DATE : / /

# Tutorial - 3

1)

(i) For SR latch

$$Q(n+1) = S + R' Q(n)$$

Here

$$S = A \oplus B = AB' + A'B$$
$$R = B$$

So,

$$\boxed{Q(n+1) = AB' + A'B + B'Q(n)}$$

(ii) Char Table

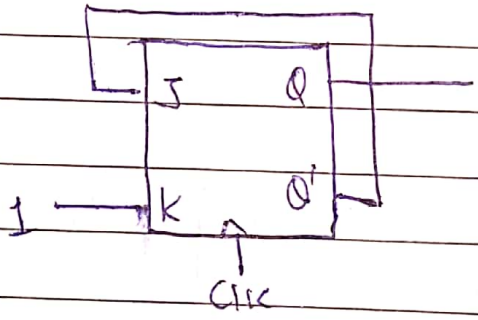
| A | B | Q(n) | Q(n+1) |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 |

PAGE :
DATE : / /

## Excitation Table

| Q(n) | Q(n+1) | A | B | |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 x |
| | | 0 | 1 | |
| 0 | 1 | 0 | 1 | |
| | | 1 | 0 | |
| 1 | 0 | 1 | 1 | |
| 1 | 1 | 0 | 0 | |
| | | 1 | 0 | |
| | | 0 | 1 | |

2)




$J = Q'$, $K = 1$

Flip flop is initially closed $\Rightarrow Q = 0$

1st Clock pulse (CP) $\Rightarrow J=1, K=1, Q(n)=0 \Rightarrow Q(n+1)=1$

2nd CP $\Rightarrow J=0, K=1, Q(n)=1 \Rightarrow Q(n+1)=0$

3rd CP $\Rightarrow J=1, K=1, Q(n)=0 \Rightarrow Q(n+1)=1$

4th CP ⇒ J=0, K=1, Q(n) = 1 ⇒ Q(n+1) = 0

5th CP ⇒ J=1, K=1, Q(n) = 0 ⇒ Q(n+1) = 1

6th CP ⇒ J=0, K=1, Q(n) = 1 ⇒ Q(n+1) = 0

3) Initially

| Assume: Clear State |
| --- |
| Q = 0 |
| $\bar{Q}$ = 1 |

For D flip flop ⇒ Q(n+1) = D

If Q(n) = 0 → If T = 0, So, D = 0 ⇒ Q(n+1) = 0

→ If T = 1 ⇒ D = 1 ⇒ Q(n+1) = 1

If Q(n) = 1

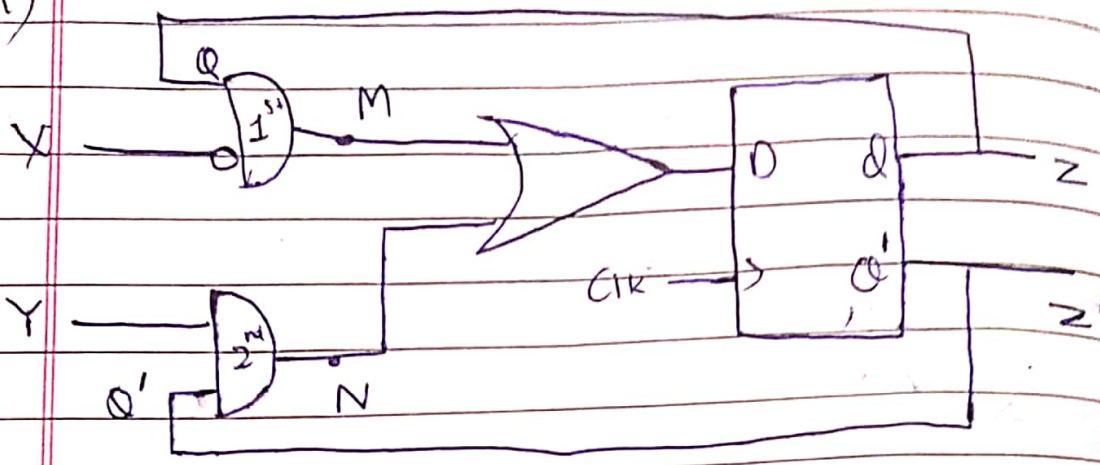
If T = 0, D = 1 ⇒ Q(n+1) = 1

If T = 1 ⇒ D = 0 ⇒ Q(n+1) = 0

| T | Q(n) | Q(n+1) |
| --- | --- | --- |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

