Circuit Diagram to state Diagram

Example:1. Circuit to state diagram

Present states:

A and B

Input:

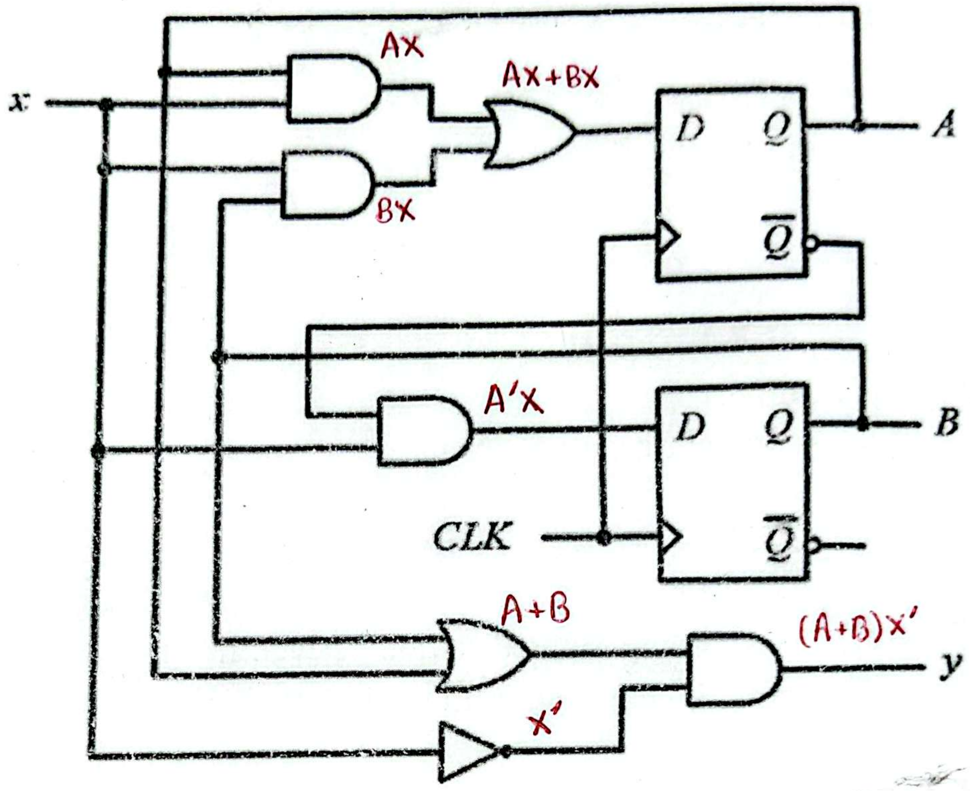
DA, DB, x

Next states:

A^+ and B^+

Output:

y



$DA = AX + BX$

$DB = A'X$

$Y = (A+B)X'$

A	B	x	DA	DB	Y
0	0	0	0	0	0
0	0	1	0	1	0
0	1	0	0	0	1
0	1	1	1	1	0
1	0	0	0	0	1
1	0	1	1	0	0
1	1	0	0	0	1
1	1	1	1	0	0

A	B	X	DA	DB	Y	A^+	B^+
0	0	0	0	0	0	0	0
0	0	1	0	1	0	0	1
0	1	0	0	0	1	0	0
0	1	1	1	1	0	1	1
1	0	0	0	0	1	0	0
1	0	1	1	0	0	1	0
1	1	0	0	0	1	0	0
1	1	1	1	0	0	1	0

