JOINT INSTITUTE
交大密西根学院

Ve270 Introduction to Logic Design

Homework 3

Assigned: May 28, 2020

Due: June 4, 2020, 2:00pm.

A pop quiz will be given on the due date.

1. Problem 2.57 (15 points)

2.57 A network router connects multiple computers together and allows them to send messages to each other. If two or more computers send messages simultaneously, the messages "collide" and the messages must be resent. Using the combinational design process of Table 2.5, create a collision detection circuit for a router that connects 4 computers. The circuit has 4 inputs labeled `M0` through `M3` that are `1` when the corresponding computer is sending a message and `0` otherwise. The circuit has one output labeled `C` that is `1` when a collision is detected and `0` otherwise.

Step 1 - Capture the function

A truth table is convenient for this problem.

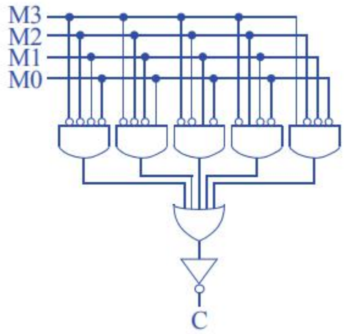
Inputs				Outputs
M3	M2	M1	M0	C
0	0	0	0	0
0	0	0	1	0
0	0	1	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	1
1	0	0	0	0
1	0	0	1	1
1	0	1	0	1
1	0	1	1	1
1	1	0	0	1
1	1	0	1	1
1	1	1	0	1
1	1	1	1	1

Step 2A - Create equation

We note that there are more 1s in the output column than there are 0s. Thus, we choose to create an equation for the inverse of the function, and we'll then add an inverter at the output. The problem could also be solved by creating a (longer) equation for the function itself rather than the inverse.

C' = M3'M2'M1'M0' + M3'M2'M1'M0 + M3'M2'M1M0' + M3'M2M1'M0' + M3M2'M1'M0'

Step 2B- Implement as a gate-based circuit



2. Problem 2.58 (15 points)

2.58 Using the combinational design process of Table 2.5, create a 4-bit prime number detector. The circuit has four inputs, N3, N2, N1, and N0 that correspond to a 4-bit number (N3 is the most significant bit) and one output P that is 1 when the input is a prime number and that is 0 otherwise.

Step 1 - Capture the function

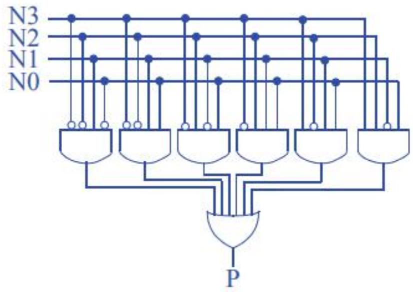
The prime numbers in the range 0-15 are 2, 3, 5, 7, 11, and 13. Rows whose input binary number correspond to those numbers have P set to a 1; the other rows get 0.

Inputs				Outputs
N3	N2	N1	N0	P
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	0
0	1	1	1	1
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	1
1	1	0	0	0
1	1	0	1	1
1	1	1	0	0
1	1	1	1	0

Step 2A - Create equations

P = N3'N2'N1N0' + N3'N2'N1N0 + N3'N2N1'N0 + N3'N2N1N0 + N3N2'N1N0 + N3N2N1'N0

Step 2B - Implement as a gate-based circuit



3. Problem 2.60 (15 points)

2.60 A car has a low-tire-pressure sensor that outputs the current tire pressure as a 5-bit binary number. Create a circuit that illuminates a “low tire pressure” indicator light (by setting an output `T` to `1`) when the tire pressure drops below 16. Hint: you might find it easier to create a circuit that detects the inverse function. You can then just append an inverter to the output of that circuit.