} Same as T flip flop Truth Table

4)




Put $X = K$ & $Y = J$

Using 1st And gate we get $M = K'Q(n)$

&

2nd And gate we get $N = JQ'(n)$

So,

$$D = JQ'(n) + K'Q(n) \quad -(1)$$

Now,

As we know in D flip-flop

$$D = Q(n+1) \quad -(2)$$

Using (1) & (2)

$$Q(n+1) = JQ'(n) + K'Q(n)$$

which is Characteristic equation of JK flip flop

Hence Proved.

5) $XY = 00 \Rightarrow$ Change State with CP
$XY = 01 \Rightarrow Q = 1$ with CP
$XY = 10 \Rightarrow Q = 0$ with CP
$XY = 11 \Rightarrow$ Change state with CP

a) So, According to This

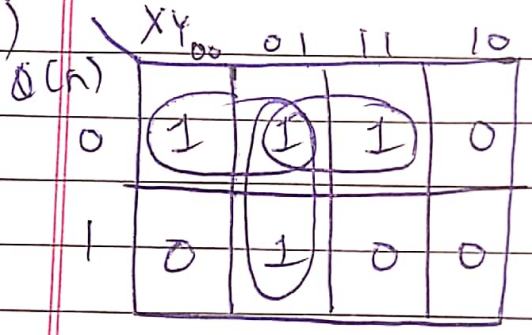
| X | Y | Q(n+1) |
|---|---|---|
| 0 | 0 | Q'(n) |
| 0 | 1 | 1 |
| 1 | 0 | 0 |
| 1 | 1 | Q'(n) |

| Q(n) | X | Y | Q(n+1) |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 |

## Excitation Table

| Q(n) | Q(n+1) | X | Y |
|---|---|---|---|
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| | | 0 | 1 |
| | | 1 | 1 |
| 1 | 0 | 0 | 0 |
| | | 1 | 0 |
| | | 1 | 1 |
| 1 | 1 | 0 | 1 |

(ii)

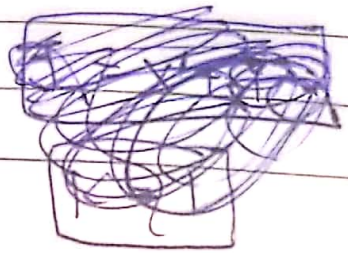



$$Q(n+1) = Q'(n)X' + Q'(n)Y + X'Y$$

$$Q(n+1) = (X' + Y)Q'(n) + X'Y$$

By characteristic equation of JK flip flop

$$Q(n+1) = JQ'(n) + K'Q(n) \quad -(1)$$



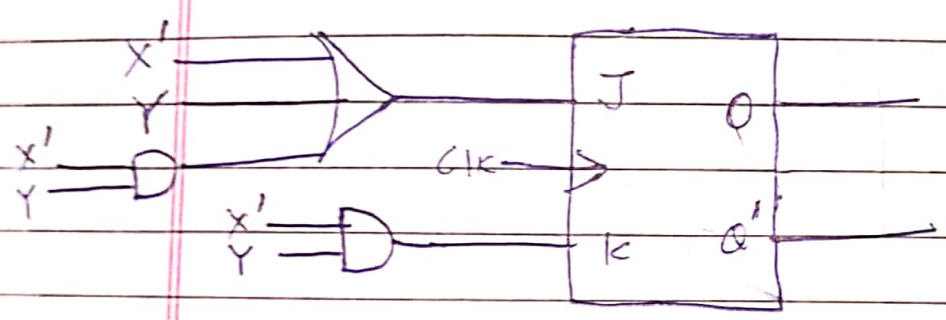
$Q(n+1) = (x' + Y)\,Q(n) + x'Y(Q(n) + Q'(n))$

$Q(n+1) = (x' + Y + x'Y)^{Q(n)} + x'Y\,Q'(n)$ ↳(2)

