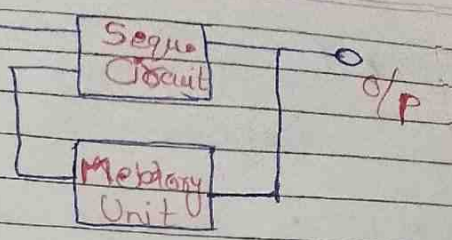
UNIT - 4

"SEQUENCIAL CIRCUIT"

Date: / / Page No.:

★ Sequencial circuit :-



★ Combinational Circuit :-

Assignment Ques.

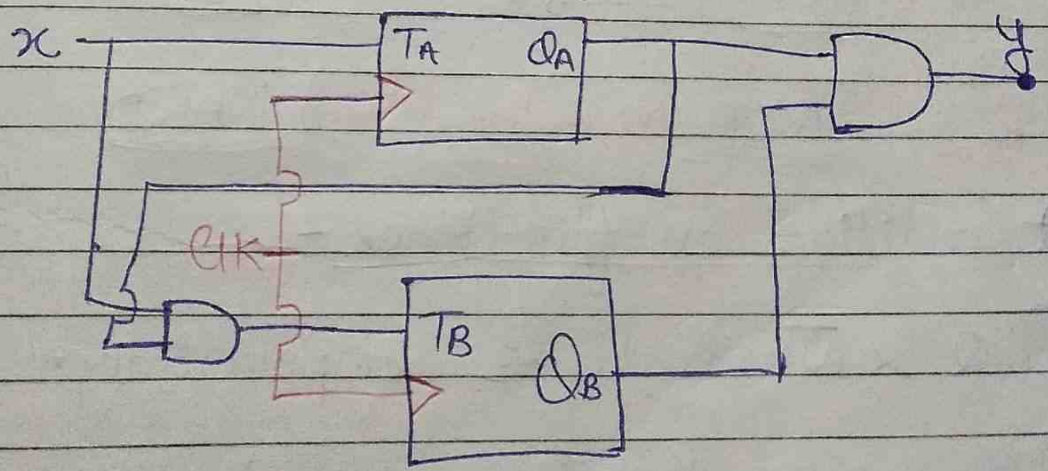
Que. 1 Write the difference b/w sequencial & combination circuit.

Que. 2 Describe clocked R.S Flip-flop.

Que. 3 Write a short note on Race around condition.

Que. 4 Same → analysis of T flip-flop.

State diagram bhi bnana hai



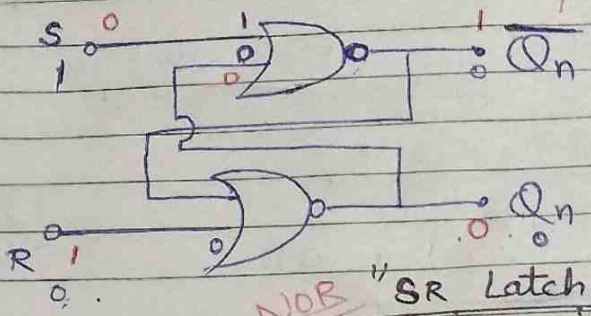
NEW STARTED

Chapter - 4
Sequential Circuit

Date 24 01 23 Page No.

★ SR Latch with NOR Gate :-

NOR		
0	0	1
0	1	0
1	0	0
1	1	0



(S → $\overline{Q}$, R → Q)

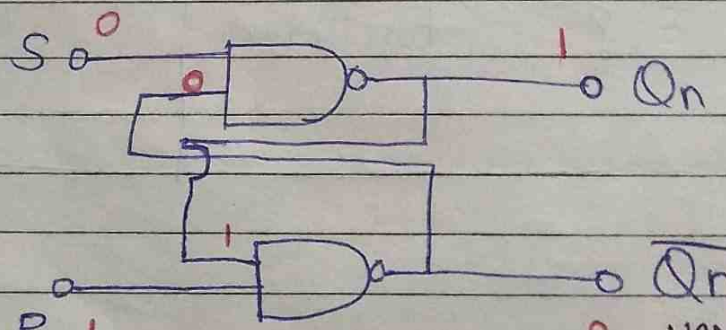
"SR Latch Table"

NOR Latch

S	R	Q_n
0	0	Last value
0	1	0
1	0	1
1	1	Invalid

★ SR Latch with NAND Gate :-

NAND		
0	0	1
0	1	1
1	0	1
1	1	0



(S → Q_n , R → $\overline{Q_n}$) (X = Invalid / ~~Last~~ / ~~Value~~)

NAND Latch

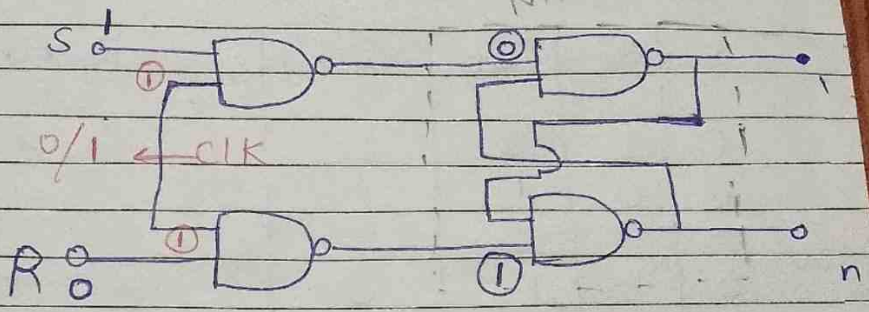
S	R	Q_n
0	0	Invalid
0	1	1
1	0	0
1	1	Last value