Step 1 - Capture the function

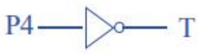
The inverse function outputs 1 if the input is 16 or greater. For a 5-bit number, we know that any number 16 or greater has a 1 in the leftmost bit, which we’ll name P4. Any number less than 16 will have a 0 in P4. Thus, an equation that detects 16 or greater is just:

T’ = P4

Step 2A - Create equations

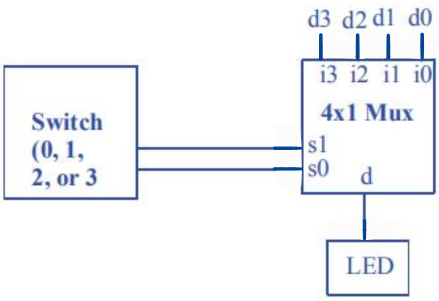
Already done

3 - Implement as a gate-based circuit

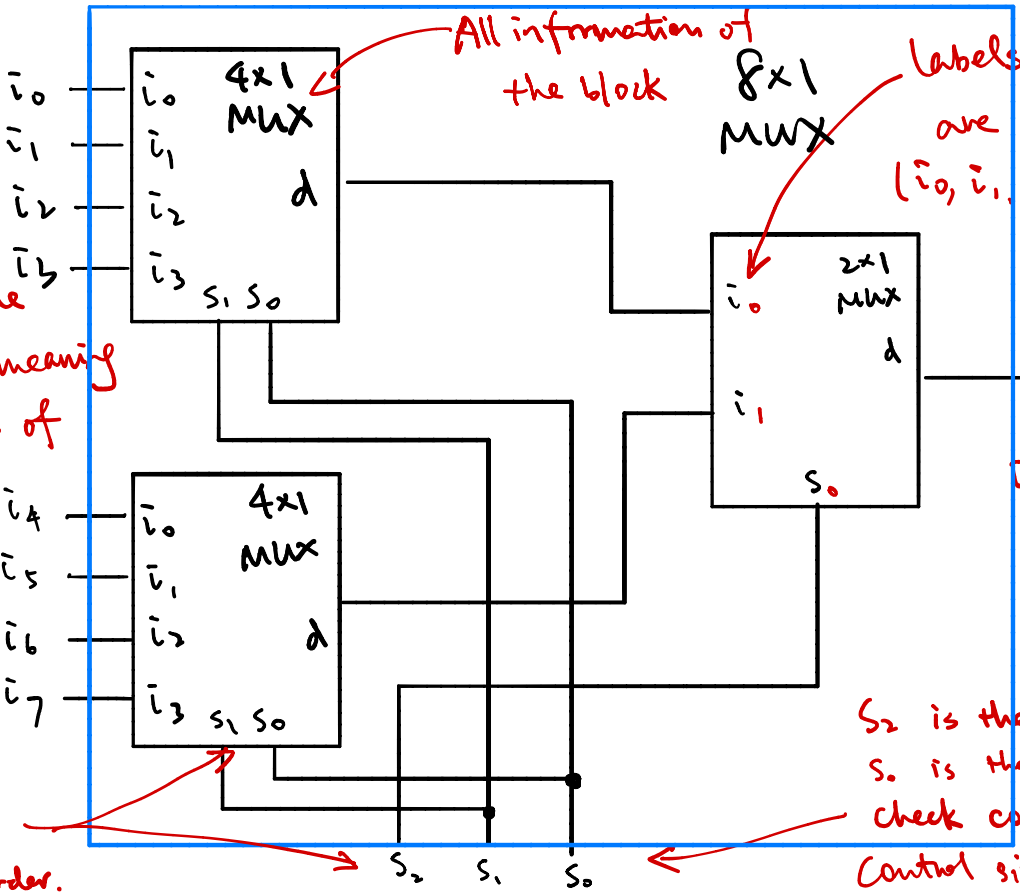


4. Problem 2.74 (15 points)

2.74 A house has four external doors each with a sensor that outputs 1 if its door is open. Inside the house is a single LED that a homeowner wishes to use to indicate whether a door is open or closed. Because the LED can only show the status of one sensor, the homeowner buys a switch that can be set to 0, 1, 2, or 3 and that has a 2-bit output representing the switch position in binary. Create a circuit to connect the four sensors, the switch, and the LED. Use at least one mux (a single mux or an N-bit mux) or decoder. Use block symbols with a clearly defined function, such as “2x1 mux,” “8-bit 2x1 mux,” or “3x8 decoder”; do not show the internal design of a mux or decoder..



