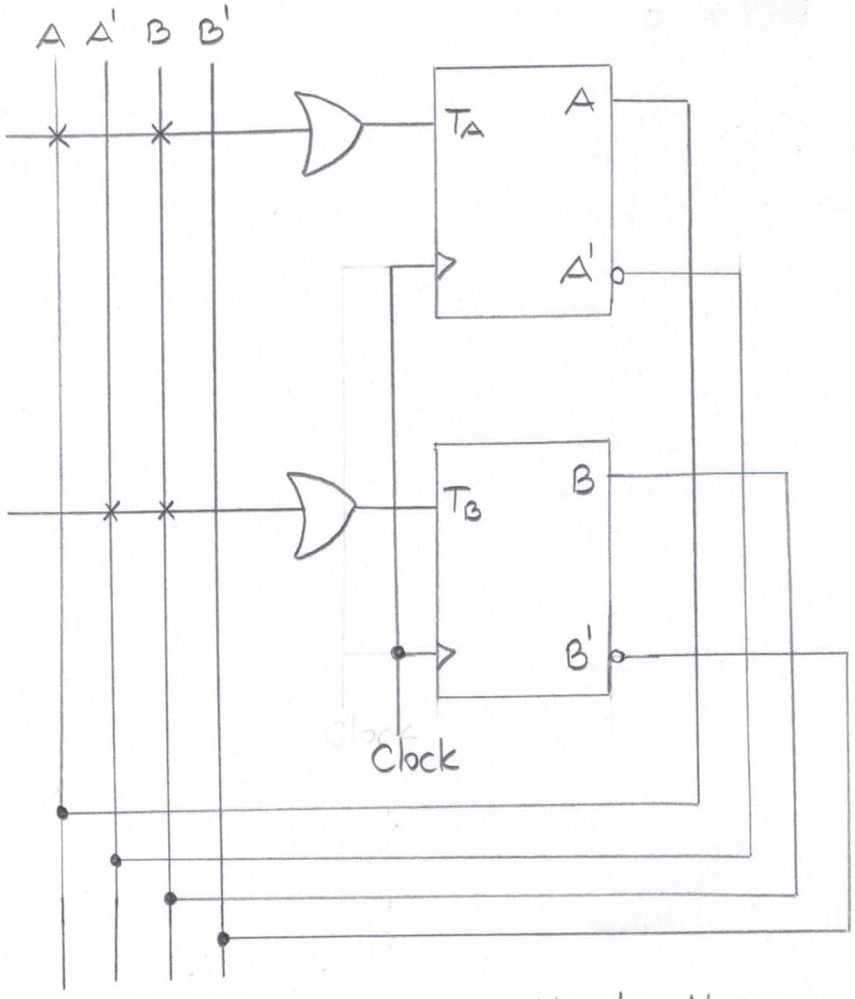
# Selected Problems – VIII

**Problem 1)** Derive the state table and the state diagram of the sequential circuit shown as follows:




Explain the function that the circuit performs.

**Solution.** We have

$$T_A = A + B$$

$$T_B = A' + B$$

Hence;

$$A(t+1) = A \oplus T_A$$

$$= A \oplus (A + B)$$

$$= A \oplus A + A \oplus B$$

$$= 0 + A \oplus B$$

$$= A \oplus B$$

$$B(t+1) = B \oplus T_B$$

$$= B \oplus (A' + B)$$

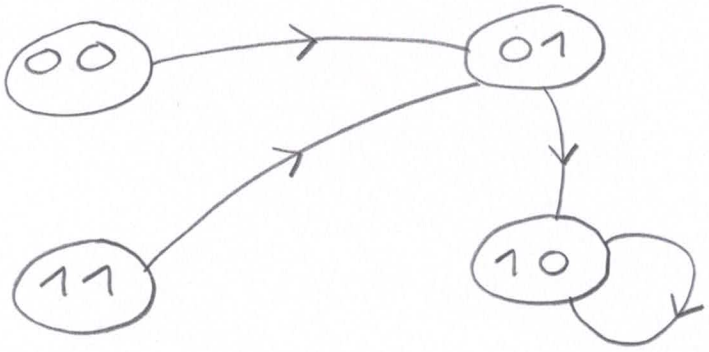
$$= B \oplus A' + B \oplus B$$

$$= B \oplus A' + 0$$

$$= B \oplus A'$$

| AB | A(t+1), B(t+1) |
|---|---|
| 00 | 01 |
| 01 | 10 |
| 10 | 10 |
| 11 | 01 |