Truth Table Same Hai

Date: / / Page No.:

★ SR FlipFlop with NAND Latch -

NAND		
0	0	1
0	1	1
1	0	1
1	1	0



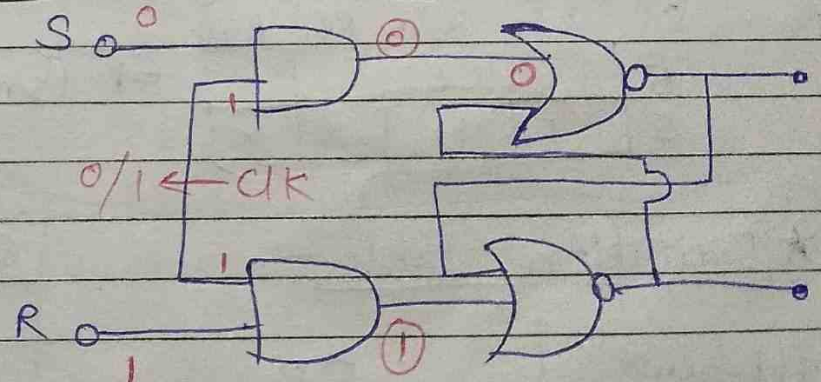
NAND Batch		
0	0	Invalid
0	1	1
1	0	0
1	1	Last value

Truth Table

CLK	S	R	Qn
0	X	X	Qn
1	0	0	Last value
1	0	1	0
1	1	0	1
1	1	1	X

★ SR FlipFlop with NOR Latch -

AND		
0	0	0
0	1	0
1	0	0
1	1	1



NOR Latch

S	R	Qn
0	0	Last Value
0	1	0
1	0	1
1	1	Invalid

Same Truth Table !

★ Characteristic Table :-

S	R	Qn	Qn+1
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
0	1	0	Invalid
1	1	1	Invalid

No Use Indirectly

~~K-Map~~

S R

0 0 → Last value
- 0 → 0
- 1 → 0

0 1 → 0

1 0 → 1

1 1 → X (Invalid)

▸ K-Map :-

S \ RQn	$\bar{R}Q_n$	$\bar{R}\bar{Q}_n$	RQ_n	$R\bar{Q}_n$
$\bar{S}$		1		
S	1	1	X	X

$\Rightarrow Q_{n+1} = S + \bar{R}Q_n$

★ Excitation Table :-

Reference → Characteristic Table of Q_n, Q_{n+1}

SR Flip Flop with NAND (OR) NOR Latch

Qn	Qn+1	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

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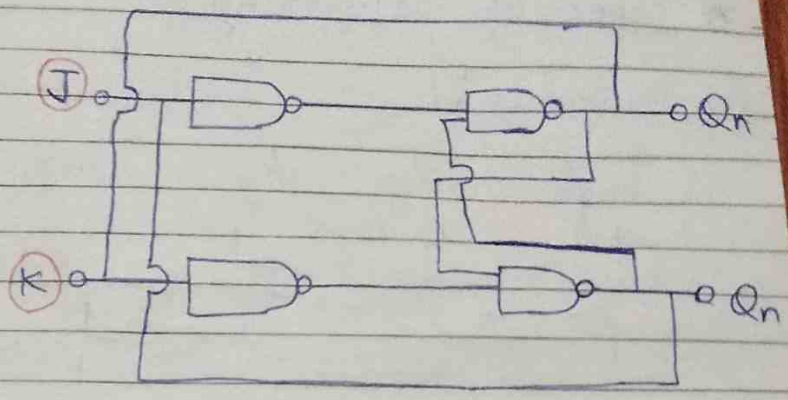
★ JK Flip Flop –

"Truth Table"

J	K	Qn
0	0	Last value
0	1	0
1	0	1
1	1	$\overline{Q_n}$



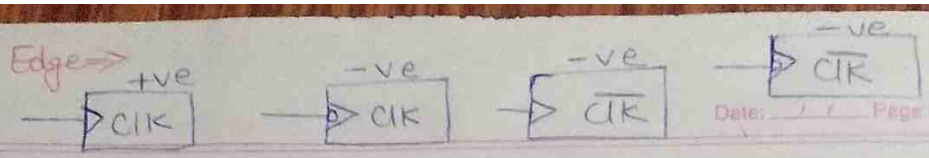
"Characteristic Table"

J	k	Qn	Qn+1
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

"Exitation Table"

