# Digital Logic Assignment 3

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## t1

A PN flipflop has four operations: clear to 0, no change, complement, and set to 1, when inputs P and N are 00, 01, 10, and 11, respectively.

### 1

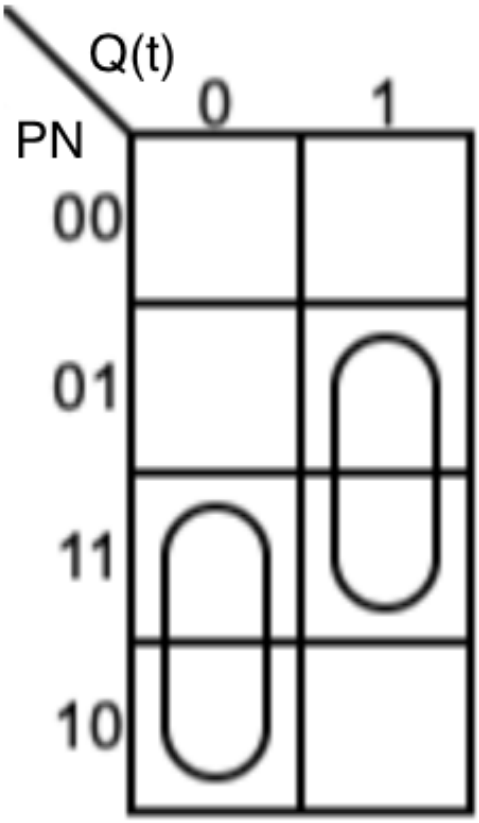
Tabulate the characteristic table

| $P$ | $N$ | $Q_{t+1}$ | |
|---|---|---|---|
| 0 | 0 | 0 | clear to 0 |
| 0 | 1 | $Q_t$ | no change |
| 1 | 0 | $Q_t'$ | complement |
| 1 | 1 | 1 | set to 1 |

### 2

Derive the characteristic equation

Fron the above characteristic table we can get the K map,




Then we can get the characteristic equation:

$$Q_{t+1} = P\,Q_t' + N\,Q_t \tag{1}$$

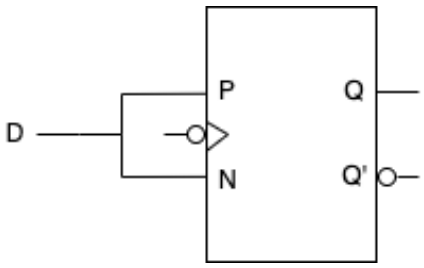
## 3

> Tabulate the excitation table

| $Q(t)$ | $Q(t+1)$ | $P$ | $N$ |
|---|---|---|---|
| 0 | 0 | 0 | $X$ |
| 0 | 1 | 1 | $X$ |
| 1 | 0 | $X$ | 0 |
| 1 | 1 | $X$ | 1 |

## 4

> Show how the PN flipflop can be converted to a D flipflop




For D flipflop, when D=0, Q(t+1)=0; D=1, Q(t+1)=1.

To convert a PN flipflop to a D flipflop, just let P and N connect to one input D before the PN flipflop, then when D=1, P=N=1, Q=1; when D=0, P=N=0, Q=0; which is the same as the output of D flipflop.

# t2

> (20 points) A sequential circuit has two JK flip-flops A and B and one input x. The circuit is described by the following flip-flop input equations: $J_A$ = x', $K_A$ =B,$J_B$ =x,$K_B$ =A'.

## 1

> Derive the state equations A(t + 1) and B(t + 1) by substituting the input equations for the J and K variables. raw the state diagram of the circuit.