D-Flip-Flop

D	Q
0	0
1	1

$\therefore DA = A^+$

$\therefore DB = B^+$

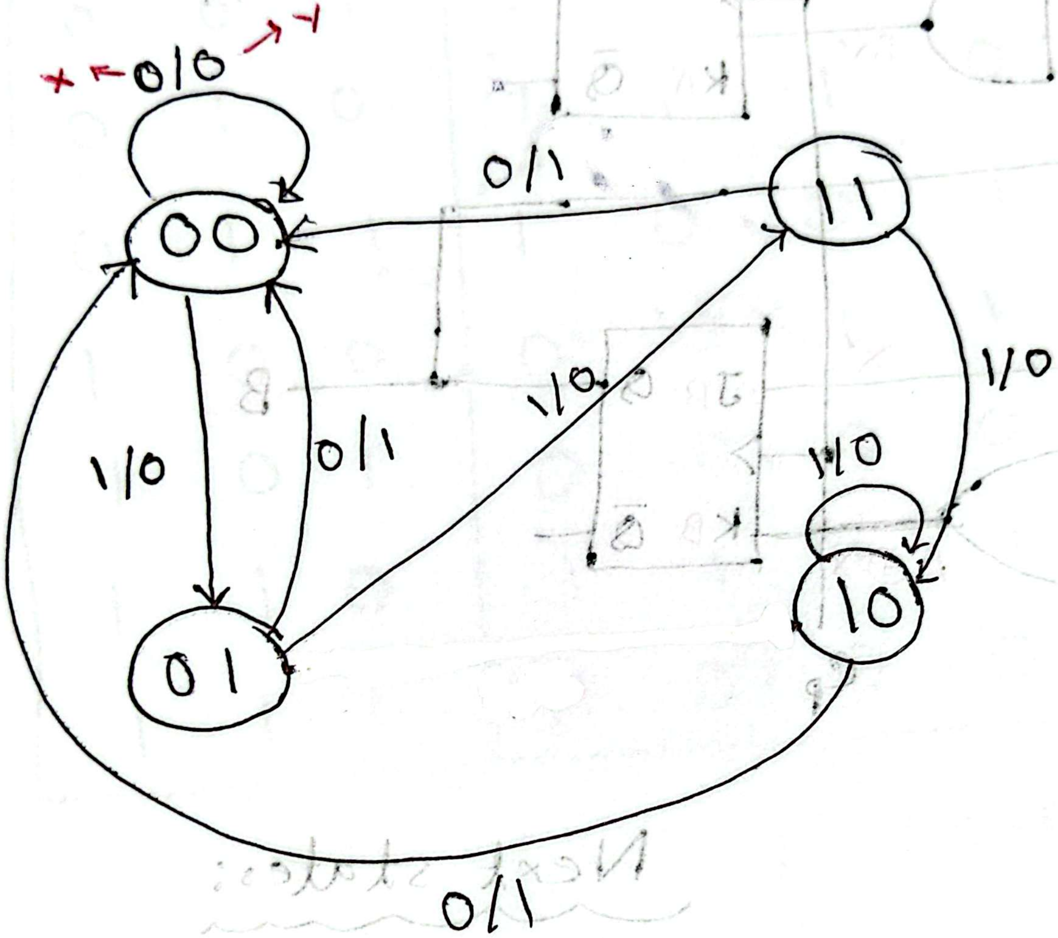
n flip-flop

2^n states

A	B	x	A^+	B^+	y
0	0	0	0	0	0
0	0	1	0	1	0
0	1	0	0	0	1
0	1	1	1	1	0
1	0	0	0	0	1
1	0	1	1	0	0
1	1	0	0	0	1
1	1	1	1	0	0

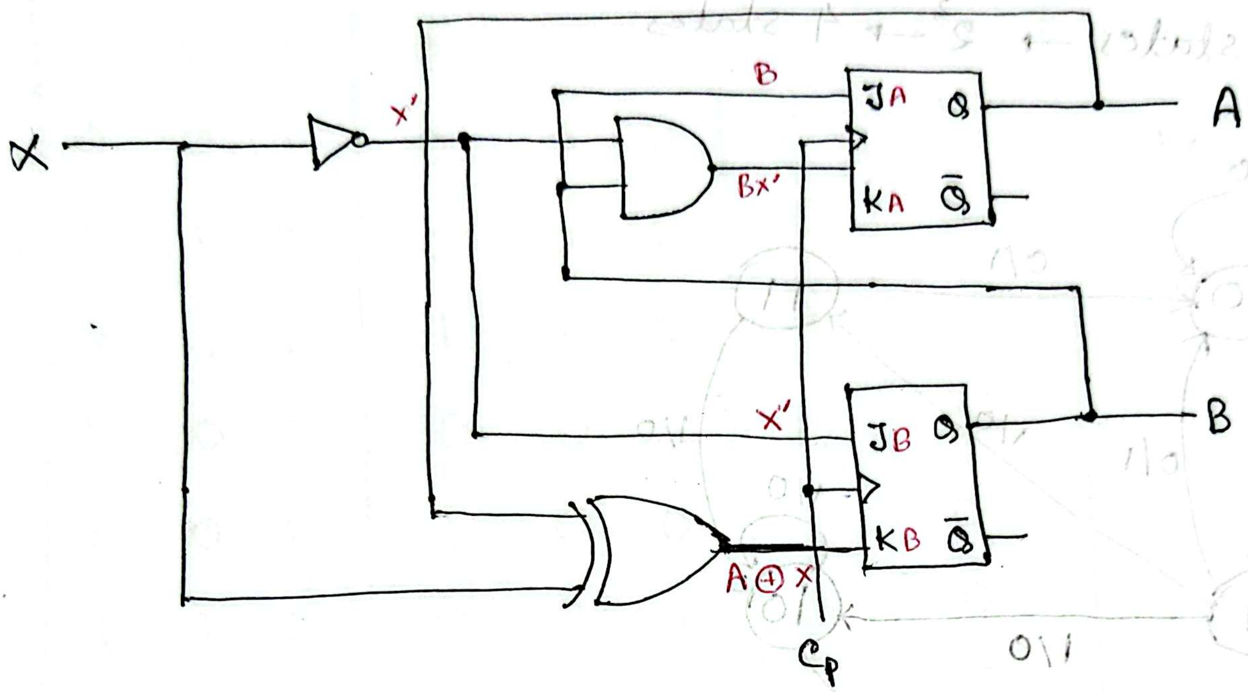
2 flip-flop

2^n states $\rightarrow$ $2^2 \rightarrow$ 4 states



State Diagram

Ex-2:



Present states:

A, B

Next states:

A^+, B^+

Input:

JA, KA, JB, KB, X

XOR

00, 11 → 0

01, 10 → 1

Here,

JA = B

KA = BX'

JB = X'

KB = A XOR X

KB = $\boxed{A \oplus X}$

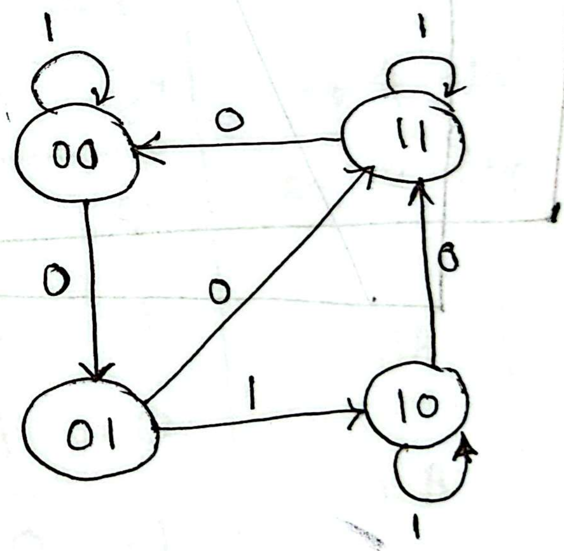
(No output given)

A	B	X	JA	KA	JB	KB	A+	B^+
0	0	0	0	0	1	0	0	1
0	0	1	0	0	0	1	0	0
0	1	0	1	1	1	0	1	1
0	1	1	1	0	0	1	1	0
1	0	0	0	0	1	1	1	~~0~~1
1	0	1	0	0	0	0	1	0
1	1	0	1	1	1	1	0	0
1	1	1	1	0	0	0	1	1

