

### Serial-9

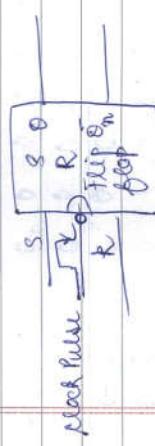
Sequential circuit

Flip Flop: It is one bit storage device.  
It is edge triggered device. There are  
two types of flip flop on the basis  
of edge triggered:

i) Rising edge triggered

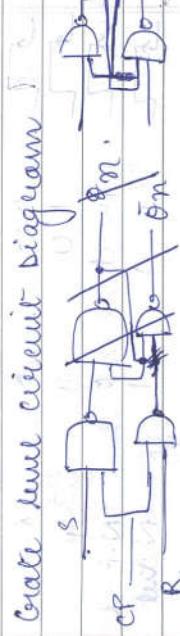
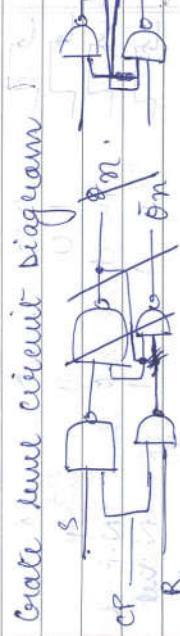
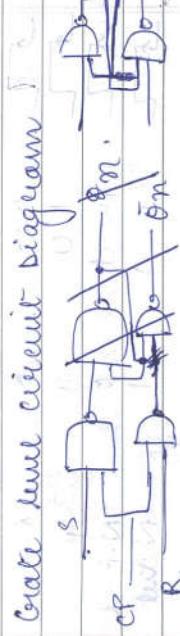
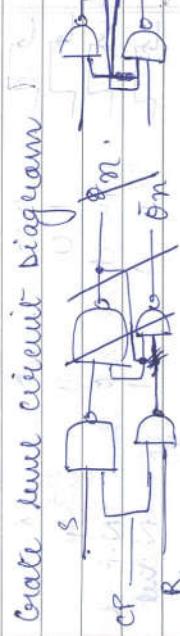
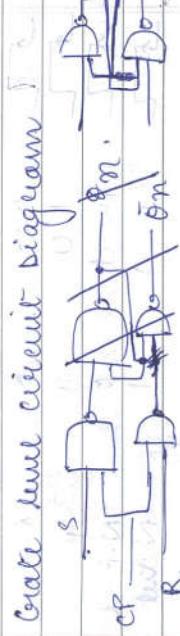
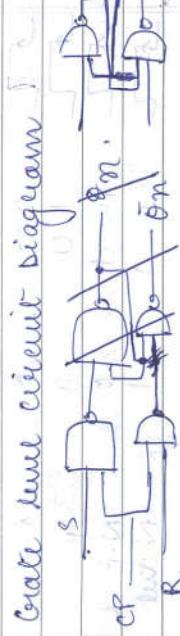
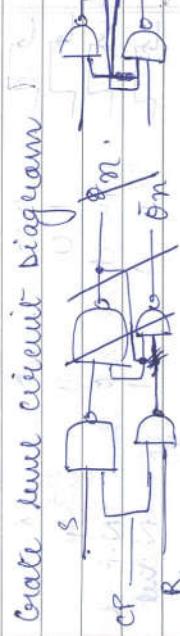
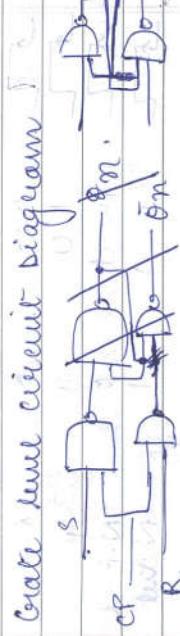
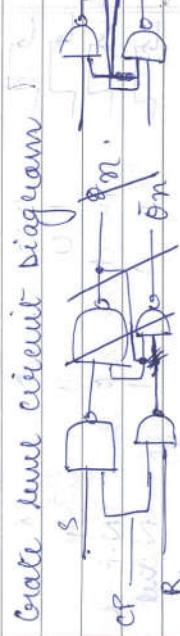
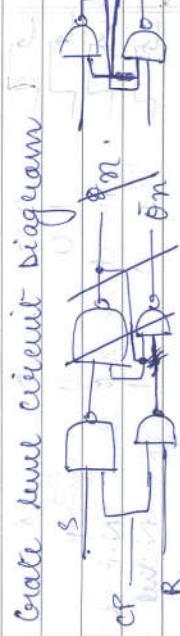
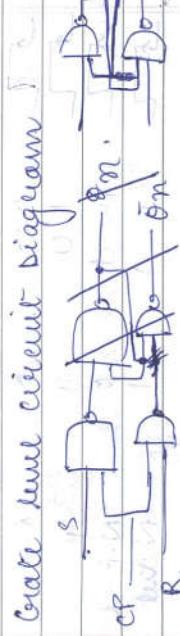
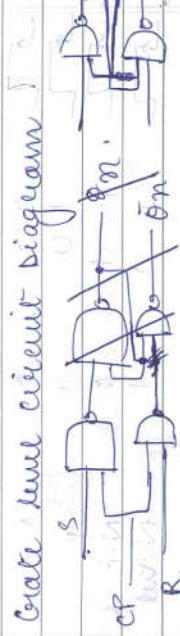
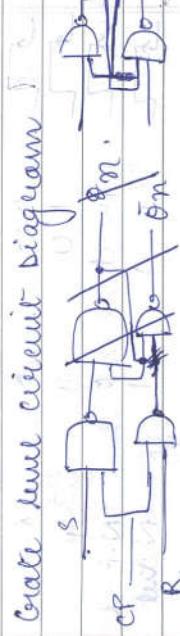
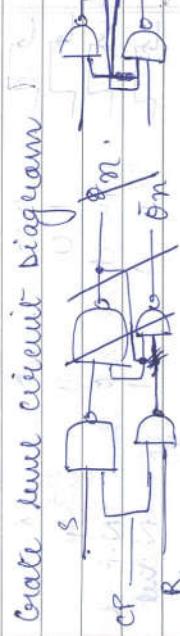