For JF flipflop,

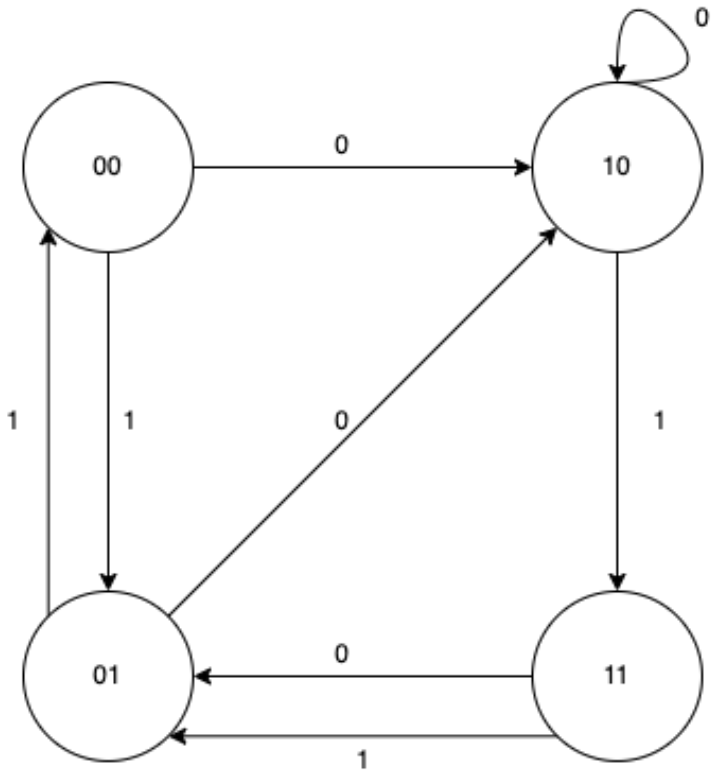
$$Q_{t+1} = JQ'_t + K'Q_t \tag{2}$$

then

$$A(t+1) = JA' + K'A = x'A' + B'A \tag{3}$$

$$B(t+1) = xB' + AB \tag{4}$$

| present | present | input | next | next |
|---|---|---|---|---|
| A(t) | B(t) | x | A(t+1) | B(t+1) |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 | 1 |

