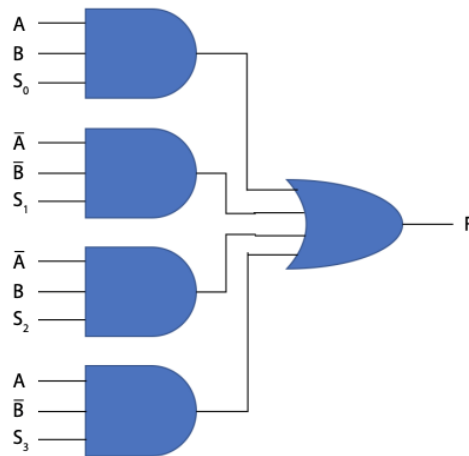


**EECS 151/251A Homework 3**Due Monday, September 27<sup>th</sup>, 2021**Problem 1: Logic [4 pts]**

Consider the circuit below. All inputs (A, B, S<sub>0</sub>, S<sub>1</sub>, S<sub>2</sub>, and S<sub>3</sub>) must be tied to 0 or 1.



What must S<sub>0</sub> thru S<sub>3</sub> be such that  $F = \text{XNOR}(A, B)$ ?

- 1) S<sub>0</sub>:
  - a. 1
  - b. 0
- 2) S<sub>1</sub>:
  - a. 1
  - b. 0
- 3) S<sub>2</sub>:
  - a. 1
  - b. 0
- 4) S<sub>3</sub>:
  - a. 1
  - b. 0
- 5) Can all 2 input logic functions of signals A and B be realized using the above architecture?
  - a. YES
  - b. NO, not all

**Problem 2: Logic Simplification [4 pts]**

Refer to this truth table containing 4 inputs (A, B, C, D) and 1 output (Q):

A	B	C	D	Q
0	0	0	0	1
0	0	0	1	1
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	1
1	0	0	1	1
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	1
1	1	1	1	0

1. Write a sum-of-products directly from the truth table:

- a  $(A'+B'+C'+D')(A'+B'+C'+D)(A'+B'+C+D')(A'+B+C'+D')(A'+B+C'+D)(A'+B+C+D')(A+B'+C'+D')(A+B'+C'+D)(A+B+C+D')$
- b  $A'B'C'D' + A'B'C'D + A'B'CD' + A'BC'D' + A'BC'D + A'BCD' + AB'C'D' + AB'C'D + ABCD'$
- c  $(A'+B'+C+D)(A'+B+C+D)(A+B'+C+D')(A+B'+C+D)(A+B+C'+D')(A+B+C'+D)(A+B+C+D)$
- d  $A'B'C'D' + A'B'C'D' + A'B'C'D + A'BC'D + ABC'D' + A'BCD' + A'BC'D' + AB'C'D + ABCD'$

2. Use a Karnaugh Map to simplify the logic and write the simplified sum-of-products representation:

- a  $A'C + C'D' + ABC + A'B'$
- b  $A'B' + C'D' + ABC' + BCD$
- c  $A'C' + B'C' + A'D' + BCD'$
- d  $A'D + A'C' + AB' + BCD$

3. Use a Karnaugh map to simplify the logic and write the simplified product-of-sums representations:

a  $(A' + B' + C)(C' + D')(A' + B + C')$

b  $(A + B' + C')(C + D)(A + B' + C)$

c  $(A + B + C)(C' + D)(A' + B' + C')$

d  $(A + B)(C + D)(A + B' + C)$

4. Using the sum-of-products representation, draw the circuit that implements this function, you may use only 2-input gates. How many AND and OR gates are there (enter it in the format of 1,2 if, for example, there are 1 AND gate and 2 OR gate).
5. Transform this circuit such that it is made up only of inverters and NAND gates, how many inverters. And NAND gates are there (enter it in the format of 1,2 if, for example, there are 1 inverter and 2 NAND gates)

### Problem 3: FSMs - Pattern Detection [6 pts]

In this problem, you are asked to design a pattern detector circuit that aims to extract the pattern "00110" from an input serial bitstream. The circuit receives a new bit every clock cycle from its input "*in*" and has an output "*out*" used to indicate a pattern has been detected. *out* is pulled high for 1 clock cycle to indicate a pattern is detected, and then pulled low to prepare for the next match.

1. Draw the state diagram of this circuit, marking the transition conditions and output values. The detected patterns should not overlap, i.e. it should take at least 5 more cycles after a pattern is detected to detect another pattern. Use a Moore state machine for your implementation. Assume an IDLE state, how many total states (including the IDLE state) are needed to implement this circuit?
2. Write the Verilog, using a case statement to represent the different states, that corresponds to your circuit. Simulate your circuit and show the waveform with two pattern detection events. Submit your code and a screenshot of the waveform.
3. Draw an updated state diagram of your circuit if we now want overlapping patterns to be detected as two patterns, i.e. "001100110" should have two pattern detection events in it. Use a Moore state machine for your implementation. Assume an IDLE state, how many total states (including the IDLE state) are needed to implement this circuit.

4. Modify your answer to the previous part to implement a Mealy state machine with as few states as possible. How many total states (including the IDLE) are needed to implement this circuit?
5. Make the necessary modifications to your Verilog and show the updated simulation results showing an overlapping detection event (2 detections separated by less than 5 cycles). Submit your code and a screenshot of the waveform.