5. Show how two 4-to-1 and one 2-to-1 MUXs could be connected to form an 8-to-1 MUX. Make sure the control signals are clearly connected and labeled. (5 points)



All information of the block

labels inside the block are fixed. i.e. (i0, i1, S0, d for 2x1 mux)

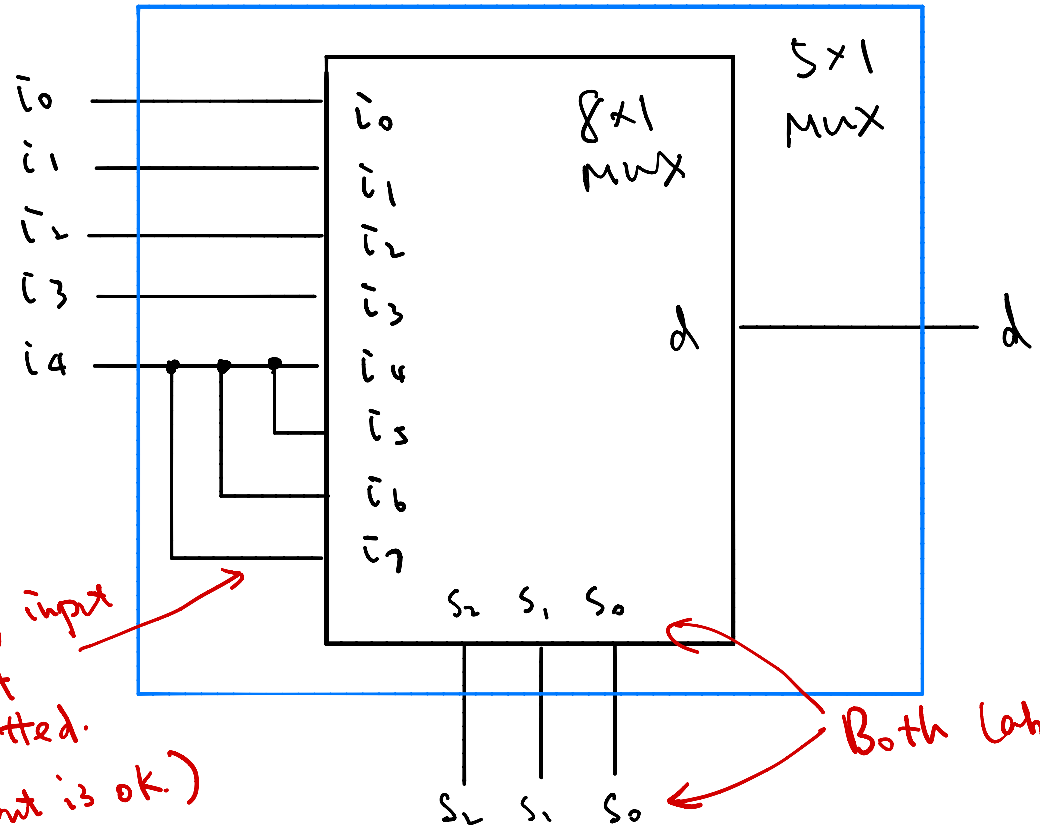
labels outside shows its meaning (the ith input of the 8x1 mux)

Do not forget output label.

control signals are recommended to write in DESCENDING order.

S2 is the MSB and S0 is the LSB. check consistency of control signal and the subscript of the input.