2 ff , $2^n = 2^2 = 4$ states

J-K Flip-Flop

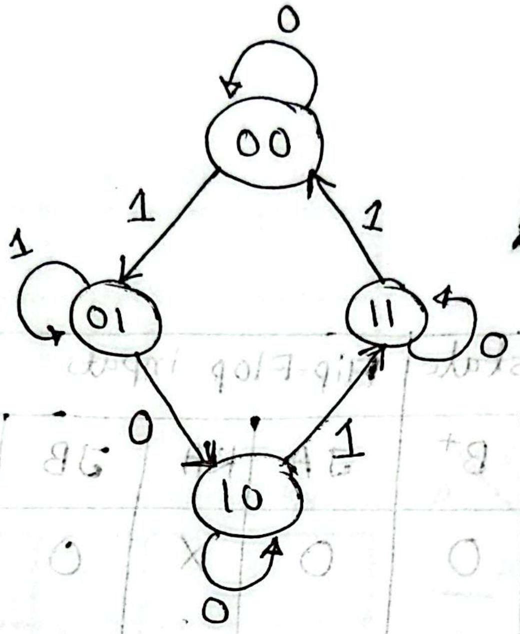
J	K	Q	Q'
0	0	No change	
0	1	0	1
1	0	~~0~~1	0
1	1	Toggle	



state Diagram

State Diagram to Circuit Diagram

Ex-1: Given state Diagram as follows, get the sequential circuit using J-K flip-flop.



Present state		input	Next state	
A	B	x	A^+	B^+
0	0	0	0	0
0	0	1	0	1
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	1	1
1	1	0	1	1
1	1	1	0	0

2^m states

m flip-flop

→ 4 states

so, 2 flip-flop

JA	JB
KA	KB

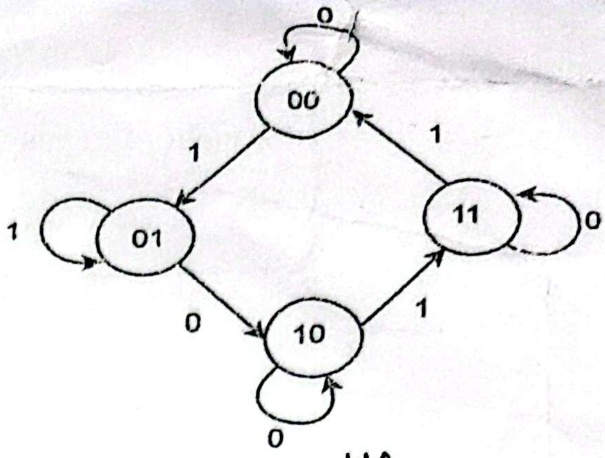
No outputs

J-K ff excitation table:

Q	Q^+	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Present state		Input	Next state		Flip-Flop inputs			
A	B	X	A^+	B^+	JA	KA	JB	KB
0	0	0	0	0	0	X	0	X
0	0	1	0	1	0	X	1	X
0	1	0	1	0	1	X	X	1
0	1	1	0	1	0	X	X	0
1	0	0	1	0	X	0	0	X
1	0	1	1	1	X	0	1	X
1	1	0	1	1	X	0	X	0
1	1	1	0	0	X	1	X	1

State to circuit diagram



Following the table,
We're doing K-MAP's
for JA, KA, JB, KB.

