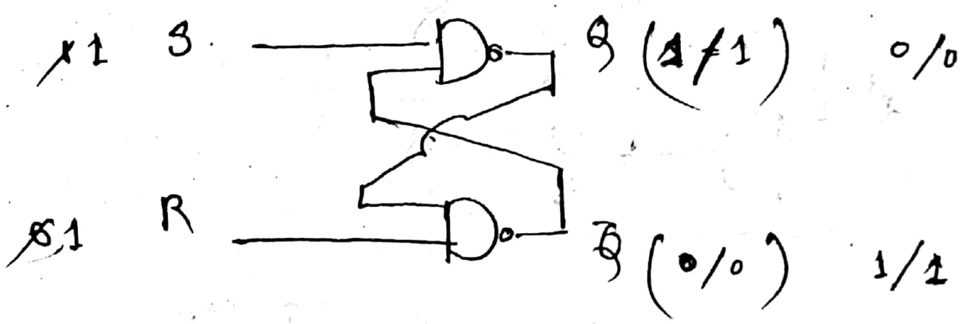
Sequential Circuits

03.28.23

NAND min 1 zero output 1

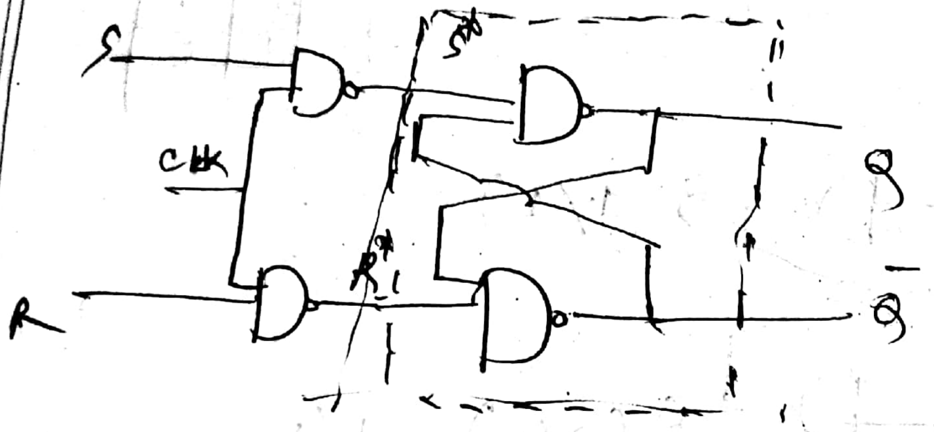
0	0	1
0	1	1
1	0	1
1	1	0



SR Latch using NAND

S	R	Q	Q'
0	0	Impossible	
0	1	1	0
1	0	0	1
1	1	0	1 [Memory/No change]

S-R Flip flop



if $\boxed{Clk = 1}$

S = Set
R = Reset

$S^* = (S \cdot Clk)' = S' + Clk'$

$R^* = (R \cdot Clk)' = R' + Clk'$

$S^* = S' + 1' = S' + 0 = S'$

$R^* = R' + 1' = R' + 0 = R'$

NAND

A	B	out
0	0	1
0	1	1
1	0	1
1	1	0

we got,

$S^* = S'$

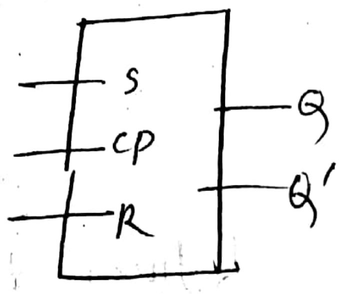
$R^* = R'$

used in latch

S	R	S*	R*	Q	Q'
0	0	1	1	Memory/ No change	
0	1	1	0	0	1
1	0	0	1	1	0
1	1	0	0	Not used	

SR F.F

S	R	Q	Q'
0	0	Memory/ No change	
0	1	0	1
1	0	1	0
1	1	Not used	



Block Diagram

* Characteristics Table

Present step

Next step

Q(t)	S	R	Q(t+1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	indeterminate
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

→ Memory / No change (Next step = Present)

* Check S R from SR. FF Truth table & Q(t+1) acc. Q(t)
↳ is Q from FF.