"state table"




- the circuit is a counter with a repected sequence of $0 \to 1 \to 2 \to 2 \to 2 \cdots$ and $3 \to 1 \to 2 \to 2 \cdots$

Problem 2) A sequential circuit has two JK flip-flops A and B, two inputs x and y, and one output z. The flip-flop input equations and circuit output equation are

$$J_A = Bx + B'y' \qquad K_A = B'xy'$$

$$J_B = A'x \qquad K_B = A + xy'$$

$$z = Ax'y' + Bx'y'$$

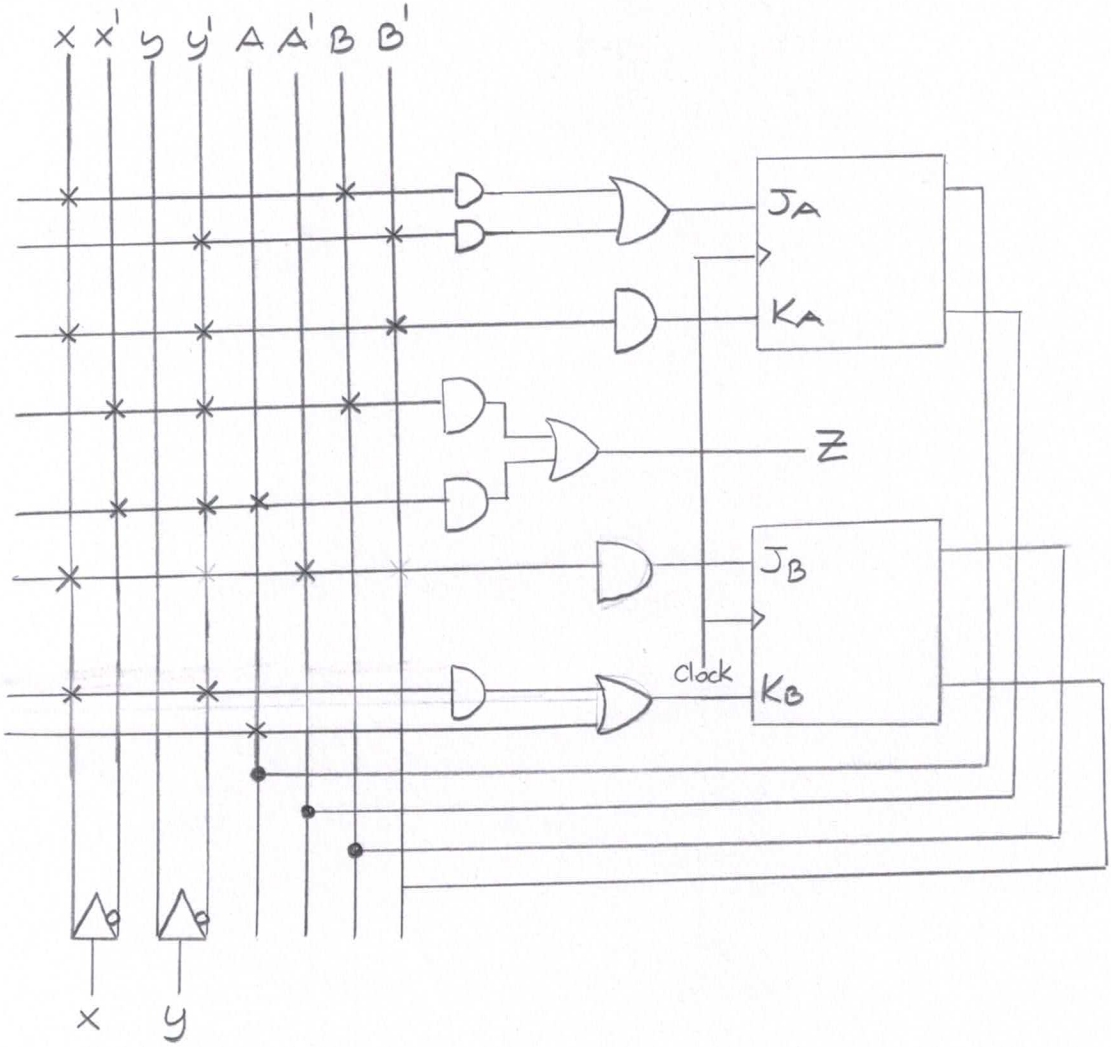
a. Draw the logic diagram for the circuit.

b. Tabulate the state table.

c. Derive the state equations for A and B.