Compare (1) & (2)

$J = x' + Y + x'Y$

$K = x'Y$




6) a) Excitation Table

| Q(n) | Q(n+1) | A | B |
|---|---|---|---|
| 0 | 0 | 1 | 0 |
| | | 1 | 1 |
| 0 | 1 | 0 | 0 |
| | | 0 | 1 |
| 1 | 0 | 0 | 0 |
| | | 1 | 0 |
| 1 | 1 | 0 | 1 |
| | | 1 | 1 |

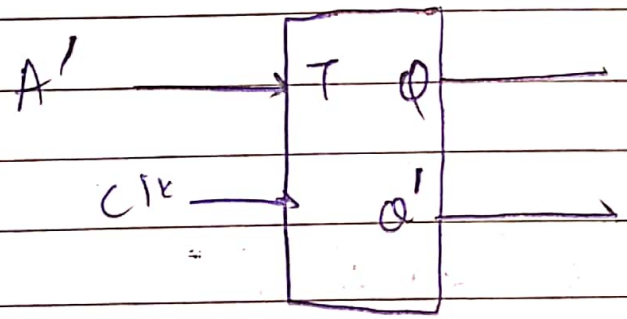
PAGE :
DATE : / /

b)

| Q(n) | A | B | Q(n+1) | T |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 0 |

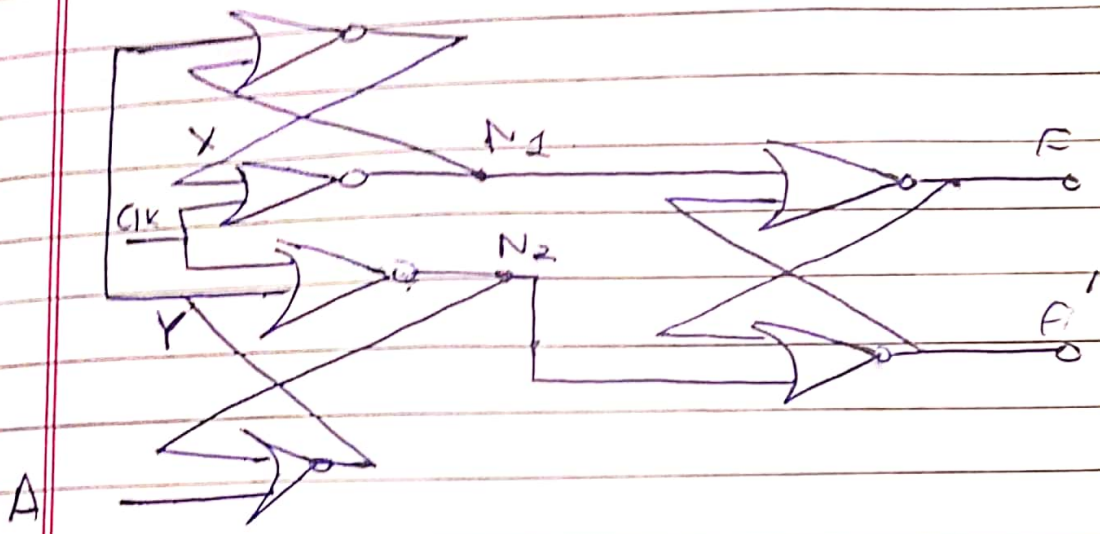
| Q(n) \ AB | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 | 0 |

$T = A'$



7)

a) Clk = 1  A → 0 to 1




XOR Truth table

| X | Y | Z |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

→ If any Input is '1' Z = 0

So, using above Concept

Before 'A' was change

If Clk = 1 & A = 0

Clk = 1 ⇒ $N_1 = 0$ , $N_2 = 0$

Now, $N_1 = 0$ ⇒ X = 0 & $F_{(n)} = 0$

Now,

$F_{(n)} = 0$ & $N_2 = 0$ ⇒ $F'_{(n)} = 1$

Now change A from 0 to 1

If Clk = 1 & A = 1 [A changes from 0 to 1]