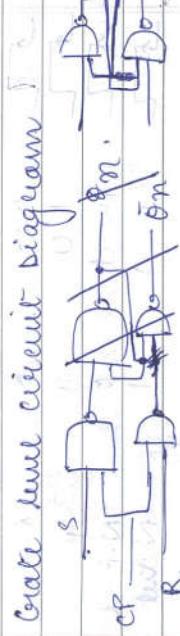
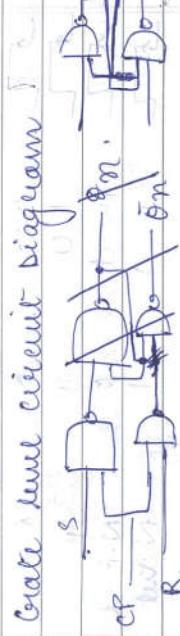
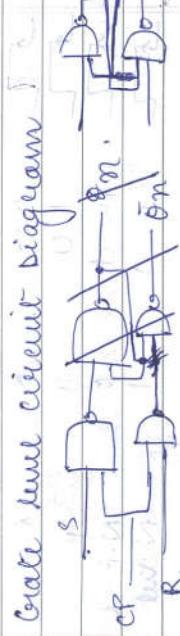
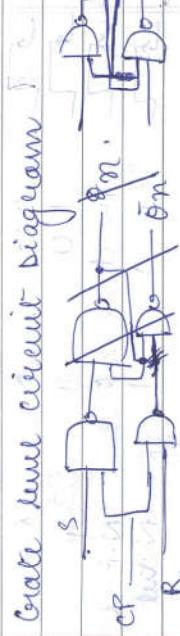
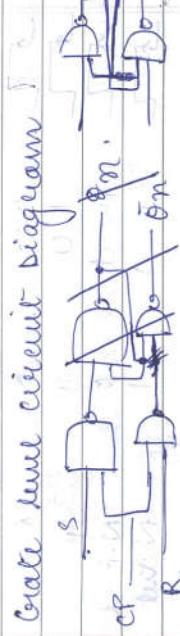
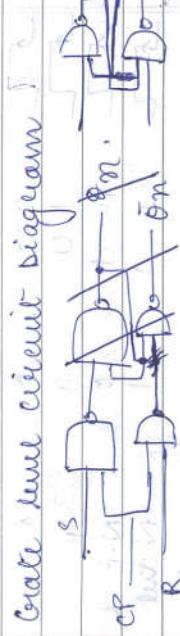
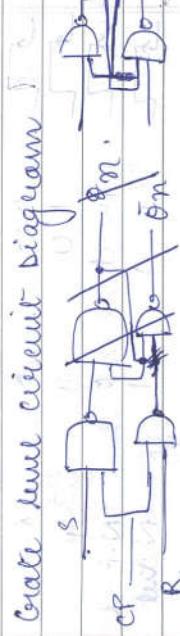
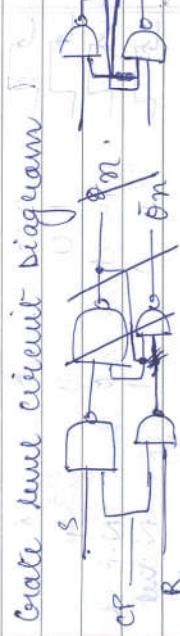
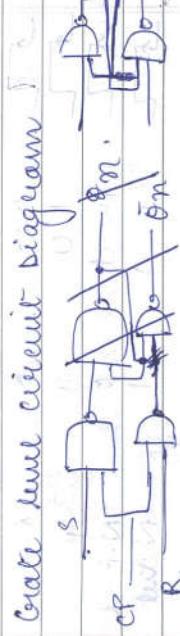
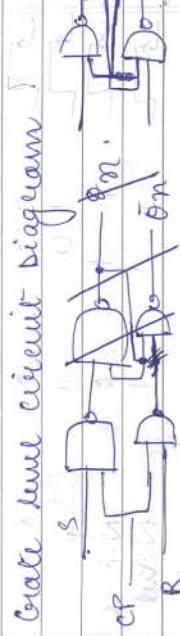
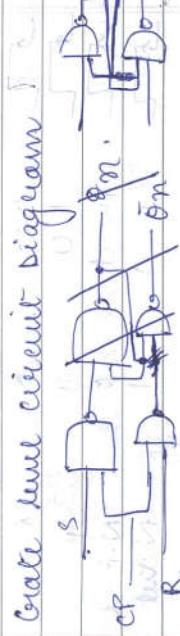
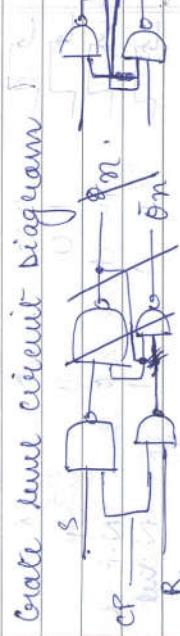
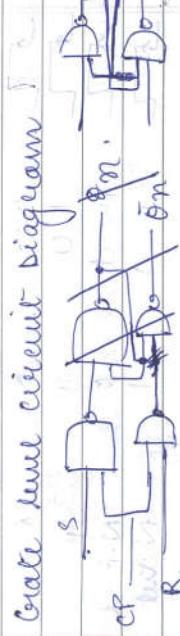
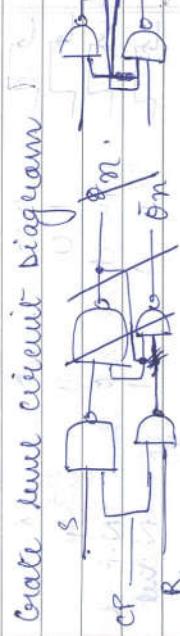
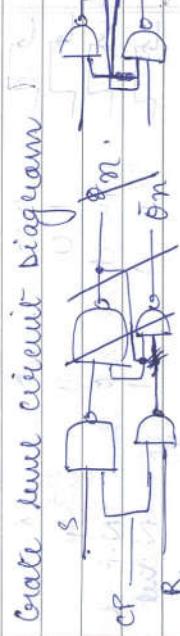
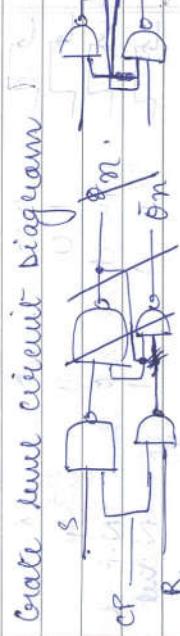
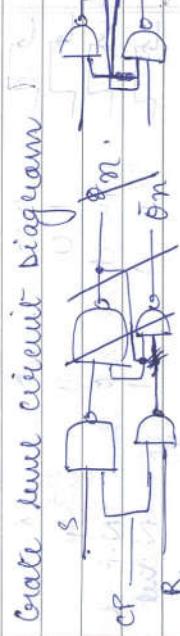
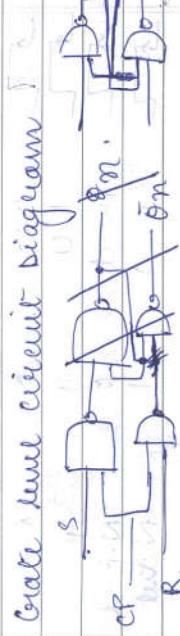
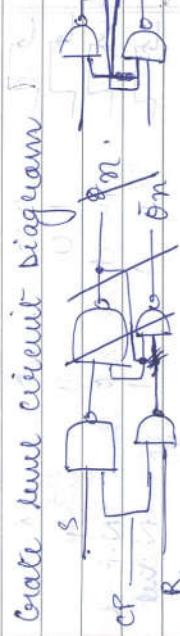
