



**UNIVERSITY OF TEHRAN**  
**Electrical and Computer Engineering Department**  
**Digital Logic Design, ECE 367 / Digital Systems I, ECE 894**  
**Fall 1404**  
**Computer Assignment 4**

Basic Memory Structures, Latches and Flip-flops - Week 10

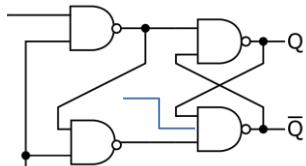
Name:

Date:

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In this assignment, you will be experimenting with latches and flip-flops and see their timing and functionality differences.

1. Generate a clocked D-latch with D and Clock inputs as shown in the following diagram. Adding another input to the lower NAND of the cross-coupled NAND structure creates an asynchronous reset to this circuit. Add this input and describe this circuit in Verilog using NAND primitives.



2. Annotate the circuit of Part 1 with gate delays that are based on switch level delays of 4 NS for the nMOS and 6 NS for the pMOS transistors.
3. Simulate the circuit of Part 2 to verify its operation. For the start of simulation, the outputs begin with X values. Apply the reset input to force the circuit into Q value of 0. Then create D and Clk signaling that will force the latch into a known and stable state. Exercise this circuit for cases where you think a glitch on output of a gate is possible. Show situations that this structure behaves as a latch, thus, has transparency. Show how the asynchronous resetting works.
4. Provide a synchronous initialization (*inz*) input for the above latch that, when active, it will force the output to 0 with the clock pulse. Hint: this should come through the input.
5. Form an 8-bit multi-shift right rotate (MSRR8) using eight of the above latches. The circuit has four modes of operation, *mode*=00, 01, 10, and 11. Mode 00 is for do-nothing, mode 01 is for right-shift one position, 10 is for rotate right one position, and 11 is for serial right-shift two positions. Use *sIn* (serial input) for the serial shift mode.
6. Simulate the circuit of Part 5 and explain why or why-not this circuit works as expected. Test its asynchronous and synchronous resetting features.
7. Build a D-type flip-flop using two of the above latches. Use the active high synchronous initialization input to the flip-flop. Simulate this flip-flop and check its edge-triggering behavior and the resetting mechanism that you inserted in the flip-flop.

8. Build an 8-bit multi-shift right rotate (MSRR8) using the flip-flops of Part 7 in a **generate** statement.
  - a. Write a testbench for this circuit and verify its clocking, resetting, and initialization operations.
  - b. Extend the testbench to include its shift operation.
9. Use an **always** statement to describe the circuit of Part 7. Verify its operation using a SystemVerilog testbench.
10. In a testbench compare simulations of the shift register built by putting gates together and the one with the **always** statement. Explain the differences.

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**Deliverables:**

Generate a report that includes all the items below:

- A. Prior coming to the lab, for all the above problems hand-drawn schematic diagrams and partial timing diagrams are required. Your SystemVerilog descriptions must correspond to the circuit diagrams. Your simulation run and the project built for this purpose must be demonstrated to the TA.
- B. For all problems, be prepared to answer questions asked about the timings, minimum pulse widths, and time distance between various signals.
- C. Below is an itemized list tasks for each of the above problems:
  1. Show diagram; Hand simulate; Write SystemVerilog
  2. Annotate circuit diagram;
  3. Perform simulation; Exercise with timing;
  4. Perform simulation; Hand analyze;
  5. Show diagram; Write SystemVerilog;
  6. Simulate and analyze;
  7. Show diagram; Write SystemVerilog; Hand simulate;
  8. Show diagram; Write SystemVerilog; Write testbench; Perform simulation
  9. Write SystemVerilog; Write testbench; Perform simulation; Compare results

Make a PDF file of your report and name it with the format shown below:

*FirstinitialLastnameStudentnumber-CAnn-ECEmmm*

Where *nn* is a two-digit number for the Computer Assignment, *mmm* is the three-digit course number under which you are registered, and hopefully you know the rest. For the *Firstinitial* use only one character. For *Lastname* and for the multi-part last names use the part you are most identified with. Use the last five digits of your student id (exclude 8101) for the *Studentnumber* field of the report file name.