6. Show how to make a 5-to-1 MUX using an 8-to-1 MUX. (5 points)

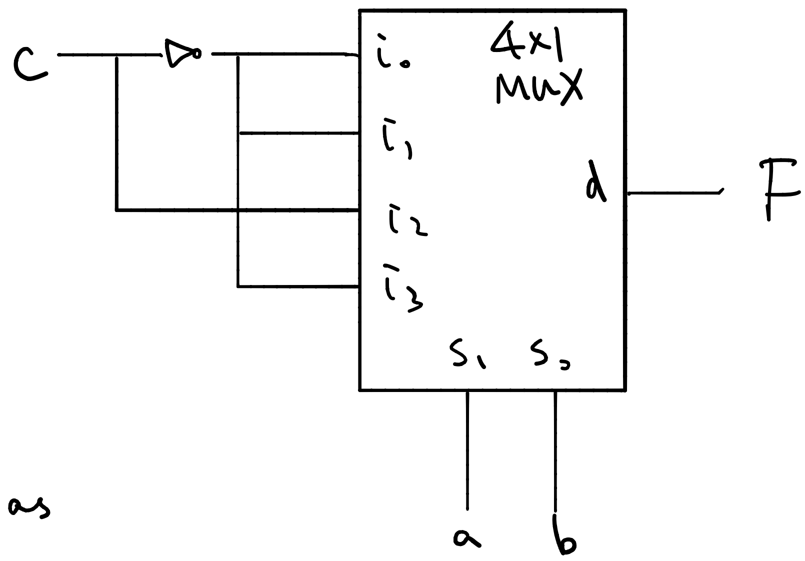


Dangling input is not permitted. (Output is ok.)

Both labels are needed.

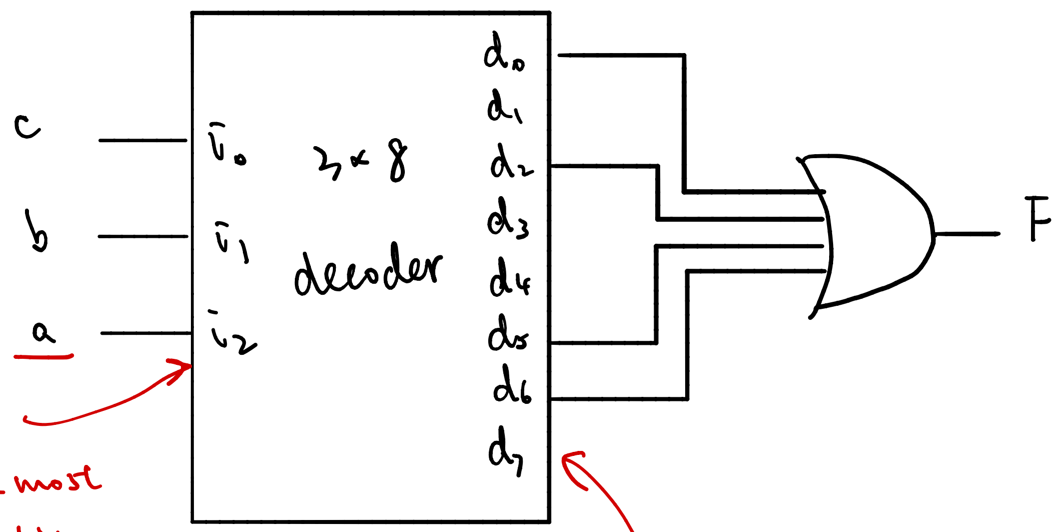
7. Use one 4-to-1 MUX and one inverter to implement a digital circuit for following truth table. (5 points)

a	b	c	F
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0



Using a, c or b, c as control signal is not recommended since digital sources will be needed.

