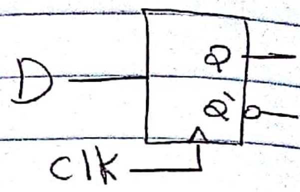
Flip Flops

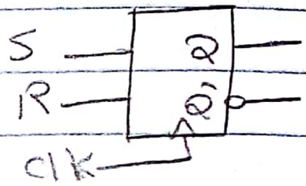
[1] D-ff ⇒ (Delay flip flop)

$$Q(t+1) = D$$



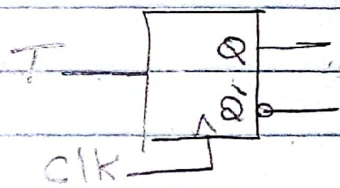
[2] SR-ff ⇒ (set/Reset flip flop)

$$Q(t+1) = S + R'Q$$



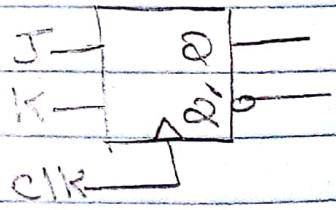
[3] T-ff ⇒ (Toggle flip flop)

$$Q(t+1) = T \oplus Q$$



[4] JK-ff

$$Q(t+1) = JQ' + K'Q$$



$Q(t+1)$

↳ is called

- Charactrestic equation or
- Next state equation or
- state equation.

Q5.3)

Show that the characteristic equation for the complement output of a JK flip flop is:

$$Q'(t+1) = J'Q' + KQ.$$

Answer:

← أولاً نجيب معادلة (Q^*) للـ (JK.)

$$Q^* \text{ or } Q(t+1) = JQ' + K'Q$$

← ثانياً نضع المعادلة على (K.map) كوحايد.

J \ KQ	K'Q'	K'Q	KQ	KQ'
J'	0	1	0	0
J	1	1	0	1

← ثم نبسط الأصفار لنحصل على معادلة (The Complement) من $(Q^*$ for JK)

$$Q'(t+1) = J'Q' + KQ$$

or implement

* How to Costruct Any flip flop from another one?

EX1:

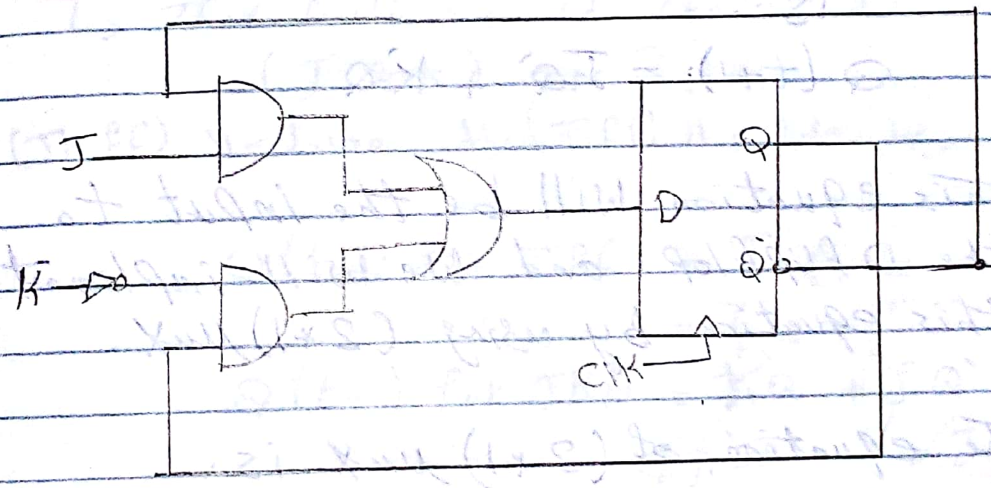
How to implement the (JKff) by using (Dff) ?

ANS:

↳ The input to the D flip flop will be The equation of The (JKff)

↓

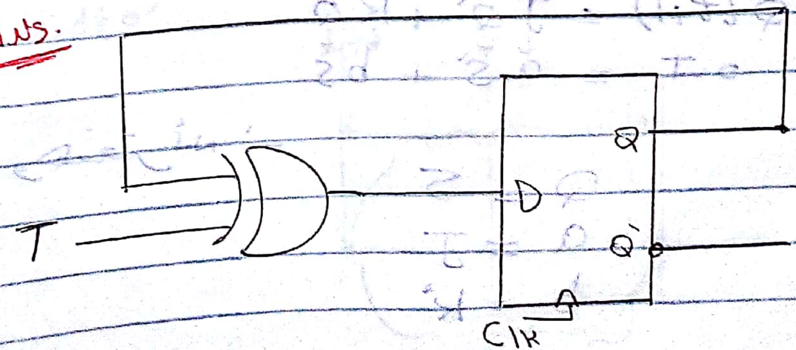
$$Q(t+1) = JQ' + K'Q$$



EX2

How to implement the (Tff) by using (Dff)?

ANS.



EX3:

~~Q5.2 in The book~~

↳ Construct a JK flip flop, using D flip flop, a two-one line multiplexer, and an inverter.

ANS:

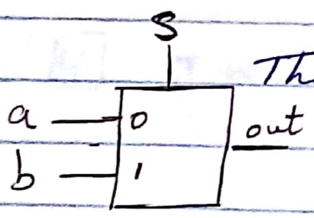
↳ We have :-

1) (2*1) Mux
2) D flip flop.
3) an inverter

To implement the JK ff where its next equ is :-

$$Q(t+1) = JQ' + K'Q$$

↳ this equation will be the input to the D flipflop and we will implement this equation by using (2*1) Mux.



The equation of (2*1) Mux is :-

$$out = aS' + bS$$

S	out
0	a
1	b

↳ هنحاول نوصل معادلة ال JK ff لمعادلة ال (2*1)Mux :

$$Q(t+1) = JQ' + K'Q$$

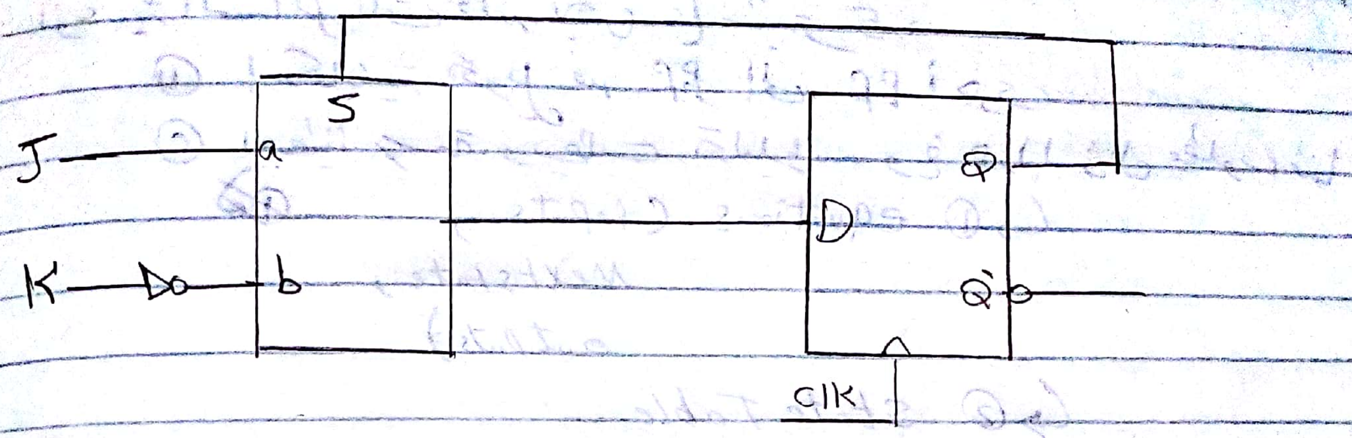
$$out = aS' + bS$$

↳ وهنعتبر أن :-

$$Q = S$$
$$a = J$$
$$b = K'$$

⟶ The block diagram.