Qn	Qn+1	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

$$Q_{n+1} = \bar{K}Q_n + J\bar{Q}_n$$



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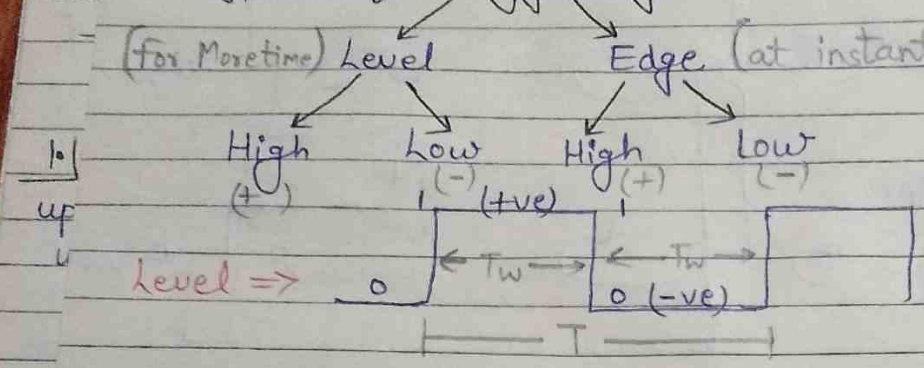
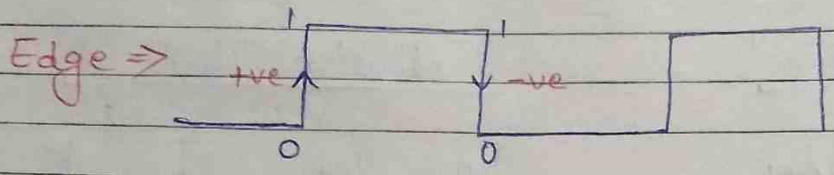
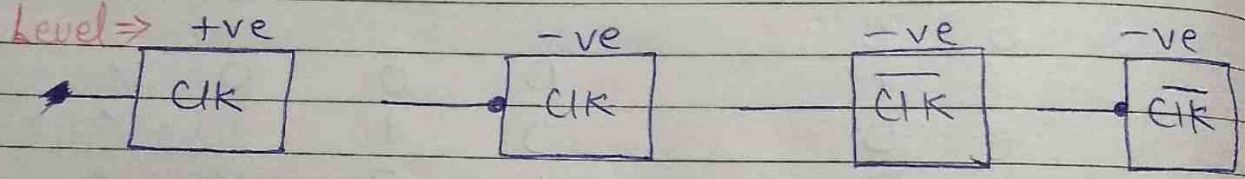
★ Types of Triggering –







★ Race Around Condition –

1. Level Triggered
2. J=K=1 (Toggle)
3. Tw >> Td (Time taken by flip-flop in proceed)

All three should happen at same Time!

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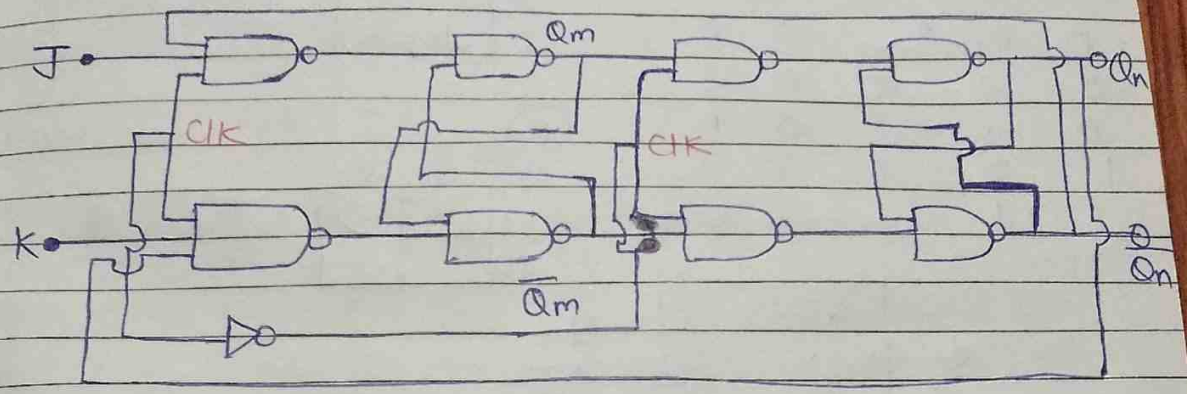
★ Master Slave flip-flop :-



Convert → SR → D

Characteristic Table of D

D	Qn	Qn+1
0	0	0
0	1	0
1	0	1
1	1	1

Exitation Table of SR

Qn	Qn+1	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

- Step:1 - Charac. Table of D (Required)
- Step:2 - Exitation Table of SR (Required)
- Step:3 - Merge
- Step:4 - K-Map of S & R.
- Step:5 - Block Diagram.

Date: / / Page No.:

★ Merge -

D	Qn	Qn+1	S	R
0	0	0	0	x
0	1	0	0	1
1	0	1	1	0
1	1	1	x	0

S

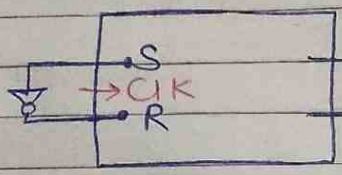
D \ Qn	$\bar{Q}_n$	Q_n
D		
$\bar{D}$		
0	1	x

$S = D$

R

D \ Qn	$\bar{Q}_n$	Q_n
D		
$\bar{D}$	x	x
0		

$R = \bar{D}$



← Block Diagram

• Convert SR → JK -

"Charac. Table of T"

T	Qn	Qn+1
0	0	0
0	1	1
1	0	1
1	1	0

"Exitation of SR"

Qn	Qn+1	S	R
0	0	0	x
0	1	1	0
1	0	0	1
1	1	x	0

★ Merge -

T	Qn	Qn+1	S	R
0	0	0	0	x
0	1	1	x	0
1	0	1	1	0
1	1	0	0	1

S

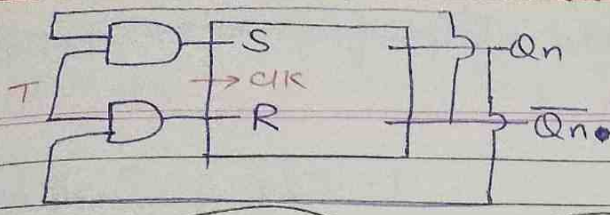
T \ Qn	$\bar{Q}_n$	Q_n
T		
$\bar{T}$		K
T	1	