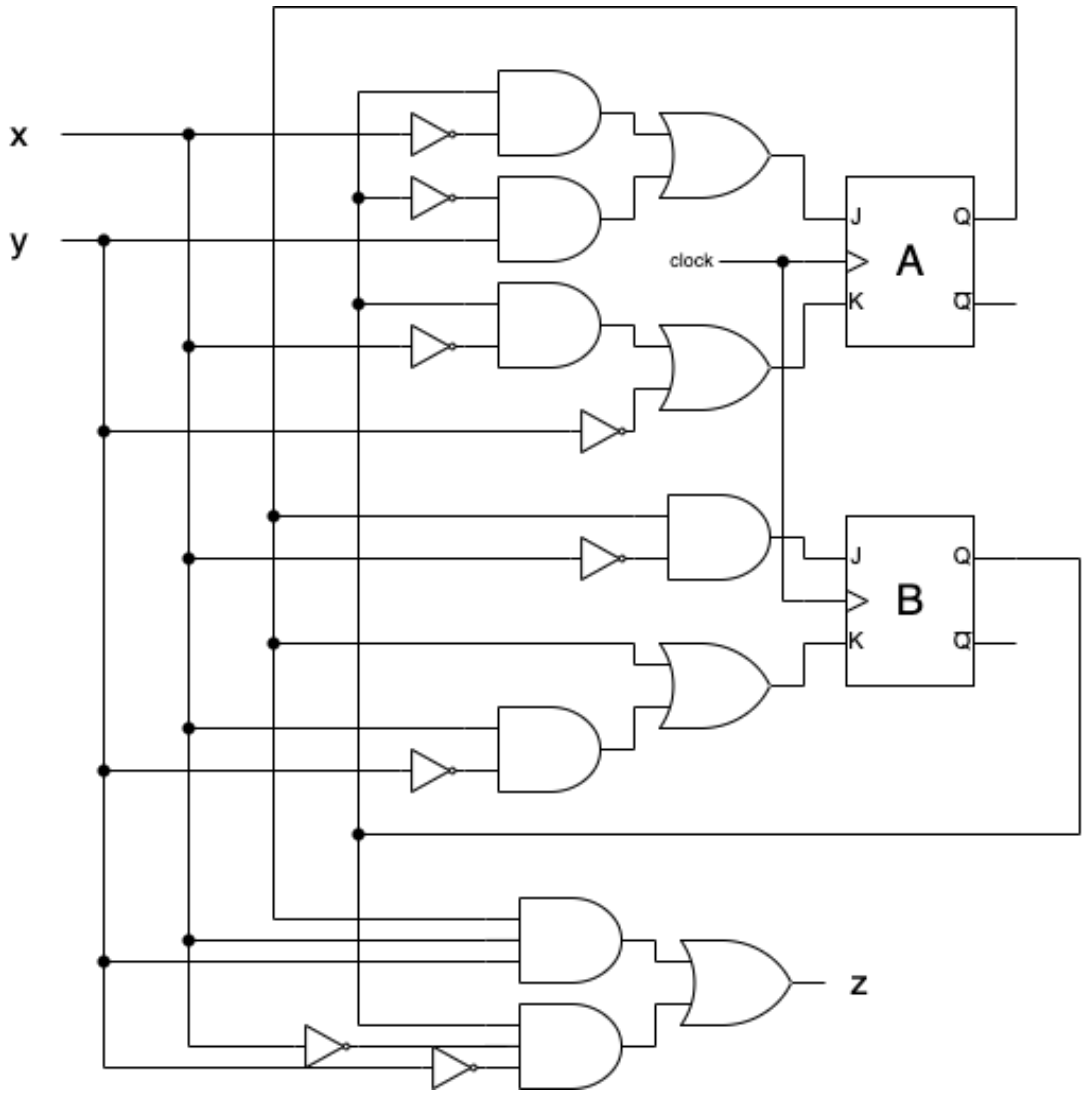



# t3

> (20 points) A sequential circuit has two JK flipflops A and B, two inputs x and y, and one output z. The flipflop input equations and circuit output equation are JA =Bx'+B'y,KA =Bx'+y',JB =Ax',KB =A+xy',z=Axy+Bx'y'.

## 1

> Draw the logic diagram of the circuit.




## 2

> Tabulate the state table.

As for JK flip flop,

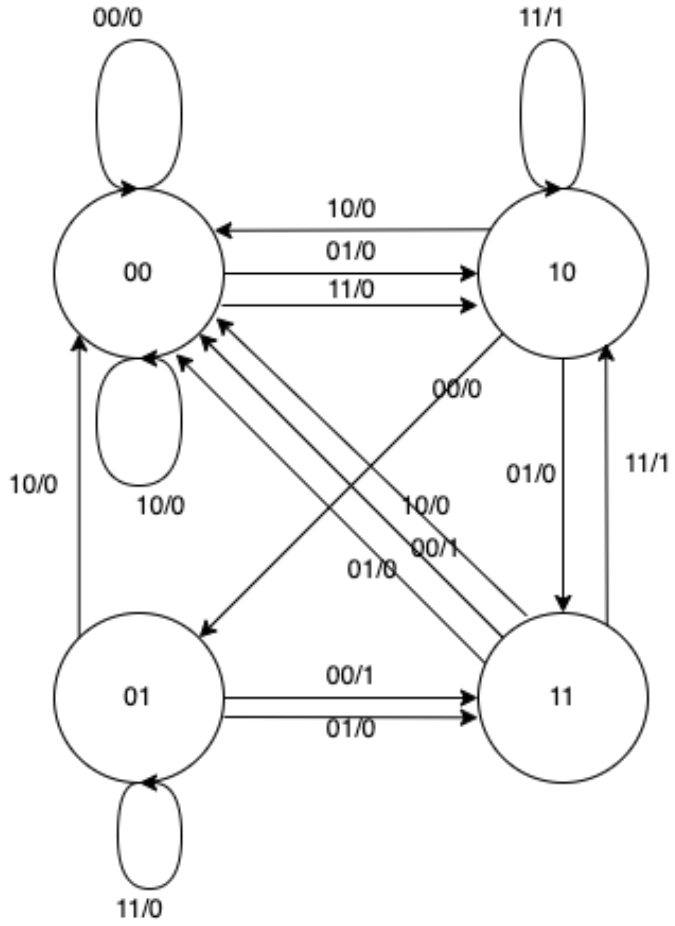
$$Q(t+1) = JQ' + K'Q \tag{5}$$

then

$$A(t+1) = (Bx\prime + B\prime y)A' + (Bx\prime + y\prime)'A \tag{6}$$

$$B(t+1) = (Ax')B' + (A + xy')'B \tag{7}$$

| present | present | input | input | next | next | output |
|---|---|---|---|---|---|---|
| A | B | x | y | A | B | z |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 0 | 1 |




## 3

> Derive the state equations for A and B.