No
Date



EX4:

How to Construct the Toggle flip flop by using JK ff?

ANS:

↳ That will be if the inputs of JK ff (J & K) are T.

↳ هنحاول نوصل معادلة الـ (T ff) إلى معادلة الـ (JK ff)

$$Q(t+1) \text{ for } T ff = T \oplus Q$$
$$= T'Q + TQ'$$
$$Q(t+1) \text{ for } JK ff = K'Q + JQ'$$

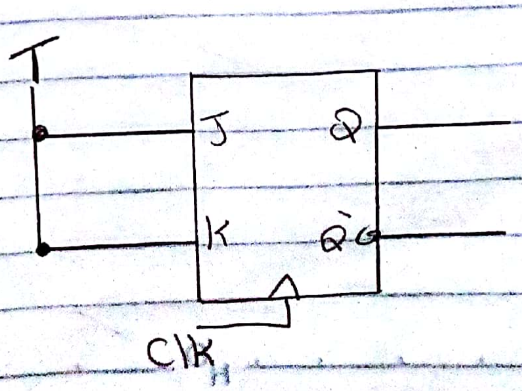
↳ $K' = T'$ ↳ $J = T$

↳ $K = T$

↳ الـ (JK ff) سوف تعمل عمل الـ (T ff) إذا أدخلنا الـ input

↳ T

على المدخلات K & J



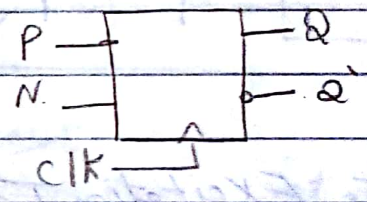
Q5.4)

* A PN flip flop 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.

a) Tabulate the Characteristic Table.
b) Derive the characteristic equation.
c) Tabulate the excitation table.
d) Show how the PN flip flop can be converted to a D-flipflop

Answer:

a) The Characteristic Table:



P	N	Q*
0	0	0 (Clear to 0)
0	1	No change >> $Q^* = Q$
1	0	Complement >> $Q^* = Q'$
1	1	1 (Set to 1)

b) The Characteristic equation:

يمكننا أن نأتي بالمعادلة من

① Characteristic Table

② or Transition Table

$$\cancel{PN}\; Q^* = P'NQ + PN'Q' + PN$$

simplify it using K.map. (3 variable)

P \ NQ	N'Q'	N'Q	NQ	NQ'
P'			1	
P	1		1	1

$Q^* = NQ + PQ'$

Q^* ← $Q(t+1)$

c) The Excitation Table :

ملحوظة : نحصل عليه من Transition Table وهو جدول مفصل لعمليات الـ f.f

P	N	Q	Q*	
0	0	0	0	Clear to 0
0	0	1	0	
0	1	0	0	No change $Q^* = Q$
0	1	1	1	
1	0	0	1	Complement $Q^* = Q'$
1	0	1	0	
1	1	0	1	Clear to 1
1	1	1	1	

The Excitation Table :

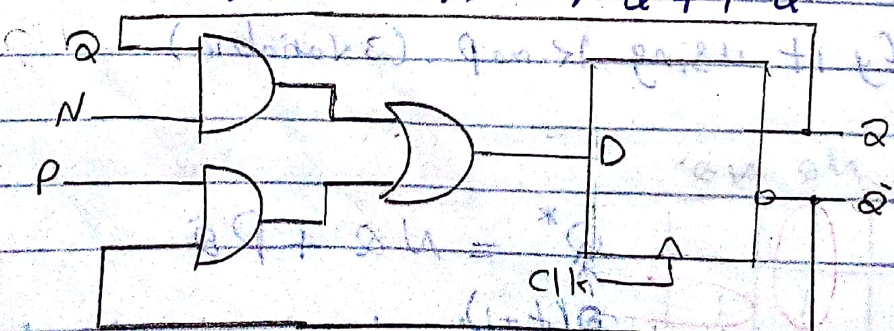
Q	Q*	P	N
0	0	0	X
0	1	1	X
1	0	X	0
1	1	X	1

P: 0 0, N: 0 1 → 0, X

P: 1, N: 0 1 → 1, X

d) We Can Convert PN ff to D-ff. Where :

$$Q(t+1) \text{ for } PN\,ff = NQ + PQ'$$



→ (Q 5.3 in Summer Exam) :

* A LM flip flop has four operations, Clear to 0, no change, Complement and set to 1, When its inputs L and M are 00, 01, 10 and 11, respectively.
a) Tabulate the Characteristic table
b) Derive the Characteristic equation.
c) Tabulate the excitation Table
d) show how the LM flip flop Can be converted to D flip flop

↳ The Same Solution of the Previous Question Put the inputs are L & M Not N & P.

Example

* A Xy flip flop has four operations, ~~Clear~~ Reset to 0, Set to 1, Change, no change, When its inputs X and y are 00, 01, 10, 11, respectively.
a) Tabulate The Characteristic table.
b) Derive the characteristic equation.
c) Tabulate the excitation table.
d) show how the Xy flip flop Can be Converted to D ff.

Answer:-

a) The Characteristic table ::

X	y	Q*
0	0	0
0	1	1
1	0	Change $Q^* = Q'$
1	1	no change $Q^* = Q$

$$Q^* = X'y + Xy'Q' + XyQ$$

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b) The Characteristic equations:

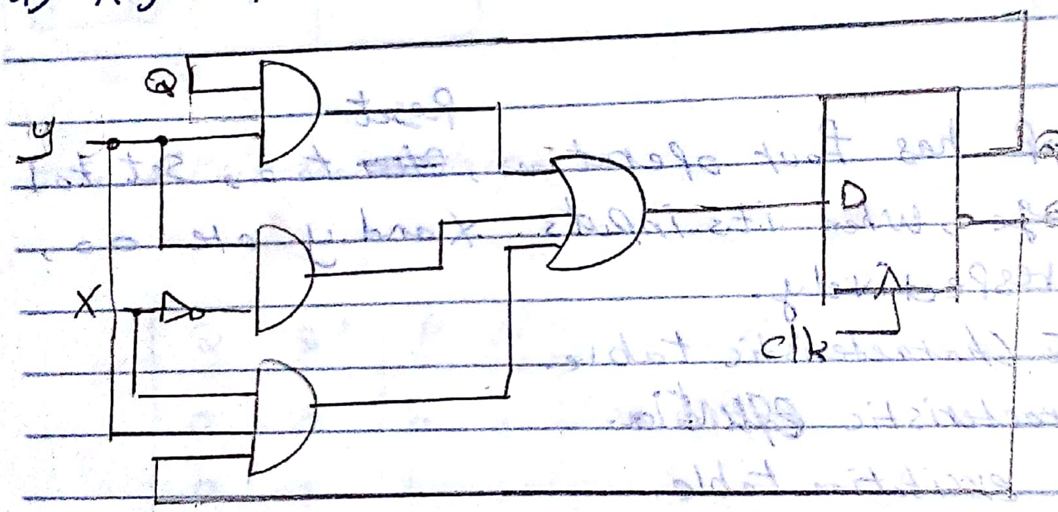
$$Q(t+1) = x'y + xy'Q' + xyQ$$

$\hookrightarrow Q^*$

x \ yQ	y'Q'	y'Q	yQ	yQ'
x'			1	1
x	1		1	

$$Q(t+1) = yQ + x'y + xy'Q'$$

d) xy flipflop can be converted to a D flipflop.



c) Excitation table:

Q	Q*	X	y
0	0	X	X
0	1	X	X
1	0	X	0
1	1	X	1

Q Q*

$0 \rightarrow 0$

x	y
0	0
1	1
X	X

Q Q*

$0 \rightarrow 1$

X	y
0	1
1	0
X	X

Q Q*

$1 \rightarrow 0$

X	y
0	0
1	0
X	0

Q Q*

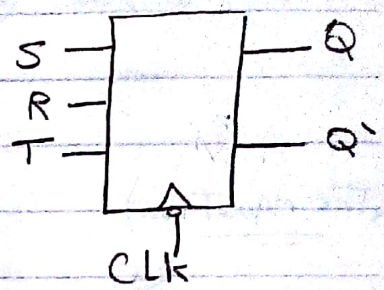
$1 \rightarrow 1$

X	y
0	1
1	1
X	1

Q1: In QUIZ #2 (2013)

⇒ A Flip flop with three inputs S, R, T, as shown.
S and R inputs behave exactly like SR FF.
While T input behaves like the toggle FF.
No more than one of these inputs may be 1 at any time

a) Show state diagram for this flipflop
b) Write an equation for Q^* in terms of S, R, T and Q



The Solution:

The truth table :-

S	R	T	q	q*	
0	0	0	0	0	No Change
0	0	0	1	1	
0	0	1	0	1	TFF, where T = 1
0	0	1	1	0	
0	1	0	0	0	Reset, where R = 1
0	1	0	1	0	
0	1	1	0	—	Not allowed, where T = 1, R = 1
0	1	1	1	—	
1	0	0	0	1	Set, where S = 1
1	0	0	1	1	
1	0	1	0	—	Not allowed, where more than one input equal "1"
1	0	1	1	—	
1	1	0	0	—	
1	1	0	1	—	
1	1	1	0	—	
1	1	1	1	—	

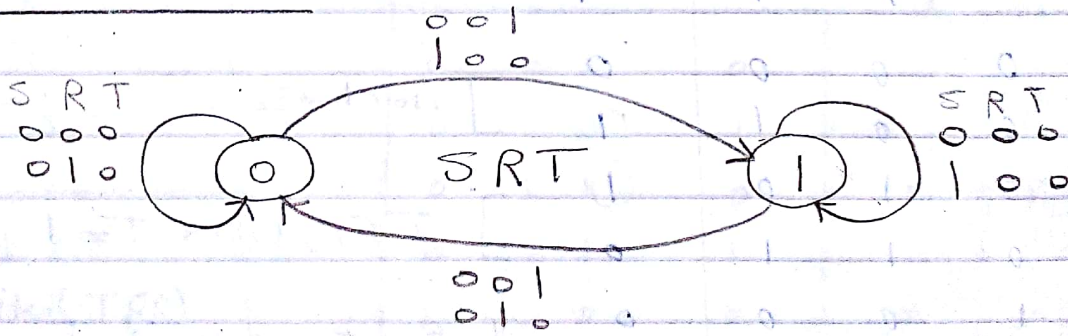
$q^* = \sum m(1,2,8,9) + \sum d(6,7,10,11,12,13,14,15)$

$TQ \backslash SR$	$S'R'$	$S'R$	SR	SR'
$T'Q'$			X	1
$T'Q$	1		X	1
TQ		X	X	X
TQ'	1	X	X	X

b) (The equation)

$\Rightarrow q^* = S + TQ' + R'T'Q$

a) $\Rightarrow$ The state diagram :-



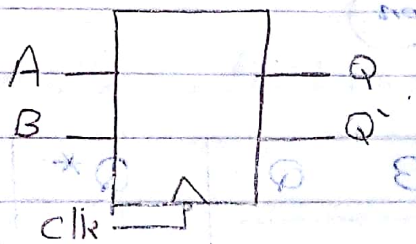
(Markovitz) book

Q5: (P. 401 Exercises) :-

⇒ We have a new type of flip flop, with inputs A and B. If $A = 0$, then $Q^* = B$; if $A = 1$, $Q^* = B'$

a) show a state diagram for this flip flop.
b) Write an equation for Q^* in terms of A, B, and Q

The Solution:



A	B	Q	Q^*
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

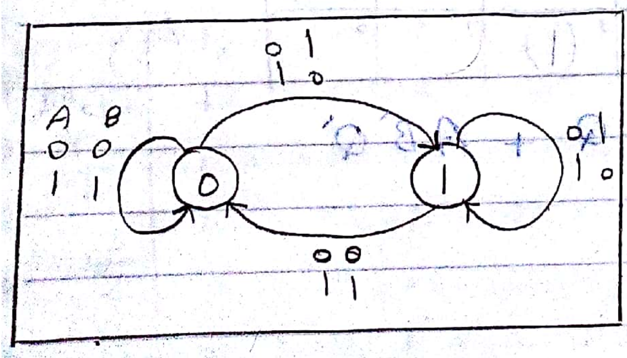
$Q^* = B$ because "A = 0"

$Q^* = B'$ because "A = 1"

$Q^* = \sum m(2, 3, 4, 5)$

AB \ Q	A'B'	A'B	AB	AB'
Q'	0:	2: 1	6:	4: 1
Q	1:	3: 1	7:	5: 1

* state diagram :-



$$Q^* = A'B + AB' = A \oplus B$$

(The equation) ⇒ $Q^* = A \oplus B$

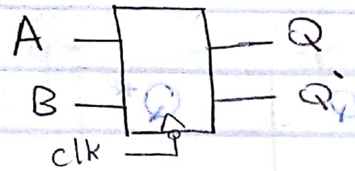
Q5.b (Final 2012):-

⇒ We have a new type of a flip flop With inputs A and B if $A=0$ then $Q^* = QB$, IF $A=1$ then $Q^* = Q`B`$