## Solution.

a.




b. We obtain

$$A(t+1) = J_A A' + K_A' A$$

$$= (Bx + B'y')A' + (B'xy')'A$$

$$= xA'B + y'A'B' + AB + x'A + yA$$

| xy \ AB | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | | 1 | 1 |
| 01 | | | 1 | 1 |
| 11 | | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 | |

$$A(t+1) = x'A + yA + xB + y'A'B'$$

$$B(t+1) = J_B B' + K_B' B$$

$$= A'xB' + (A + xy')'B$$

$$= xA'B' + A'(x'+y)B$$

$$= xA'B' + x'A'B + yA'B$$

| A B \ xy | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 0 | 10,1 | 01,0 | 10,0 | 10,0 |
| 0 1 | 00,1 | 01,0 | 10,0 | 10,0 |
| 1 1 | 01,1 | 11,0 | 10,0 | 10,0 |
| 1 0 | 11,0 | 10,0 | 10,0 | 00,0 |

$A(t+1), B(t+1), z$

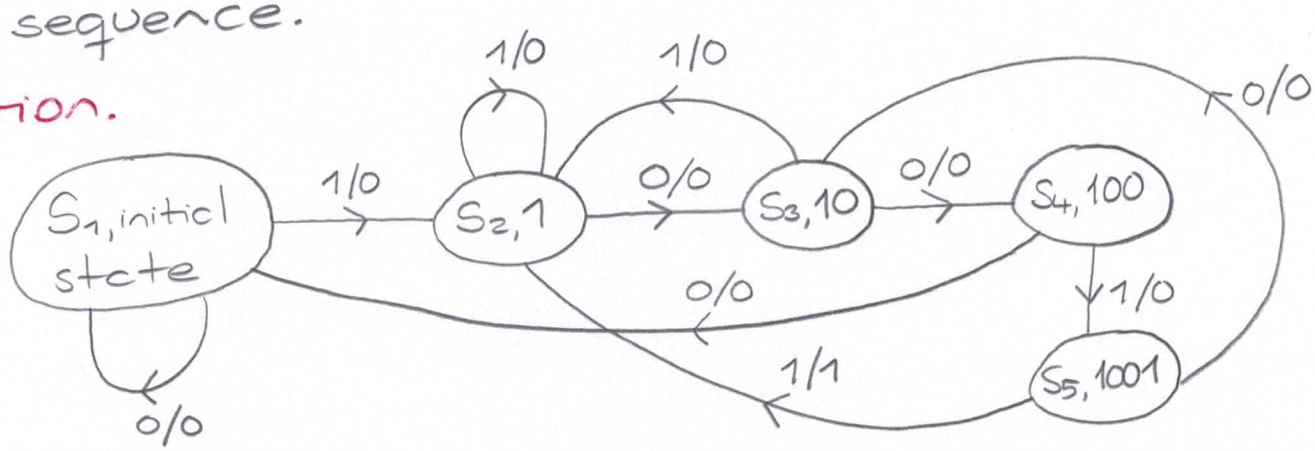
c. We have already derived in part b as

$$A(t+1) = x'A + yA + xB + y'A'B'$$

$$B(t+1) = xA'B' + x'A'B + yA'B$$

Problem 3) Derive the state diagram of a sequential circuit system with one input x and one output z such that z=1 if and only if the binary bit pattern of 10011 is recognized or detected throughout the input sequence.

Solution.



Problem 4) Design a sequential circuit with two D type flip-flops A and B and one input x.

a. When $x = 0$, the state of the circuit remains the same. When $x=1$, the circuit goes through the state transitions from 00 to 01, to 11, to 10, back to 00, and repeats.

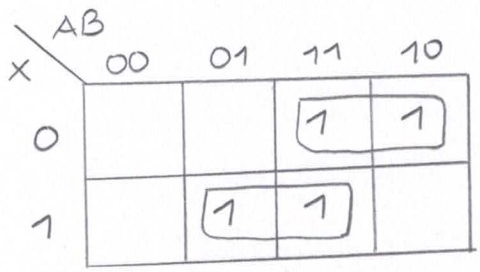
b. When $x = 0$, the state of the circuit remains the same. When $x=1$, the circuit goes through the state transitions from 00 to 11, to 01, to 10, back to 00, and repeats.