$S = T\bar{Q}_n$

R

T \ Qn	$\bar{Q}_n$	Q_n
T		
$\bar{T}$	x	
T		1

$R = TQ_n$



(Diagram of previous Page)

Date: / /

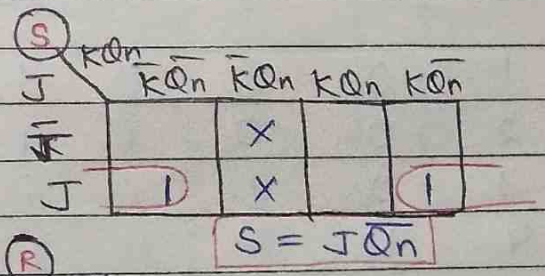
★ Convert SR → JK :-

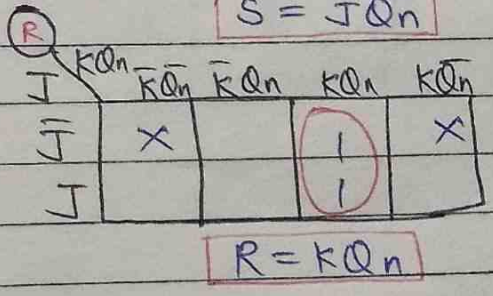
"Charac. Table of JK"

J	K	Qn	Qn+1
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

"Exitation Table of S.R"

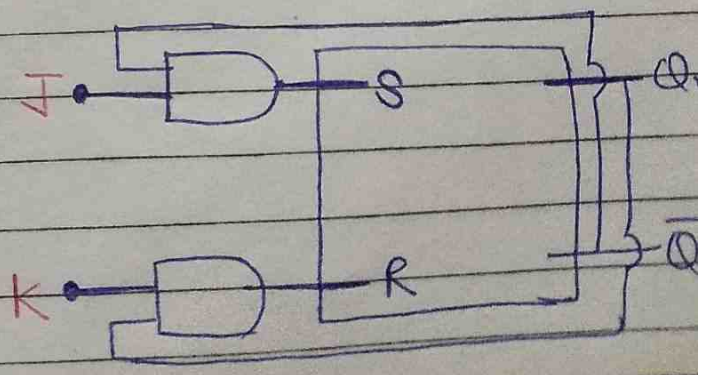
Qn	Qn+1	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0





★ Merge :-

J	K	Qn	Qn+1	S	R
0	0	0	0	0	X
0	0	1	1	X	0
0	1	0	0	0	X
0	1	1	0	0	1
1	0	0	1	1	0
1	0	1	1	X	0
1	1	0	1	1	0
1	1	1	0	0	1



[Register mai D flip-flop use hota hai]

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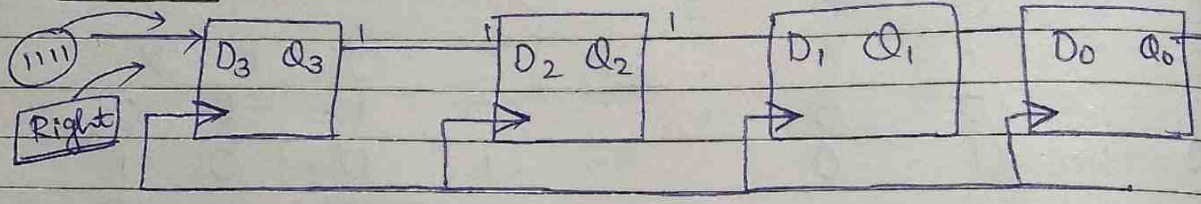
★ Register –

Left shift (×) Right shift (÷)

Multiple	Division
0001	1000
0010	0100
0100	0010
1000	0001

★ SISO – (Serial Input Serial Output)



CIK	D0	D1	D2	D3	Q0	Q1	Q2	Q3
1	0	0	0	1	0	0	0	1
2	0	0	1	1	0	0	1	1
3	0	1	1	1	0	1	0	0
4	1	1	1	1	1	1	1	1

CLK_S $\frac{+3}{n-1}$

Jitne bit hote hai utni hi bits lagti hai SISO mai
4bit = 4bit
nbit = nbit

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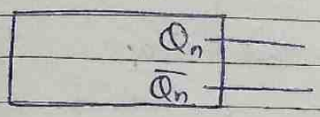
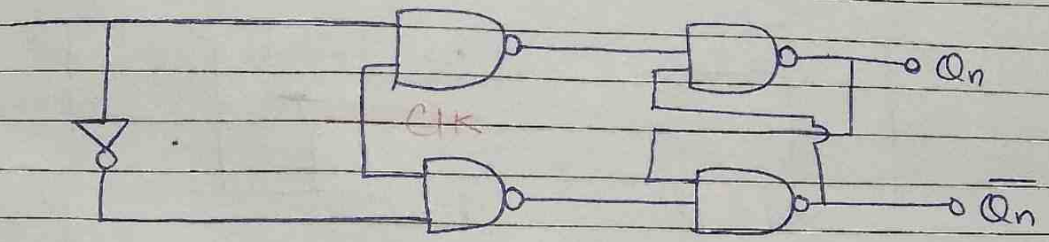
★ D Flip-flop :-