As for JK flip flop,

$$Q(t+1) = JQ' + K'Q \tag{8}$$

then

$$A(t+1) = (Bx' + B'y)A' + (Bx' + y')'A = A'Bx' + B'y + Axy \tag{9}$$

$$B(t+1) = (Ax')B' + (A + xy')'B = AB'x' + A'Bx' + A'By \tag{10}$$

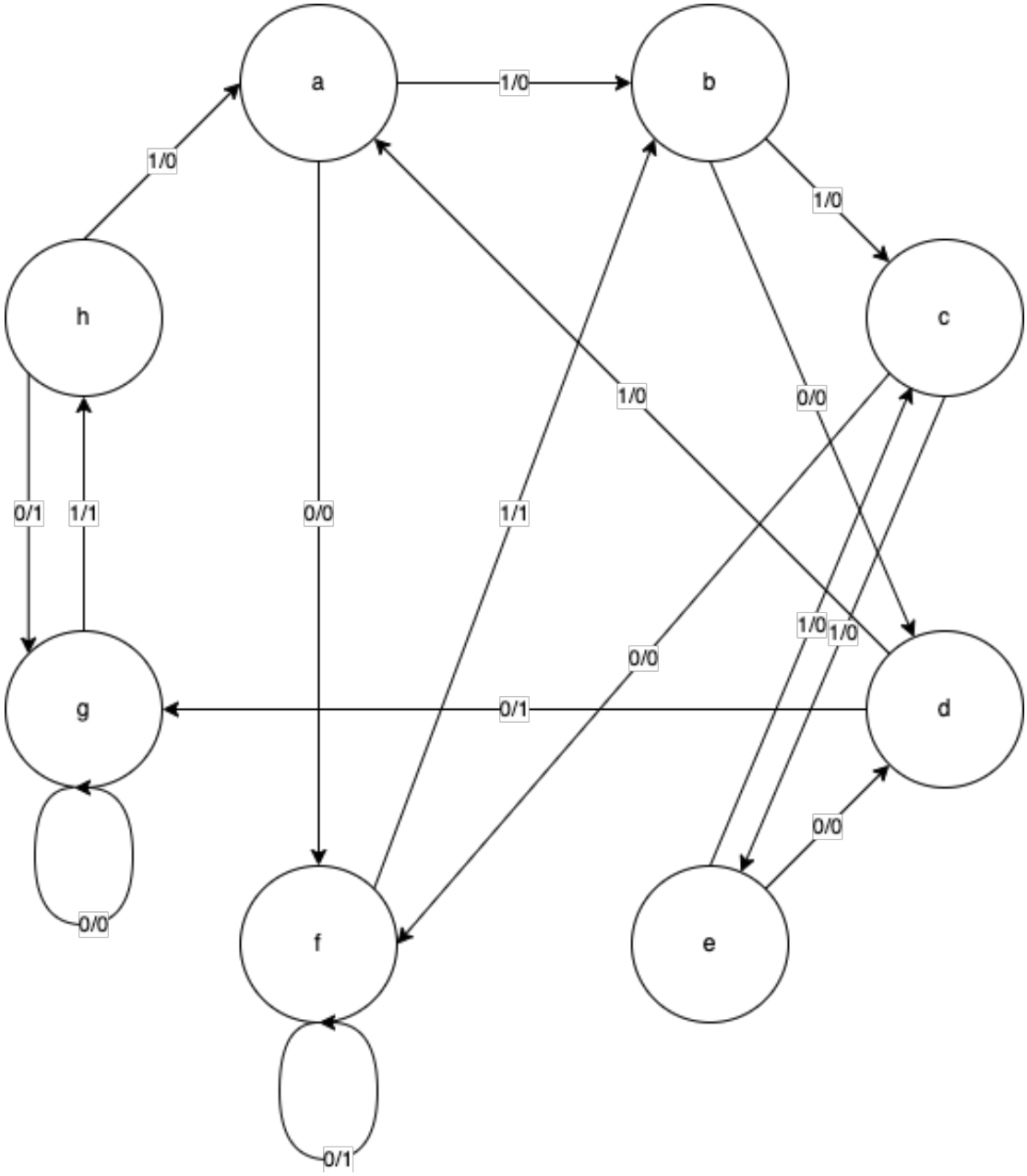
# t4

(20 points) For the following state table

| Present State | Next State | | Output | |
|---|---|---|---|---|
| | $x = 0$ | $x = 1$ | $x = 0$ | $x = 1$ |
| $a$ | $f$ | $b$ | $0$ | $0$ |
| $b$ | $d$ | $c$ | $0$ | $0$ |
| $c$ | $f$ | $e$ | $0$ | $0$ |
| $d$ | $g$ | $a$ | $1$ | $0$ |
