Digital Systems & Microcontrollers

Practice Questions
23 October, 2025

Question-1

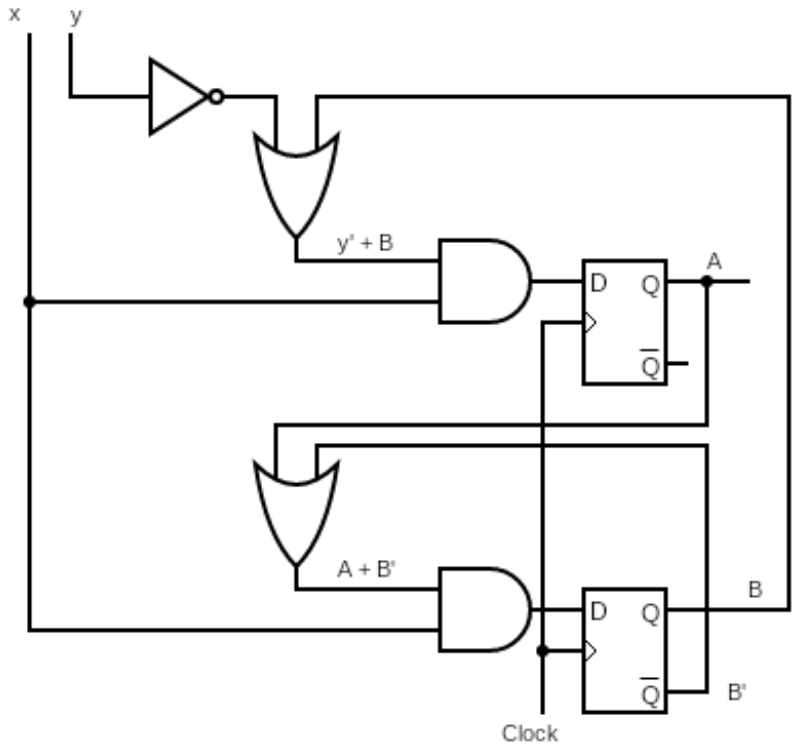
A sequential circuit with 2 D-flip flops A and B, two inputs x,y and one o/p z is specified by the following next-state and output equations:

$$A(t+1) = xy' + xB$$
$$B(t+1) = xA + xB'$$
$$z = A$$

a. Draw the logic diagram of the circuit.
b. List the state table of the sequential circuit.
c. Draw the corresponding state diagram.

Solution:

Circuit Diagram



State Table

Current State		Input		Next State		Output
A	B	x	y	A	B	z
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	1	0	1	1	0
0	0	1	1	0	1	0
0	1	0	0	0	0	0
0	1	0	1	0	0	0
0	1	1	0	1	0	0
0	1	1	1	1	0	0
1	0	0	0	0	0	1
1	0	0	1	0	0	1
1	0	1	0	1	1	1
1	0	1	1	0	1	1
1	1	0	0	0	0	1
1	1	0	1	0	0	1
1	1	1	0	1	1	1
1	1	1	1	1	1	1

State Table for the Sequential Circuit

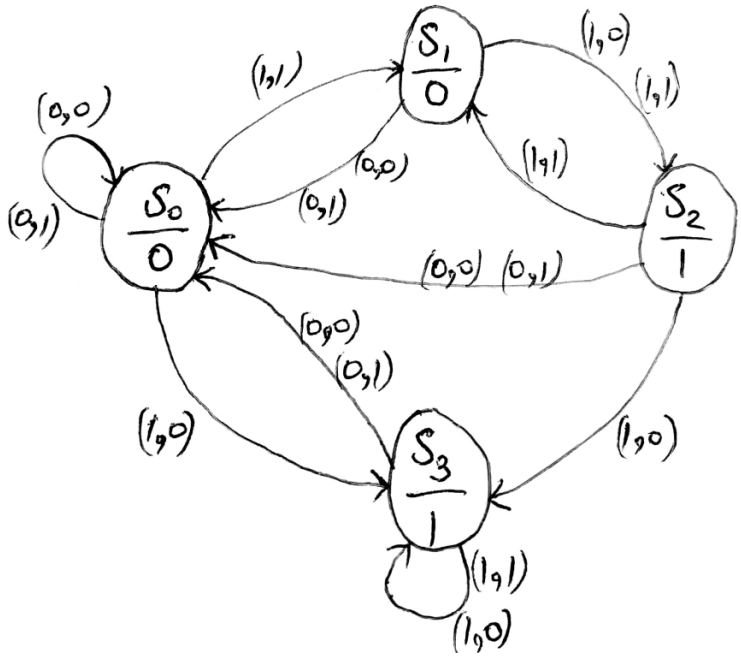
Observations:

1) From the State Table and Circuit Diagram, we can clearly see that the output of the sequential circuit given only depends on the current state 'A', ~~therefore it is a Moore Machine.~~

2) None of the states can be reduced because all the states are unique and have different outputs.