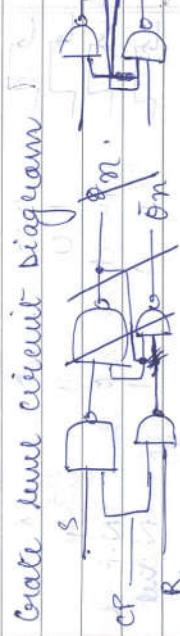
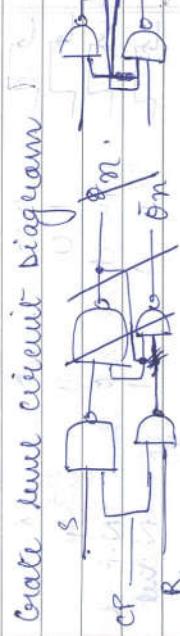
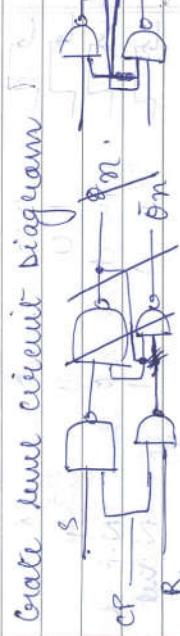
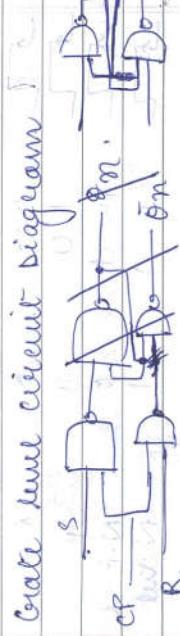
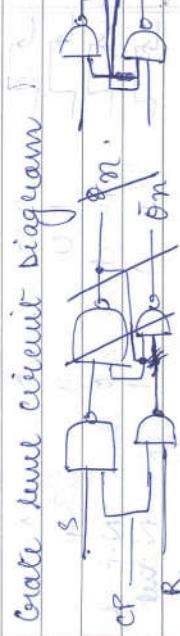
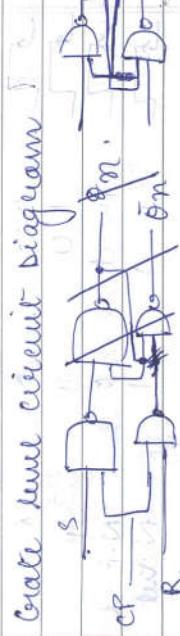
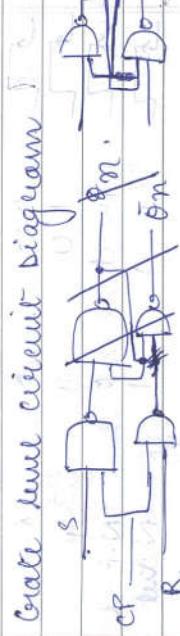
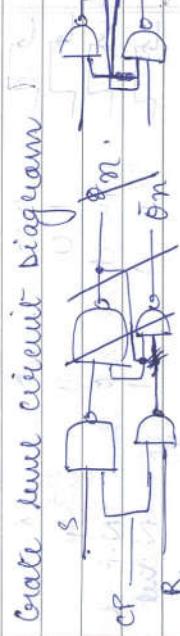
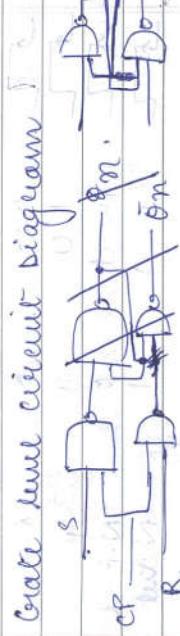
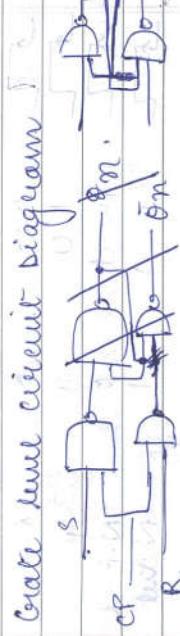
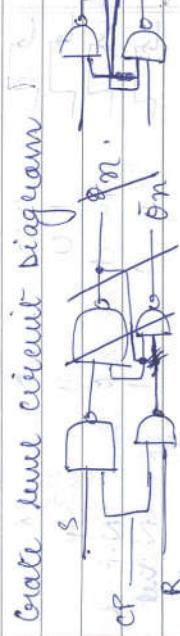
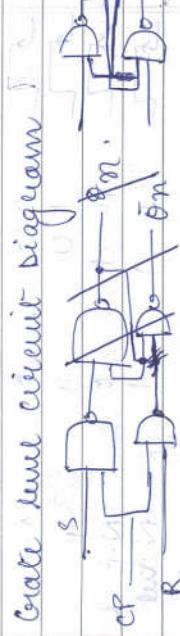
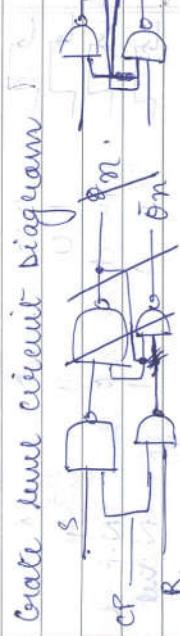
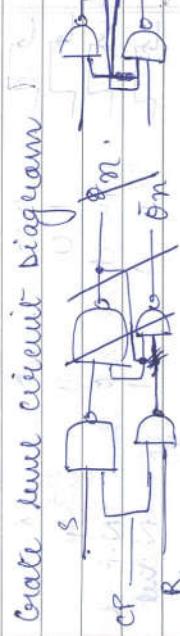
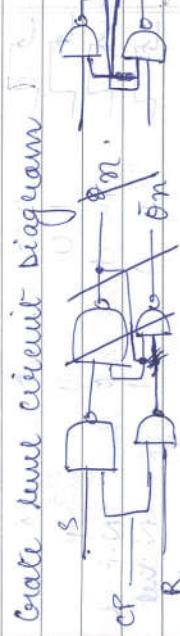
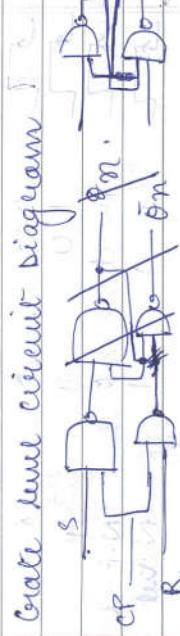
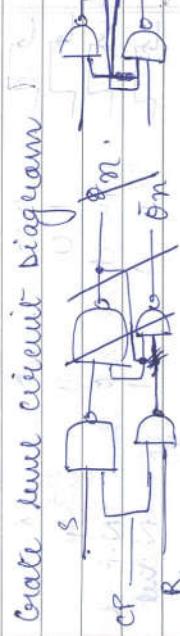
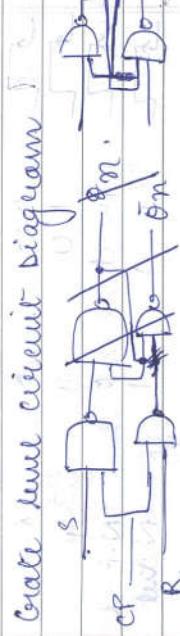
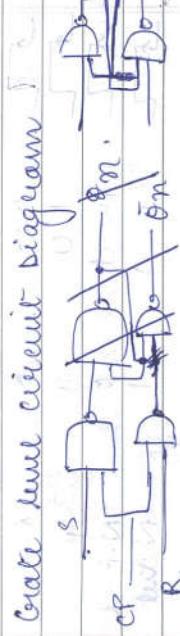
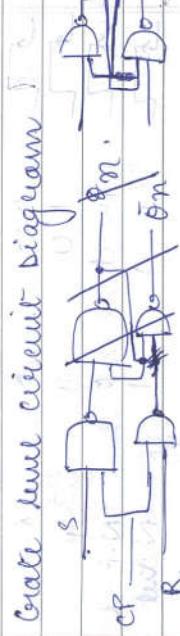
