

Name: _____

ES 4 Problem Set 5

Due Wednesday, November 3 at class time via Gradescope and VHDLweb

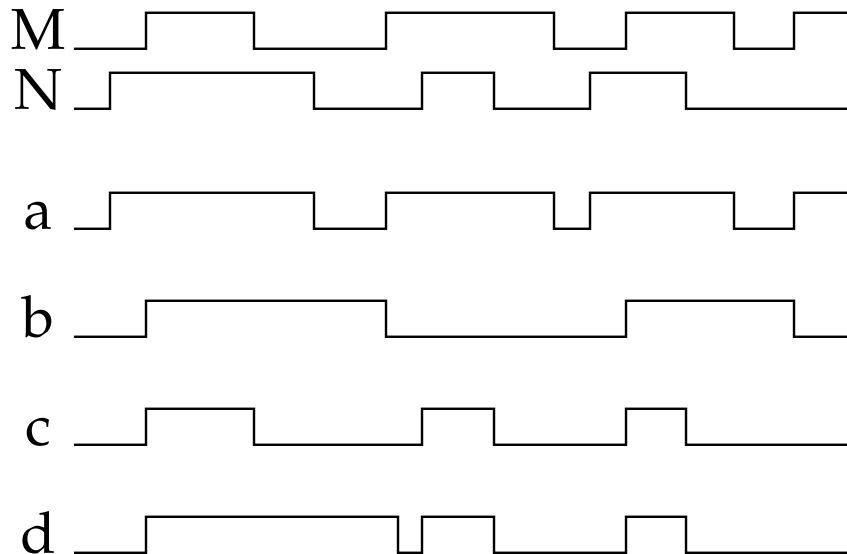
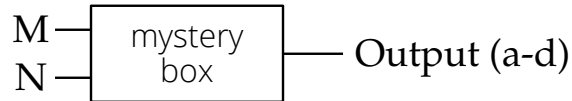
Optional book problems

These are selected problems from the book which may be helpful for practice and review. The answers to these problems are online at <https://booksite.elsevier.com/9780128000564/solutions.php>

- 3.1, 3.3, 3.5 (Latches and flip-flops)
- 5.47 (Up-down counter)
- 5.48/5.49 (A load-able counter) *Note: The book doesn't say it, but what you're building here is actually a simple but crucial piece of a processor.*
- 5.51 (Scan-chain flip-flops)

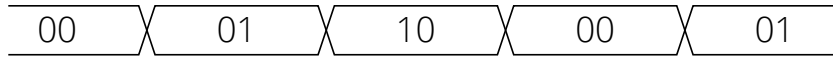
Problem 1: What's in the box?

For each of the four waveforms below, identify what is in the box. It could be an SR latch, a D latch, a D flip-flop, or a single combinational logic gate (NAND, XOR, etc).

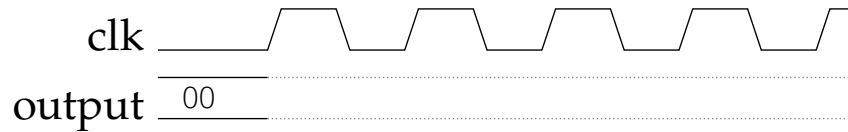
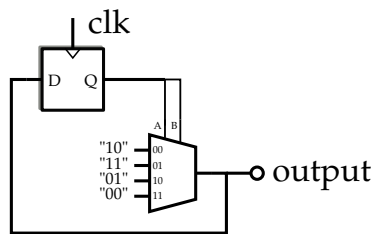


Problem 2: A sequential circuit

Below is a small sequential circuit which contains a 2-bit register. Draw its output as a function of time on the waveform diagram below, assuming it starts at "00". The conventional way to draw a bus of signals is to draw the signal as both high and low (since some bits are high and others are low), and to write the numerical value (in whatever base) in the spaces in between:

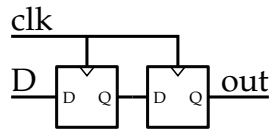


Note: The multiplexer is actually two multiplexers stacked together, which collectively drive the bus. The same select lines go to each multiplexer, so the result on the output is the bit pattern shown on the left. This is how Radiant (and other tools) typically draw multiplexed buses.

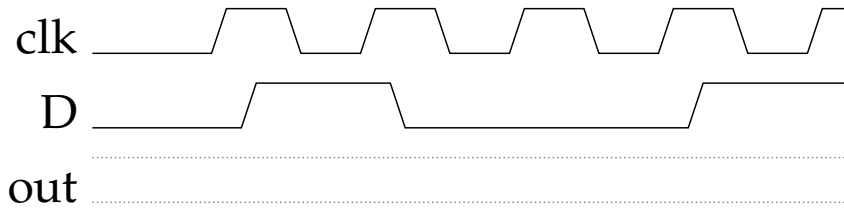


Problem 3: Another sequential circuit

The circuit below is a 2-bit shift register (briefly discussed in section 5.4.2 of the textbook).



Draw the output as a function of the input signals below. Be sure to clearly mark the section of time when the output is unknown.



Problem 4: VHDLweb problems

Complete the problems listed under homework 5 on VHDLweb:

- One-hot counter
- Johnson counter
- Binary counter with enable
- Linear-feedback shift register
- Binary counter with rollover

If you'd like to simulate your designs and view the waveforms, you can use ModelSim (an industry-standard tool for HDL simulation which runs on Windows and Linux) or GHDL (an open-source tool that runs on Windows/Mac/Linux). Tutorials for using both tools are posted on the course website.

Problem 5: Reflection

(1 Points) How long did you spend on this assignment?