I) show a state diagram for this flip flop

II) Write an equation for Q^* in terms of A, B and Q

The solution

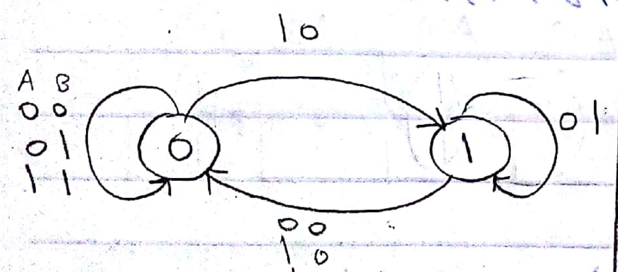


A	B	Q	Q*
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	0

$A=0$ ↳ $Q^*=QB$

$A=1$ ↳ $Q^*=Q`B`$

⇒ The state diagram :-

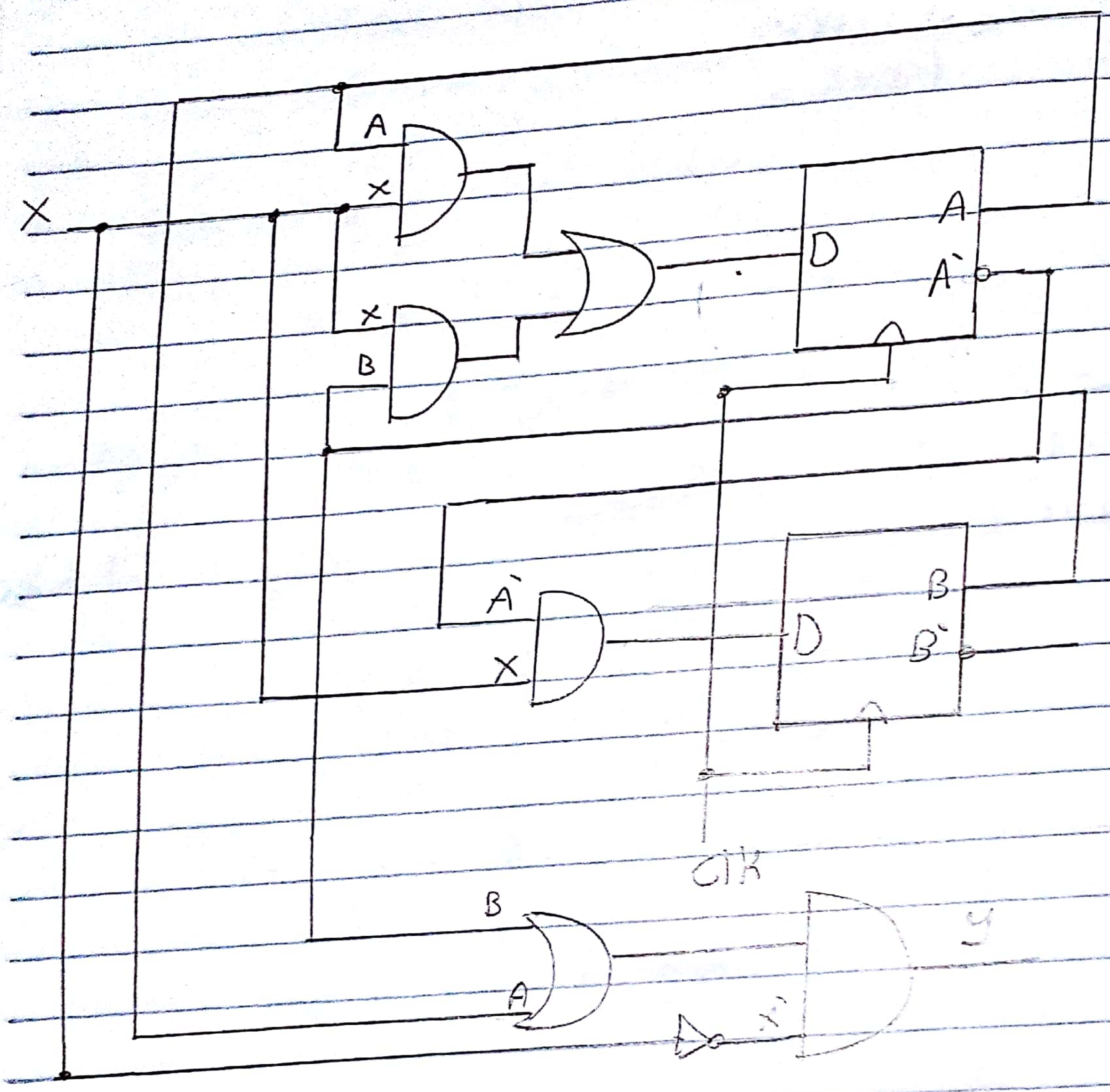


$Q^* = \Sigma m(3,4)$

Q \ AB	A`B`	A`B	AB	AB`
Q`	0	2	6	4 1
Q	1	3 1	7	5

$Q^* = A`BQ + AB`Q`$

EX5:
Analyze the following sequential Circuit:



ANS.

* The analysis of the sequential Circuit is by:
1) obtaining on The inputs equations, The output equation, Next state equations.
2) Constructing the State table.
3) Drawing the state diagram.

→

1 The equations..

In D flip flop $\Rightarrow Q(t+1) = D$

For A flip flop..

$\hookrightarrow D_A = AX + BX$

$\hookrightarrow A(t+1) = D_A = AX + BX$

For B flip flop..

$\hookrightarrow D_B = A'X$

$\hookrightarrow B(t+1) = D_B = A'X$

The out put equation..

$y = X'(A+B)$

---

2 State Table:

للحصول على ال State table نحدد أولاً قيم المعادلات عندما X=0,1:
وذلك لسهولة التعويض في المعادلات وبناء الجدول.

$A(t+1) = AX + BX$

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

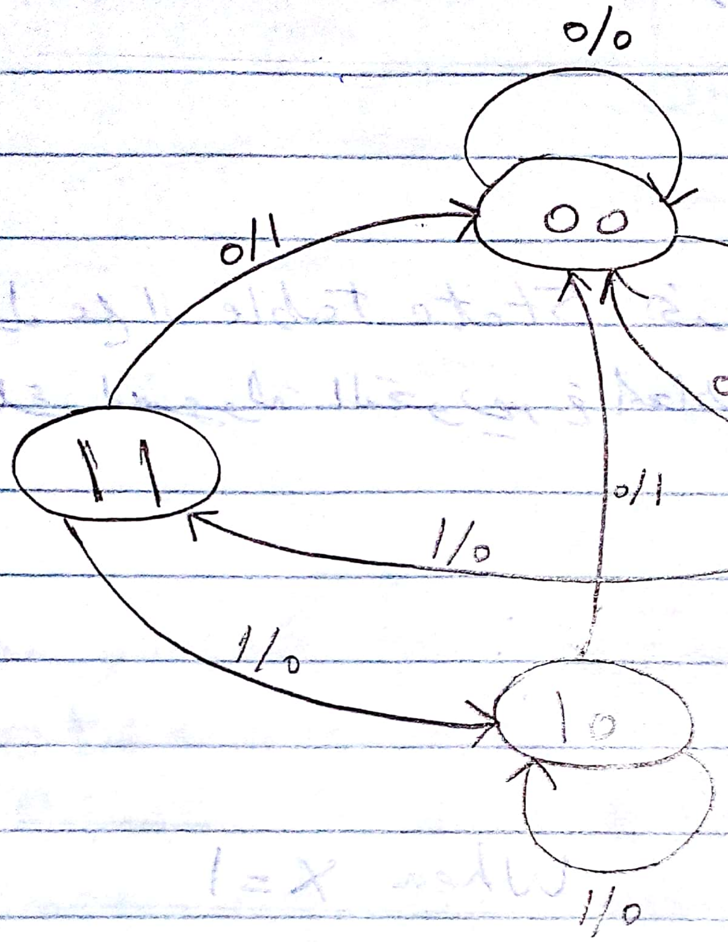
$y = X'(A+B)$

When $X=0$	When $X=1$
$A(t+1) = 0$	$A(t+1) = A+B$
$B(t+1) = 0$	$B(t+1) = A'$
$y = A+B$	$y = 0$

The state table :-

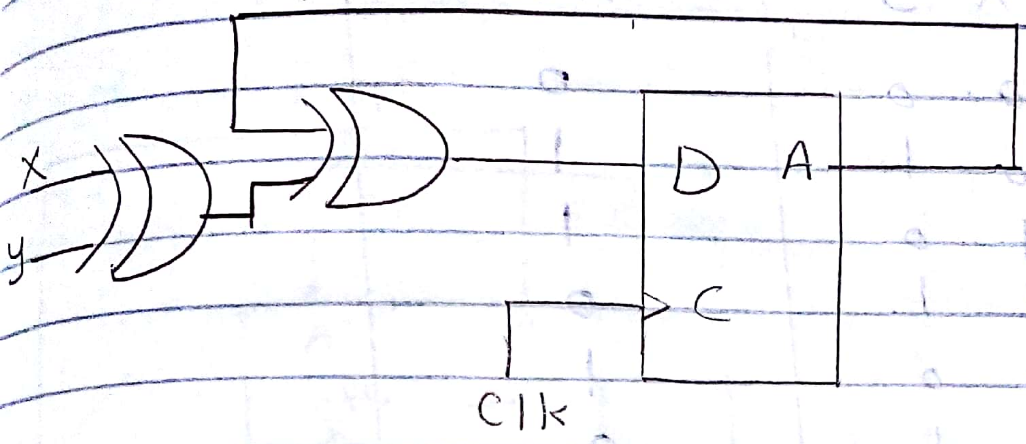
input	Present state		next state		output
X	A	B	A*	B*	Y
0	0	0	0	0	0
0	0	1	0	0	1
0	1	0	0	0	1
0	1	1	0	0	1
1	0	0	0	1	0
1	0	1	1	1	0
1	1	0	1	0	0
1	1	1	1	0	0

3) The state Diagram :-



Ex 6:

* Analyze the following sequential Circuit:



ANS.