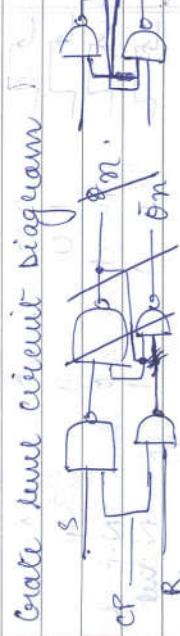
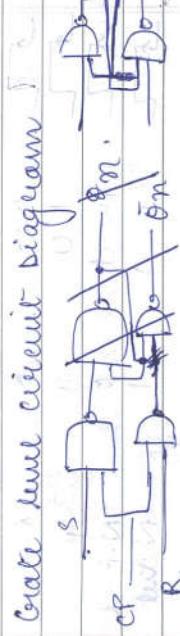
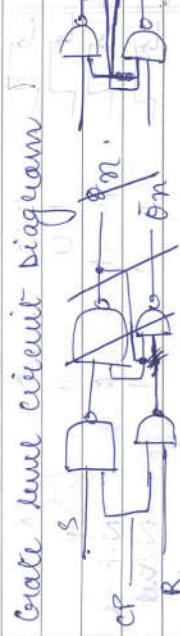
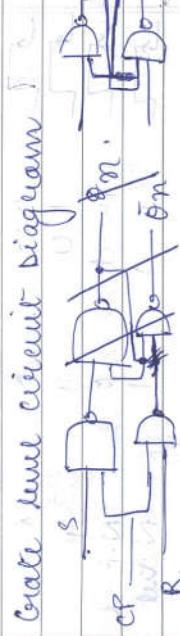
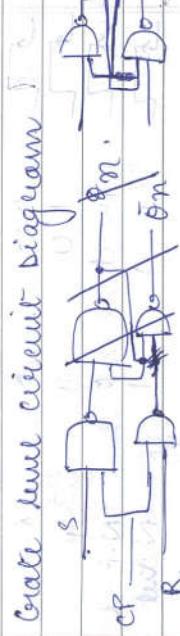
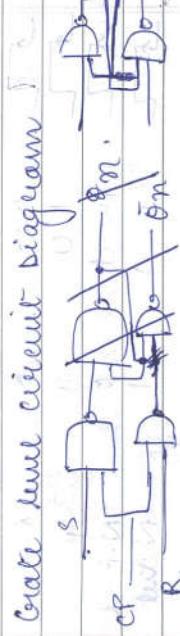
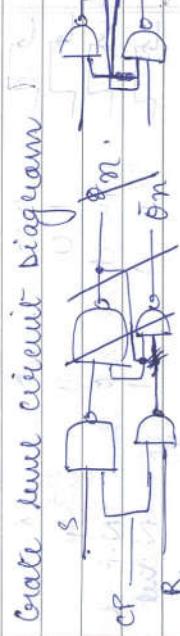
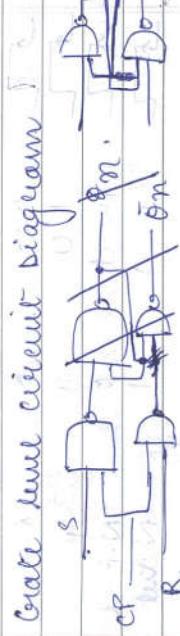
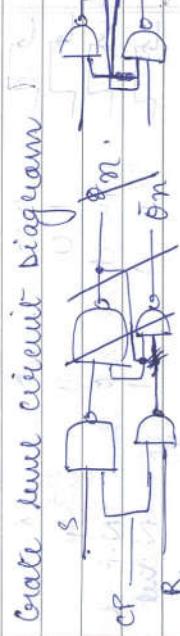
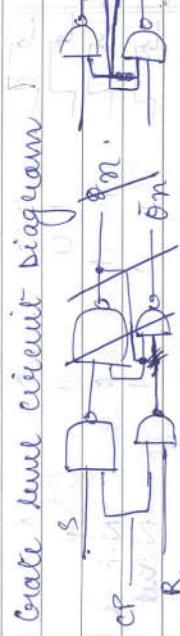
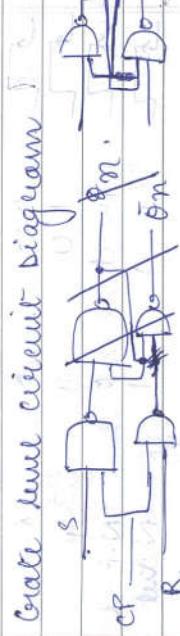
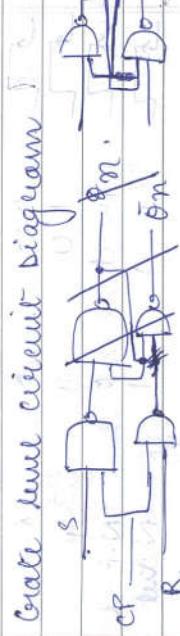
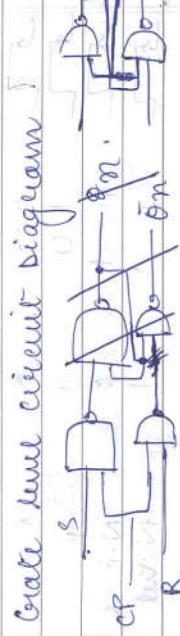
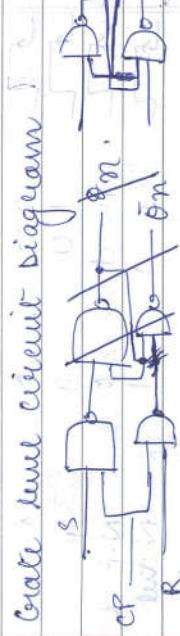
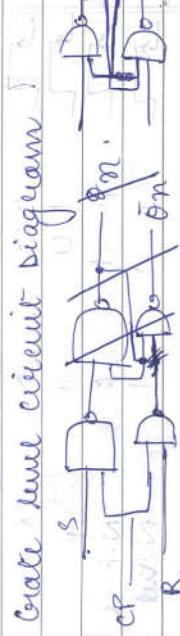
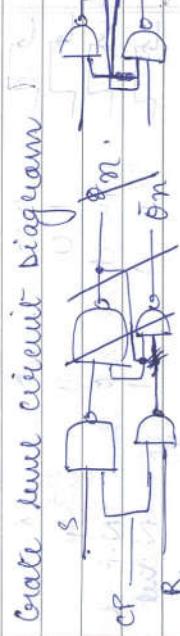
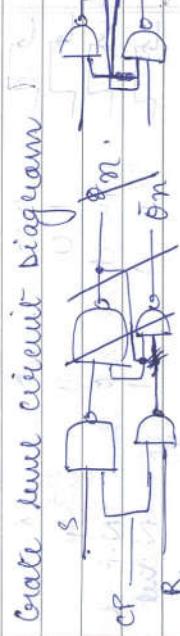
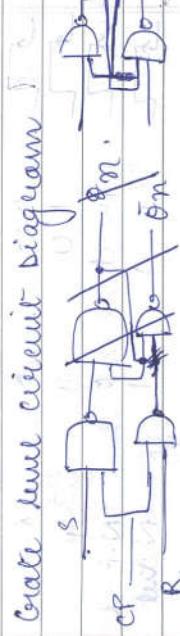
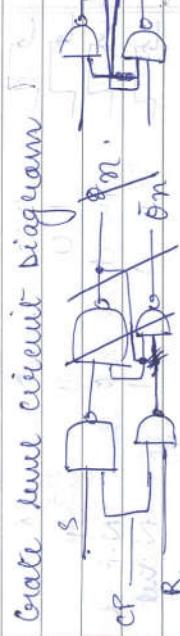