Clk = 1 ⇒ $N_1 = 0$, $N_2 = 0$

Now,

$N_1 = 0$ ⇒ X = 0 & F(n+1) = 0

Now,

F(n+1) = 0 & $N_2 = 0$ ⇒ f'(n+1) = 1

So, By comparing before A was change & after A change we get

$$F(n) = f(n+1)$$

b) Before Clk was changed

A = 1 & Clk = 1

Clk = 1 ⇒ $N_1 = 0$, $N_2 = 0$

Now,

$N_1 = 0$ ⇒ X = 0 & F(n) = 0

Now,

F(n) = 0 & $N_2 = 0$ ⇒ F'(n) = 1

After Clk changed from '1' to '0'

Clk = 0 & A = 1

If $A = 1 \Rightarrow Y = 0$

Now,

$Y = 0$ & $clk = 0 \Rightarrow N_2 = 1$

Now,

If $N_2 = 1 \Rightarrow F'(n+1) = 0$

Now

$Y = 0 \Rightarrow$ & ($N_1$ initial value before clk changed $= 0$)

So,

$X = 1$

Now

$X = 1 \Rightarrow N_1 = 0$

$N_1 = 0$ & $F'(n+1) = 0 \Rightarrow F(n+1) = 1$

So,

Comparing after & before clk changed value we get

$$\boxed{F(n) = F'(n+1)}$$

PAGE :
DATE : / /

(c) Before A was changed :