| $e$ | $d$ | $c$ | $0$ | $0$ |
| $f$ | $f$ | $b$ | $1$ | $1$ |
| $g$ | $g$ | $h$ | $0$ | $1$ |
| $h$ | $g$ | $a$ | $1$ | $0$ |

**1**

Draw the corresponding state diagram.




## 2

> Tabulate the reduced state table.

When the presnet state is e or b, other elements in the row is same, so e row is deleted, and e is replaced by b.

And for the same reason, h can be replaced by d.

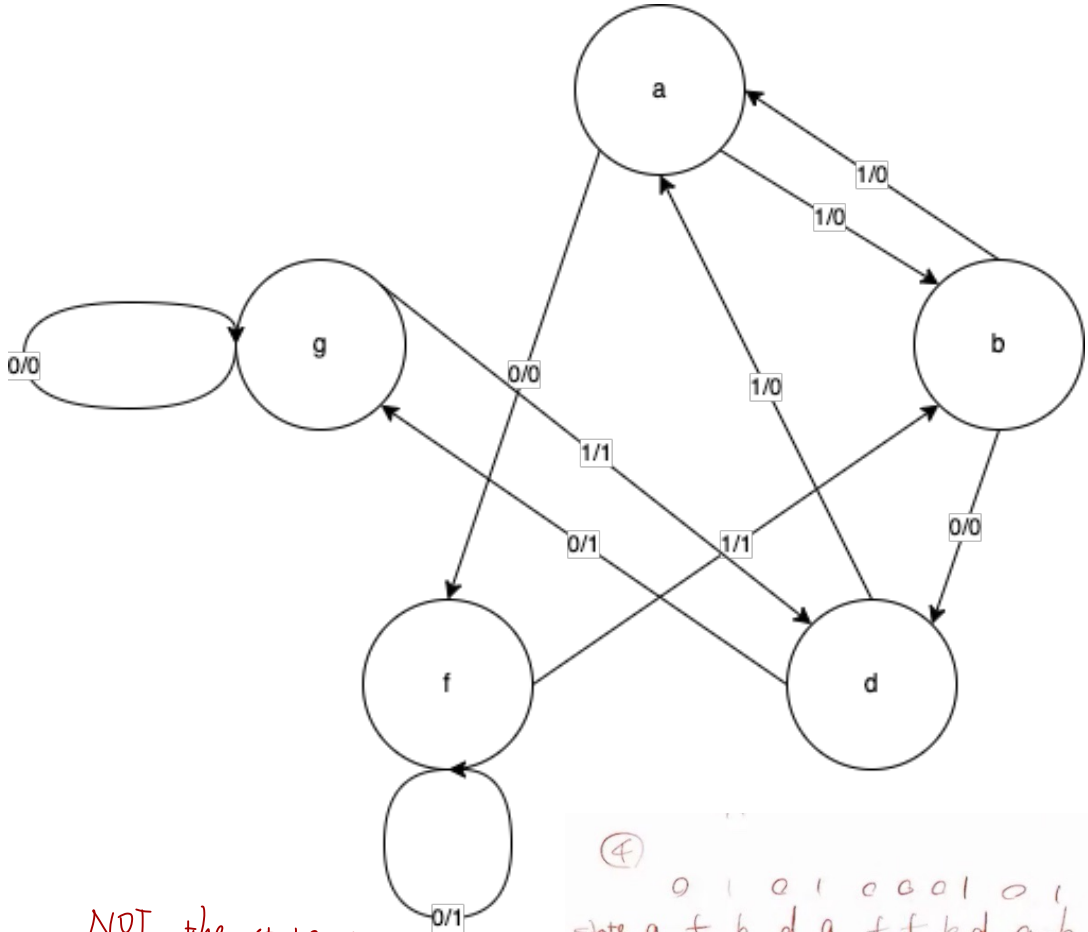
After replacing e by b, the c row and a row become similar, and c is replaced by a.