JA

A \ Bx	00 B'x'	01 B'x	11 Bx	10 Bx'
0 A'	0	1	3	1 2
1 A	X 4	X 5	X 7	X 6

KA

A \ Bx	00 B'x'	01 B'x	11 Bx	10 Bx'
0 A'	X 0	X 1	X 3	X 2
1 A	4	5	1 7	6

JB

A \ Bx	00 B'x'	01 B'x	11 Bx	10 Bx'
0 A'	0	1 1	X 3	X 2
1 A	4	1 5	X 7	X 6

KB

A \ Bx	00 B'x'	01 B'x	11 Bx	10 Bx'
0 A'	X 0	X 1	3	1 2
1 A	X 4	X 5	1 7	6

$A'x'$

Ax

$= Ax + A'x'$
$= (A \odot x) = ($

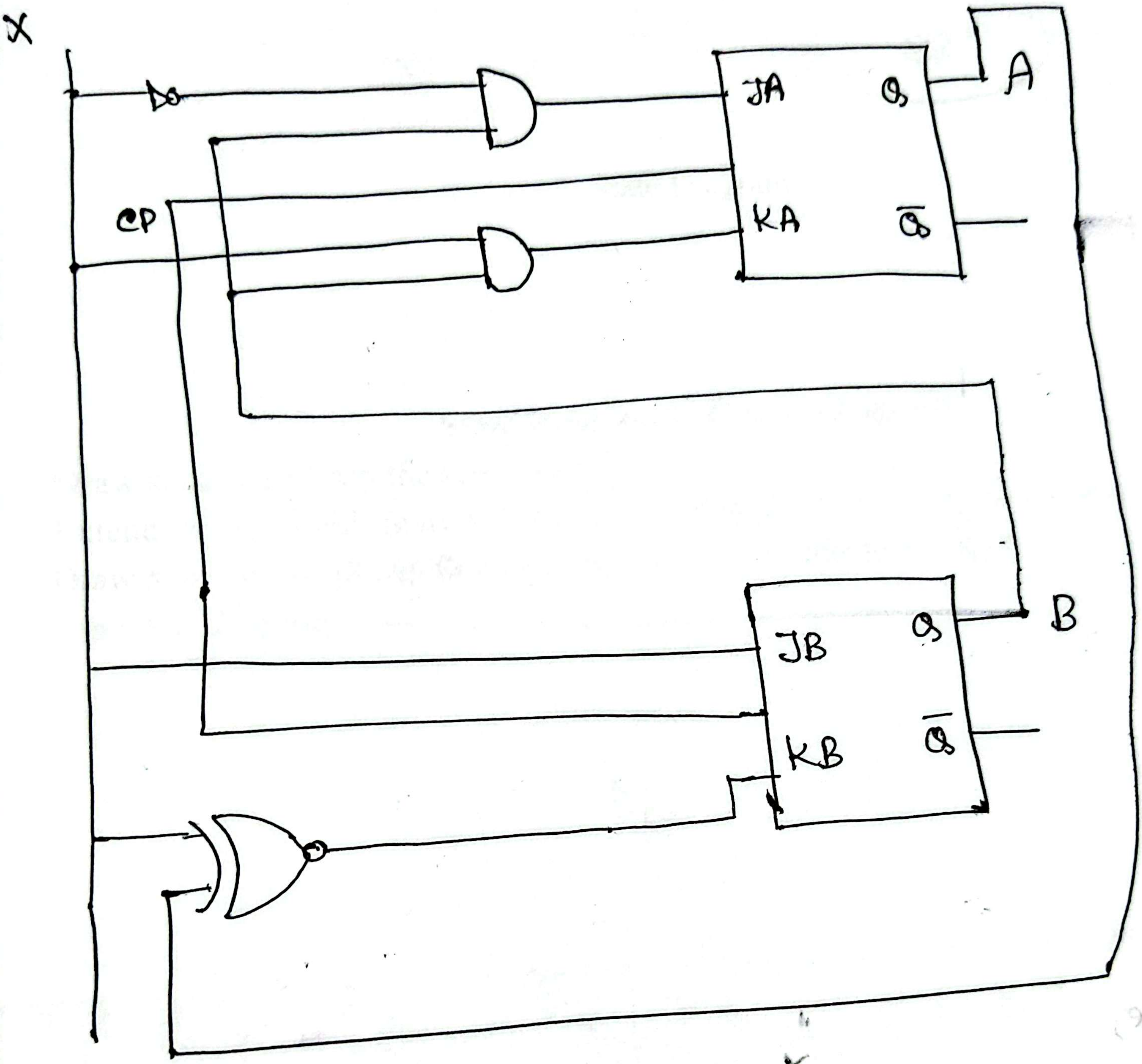
From here,

$\therefore JA = Bx'$

$\therefore KA = Bx$

$\therefore JB = x$

$\therefore KB = (A \oplus x)'$



Circuit Diagram

Ex-2: Using D-ff find circuit Diagram →

Present state		Input	Next State		Output		
A	B	x	A^+	B^+	y	DA	DB
0	0	0	0	0	0	0	0
0	0	1	0	1	1	0	1
0	1	0	1	0	0	1	0
0	1	1	0	1	0	0	1
1	0	0	1	0	0	1	0
1	0	1	1	1	1	1	1
1	1	0	1	1	0	1	1
1	1	1	0	0	0	0	0

D-ff excitation table

Q	Q^+	D
0	0	0
0	1	1
1	0	0
1	1	1

A \ Bx	$B'x'$	$B'x$	Bx	Bx'
A' 0	0	1	3	2: 1
A 1	4: 1	5: 1	7	6: 1

$DA = AB' + Bx'$

A \ Bx	$B'x'$	$B'x$	Bx	Bx'
A' 0	0	1: 1	3: 1	2
A 1	4	5: 1	7	6: 1

$DB = A'x + B'x + ABx'$

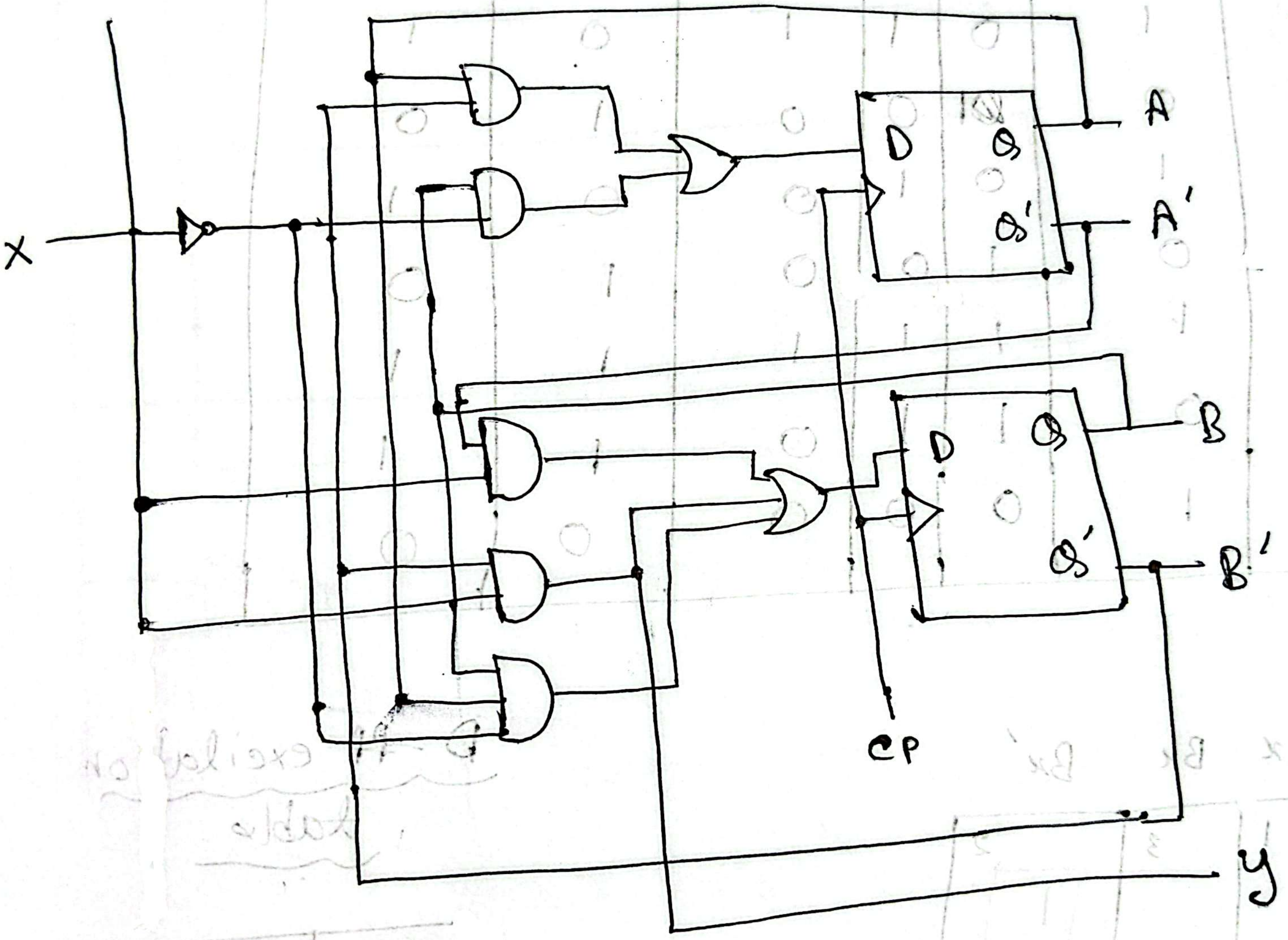
A \ Bx	$B'x'$	$B'x$	Bx	Bx'
A' 0	0	1: 1	3	2
A 1	4	5: 1	7	6