Clk = 0 & A = 1

If A = 1 ⇒ Y = 0

Now

Y = 0 & Clk = 0 ⇒ $N_2$ = 1

Now

$N_2$ = 1 ⇒ F'(n) = 0

Now

Y = 0 & ($N_1$ value = 0 initially) ⇒ X = 1

Now

X = 1 ⇒ $N_1$ = 0

$N_1$ = 0 & F'(n) = 0 ⇒ F(n) = 1

Now, A is changed

Clk = 0 & A = 0

(Initial $N_2$ = 1) & A = 0 ⇒ Y = 0

Now,

Y = 0 & Clk = 0 ⇒ $N_2$ = 1

Now,

$N_2$ = 1 ⇒ F'(n+1) = 0

$Y = 0$ & (Initial $N_1 = 0$) $\Rightarrow X = 1$

Now,

$X = 1 \Rightarrow N_1 = 0$

$N_1 = 0$ & $F'(n+1) = 0 \Rightarrow F(n+1) = 1$

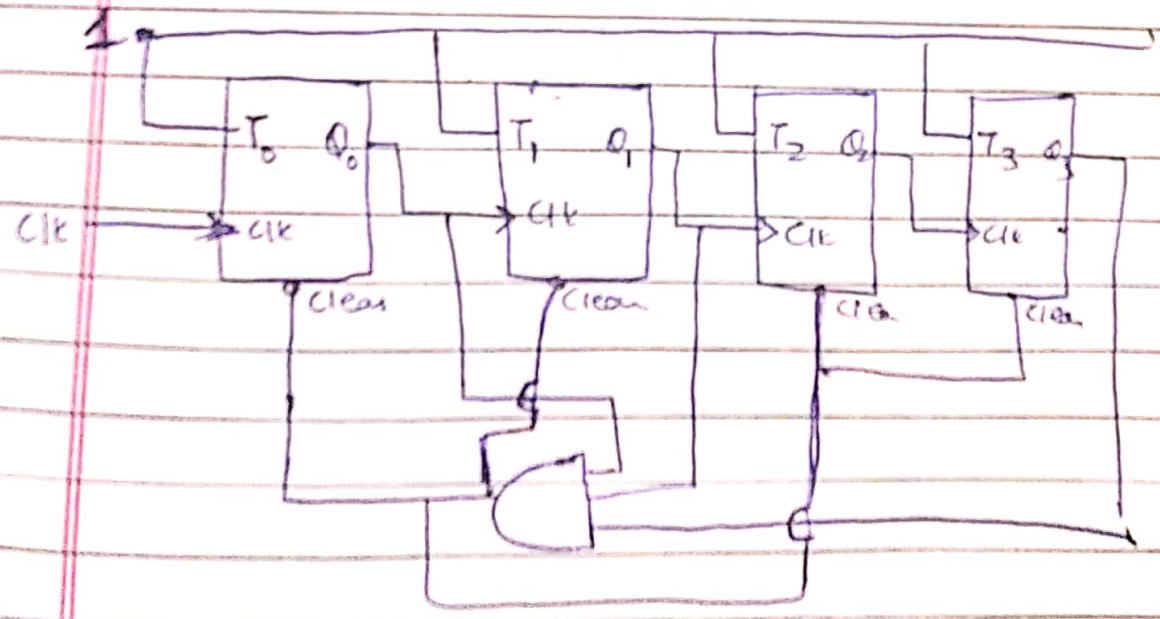
So, by comparing before & after we get

$$F(n) = F(n+1)$$

8) Mod = 13 $\Rightarrow$ (binary) $2^3$ to 2(4)

$\Downarrow$

No of T flip flop required = 4




$Q_3\ Q_2\ Q_1\ Q_0$

13 $\Rightarrow$ 1 1 0 1 $\Rightarrow$ Connect And gate to those output with value '1'

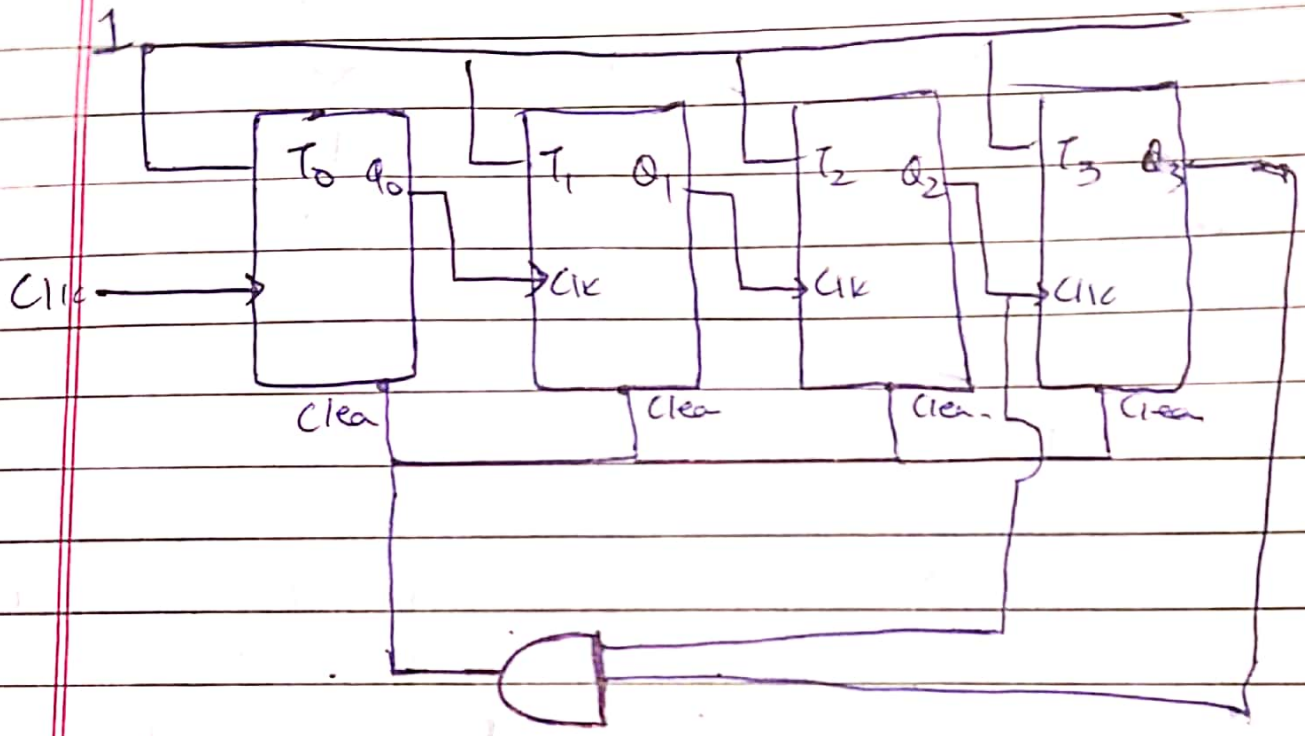
| Clk | $Q_3$ | $Q_2$ | $Q_1$ | $Q_0$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 1 | 0 |
| 3 | 0 | 0 | 1 | 1 |
| 4 | 0 | 1 | 0 | 0 |
| 5 | 0 | 1 | 0 | 1 |
| 6 | 0 | 1 | 1 | 0 |
| 7 | 0 | 1 | 1 | 1 |
| 8 | 1 | 0 | 0 | 0 |
| 9 | 1 | 0 | 0 | 1 |
| 10 | 1 | 0 | 1 | 0 |
| 11 | 1 | 0 | 1 | 1 |
| 12 | 1 | 1 | 0 | 0 |
| 13 | 1 | 1 | 0 | 1 |
| 14 | 0 | 0 | 0 | 1 |
| 15 | 0 | 0 | 1 | 0 |