1 The equations:

$$D_A = (X \oplus y) \oplus A$$

$$A(t+1) = D_A = X \oplus y \oplus A$$

Where in D flip flop $Q(t+1) = D$

2 The State Table:

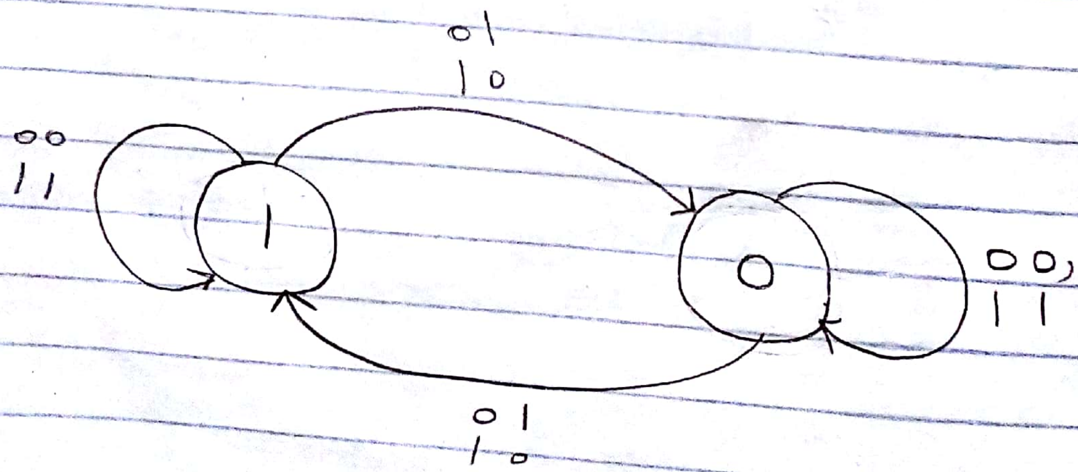
The State table ::

inputs		Present State	Next State
x	y	A	A*
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

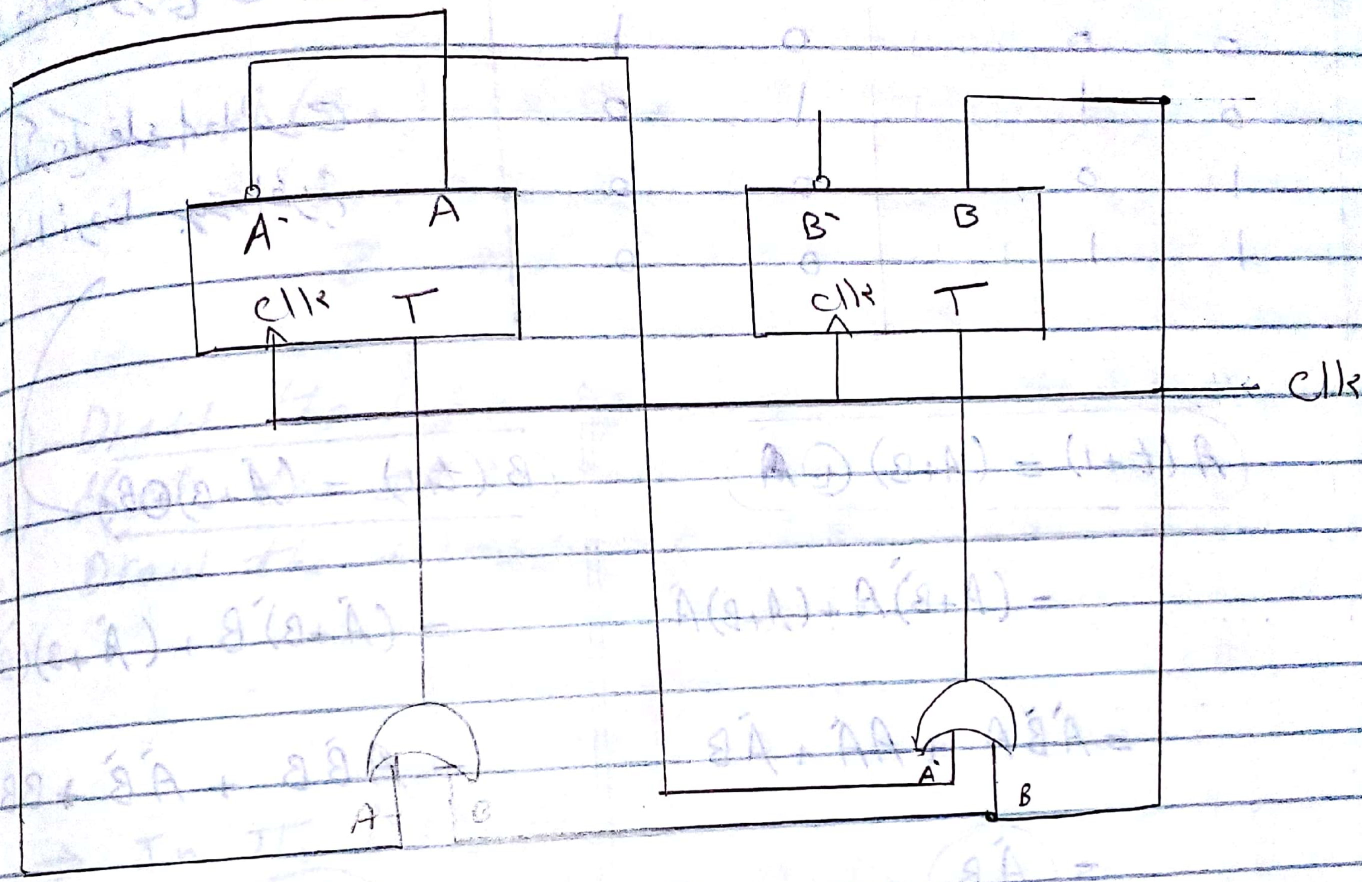
$A^* \leftarrow A(t+1) = x \oplus y \oplus A$

③ The State Diagram:

لو لدينا (DFF) واحدة ~~FF~~ (A) نلاحظ مرة State table
أن (A) ممكن أن تكون ٠ أو ١
لذلك هناك حالتان 2(state)



Ex1 Derive the state table and the state diagram of the sequential circuit in the following figure:



ANS.

[1] The equations. ⟺ The used flip flops are T. ff.

For A ff:

↳ $T_A = A + B$

↳ $Q(t+1) \Rightarrow A(t+1) = T_A \oplus A$

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

For B ff:

↳ $T_B = \grave{A} + B$

↳ $B(t+1) = T_B \oplus B$

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

$$A(t+1) = (A+B) \oplus A$$
$$B(t+1) = (A'+B) \oplus B$$
$$\Downarrow$$

[2] The state table

Present state				Next state	
A	B	A+B	A'+B	A(t+1)	B(t+1)
0	0	0	1	0	1
0	1	1	1	1	0
1	0	1	0	0	0
1	1	1	1	0	0

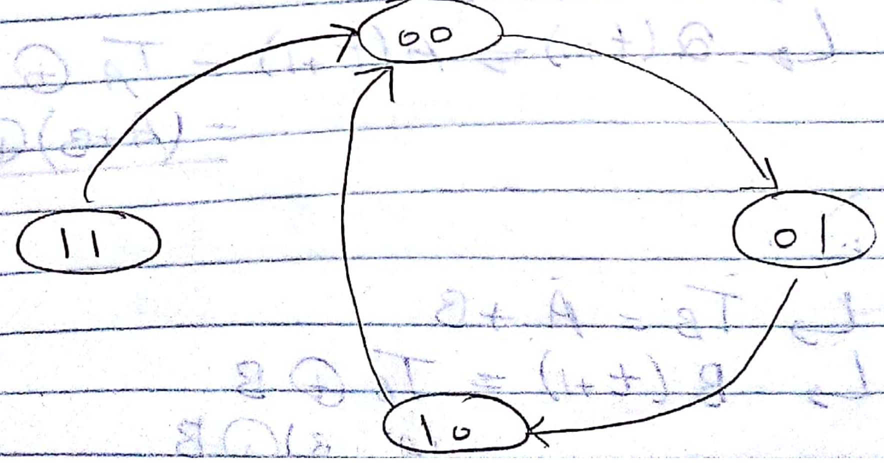
لا يمكن توزيع XoR $\oplus$

لكن يمكن فك المعادلات إذا أردنا بهذه الطريقة

$$A(t+1) = (A+B) \oplus A$$
$$= (A+B)'A + (A+B)A'$$
$$= A'B'A + AA' + A'B$$
$$= A'B$$