• Characteristic Table :-

D	Qn	Qn+1
0	0	0
0	1	0
1	0	1
1	1	1

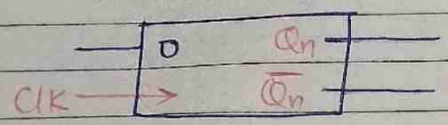
• Exitation Table :-

Qn	Qn+1	D
0	0	0
0	1	0
1	0	1
1	1	1

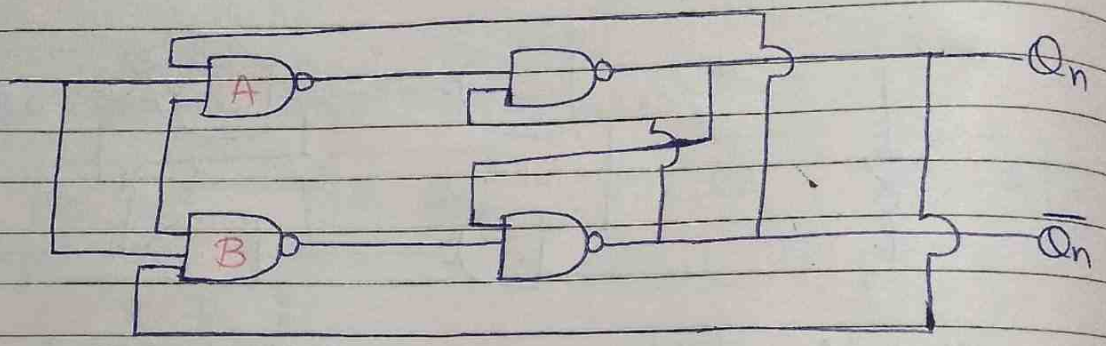
Character. eq. $\Rightarrow Q_{n+1} = D$

(Toggle flip-flop) (Same value pr change nhi hota)

★ T → flip-flop :-



T	Qn
0	Qn
1	Q̄n



★ Characteristic Table :-

T	Qn	Qn+1
0	0	0
0	1	1
1	0	1
1	1	0

★ Exitation Table :-

Qn	Qn+1	T
0	0	0
0	1	1
1	0	1
1	1	0

★ $Q_{n+1} = T\bar{Q}_n + Q_n\bar{T}$

S = Serial
P = Parallel

"Charac. Table Samj lo"

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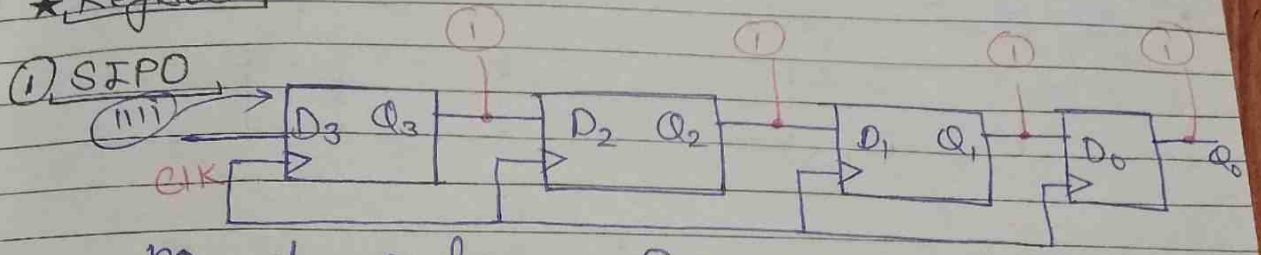
★ Register