At this
⇒ Clear will get value
1
↓
making $Q_3Q_2Q_1Q_0 = 0000$

After
Clear these
two will start
from top

9) Mod $\Rightarrow$ 12 $\Rightarrow$ $2^3$ to 2 (4)

No of T flip flop required = 4




| | $Q_3$ | $Q_2$ | $Q_1$ | $Q_0$ |
|---|---|---|---|---|
| 12 $\Rightarrow$ | 1 | 1 | 0 | 0 |

10) No of JK flip flop required = (3)

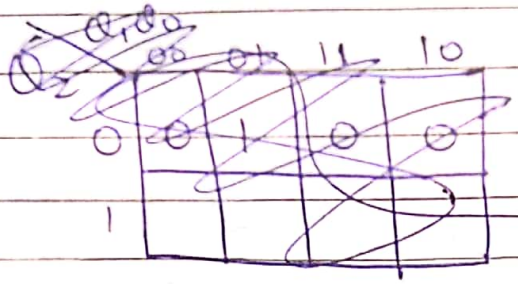
11) ~~Present State Next~~

Excitation Table of JK

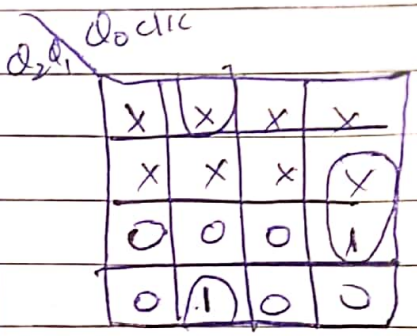
| $Q_n$ | $Q_{n+1}$ | J | K |
|---|---|---|---|
| 0 | 0 | 0 | x |
| 0 | 1 | 1 | x |
| 1 | 0 | x | 1 |
| 1 | 1 | x | 0 |

| Present State $Q_2\ Q_1\ Q_0$ | CLK | Next State $Q_2^+\ Q_1^+\ Q_0^+$ | $J_2\ K_2$ | $J_1\ K_1$ | $J_0\ K_0$ |
|---|---|---|---|---|---|
| 0 0 0 | 0 | 0 0 1 | 0 x | 0 x | 1 x |
| 0 0 0 | 1 | 1 1 1 | 1 x | 1 x | 1 x |
| 0 0 1 | 0 | 0 1 0 | 0 x | 1 x | x 1 |
| 0 0 1 | 1 | 0 0 0 | 0 x | 0 x | x 1 |
| 0 1 0 | 0 | 0 1 1 | 0 x | x 0 | 1 x |
| 0 1 0 | 1 | 0 0 1 | 0 x | x 1 | 1 x |
| 0 1 1 | 0 | 1 0 0 | 1 x | x 1 | x 1 |
| 0 1 1 | 1 | 0 1 0 | 0 x | x 0 | x 1 |
| 1 0 0 | 0 | 1 0 1 | x 0 | 0 x | 1 x |
| 1 0 0 | 1 | 0 1 1 | x 1 | 1 x | 1 x |
| 1 0 1 | 0 | 1 1 0 | x 0 | 1 x | x 1 |
| 1 0 1 | 1 | 1 0 0 | x 0 | 0 x | x 1 |
| 1 1 0 | 0 | 1 1 1 | x 0 | x 0 | 1 x |
| 1 1 0 | 1 | 1 0 1 | x 0 | x 1 | 1 x |
| 1 1 1 | 0 | 0 0 0 | x 1 | x 1 | x 1 |
| 1 1 1 | 1 | 1 1 0 | x 0 | x 0 | x 1 |