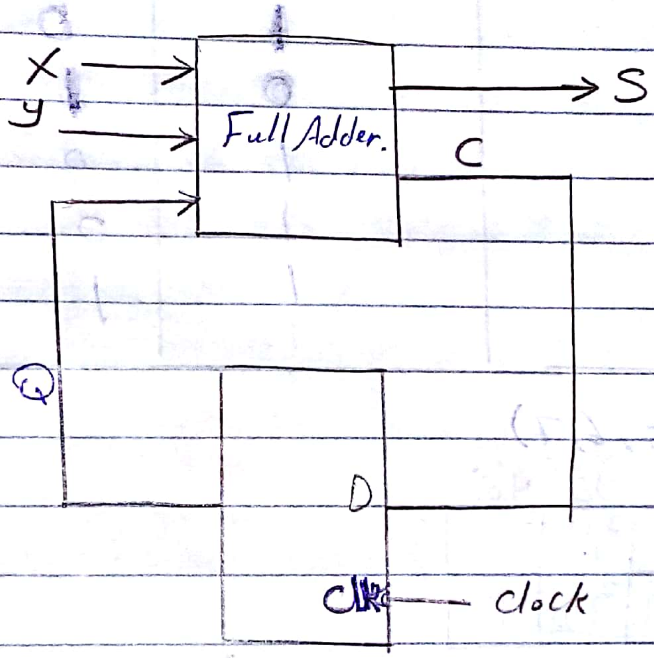
$$B(t+1) = (A'+B) \oplus B$$
$$= (A'+B)'B + (A'+B)(B')$$
$$= AB'B + A'B' + BB'$$
$$= A'B'$$

[3] The state diagram



Q4 : Sheet 4 : Q (5-7)

⇒ A sequential circuit has one flip flop Q, two inputs x and y, and one output S, it consists of a full-adder circuit connected to a D flip flop, as shown in the following figure.
Derive the state table and the state diagram of the sequential circuit.



Ans

⇒ From the Diagram :

$D = C$ [Cout]

The next state of Dff is ⇒ $\boxed{Q^* = D}$

So :

Q^* or $Q(t+1) = D = C$

⟶

The state table:

inputs		Present state	Next state	Output
x	y	Q	$Q^* = C_{out}$	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

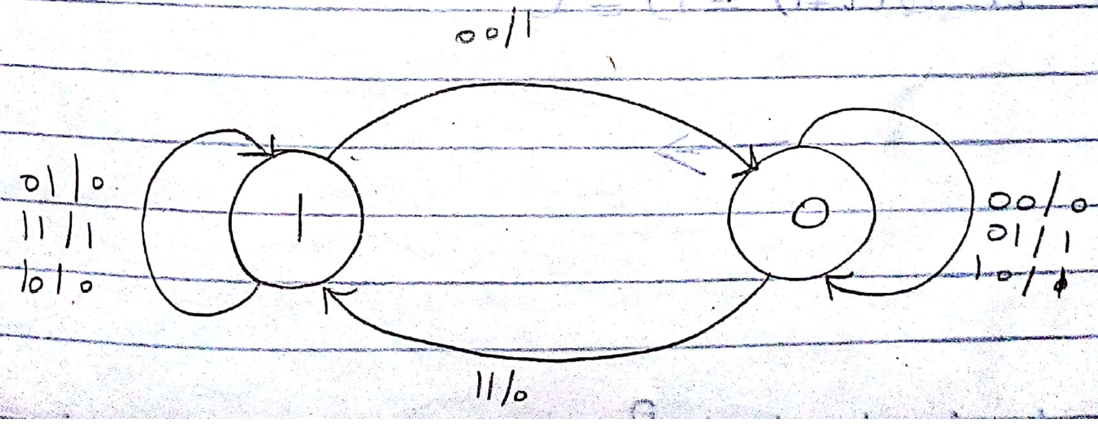
$$Q^* = \sum m(3, 5, 6, 7)$$

x \ yQ	$y'Q'$	$y'Q$	yQ	yQ'
x'	0	1	3: 1	2
x	4	5: 1	7: 1	6: 1

$$Q(t+1) = yQ + xQ + xy$$

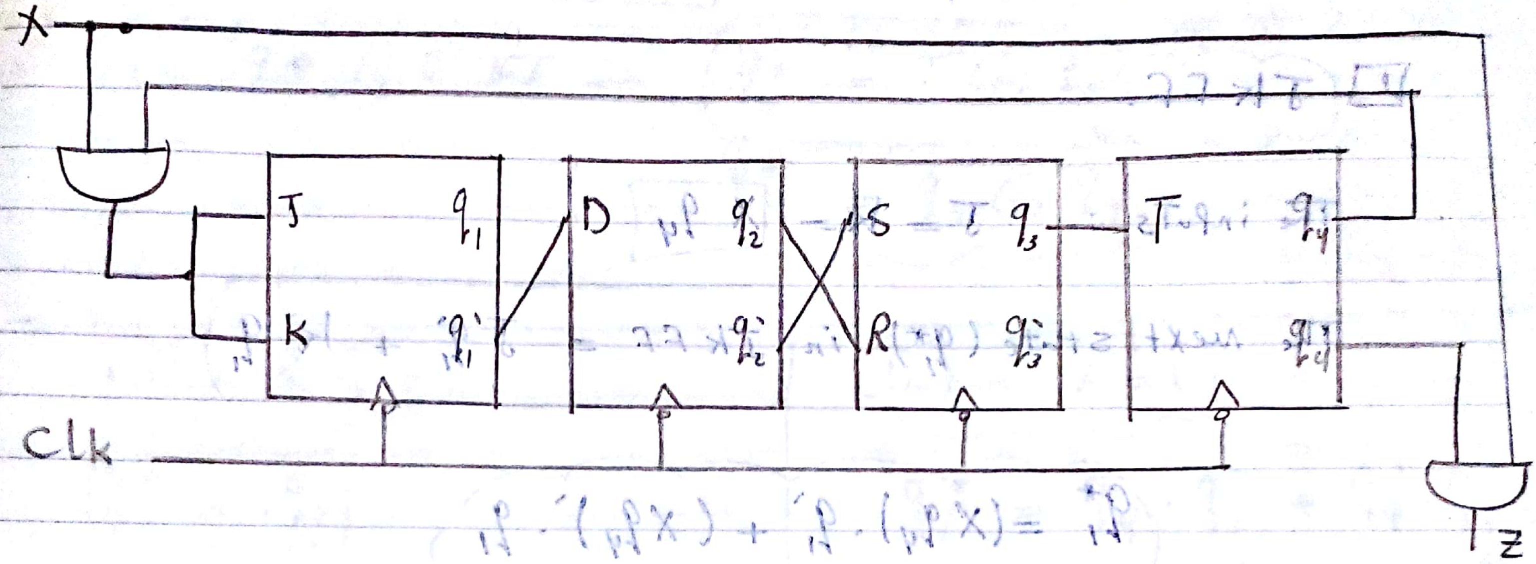
$$S = x \oplus y \oplus Q$$

The State Diagram:



Q.8 (2009)

Given the following circuit:



a) The state model: is (Mealy model)

because, the output ($Z = (X q_4')$) depends on the state and the input.

b) Build the state table:

$\Longrightarrow$

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From the design:

↳ we have 4 flip flops:

1 JK FF.

The inputs: $J = K = \boxed{X\, q_4}$

The next state (q_1^*) in $\boxed{JK\,FF = J q_1' + K' q_1}$

$$q_1^* = (X q_4) \cdot q_1' + (X q_4)' \cdot q_1$$

2 D FF

The inputs: $\boxed{D = q_1'}$

q_2^* in D FF $\Rightarrow$ $\boxed{q_2^* = D}$

$$q_2^* = q_1'$$

3 SR FF

The inputs: $\boxed{S = q_2'}$, $\boxed{R = q_2}$

q_3^* in SR FF $\Rightarrow$ $\boxed{S + R' q_3}$

$$q_3^* = q_2' + q_2' q_3 = q_2' (1 + q_3)$$

$$q_3^* = q_2'$$

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4 TFF :

The inputs : $\boxed{T = q_3}$

q^* in T FF $\Rightarrow$ $q_4^* = T \oplus q_4$

$$q_4^* = q_3 \oplus q_4$$

When $X = 0$

$\boxed{q_1^* = q_1}$

$\boxed{q_2^* = q_1'}$

$\boxed{q_3^* = q_2'}$

$\boxed{q_4^* = q_3 \oplus q_4}$

$\boxed{Z = 0}$

When $X = 1$

$q_1^* = q_4 \cdot q_1' + q_4' \cdot q_1$

$\boxed{q_1^* = (q_4 \oplus q_1)}$

$\boxed{q_2^* = q_1'}$

$\boxed{q_3^* = q_2'}$

$\boxed{q_4^* = q_3 \oplus q_4}$

$\boxed{Z = q_4'}$

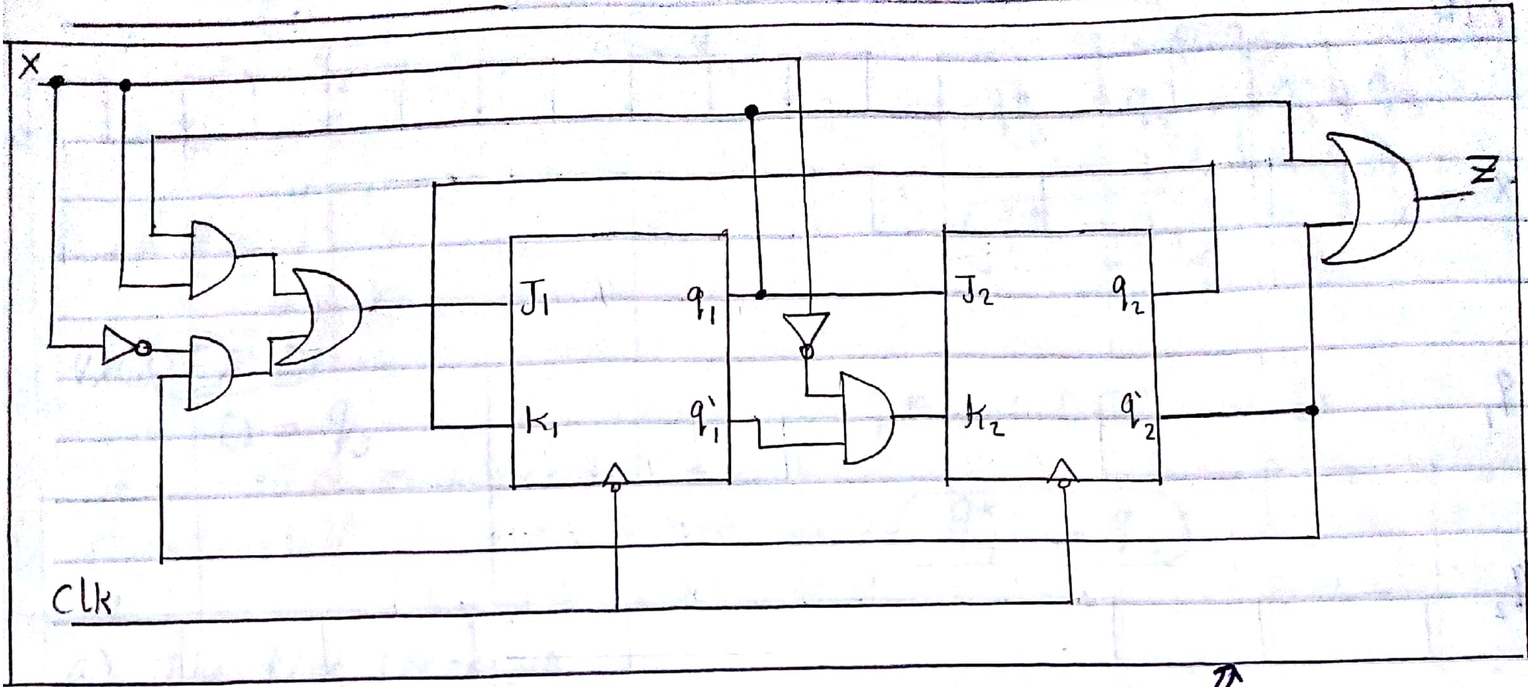
$\Rightarrow$ The state table : $\Rightarrow$

$Z = x\,q_4'$

The state table.

Present state q_1	q_2	q_3	q_4	Next state $x = 0$: q_1^*	q_2^*	q_3^*	q_4^*	$x = 1$: q_1^*	q_2^*	q_3^*	q_4^*	output (Z) $x = 0$, $Z = 0$	$x = 1$, $Z = q_4'$
0	0	0	0	0	1	1	0	0	1	1	0	0	1
0	0	0	1	0	1	1	1	1	1	1	1	0	0
0	0	1	0	0	1	1	1	0	1	1	1	0	1
0	0	1	1	0	1	1	0	1	1	1	0	0	0
0	1	0	0	0	1	0	0	0	1	0	0	0	1
0	1	0	1	0	1	0	1	1	1	0	1	0	0
0	1	1	0	0	1	0	1	0	1	0	1	0	1
0	1	1	1	0	1	0	0	1	1	0	0	0	0
1	0	0	0	1	0	1	0	1	0	1	0	0	1
1	0	0	1	1	0	1	1	0	0	1	1	0	0
1	0	1	0	1	0	1	1	1	0	1	1	0	1
1	0	1	1	1	0	1	0	0	0	1	0	0	0
1	1	0	0	1	0	0	0	1	0	0	0	0	1
1	1	0	1	1	0	0	1	0	0	0	1	0	0
1	1	1	0	1	0	0	1	1	0	0	1	0	1
1	1	1	1	1	0	0	0	0	0	0	0	0	0

Q1 : Quiz-3 (2012) :



⇒ obtain the high level description of the following sequential network, and complete the timing diagram:-

The Solution:-

* This design is "MooRe Model" Where :
  The output ($Z = q_1 + q_2'$) depends only on the state.