3) The inputs (0,0) and (0,1) acts like a reset for the circuit. These brings the circuit back to the initial state (0,0).

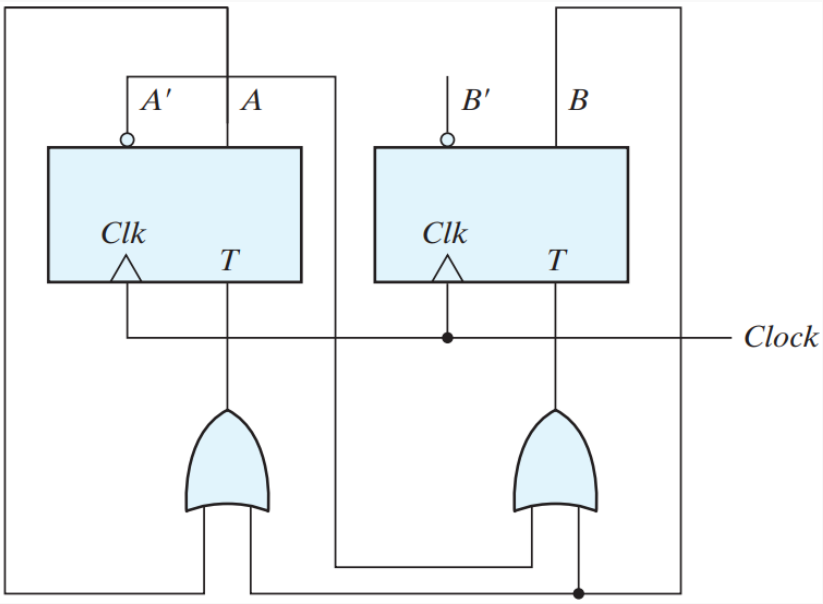
State Diagram



The Binary States A and B are represented by the subscript under capital letter S that is S_o represents $A = 0$ & $B = 0$, similarly S_1 represents $A = 0$ & $B = 1$.
The arrows show the transition from one state to another when clock pulse comes. The output of the circuit is the value of A (z) at the current state. The inputs are (x,y) which are represented along with the transition arrows.

Question-2

Derive the state table and the state diagram of the sequential circuit shown below. Explain the function that the circuit performs.



Solution: As shown in the above circuit diagram, we have only two T flip flops and no inputs therefore maximum no. of states possible are 4.

State Logic

T flip flop togges the output when T=1 and remains same when T=0. Therefore, the state logic can be written as follows:

For A:

$$A(t+1) = A \quad \text{if } A+B=0$$
$$= A' \quad \text{if } A+B=1$$

For B:

$$B(t+1) = B \quad \text{if } A'+B=0$$
$$= B' \quad \text{if } A'+B=1$$

State Table

Current State		Next State	
A	B	A(t+1)	B(t+1)
0	0	0	1
0	1	1	0
1	0	0	0
1	1	0	0

Observations:

1) None of the states can be reduced because all the states are unique and have different outputs.

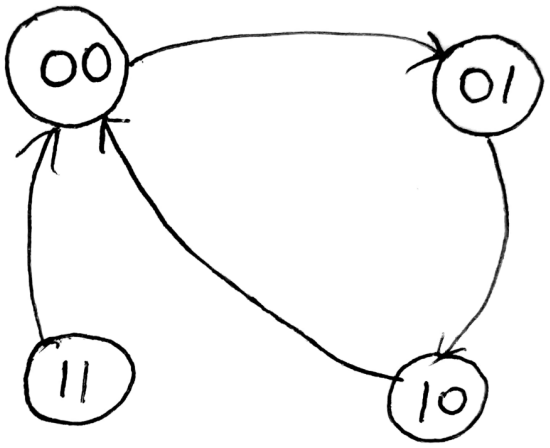
2) The machine comes back to the initial state after every 2 clock pulses.

State Equations

By observing the state table, we can write the state equations as follows:

$$A(t+1) = A'B$$
$$B(t+1) = A'B'$$

State Diagram



This circuit functions like a counter. It counts from 0 to 2 and then resets to 0.

Question-3

Design a four-bit counter circuit using D flip-flops that jumps through only the 4-bit prime numbers sequentially. The counter goes back to 2 after 13. Assume that the circuit resets to 0010 by default.

Solution: Approach: Identify the present and next states. Construct state table. Write the expression for each bit in Next state in terms of present state.

Question-4

a. Give the design of a D flip-flop. Include a provision for asynchronous clear.

b. Give the design of a JK Master-Slave flip-flop with AND and NOR gates. Include a provision for asynchronous clear.