K map for $J_2$



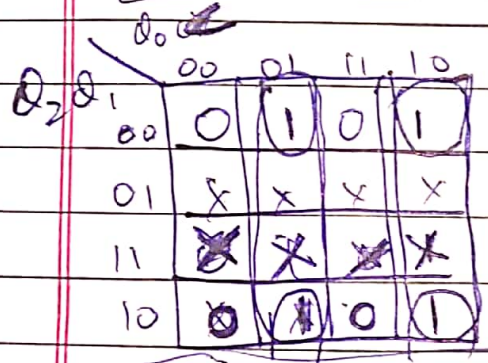

K map for $K_2$



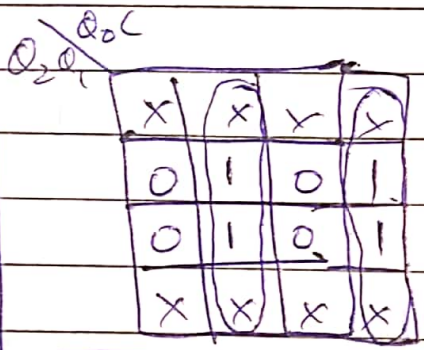

$$J_2 = Q_1'Q_0'\,clk + Q_1Q_0\,C'$$



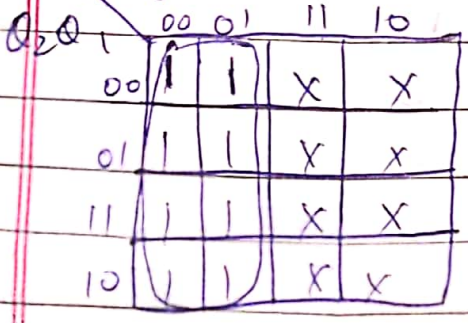

$$K_2 = Q_1'Q_0'C + Q_1Q_0C'$$



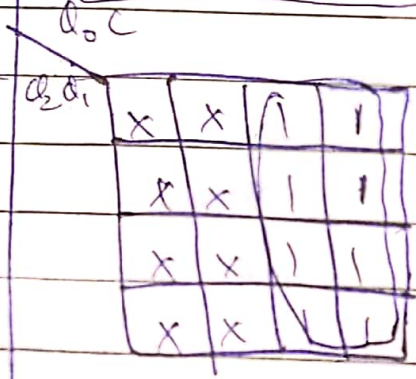

$$J_1 = Q_0'C + Q_0C'$$




$$K_1 = Q_0'C + Q_0C'$$




$$J_0 = Q_0'$$




$$K_0 = Q_0$$

PAGE :
DATE : / /

11) Asynchronous BCD using JK

BCD counter ⇒ 0 to 9

⇓

So, No of states of (10)

10 ⇒ $2^3$ to $2^4$

No of JK flip = (4)

Truth Table

| Clk | D | C | B | A | R (Reset) | |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 | |
| 1 | 0 | 0 | 0 | 1 | 1 | |
| 2 | 0 | 0 | 1 | 0 | 1 | |
| 3 | 0 | 0 | 1 | 1 | 1 | |
| 4 | 0 | 1 | 0 | 0 | 1 | |
| 5 | 0 | 1 | 0 | 1 | 1 | |
| 6 | 0 | 1 | 1 | 0 | 1 | |
| 7 | 0 | 1 | 1 | 1 | 1 | |
| 8 | 1 | 0 | 0 | 0 | 1 | |
| 9 | 1 | 0 | 0 | 1 | 1 | ⇒ Clear state to be invoked |
| 10 | 1 | 0 | 1 | 0 | 0 | |
| 11 | 1 | 0 | 1 | 1 | 0 | |
| 12 | 1 | 1 | 0 | 0 | 0 | |
| 13 | 1 | 1 | 0 | 1 | 0 | |
| 14 | 1 | 1 | 1 | 0 | 0 | |
| 15 | 1 | 1 | 1 | 1 | 0 | |