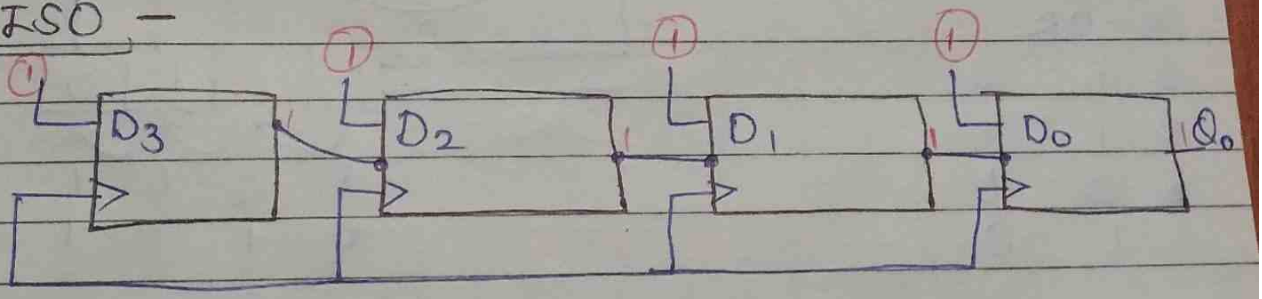
① SIPO



no. of cycle = 0

CLK	D_0	D_1	D_2	D_3	Q_0	Q_1	Q_2	Q_3
1	0	0	0	1	0	0	0	1
2	0	0	1	1	0	0	1	1
3	0	1	1	1	0	1	1	1
4	1	1	1	1	1	1	1	1

② PISO –



no. of cycle required = n-1

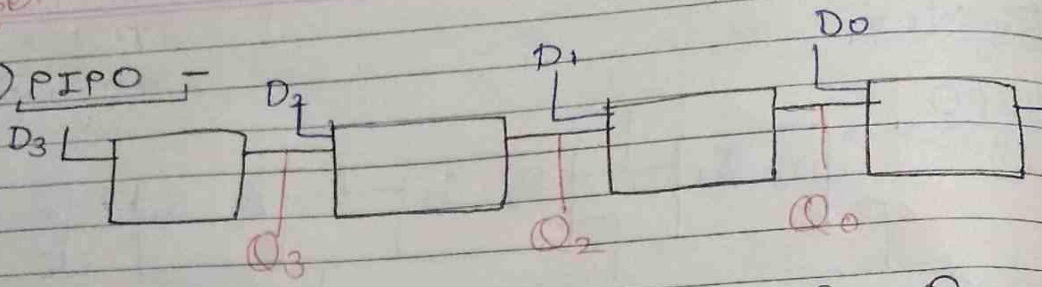
CLK	D_0	D_1	D_2	D_3	Q_0	Q_1	Q_2	Q_3
①	1	1	1	1	1	1	1	1

Que. in Paper (Flip-flop, register, convertion)

Date: / / Page No.

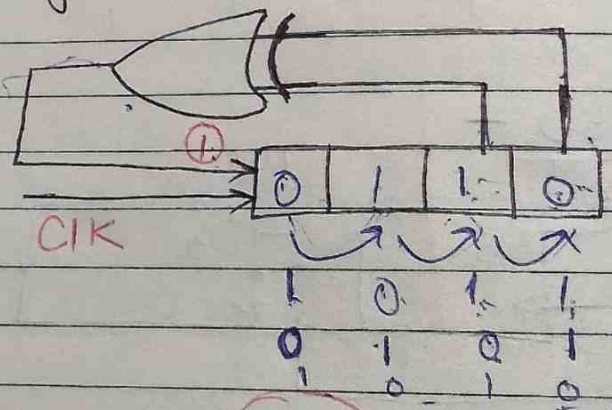
6 Mark

③ PIPO –



	CIK,	D_0	D_1	D_2	D_3	Q_0	Q_1	Q_2	Q_3
	①	1	1	1	1	1	1	1	1

Que. In a 4 bit right-shift register how many clock pulses are required to change the content of register **all 1**.



X-OR

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

CIK,	1	0	1	1
CIK_2	0	1	0	1
CIK_3	1	0	1	0
CIK_4	1	1	0	1
CIK_5	1	1	1	0
CIK_6	1	1	1	1

(6) Ans.

M.E* ★★★★★ "Confirm"

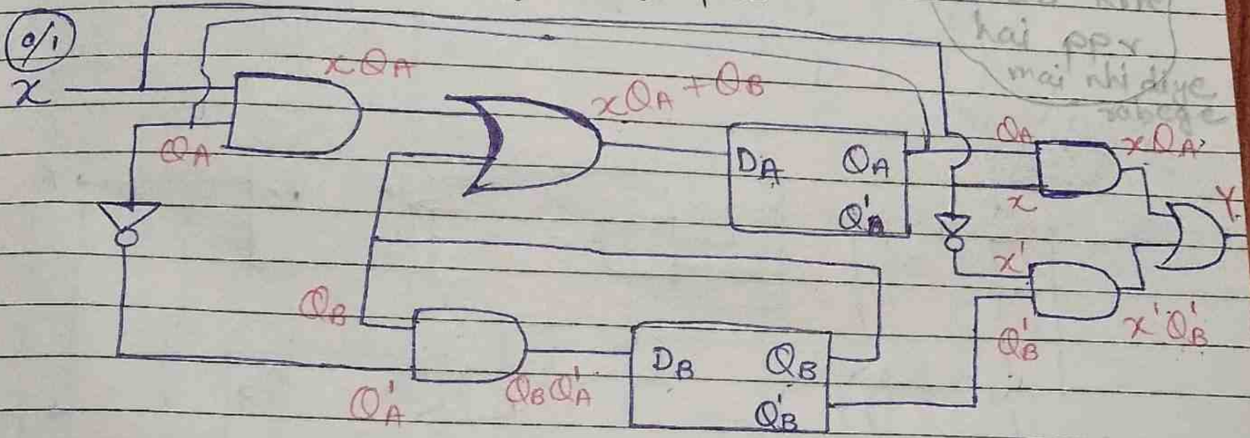
6 Marks Que in exam

Hold mai Jo value phle hai vahi rahegi

Red Pen wale terms Yaad krne hai ppr mai nhi diye rahenge

★ Analysis of sequencial circuit :-

- Analysis of D-flip-flop :-



i/p ⇒ $D_A = xQ_A + Q_B$

$D_B = Q_B \cdot Q_A'$

$D_A = Q_A^+$
$D_B = Q_B^+$

o/p ⇒ $y = xQ_A + x'Q_B'$

D_{ff}

★ State Table

Q_A	Q_B	x	D_A	D_B	Q_A^+	Q_B^+	y
0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0
0	1	0	1	1	1	1	0
0	1	1	1	1	1	1	
1	0	0	0				
1	0	1	1				
1	1	0	1				
1	1	1	1				