$Y = B'x$

$DA = AB' + Bx'$

$DB = A'x + B'x + ABx'$

$Y = B'x$



Circuit Diagram

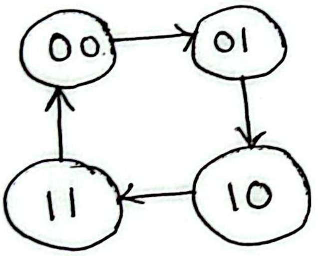
Counter Design

Synchronous (Parallel Counters):

* Design a 2-bit synchronous UP binary counter (Using T-ff)

$n = 2$

states $\rightarrow 2^n = 2^2 = 4$



Present state		Next state		ff inputs	
A_1	A_0	A_1^+	A_0^+	TA_1	TA_0
0	0	0	1	0	1
0	1	1	0	1	1
1	0	1	1	0	1
1	1	0	0	1	1

A1 \ A0	A0'	A0
A1'	(0)	(1) 1
A1	(2)	(3) 1

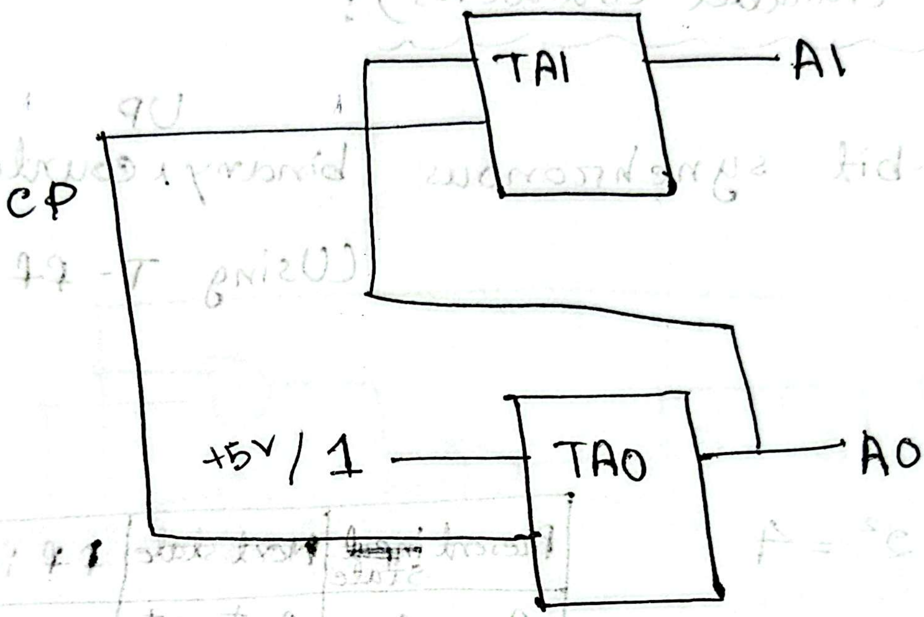
$TA_1 = A0$

A1 \ A0	A0'	A0
A1'	(0) 1	(1) 1
A1	(2) 1	(3) 1

$TA_2 = 1$

Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

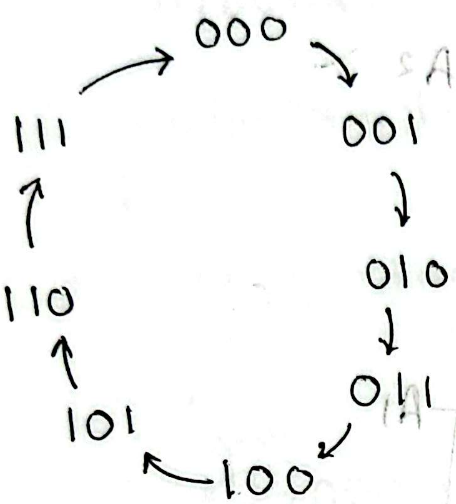
Excitation Table of t-ff



$TA_1 = A_0$

$TA_0 = 1$

Design a 3-bit synchronous binary UP counter (Using T)



Present state			Next state			F-F inputs		
A_2	A_1	A_0	A_2^+	A_1^+	A_0^+	TA_2	TA_1	TA_0
0	0	0	0	0	1	0	0	1
0	0	1	0	1	0	0	1	1
0	1	0	0	1	1	0	0	1
0	1	1	1	0	0	1	1	1
1	0	0	1	0	1	0	0	1
1	0	1	1	1	0	0	1	1
1	1	0	1	1	1	0	0	1
1	1	1	0	0	0	1	1	1

A_2 \ A1A0				
A_2'	(0)	(1)	(3) 1	(2)
A_2	(4)	(5)	(7) 1	(6)

$TA_2 = A_1 A_0$

A_2 \ A1A0	$A_1'A_0'$	$A_1'A_0$	A_1A_0	A_1A_0'
A_2'	(0)	(1) 1	(3) 1	(2)
A_2	(4)	(5) 1	(7) 1	(6)