DATE : / /

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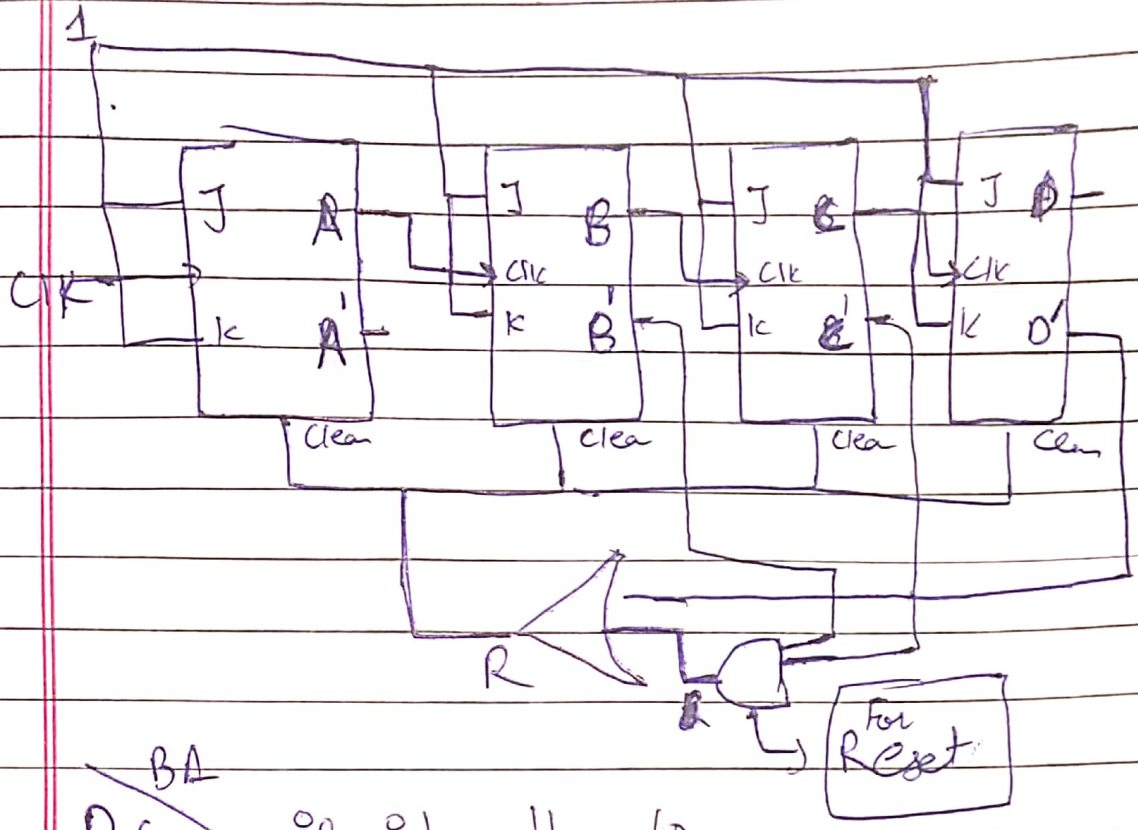


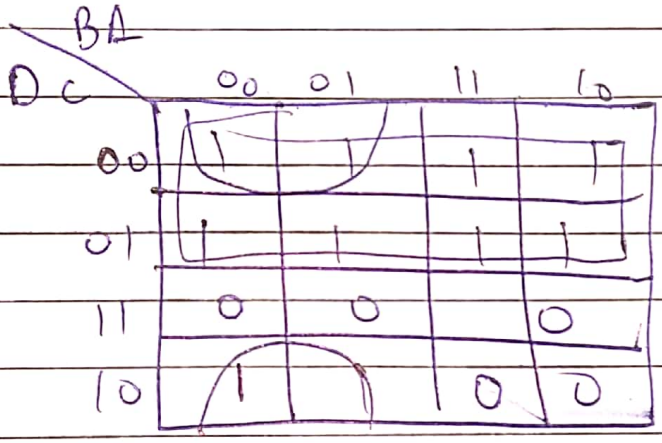


$R = D' + B'C'$

↑

k map to find Reset Gate