Then we get the table below:

| present state | Next state | next state | output | output |
|---|---|---|---|---|
| | x=0 | x=1 | x=0 | x=1 |
| a | f | b | 0 | 0 |
| b | d | a | 0 | 0 |
| d | g | a | 1 | 0 |
| f | f | b | 1 | 1 |
| g | g | d | 0 | 1 |

## 3

> Draw the state diagram corresponding to the reduced state table.




NOT the state sequence
the OUTPUT sequence
what we need is

## 4

> Determine the output sequence for input sequence 01010010111 (from left to right) with the original state table and the reduced state table, starting from a.

- Original: a--f(0)--b(1)--d(0)--a(0)--f(0)--f(1)--b(1)--d(0)--a(0)--b(0)--c(0)
- Reduced: a--f(0)--b(1)--d(0)--a(0)--f(0)--f(1)--b(1)--d(0)--a(0)--b(0)--a(0)

## t5

{ excitation table
{ ff type
J/K/D/T ← state

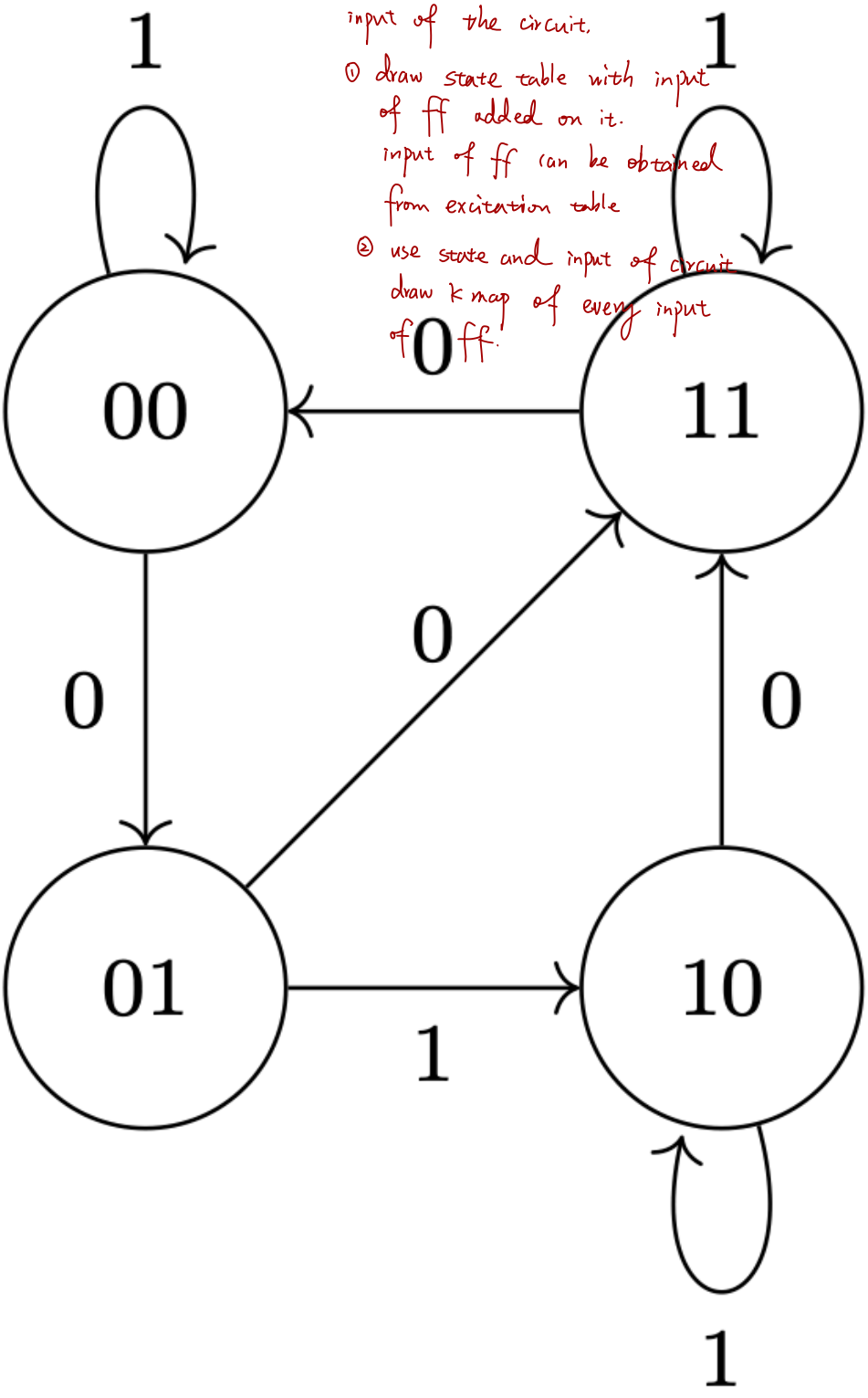
(20 points) Obtain the simplified input equations for a sequential circuit that uses T flip-flops and is specified by the state diagram below.