(*) Excitation table

PS Q	FS Q^+	S	R
0	0	0	x
0	1	1	0
1	0	0	1
1	1	x	0

D flip flop

D	Q	Q'
0	0	1
1	1	0

from flip flop table excluding 1st & last row

D flip flop Charac

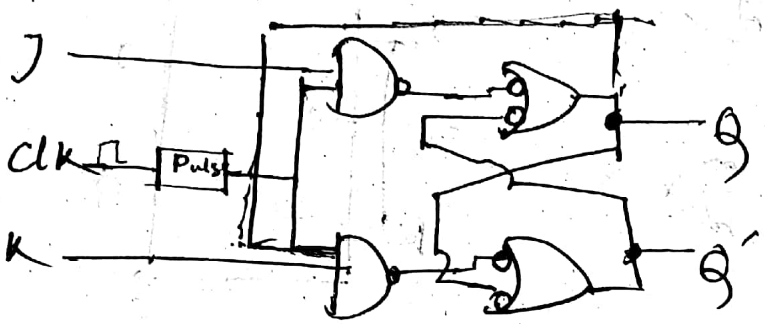
Q(t)	D	Q (t+1)
0	0	0
0	1	1
1	0	0
1	1	1

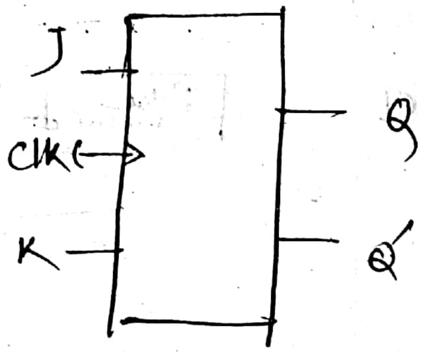
(*) Excitation

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

J-K flip flop

* Jack kilbye





Truth table

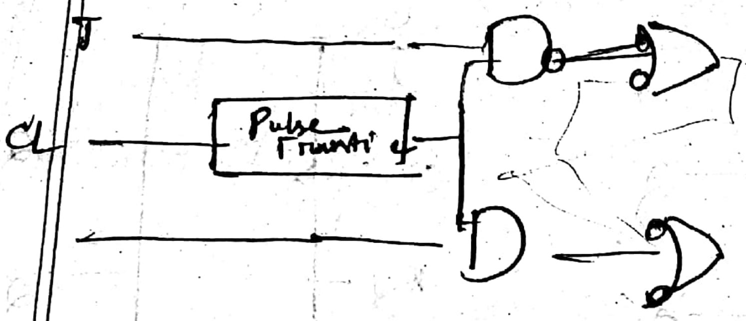
J	K	Q	Q'
0	0	Memory	No Change
0	1	0	1
1	0	1	0
1	1	Toggle	Toggle

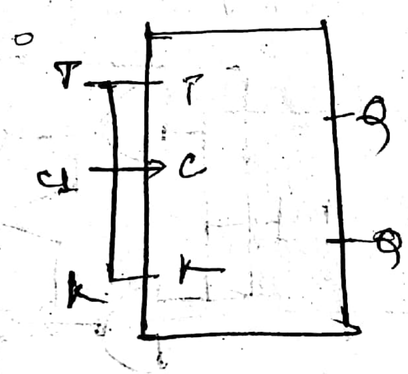
Characteristic

Q	J	K	Q(t+1)
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

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

T-flip flop





excitation

P.S Q	N.S Q^+	FF,IT T
0	0	0.
0	1	1.
1.	0	1
1	1.	0

truth table

T	Q	Q'
0	No Change	
1	Toggle	

Characteristic

Sequential Circuit Analysis

Circuit Diagram to State Diagram !