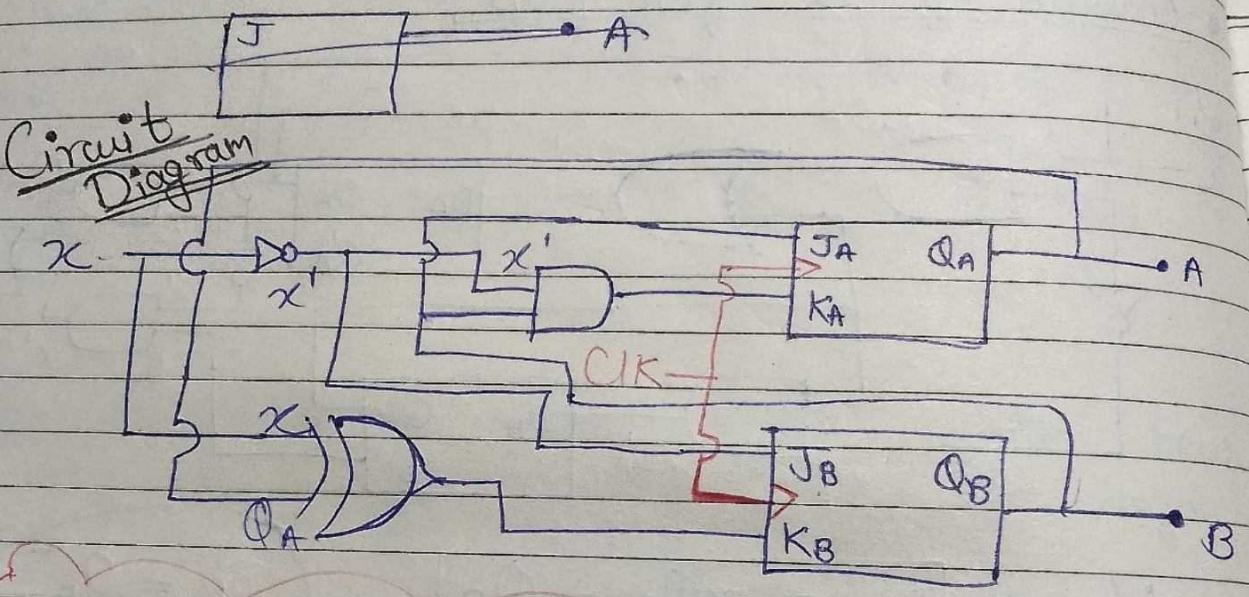
[Circuit Diagram aaega only]
Circuit alag aa skta hai

Page No. 07/02/2

Confirm in ppr

★ Analysis with JK flip-flop :-

Circuit Diagram



$J_A = Q_B$

$K_A = x'Q_B = K_A = x'J_A$

$J_B = x'$

$K_B = x \oplus Q_A = x'Q_A + xQ_A'$

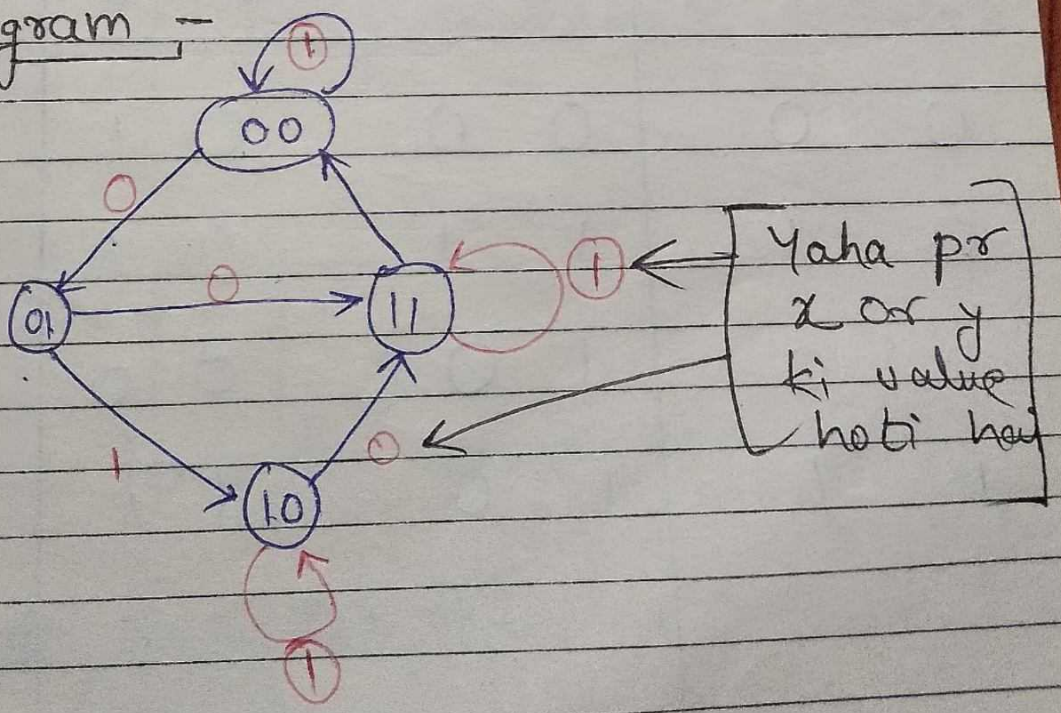
2/23

Q_A^+ / Q_B^+ Par hi change aaega acc. To flip-flop (Jo bhi flip-flop use ke hisab se)