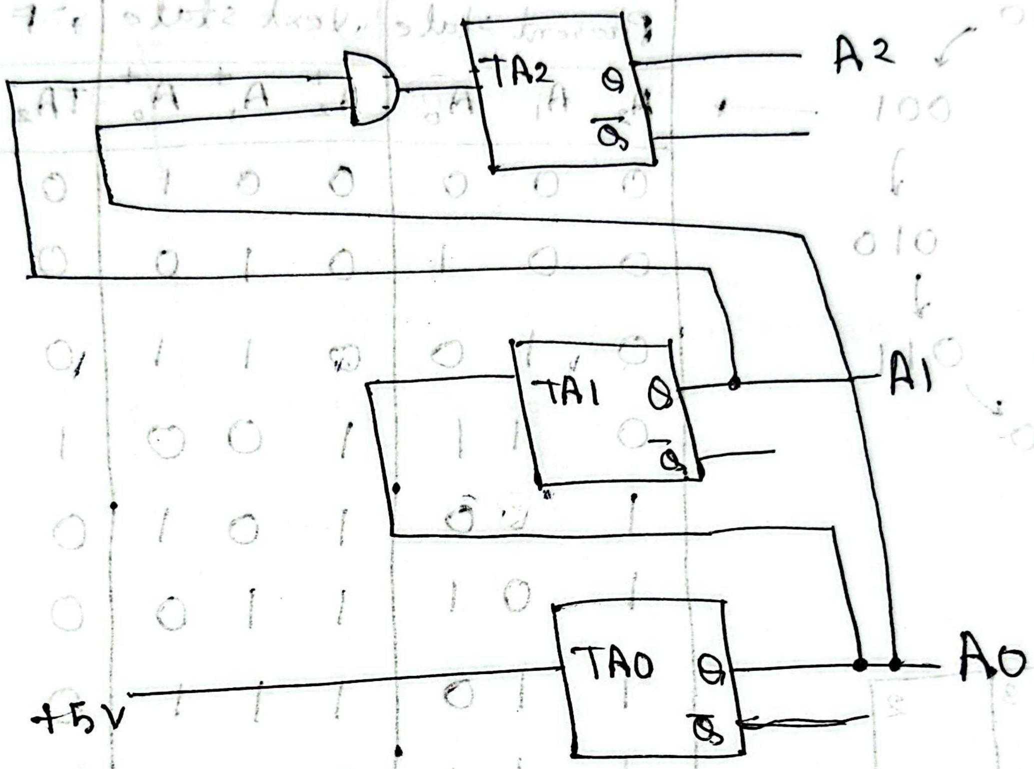
$TA_1 = A_0$

A_2 \ A1A0				
A_2'	(0) 1	(1) 1	(3) 1	(2) 1
A_2	(4) 1	(5) 1	(7) 1	(6) 1

$TA_0 = 1$

Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

Excitation table of T f-f



Circuit Diagram

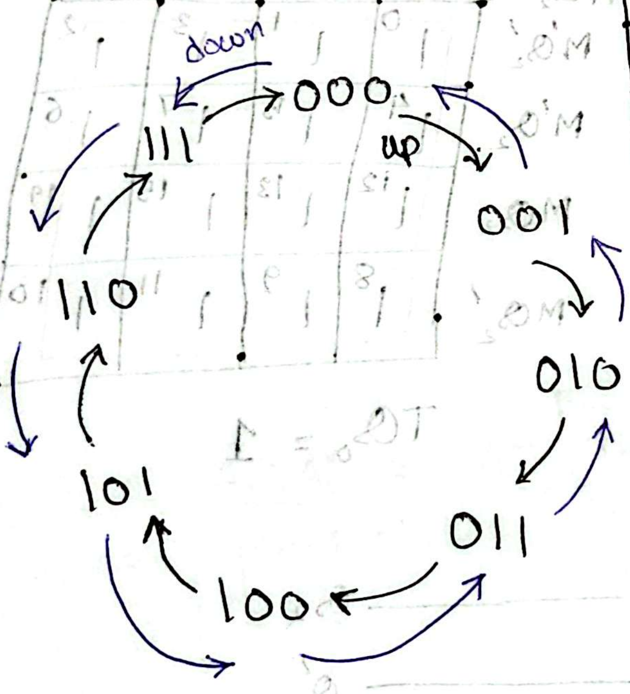
* DO 4-bit synchronous up counter.

UP/DOWN synchronous Counters

UP/DOWN = 0 → Count upward

UP/DOWN = 1 → Count downward

* 3 bit synchronous UP/DOWN Counter:



U/D	Present states			Next States			Flip-Flop inputs		
M	Q_2	Q_1	Q_0	Q_2^+	Q_1^+	Q_0^+	TQ_2	TQ_1	TQ_0
0	0	0	0	0	0	1	0	0	1
0	0	0	1	0	1	0	0	1	1
0	0	1	0	0	1	1	0	0	1
0	0	1	1	1	0	0	1	1	1
0	1	0	0	1	0	1	0	0	1
0	1	0	1	1	1	0	0	1	1
0	1	1	0	1	1	1	0	0	1
0	1	1	1	0	0	0	1	1	1
1	0	0	0	1	1	1	1	1	1
1	0	0	1	0	0	0	0	0	1
1	0	1	0	0	0	1	0	1	1
1	0	1	1	0	1	0	0	0	1
1	1	0	0	0	1	1	1	1	1
1	1	0	1	1	0	0	0	0	1
1	1	1	0	1	0	1	0	1	1
1	1	1	1	1	1	0	0	0	1

Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

$MQ_2 \backslash Q_1Q_0$	$Q_1'Q_0'$	$Q_1'Q_0$	Q_1Q_0	Q_1Q_0'
$M'Q_2'$	(0)	(1)	(3) 1	(2)
$M'Q_2$	(4)	(5)	(7) 1	(6)
MQ_2	(12) 1	(13)	(15)	(14)
MQ_2'	(8) 1	(9)	(11)	(10)