① **Present Sates :** A & B **Next step :** A^+ & B^+

Input : DA , DB , x **Output :** y

equations :

②
$DA = Ax + Bx$

$DB = A'x$

$y = (A+B)x'$

③ state table

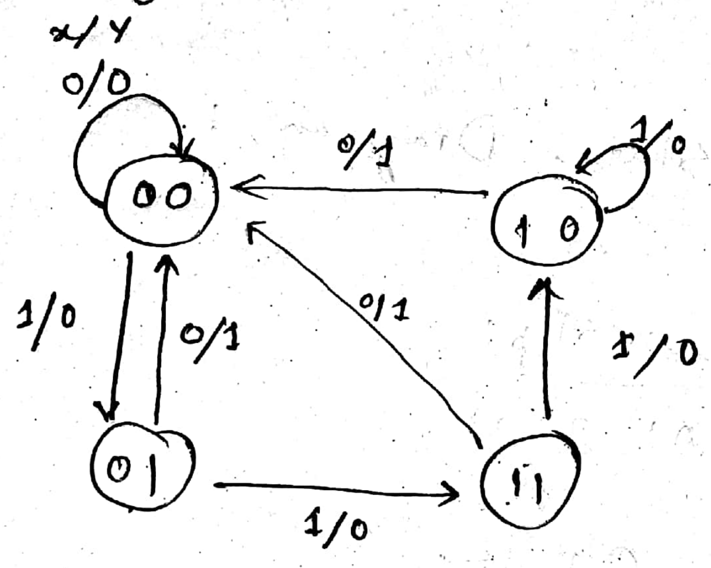
A	B	x	DA	DB	y	A+	B+
0	0	0	0	0	0	0	0
0	0	1	0	1	0	0	1
0	1	0	0	0	1	0	0
0	1	1	1	1	0	1	1
1	0	0	0	0	1	0	0
1	0	1	1	0	0	1	0
1	1	0	0	0	1	0	0
1	1	1	1	0	0	1	0

t.t for D f.f

Next step

D	Q
0	0
1	1

④ diagram :



④ Using JK

① Present States — A & B

Next States — A+ B+

Input :

JA , KA , JB , KB , x

② equations :

$JA = B$

$KA = Bx'$

$JB = x'$

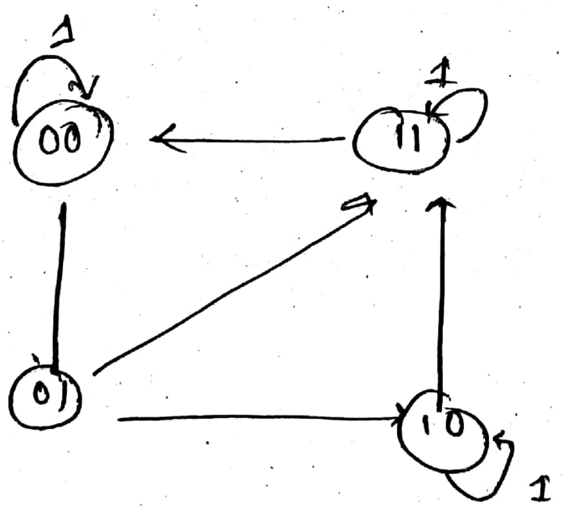
$KB = A \oplus x$

③ State table

Inputs			Present States				Next States	
A	B	x	JA	KA	JB	KB	A+	B+
0	0	0					0	1
0	0	1					0	0
0	1	0					1	1
0	1	1					1	0
1	0	0					1	1
1	0	1					1	0
1	1	0					0	0
1	1	1					1	1

T.T. of JK flipflop.

④



State Diagram to Circuit Diagram

Present state		Input	Next State		F.F. inputs			
A	B	x	A+	B+	JA	KA	JB	KB

kmaps

~~input ff function:~~

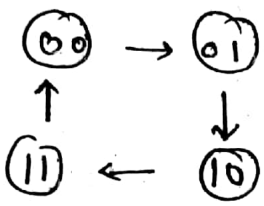
$JA = B.x'$ $JB = x$

$KA = B.x$ $KB = (A \oplus x)'$

Logic Diagram:

Counters:

① Synchronous (2bit) ②



P.S		N.S		F.F. input	
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

③

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

excitatio t. of T.ff.