▸ State Table

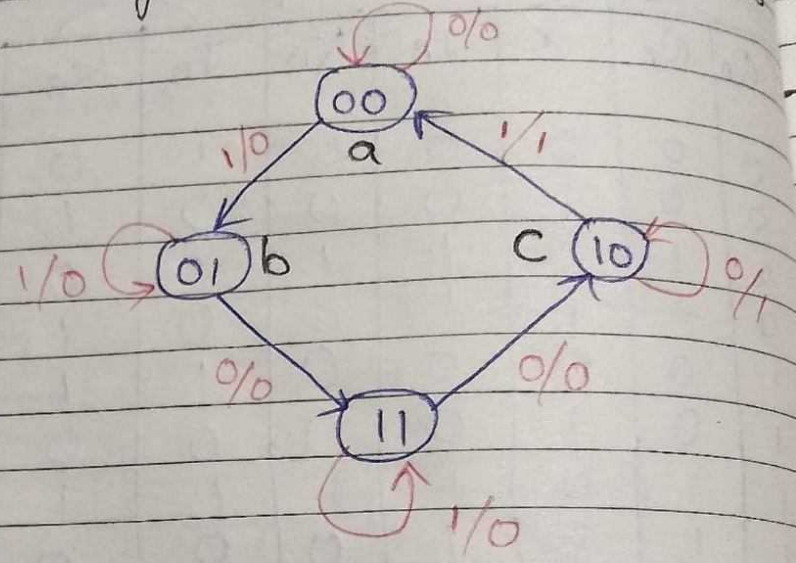
Q_A	Q_B	x	J_A	K_A	J_B	K_B	Q_A^+	Q_B^+
0	0	0	0	0	1	0	0	1
0	0	1	0	0	0	1	0	0
0	1	0	1	1	1	0	1	1
0	1	1	1	0	0	1	1	0
1	0	0	0	0	1	1	1	1
1	0	1	0	0	0	0	1	0
1	1	0	1	1	1	1	0	0
1	1	1	1	0	0	0	1	1

★ State Diagram :-



Date: / / Page No.:

Que. Reserve of analysis of sequicial circuit.



Present State Q_A Q_B	Next State $x=0$ Q_A^+ Q_B^+	Next State $x=1$ Q_A^+ Q_B^+	O/P (y) $x=0$	O/P (y) $x=1$
0 0	0 0	0 1	0	0
0 1	1 1	0 1	0	0
1 0	1 0	0 0	1	1
1 1	1 0	1 1	0	0

circuit.

Date: / / Page No.:

• Find circuit excitation Table, -

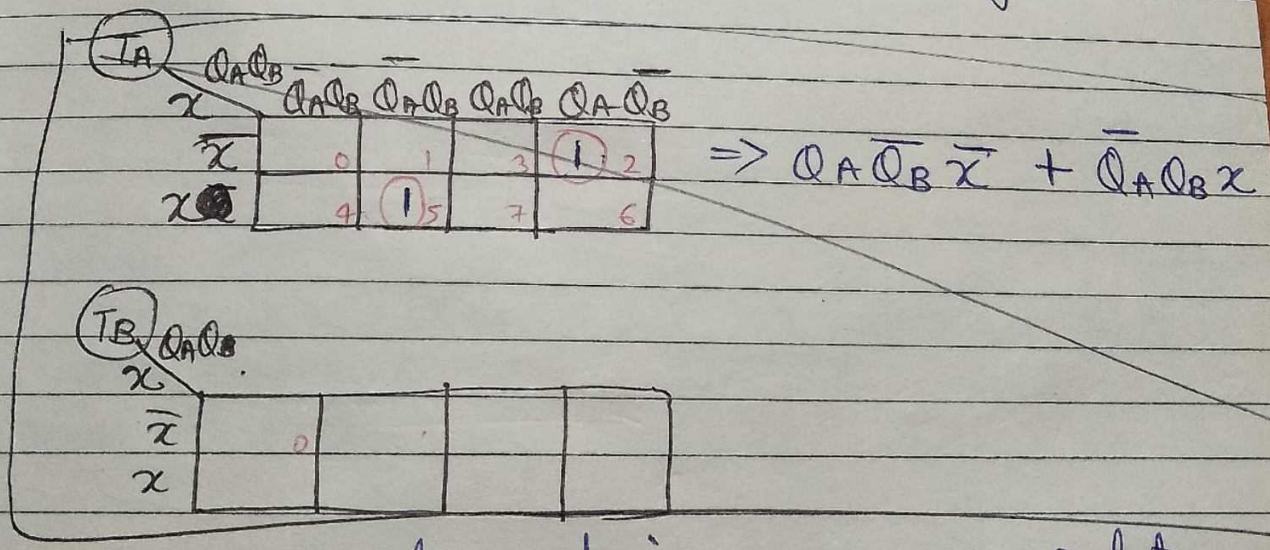
▸ Excitation Table -

Q_A	Q_B	x	Q_A^+	Q_B^+	T_A	T_B	y
0	0	0	0	0	0	0	0
0	0	1	0	1	1	1	0
0	1	0	1	1	2	0	0
0	1	1	0	1	3	0	0
1	0	0	1	0	4	0	1
1	0	1	0	0	5	0	1
1	1	0	1	0	6	1	0
1	1	1	1	1	7	0	0

$T_A = Q_A Q_B' x + Q_A' Q_B x'$

$T_B = Q_A' Q_B' x + Q_A Q_B x'$

$y = Q_A Q_B'$



$\Rightarrow Q_A \bar{Q}_B \bar{x} + \bar{Q}_A Q_B x$

[Yaha line se lena hai wrna ans. galat aaega]