{ 0 : no change
{ 1 : complement

To obtain the input equation from state and input of the circuit.

① draw state table with input of ff added on it.
input of ff can be obtained from excitation table

② use state and input of circuit draw k map of every input of ff.

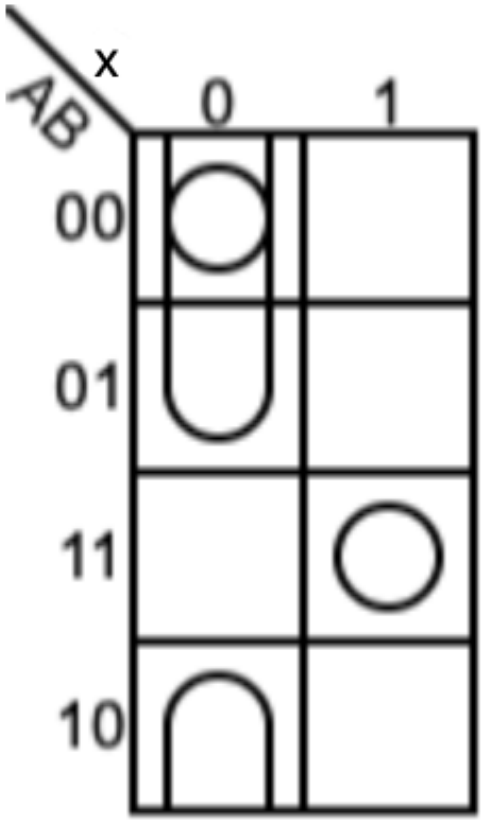



Let x be the input, the state of A and B be the state of 2 T flip flops.

