

# Homework 7

Max marks: 60

Due on Nov 1st, 2021, 9 AM, before class.

**Problem 1** Consider the timing diagram in Figure 1. Assuming that the D and Clock inputs shown are applied to the circuit in Figure 2, draw waveforms for the  $Q_a$ ,  $Q_b$ , and  $Q_c$  signals. (10 marks) [1, Prob 5.1]

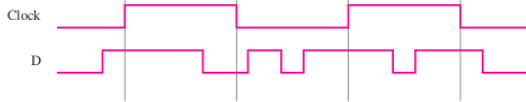


Figure 1: Inputs for Prob 1

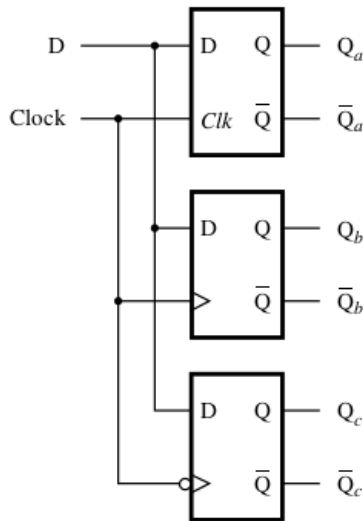


Figure 2: Circuit for Prob 1. Recall that  $Clk$  with a “▷” symbol indicates rising-edge (positive-edge) triggered flip-flop.  $Clk$  without “▷” symbol indicates a level-triggered latch.  $Clk$  with “◁” symbol indicates a falling-edge (negative-edge) triggered flip-flop.

**Problem 2** Figure 3 shows a S-R latch built with NOR gates. Draw a similar latch using

NAND gates. Derive its characteristic table and show its timing diagram. Assume that  $\bar{S}$  and  $\bar{R}$  are available. (10 marks) [1, Prob 5.2].

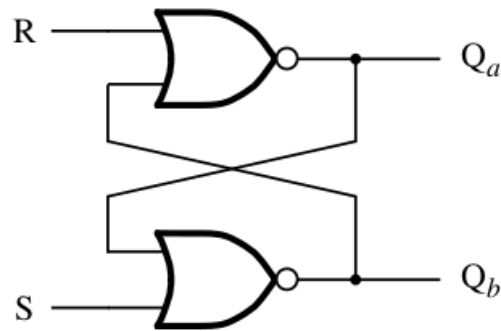


Figure 3: Circuit for Prob 2

**Problem 3** An SR flip-flop is a flip-flop that has set and reset inputs like a gated SR latch. Show how an SR flip-flop can be constructed using a D flip-flop and other logic gates. (10 marks) [1, Prob 5.5]

**Problem 4** Show how a JK flip-flop can be constructed using a T flip-flop and other logic gates (10 marks) [1, Prob 5.7].

**Problem 5** Design a three-bit up/down counter using T flip-flops. It should include a control input called Up/Down. If Up/Down = 0, then the circuit should behave as an up-counter. If Up/Down = 1, then the circuit should behave as a down-counter. You can use a 2-1 MUX for the switching or you can use basic logic gates (10 marks) [1, Prob 5.15].

**Problem 6** The circuit in Figure 4 looks like a counter. What is the counting sequence of this circuit (10 marks) [1, Prob 5.17]?

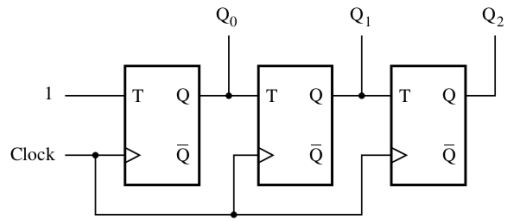


Figure 4: Circuit for Problem 6.

## References

- [1] S. Brown and Z. Vranesic. *Fundamentals of Digital Logic with Verilog Design: Third Edition*. McGraw-Hill Higher Education, 2013.