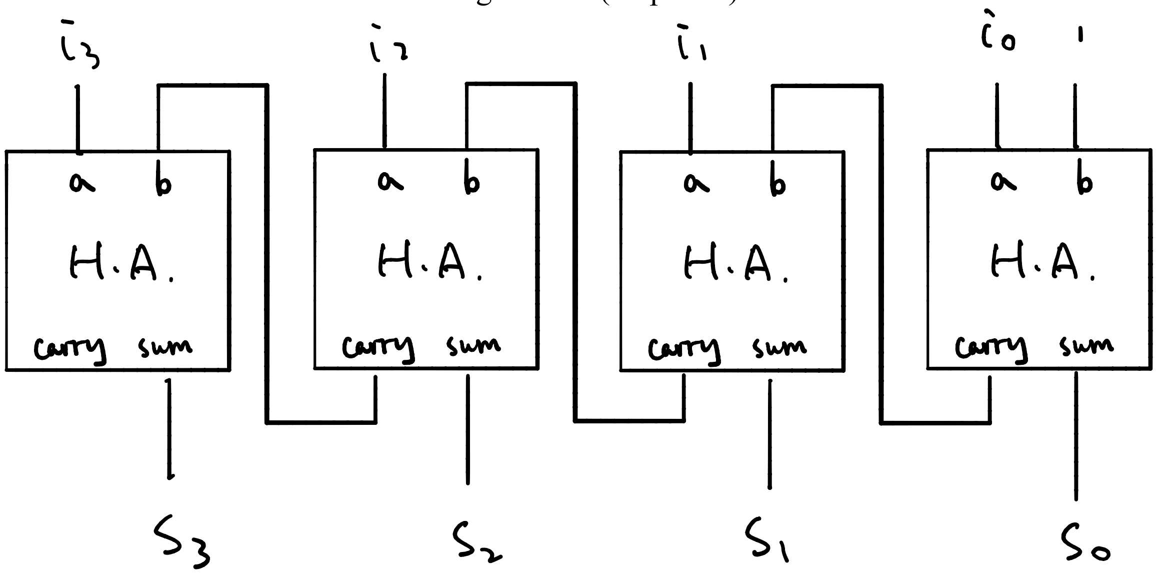
8. Use one 3-by-8 decoder and other components to implement a digital circuit for above truth table. (10 points)



i_2 is the most sigficant bit.

Dangling output is acceptable.

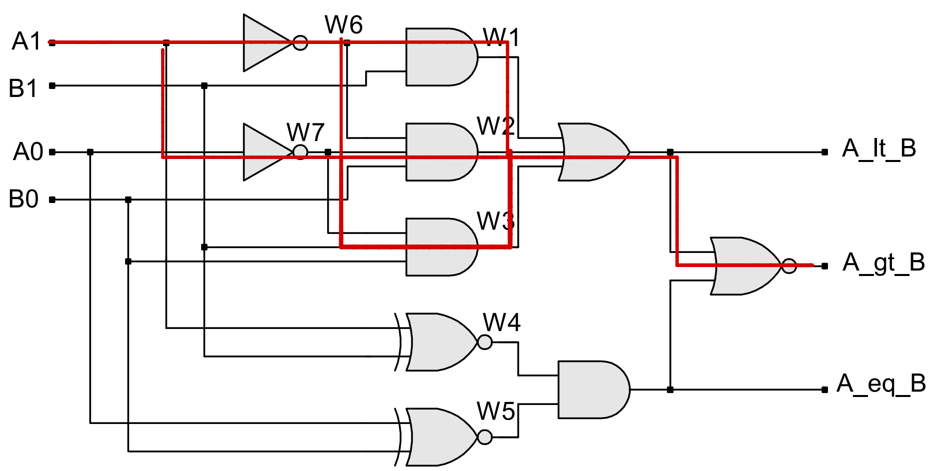
9. An incrementor is a combinational circuit that always adds “1” to the input. Design a 4-bit incrementor with half-adder building blocks. (10 points)



Input: $i_3 i_2 i_1 i_0$. output: $S_3 S_2 S_1 S_0$

Note: 4-bit half adder doesn't exist!

10. Highlight the critical paths of the following circuit. Assume that each gate (including the individual inverters, NOR, and XNOR gates) has a delay of 2 ns and each wire has a delay of 1 ns. (5 points)



Mark all the critical paths.