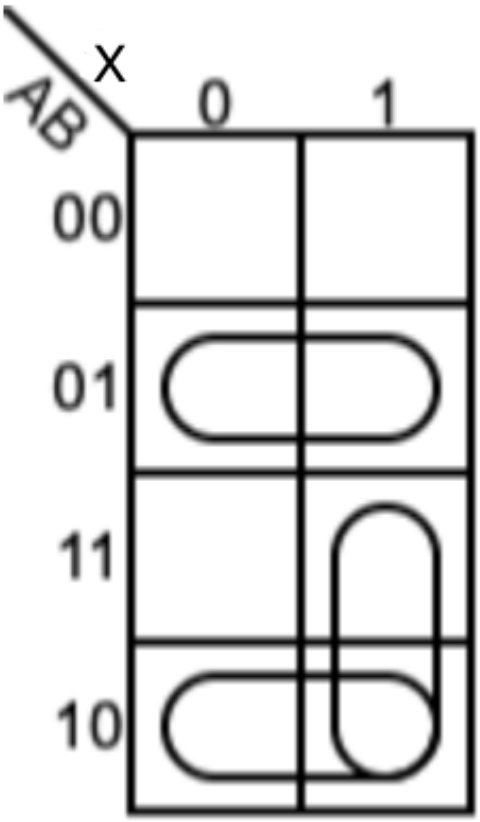
From the above state diagram, we can get the state table:

| present | present | input | next | next | T flip flop | T flip flop |
|---|---|---|---|---|---|---|
| A | B | x | A | B | $T_A$ | $T_B$ |
| 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 | 1 | 1 |
| 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 0 | 0 |

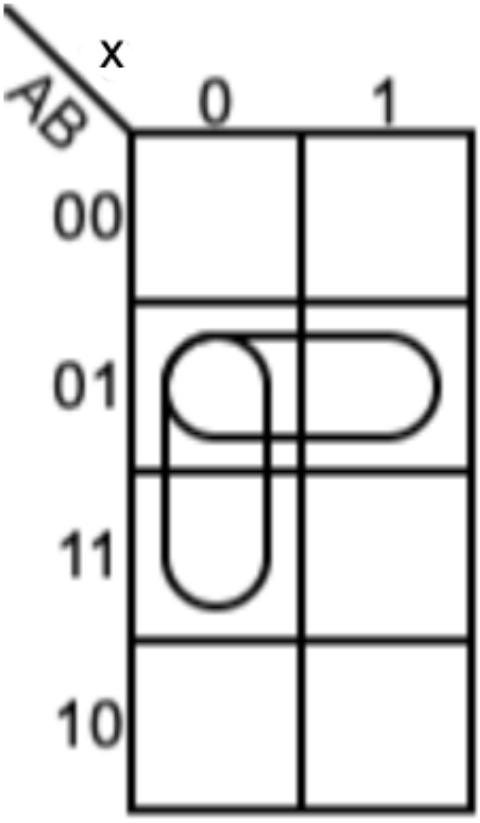
Then we get the K map of $A$, $B$, $T_A$, $T_B$



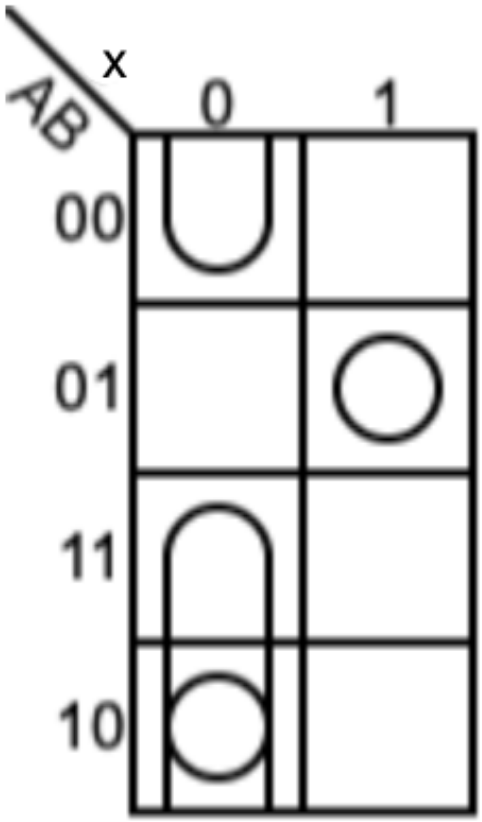

$$A_{t+1} = A'B + AB' + Ax \tag{11}$$




$$B_{t+1} = A'x' + B'x' + ABx \tag{12}$$




$$T_A = Bx' + A'B \tag{13}$$




$$T_B = Ax' + B'x' + A'Bx \tag{14}$$