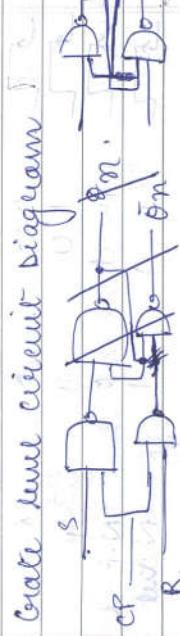
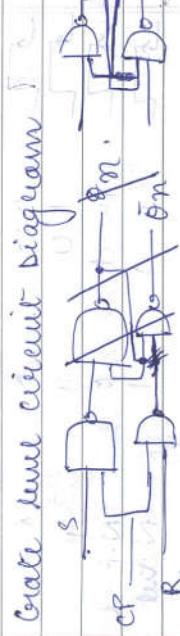
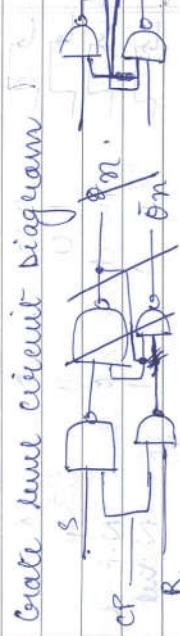
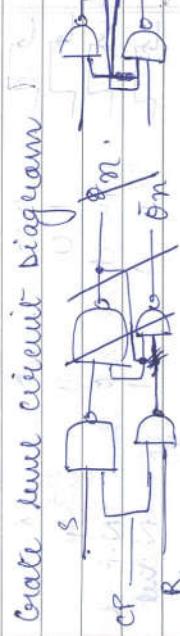
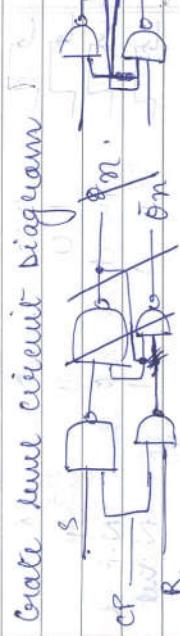
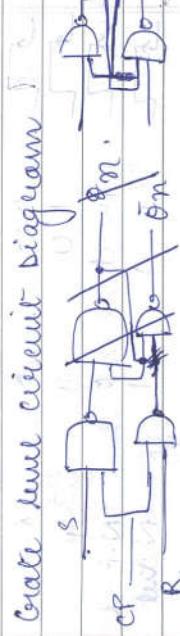
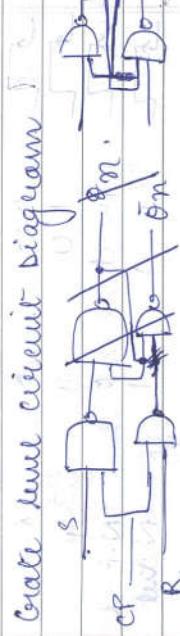
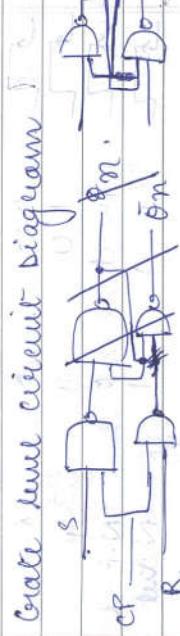
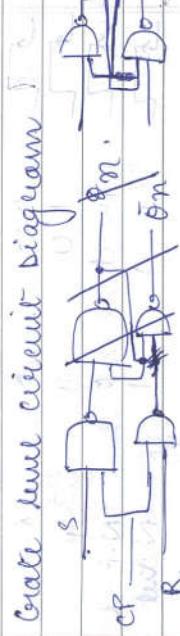
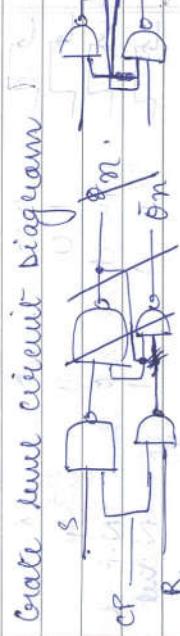
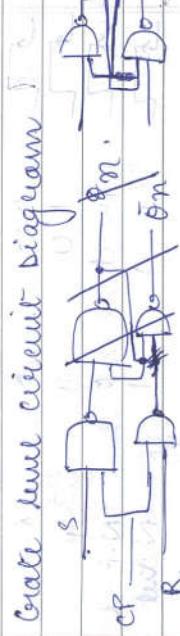
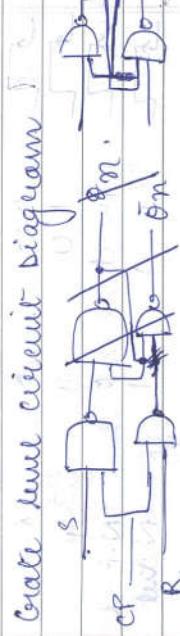
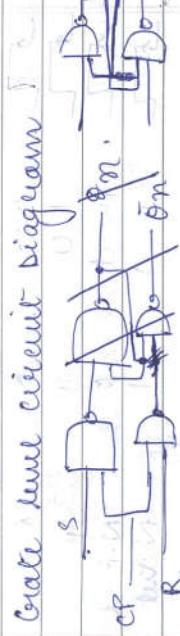
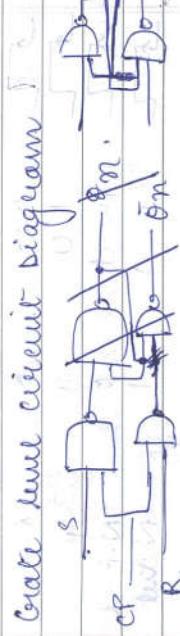
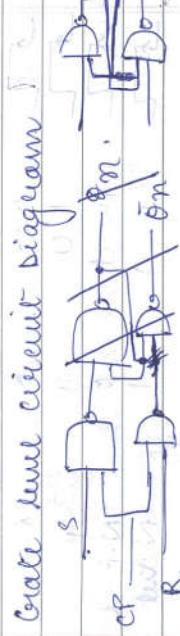
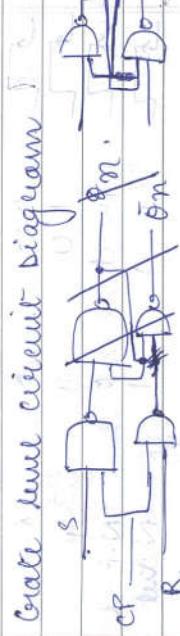
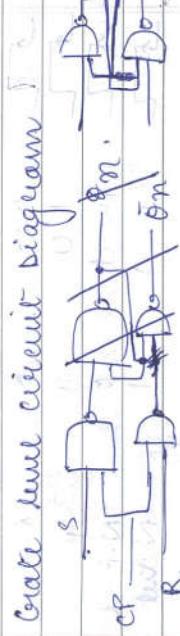
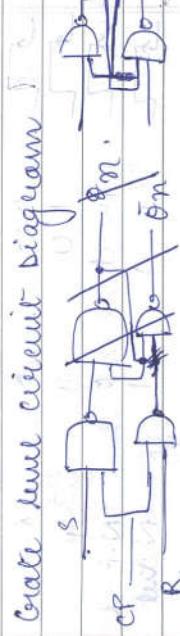
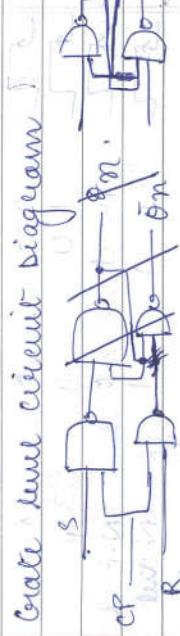
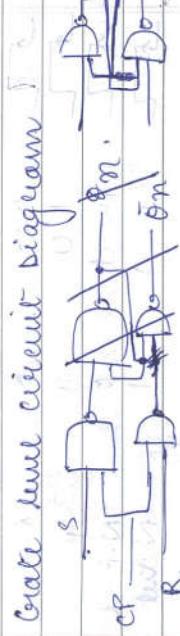