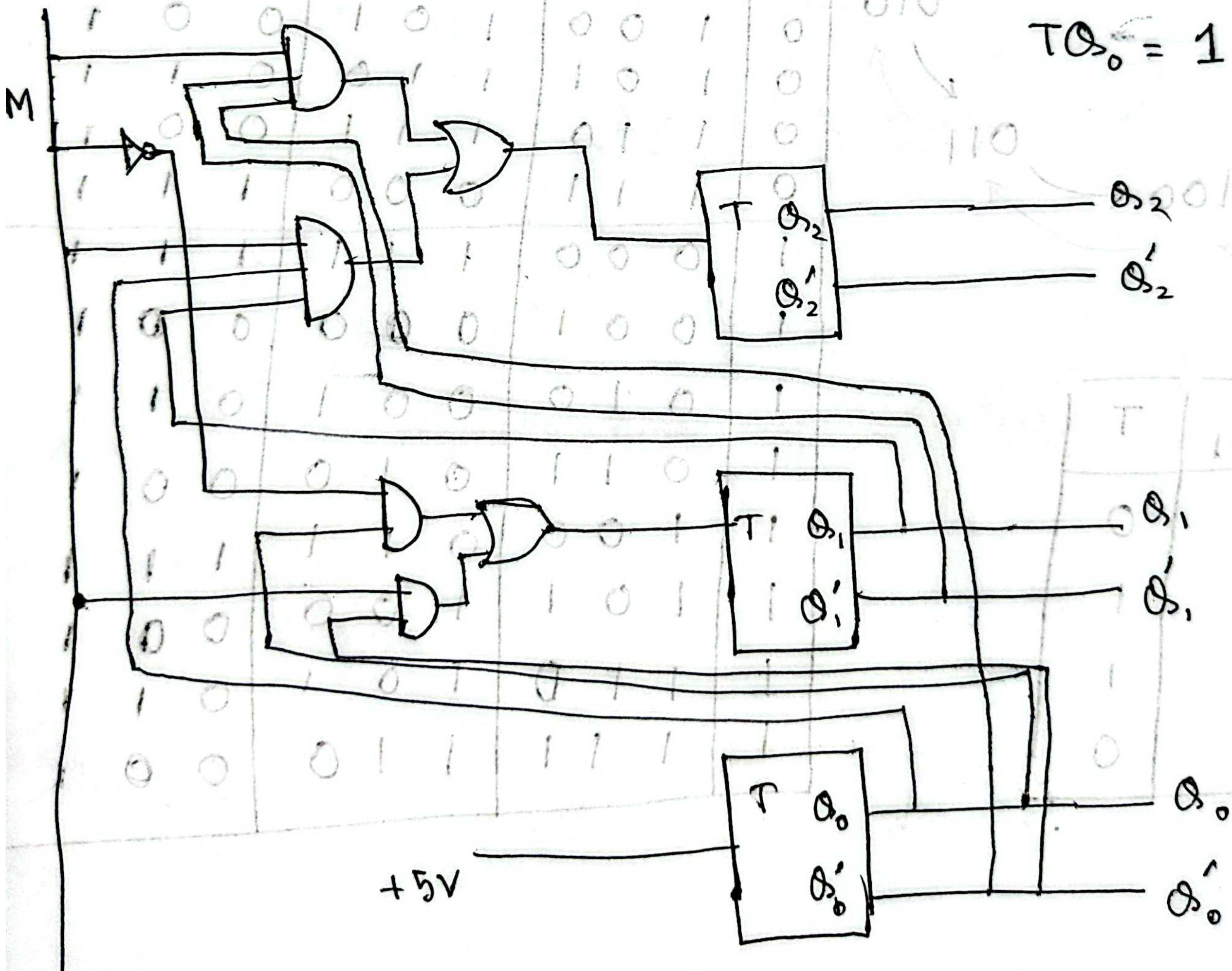
$$TQ_2 = MQ_1Q_0 + MQ_1'Q_0'$$

$MQ_2 \backslash Q_1Q_0$	$Q_1'Q_0'$	$Q_1'Q_0$	Q_1Q_0	Q_1Q_0'
$M'Q_2'$	(0)	(1) 1	(3) 1	(2)
$M'Q_2$	(4)	(5) 1	(7) 1	(6)
MQ_2	(12) 1	(13)	(15)	(14) 1
MQ_2'	(8) 1	(9)	(11)	(10) 1

$$TQ_1 = M'Q_0 + MQ_0'$$

$MQ_2 \backslash Q_1Q_0$				
$M'Q_2'$	(0) 1	(1) 1	(3) 1	(2) 1
$M'Q_2$	(4) 1	(5) 1	(7) 1	(6) 1
MQ_2	(12) 1	(13) 1	(15) 1	(14) 1
MQ_2'	(8) 1	(9) 1	(11) 1	(10) 1

$$TQ_0 = 1$$

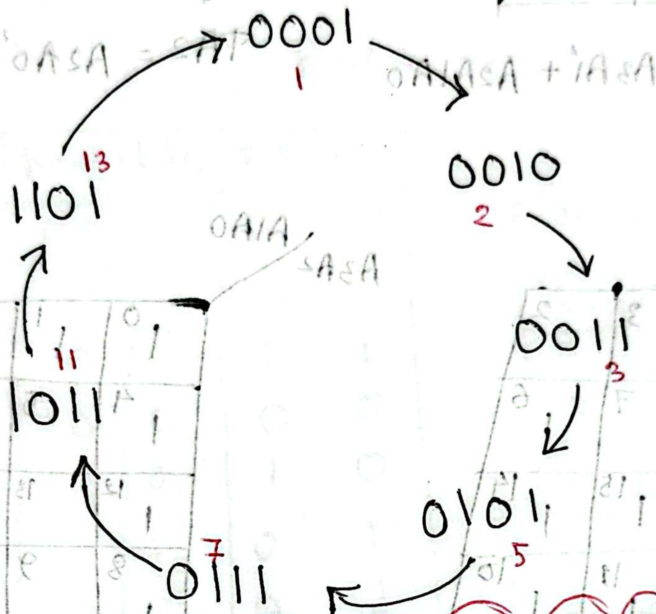


Circuit Diagram

Implement the following counter using TFF:

$1 \rightarrow 2 \rightarrow 3 \rightarrow 5 \rightarrow 7 \rightarrow 11 \rightarrow 13 \rightarrow 1$

↳ 4 bit



Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

Excitation table of T flip-flop

Present states				Next states				Flip-flop inputs			
A_3	A_2	A_1	A_0	A_3^+	A_2^+	A_1^+	A_0^+	TA_3	TA_2	TA_1	TA_0
0	0	0	0	0	0	0	1	0	0	0	1
0	0	0	1	0	0	1	0	0	0	1	1
0	0	1	0	0	0	1	1	0	0	0	1
0	0	1	1	0	1	0	1	0	1	1	0
0	1	0	0	0	0	0	1	0	1	0	1
0	1	0	1	0	1	1	1	0	0	1	0
0	1	1	0	0	0	0	1	0	1	1	1
0	1	1	1	1	0	1	1	1	1	0	0
1	0	0	0	0	0	0	1	1	0	0	1
1	0	0	1	0	0	0	1	1	0	0	0
1	0	1	0	0	0	0	1	1	0	1	1
1	0	1	1	1	1	0	1	0	1	1	0
1	1	0	0	0	0	0	1	1	1	0	1
1	1	0	1	0	0	0	1	1	1	0	0
1	1	1	0	0	0	0	1	1	1	1	1
1	1	1	1	0	0	0	1	1	1	1	0

For not mentioned state
↳ use 0001 (Initial state)

[OR Don't care Use]
XXXX

$A_3A_2 \backslash A_1A_0$	00	01	11	10
00	0	1	3	2
01	4	5	7: 1	6
11	12: 1	13: 1	15: 1	14: 1
10	8: 1	9: 1	11	10: 1

$$TA_3 = A_3A_0' + A_3A_1' + A_2A_1A_0$$

$A_3A_2 \backslash A_1A_0$	00	01	11	10
00	0	1	3: 1	2
01	4: 1	5	7: 1	6: 1
11	12: 1	13: 1	15: 1	14: 1
10	8	9	11: 1	10

$$TA_2 = A_2A_0' + A_3A_2 + A_1A_0$$

$A_3A_2 \backslash A_1A_0$	00	01	11	10
00	0	1: 1	3: 1	2
01	4	5: 1	7	6: 1
11	12	13	15: 1	14: 1
10	8	9	11: 1	10: 1

$$TA_1 = A_3'A_1'A_0 + A_3'A_2'A_0$$

$$+ A_2A_1A_0' + A_3A_1$$

$A_3A_2 \backslash A_1A_0$	00	01	11	10
00	0: 1	1: 1	3	2: 1
01	4: 1	5	7	6: 1
11	12: 1	13	15	14: 1
10	8: 1	9	11	10: 1

$$TA_0 = A_0' + A_3'A_2'A_1'$$

Then DRAW the Circuit →

(If we need to go in 3 or more states we need 2 or more inputs like x)

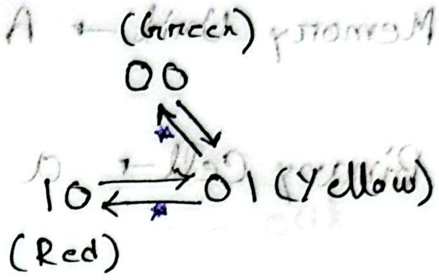
Implement the following counter using DFF:

Green (00) → Yellow (01) → Red (10) → Yellow (01) → Green (00).

Let's assume: Green 00

Yellow 01

Red 10



x A B → then x, AB in K-MAP

Present states			Next states		F-F inputs	
A	B	x	A^+	B^+	DA	DB
0	0	0	0	1	0	1
0	0	1	0	1	0	1
0	1	0	0	0	0	0
0	1	1	1	0	1	0
1	0	0	0	1	0	1
1	0	1	0	1	0	1
1	1	0	X	X	X	X
1	1	1	X	X	X	X

Excitation table of D-FF

Q_n	Q_{n+1}	D
0	0	0
0	1	1
1	0	0
1	1	1

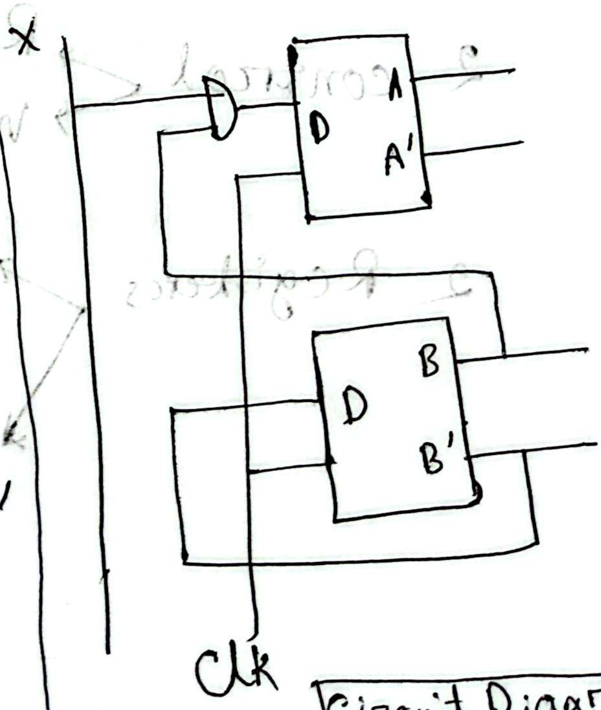
We have used don't care XX

A \ Bx	B'x'	B'x	Bx	Bx'
A'	(0)	(1)	(3) 1	(2)
A	(4)	(5)	(7) X	(6) X

$DA = Bx$

A \ Bx	B'x'	B'x	Bx	Bx'
A'	(0) 1	(1) 1	(3)	(2)
A	(4) 1	(5) 1	(7) X	(6) X

$DB = B'$



Circuit Diagram