* From The design, there are two FlipFlops ⇒ (JK FF) :-

* The inputs:-

JK FF_1 :-

$$J_1 = X q_1 + X' q_2'$$
$$K_1 = q_2$$

JK FF2 :-

$$J_2 = q_1$$
$$K_2 = X' q_1$$

* The next state in JK FF: $= \boxed{J q' + K' q}$

$$q_1^* = J_1 q_1' + K_1' q_1$$

$$= (x \cdot q_1 + x' q_2') \cdot q_1' + (q_2') q_1$$

$$= x' q_1' q_2' + q_1 q_2'$$

$$= q_2' (x' q_1' + q_1) = q_2' (x' + q_1)$$

$$\boxed{q_1^* = q_2' (x' + q_1)}$$

$$q_2^* = J_2 q_2' + K_2' q_2$$

$$= q_1 q_2' + (x' \cdot q_1')' q_2$$

$$= q_1 q_2' + (x + q_1) q_2$$

$$= q_1 q_2' + x q_2 + q_1 q_2$$

$$= q_1 (q_2' + q_2) + x q_2$$

$$\boxed{q_2^* = q_1 + x q_2}$$

$\longrightarrow$

$$q_1^* = q_2'\,(x' + q_1)$$

$$q_2^* = q_1 + x\,q_2$$

When $x = 0$

$$q_1^*\big|_{x=0} = q_2'$$

$$q_2^*\big|_{x=0} = q_1$$

When $x = 1$

$$q_1^*\big|_{x=1} = q_1\,q_2'$$

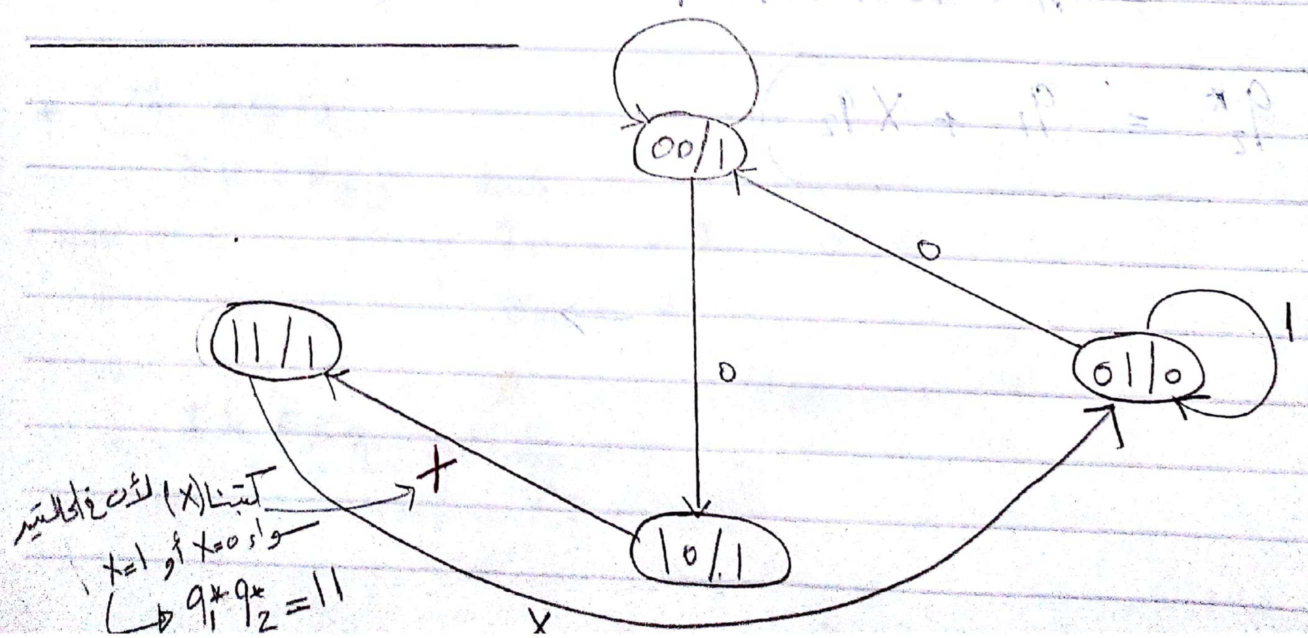
$$q_2^*\big|_{x=1} = q_1 + q_2$$

* The state table:-

$(Z = q_1 + q_2')$

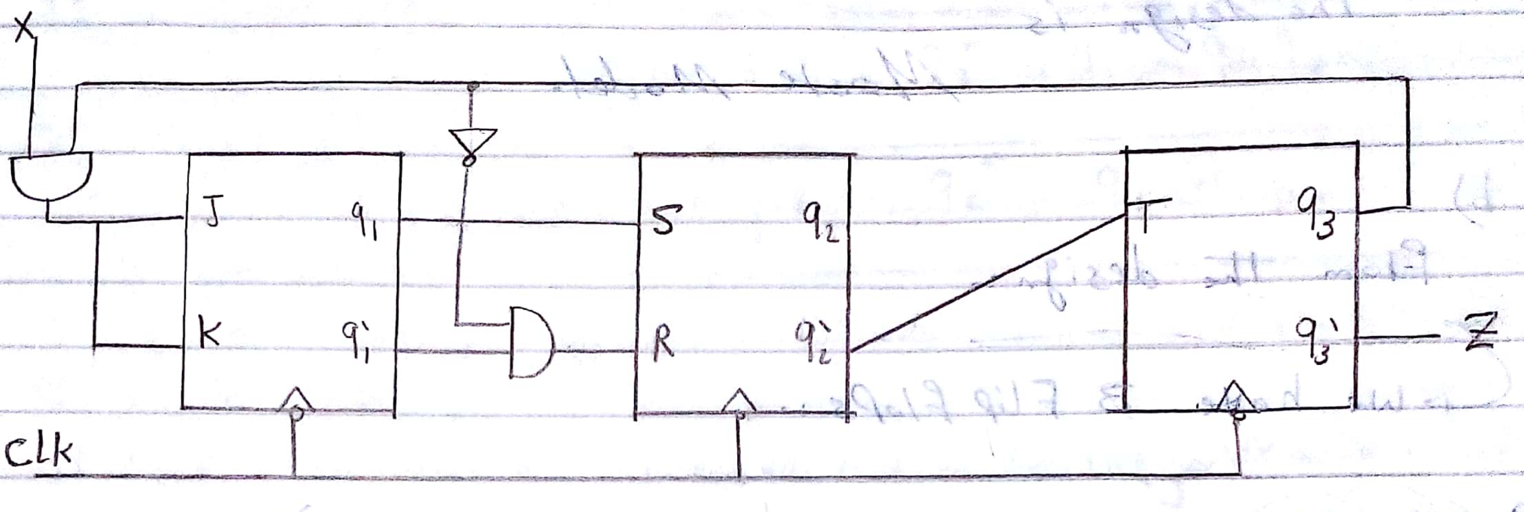
Present state		Next state				out put
		$x=0$		$x=1$		
q_1	q_2	q_1^*	q_2^*	q_1^*	q_2^*	Z
0	0	1	0	0	0	1
0	1	0	0	0	1	0
1	0	1	1	1	1	1
1	1	0	1	0	1	1

* The State Diagram:-



Q7. (June 2010) :

Given the following Circuit :



a) State the design model

b) Build the state table

The Solution :-

a) The output ($Z = q_3'$) depends only on the state, So The design is

Moore Model.

b)

From the design:

We have 3 Flip Flops :-

① JK FF

$J = K = X q_3$

$$q^*_{JK} = J q_1' + K' q_1$$

$$= X q_3 q_1' + (X q_3)' q_1$$

$$\boxed{q_1^* = X q_3 q_1' + (X' + q_3') q_1}$$

② SR FF

$S = q_1 \quad , \quad R = q_1' q_3'$

$$q^*_{SR} = S + R' q_2$$

$$q_2^* = q_1 + (q_1' q_3')' q_2$$

$$= q_1 + (q_1 + q_3) q_2$$

$$= q_1 + q_1 q_2 + q_3 q_2$$

$$\boxed{q_2^* = q_1 + q_3 q_2}$$

③ T FF

$T = q_2'$

$$q_3^* = T \oplus q_3$$

$$\boxed{q_3^* = q_2' \oplus q_3}$$

When $X=0$	When $X=1$
$q_1^* = q_1$	$q_1^* = q_3 q_1' + q_3' q_1$ $q_1^* = q_1 \oplus q_3$
$q_2^* = q_1 + q_2 q_3$	$q_2^* = q_1 + q_2 q_3$
$q_3^* = q_2' \oplus q_3$	$q_3^* = q_2' \oplus q_3$

The state table :-

$Z = q_3'$

Present State q_1	q_2	q_3	Next State $X=0$ q_1^*	q_2^*	q_3^*	$X=1$ q_1^*	q_2^*	q_3^*	Z
0	0	0	0	0	1	0	0	1	1
0	0	1	0	0	0	1	0	0	0
0	1	0	0	0	0	0	0	0	1
0	1	1	0	1	1	1	1	1	0
1	0	0	1	1	1	1	1	1	1
1	0	1	1	1	0	0	1	0	0
1	1	0	1	1	0	1	1	0	1
1	1	1	1	1	1	0	1	1	0

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