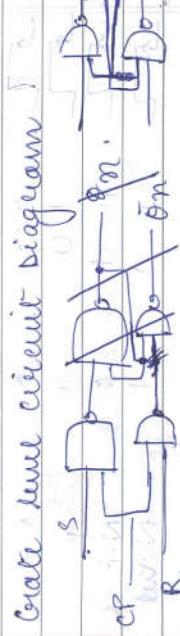
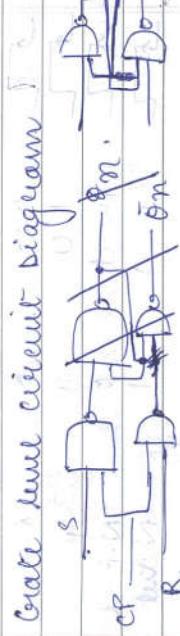
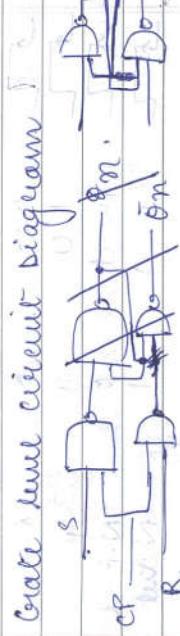
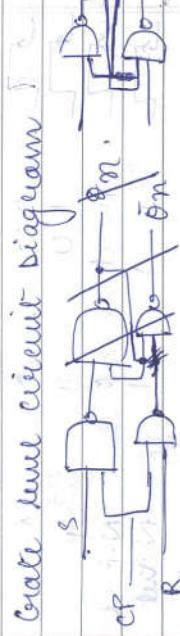
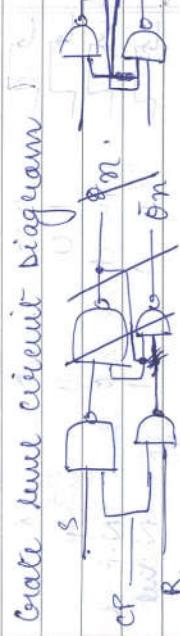
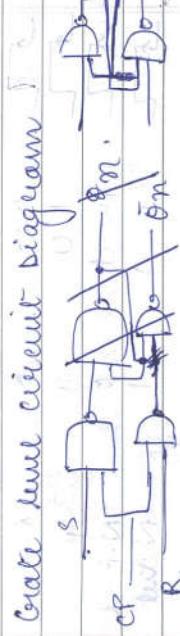
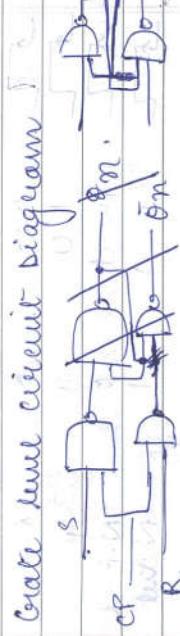
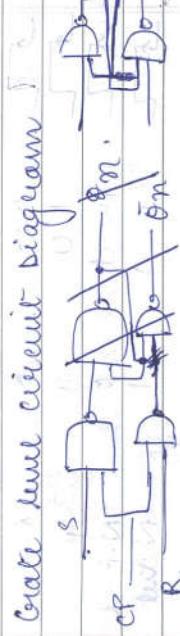
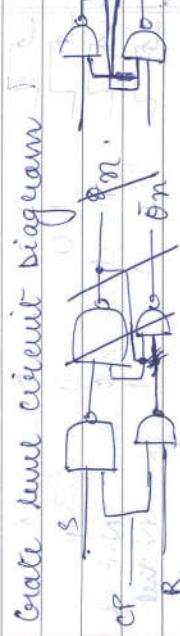
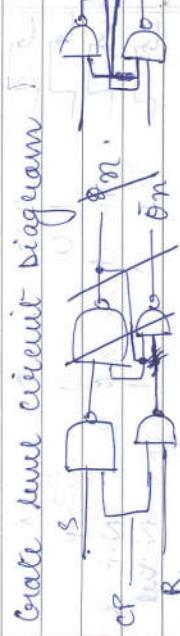
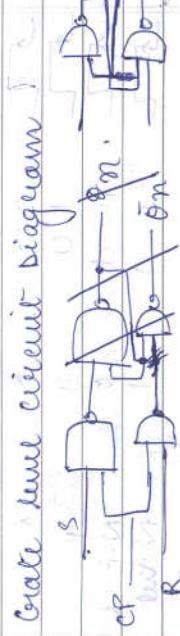
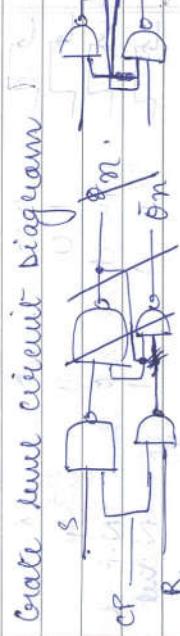
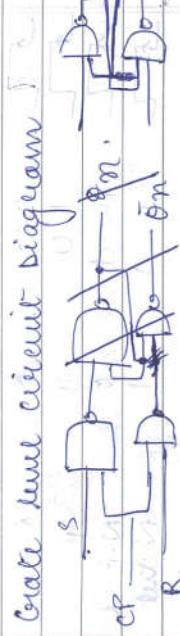
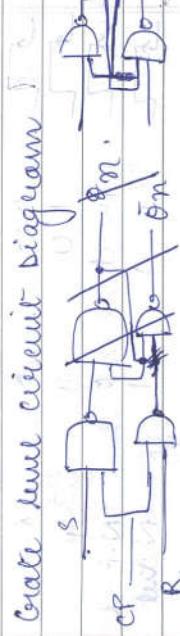
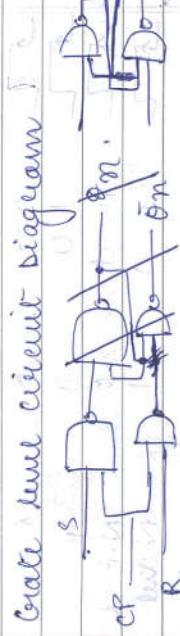
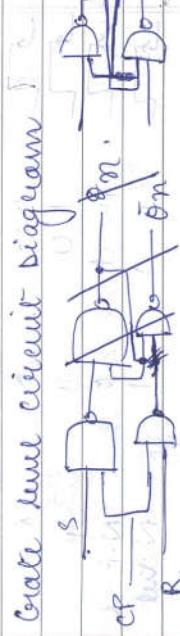
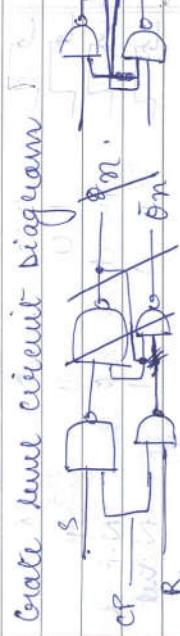
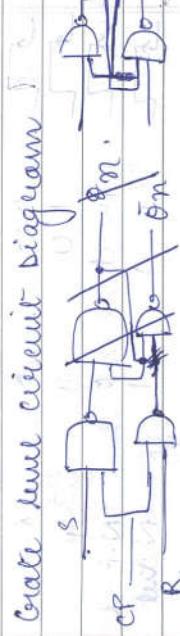
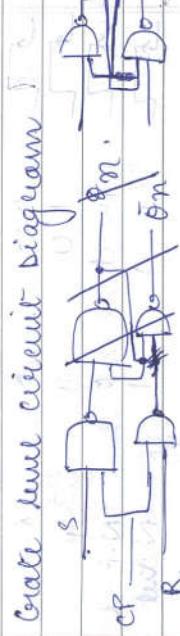