Solution.

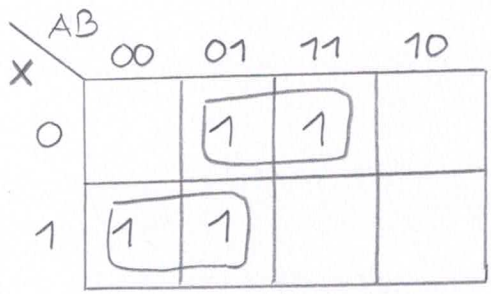
a.

| AB \ x | 0 | 1 |
|---|---|---|
| 00 | 00 | 01 |
| 01 | 01 | 11 |
| 11 | 11 | 10 |
| 10 | 10 | 00 |

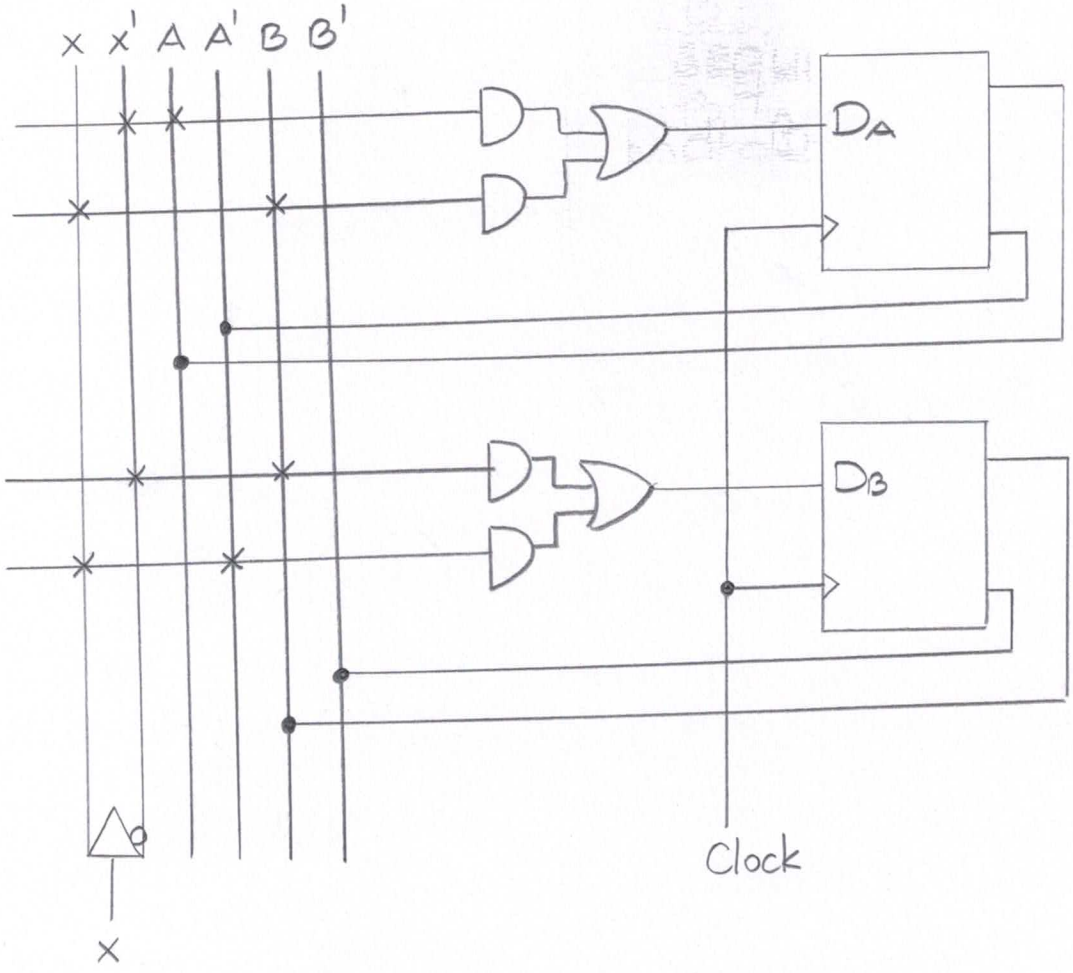
A(t+1), B(t+1)