④ $TA_1 = 0$

$TA_0 = 1$

present state would be kmap input

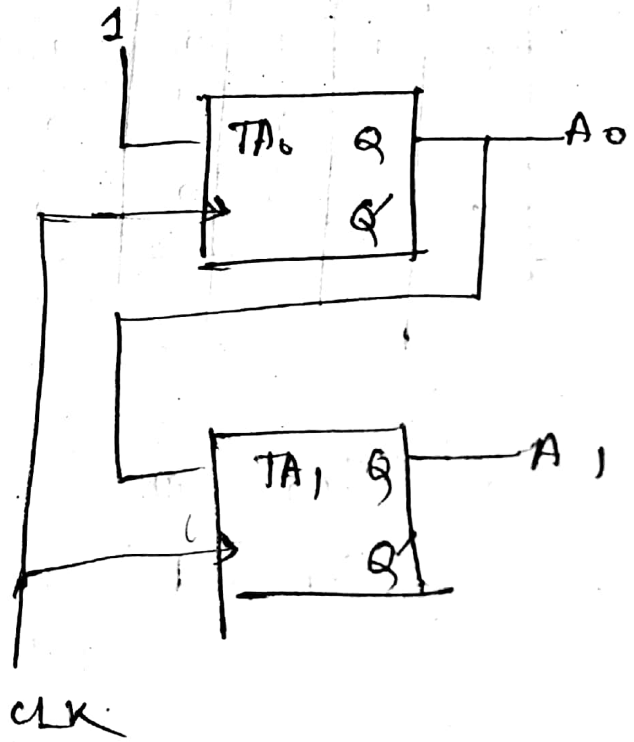
	A0'	A0
A1'		
A1		

Quiz 4 on
slide 29

$TA_1 = A_1' A_0 + A_1 A_0$

$= A_0$

$TA_0 = 1$



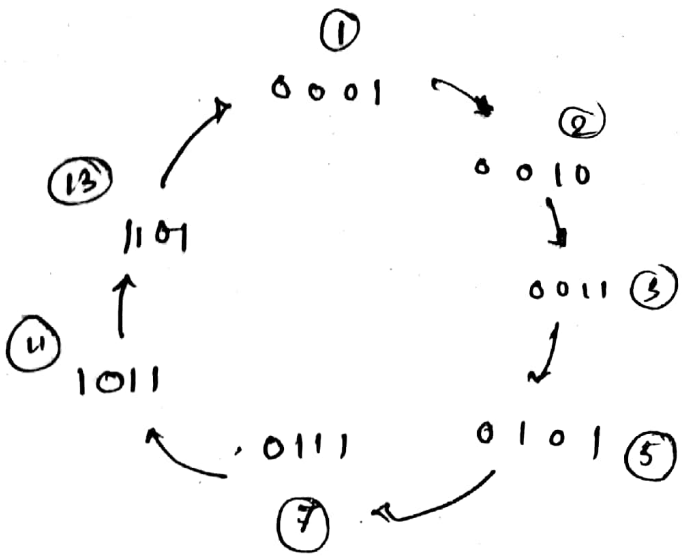
- JK sorted = T flipflop
- Up Counter
- Down Counter (3 bit)
- Synchronous Up/Down

Slide 30

3 bit Synchronous Up/Down Counter

Implementation counter T.FF

1 → 2 → 3 → 5 → 7 → 11 → 13 → 1



excitation

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

state table

present state				Next states				Flipflop ins			
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	0	1	0	0	1	0	0			
0											
0											
0											
0											
0											
0											
1											
1											
1											
1											
1											
1											
1											
1											

Imp prac slide

Draw Circuits for kmap functions :

00 $\quad \boxed{01 \rightarrow 10} \quad \boxed{01 \rightarrow 00}$

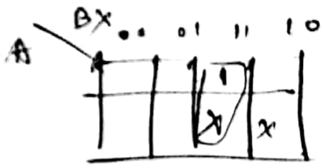
Green → Yellow → Red → Yellow → Green

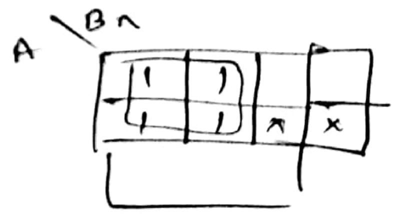
00 → 01
01 → 10/00
10 → 01

Present	States		Next State		FF D	
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 D f.f

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





1 state → 3rd state

external input 2 {x, y}

$2^4 = 16$ possible combination.