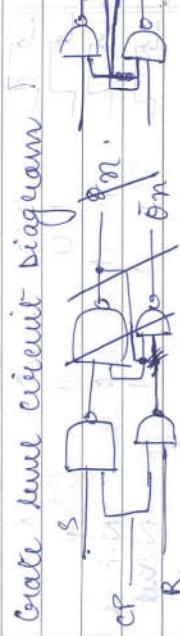
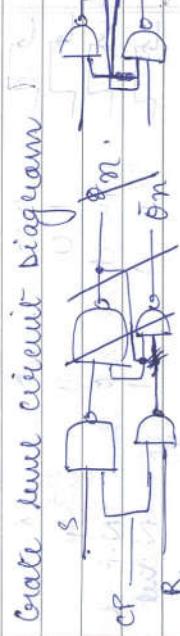
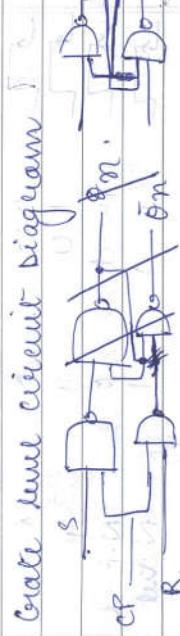
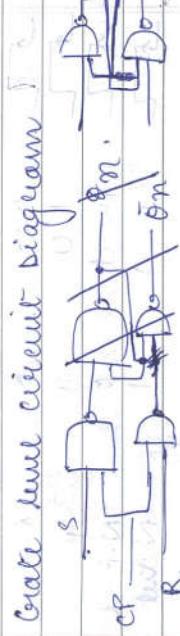
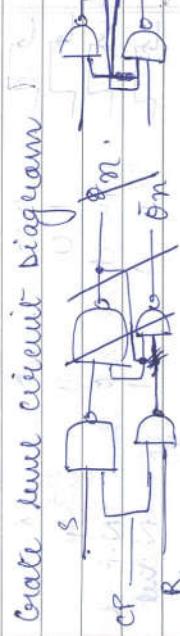
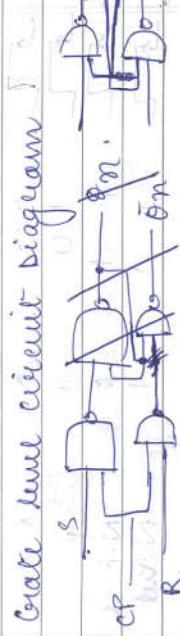
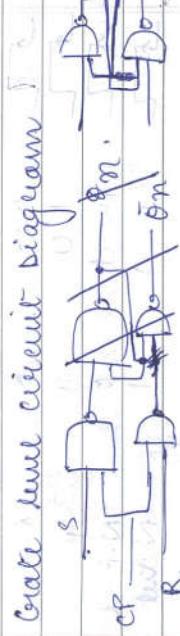
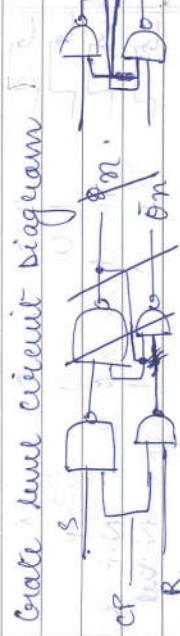
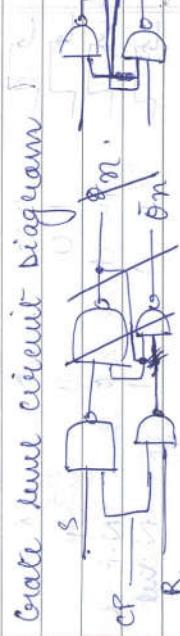
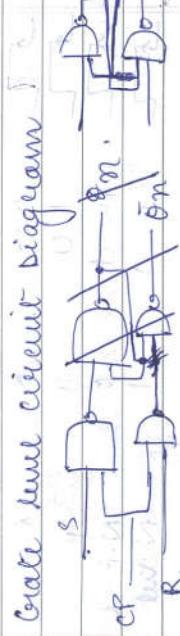
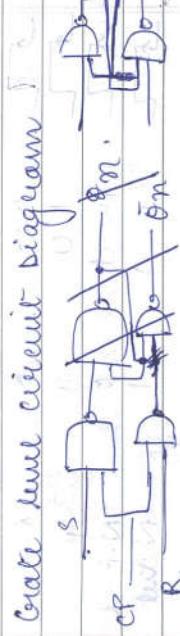
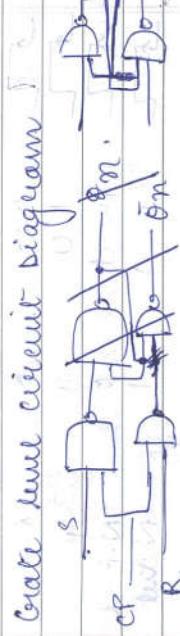
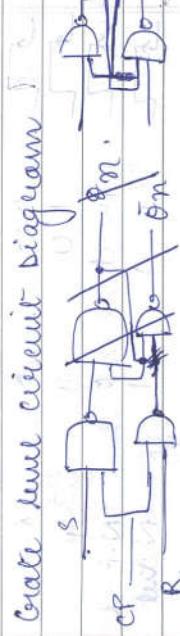
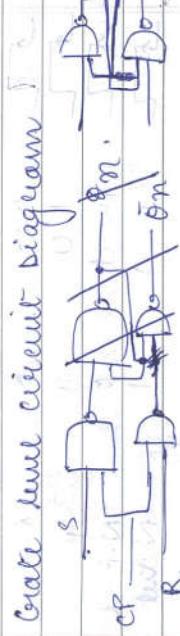
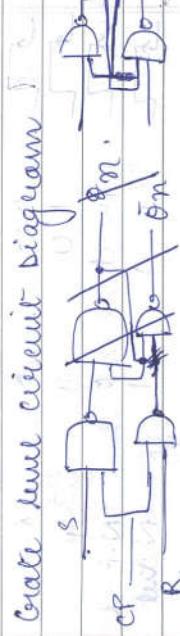
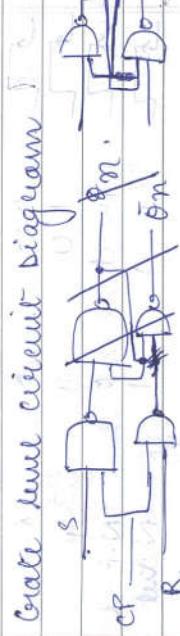
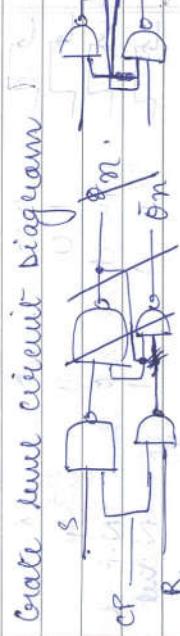
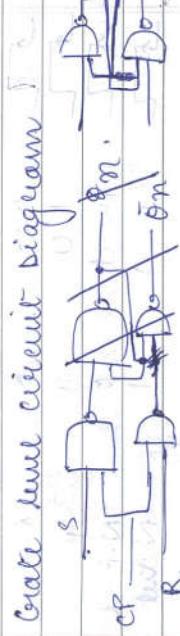
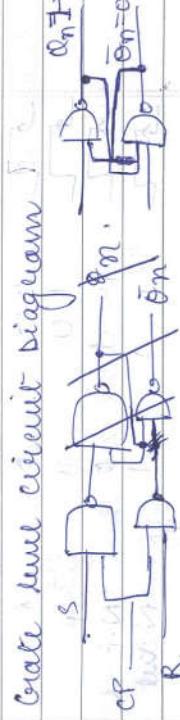
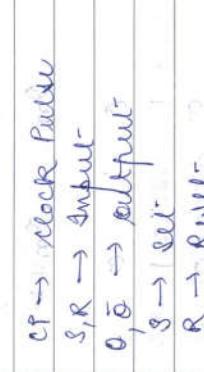