$A(t+1) = D_A = x'A + xB$



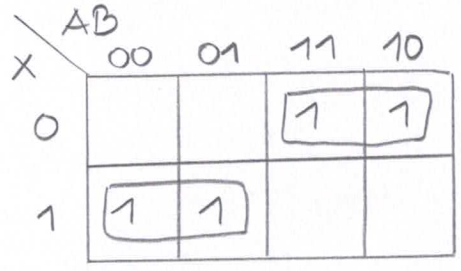

$B(t+1) = D_B = x'B + xA'$



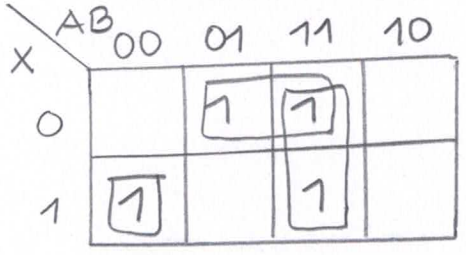

b.

| AB \ x | 0 | 1 |
|---|---|---|
| 00 | 00 | 11 |
| 01 | 01 | 10 |
| 11 | 11 | 01 |
| 10 | 10 | 00 |

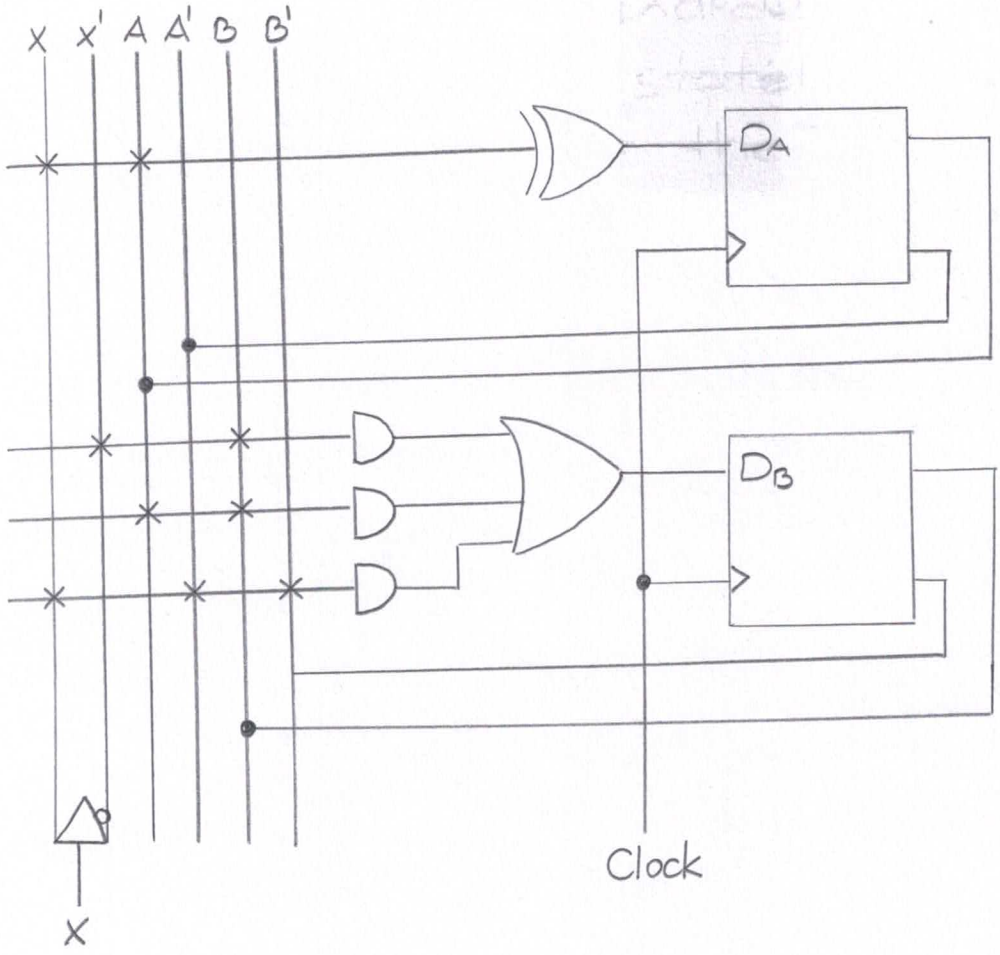
A(t+1), B(t+1)




$$A(t+1) = D_A = x'A + xA'$$
$$= x \oplus A$$




$$B(t+1) = D_B = x'B + AB + xA'B'$$


X
X'
A
A'
B
B'
$D_A$
$D_B$
Clock
X