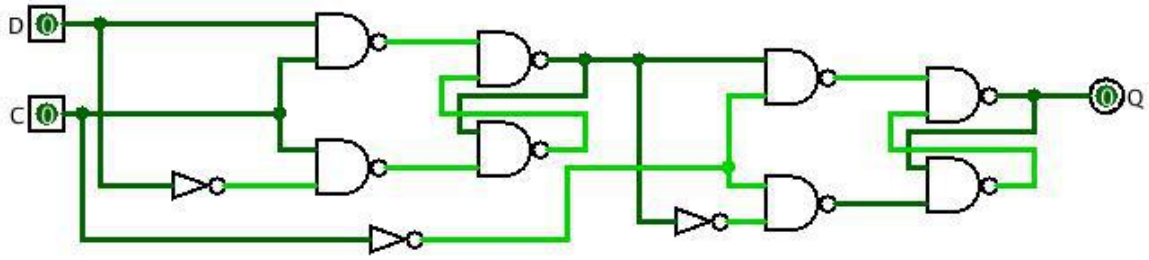
12. From this new picture, repeat for $S = 1$ and $R = 0$ also transitioning to 1.

13. Fill in the $S = R = 1$ case for the clock rising and then falling. What happens?

2 Mystery2

Implement the following circuit from Figure 2, wiring the D input to switch S_7, and the C input to switch S_1, and the Q output to LED display digit 1.

Figure 2: Mystery Circuit 2

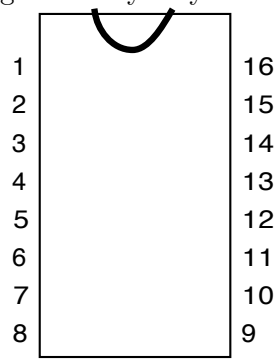


1. Using a similar strategy to that employed in the last problem, map out a truth table for outputs Q based on the inputs D, C, and the *prior* value of Q. Do your best to characterize the behavior of these outputs. Note any cases where unstable or erratic behavior occurs.

3 Mystery3

In this part of the lab, you are simply going to experiment with an unfamiliar chip, the 7476.

Figure 3: Mystery Circuit 3



1. Wire pin 5 to +5 volts, and pin 13 to ground.
2. Wire pin 4 to S_7, pin 16 to S_8, and set both to 0.
3. Wire pin 1 to S_1, pin 2 to S_2, and pin 3 to S_3.
4. Set S_1 to 0 and S_2 to 1. Toggle S_3 to 0, then back and leave it at 1.
5. Finally, wire pin 15 to LED display digit 1 and pin 14 to LED display digit 2.

If done carefully, and in the order given, you should have digit 1 with 0, and digit 2 with 1. If not, toggle switch S_3 to 0, then back to (and leave it at) 1.

Draw a truth table with input columns labeled J, K, and Q_0. In our wiring, S_7 corresponds to J, S_8 corresponds to K, and S_1 is our clock. LED display digit 1 is both the output Q and will give the entry in the table for Q_0 for our previous value of Q in setting up for a new result.

Fill in the truth table through experimentation.