ii) Falling edge triggered.



### Types of flip flop

- i) SR Flip Flop.
- ii) JK Flip Flop.
- iii) T Flip Flop.
- iv) D Flip Flop.
- v) SR flip flop. (edge triggered) (rising edge triggering)
- vi) SR flip flop. (edge triggered) (falling edge triggering)



### Excitation Table for SR flip flop.

CP	S	R	Q on t <sub>1</sub>	Q on t <sub>2</sub>
High	High	Low	High	High
High	Low	High	Low	High
Low	High	High	Low	Low
Low	Low	Low	Low	Low

NOT ENABLER

ENABLER

On → Present state  
Off → Next state

### Truth Table for SR flip flop

CP	S	R	On t <sub>1</sub>	On t <sub>2</sub>
High	0	0	0	0
High	0	0	1	1
High	0	1	0	0
High	0	1	1	0
Low	0	0	0	0
Low	0	1	1	1
Low	1	0	1	0
Low	1	1	0	1

N.B. N.E.

### Conversion table of SR flip flop.

On	On +1 output	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

1)	S R	SR	2)	SR	to	Set
	0 0	0 1		0 1		

3)	SR	SR	4)	SR	to	Set
	0 0	0 1		0 0		

Later is level triggered device. It is also one edge triggered device.  
Later is pulse triggered device  
Pulse trigger is high to low transition.

- we focus on low level trigger.

Q) JK flip flop



$C_P \rightarrow$  Clock Pulse ;  $J, K \rightarrow$  Input ;  $Q, Q \rightarrow$  Output

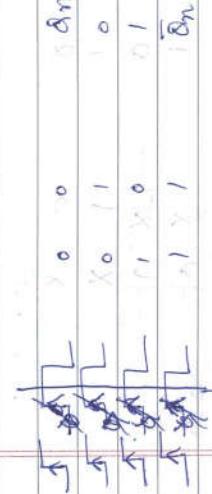
DRAFT BOUNDARY FOR JAPAN

J → Tick  
R → Riley

gate level circuit diagram JK flip flop

## Evaporation Table for JK Flip Flop

卷之三



Truth Table for JK Flip Flop

J. MATH. ANAL.

卷之三

	$J$	$K$	$D_m$	$Q_{m+1}$	$Q_m$
1	0	0	0	0	0
2	0	0	1	1	0
3	0	1	0	0	1
4	1	0	0	1	1
5	1	0	1	0	0
6	1	1	0	0	1
7	1	1	1	1	1

	$J$	$K$	$D_m$	$Q_{m+1}$	$Q_m$
1	0	0	0	0	0
2	0	0	1	1	0
3	0	1	0	0	1
4	1	0	0	1	1
5	1	0	1	0	0
6	1	1	0	0	1
7	1	1	1	1	1

Evaluation Table for JK latch

Conclusion Value of JK Flip flop

$$Q_m \quad Q_{m+1} \quad J \quad K$$

$Q_m$	$Q_{m+1}$	$J$	$K$
0	0	0	0
0	1	0	1
1	0	1	0
1	1	1	1

- X → dont care value in evaluation
- JK latch
- D → Data or delay.
- clock pulse.
- for D flip flop.
- Positive level or high level.

3) D Flip flop.

	$D$	$Q$	$Q'$
1	0	0	1
2	0	1	0
3	1	1	0
4	1	0	1

	$D$	$Q$	$Q'$
1	0	0	1
2	0	1	0
3	1	1	0
4	1	0	1

→ Data or delay.

Evaluation Table

for D flip flop.

$e_p$   $S$   $D$   $Q_{n+1}$

$\uparrow$	$\uparrow$	$\uparrow$	$\uparrow$
0	0	0	0
0	0	1	1
0	1	0	1

Initial AND Signaling Condition

Truth Table for D Flip Flop.

$e_p$	$S$	$D$	$Q_{n+1}$
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Conversion Table of D flip flop -

$Q_n$	$Q_{n+1}$	Condition
0	0	Initial
0	1	$e_p = 1, S = 0$
1	0	$e_p = 1, S = 1$
1	1	$e_p = 0, S = 0$

No combination

D - latch



c.p.  $\rightarrow$  latch

Excitation Table for D latch.

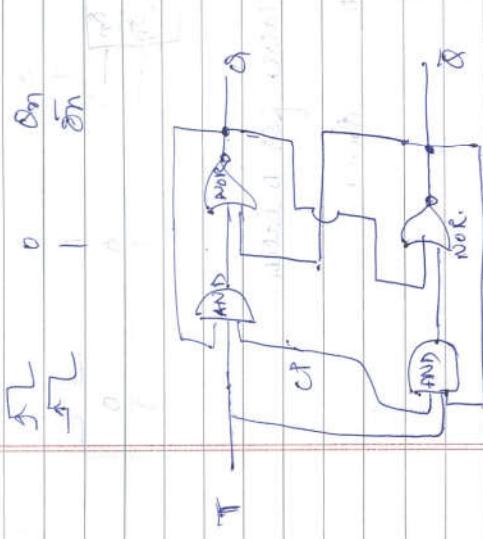
$e_p$	$D$	$Q_{n+1}$
0	0	0
0	1	1
1	0	1

Excitation Table for T flip flop.

$e_p$	$T$	$Q_{n+1}$
0	0	0
0	1	1
1	0	1

Excitation Table for T flip flop.

CP T Qn+1



Qn+1 Qn CP T

Commutation Table of T Flip Flop

Qn Qn+1 T

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

T latch



Truth Table for T Flip Flop

clk T Qn Qn+1

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

Excitation Table for T latch

clk T Qn+1

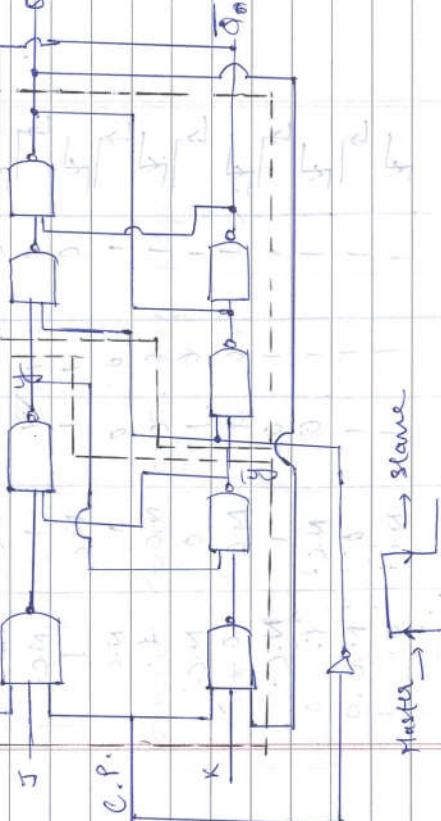
0	0
1	1

Racing around condition excitation  
table for JK latch

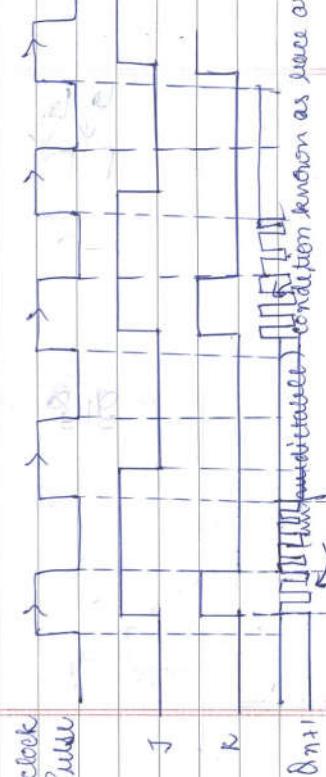
$J$	$K$	$Q_{n+1}$
0	0	$Q_n$
0	1	0
1	0	1
1	1	$\overline{Q_n}$

~~Solution of question~~ ~~about the flip flop~~  
 When input of the JK latch  $J=1$  and  $K=1$   
 output is toggled till the next ~~clock~~  
~~edge~~ level. That at the ~~edge~~ end of the  
 + the level what is the output of JK latch  
 we cannot predict. This uncertainty  
 of the latch can not be predicted.

JK flip flop master



Q = Y  
 $J = K$



Q = Y

$JK \rightarrow SR \rightarrow$  is not possible.  
II no output -

Truth table for Master Slave JK flip flop.

clk	$Q_m$	J	K	$Y_{out}$	$Q_{m+1}$
0	0	0	0	0	0
1	0	0	0	0	0
0	1	0	0	1	1
1	1	0	0	0	0
0	0	1	0	0	0
1	0	1	0	1	1
0	1	1	0	1	0
1	1	1	0	0	1
0	0	0	1	0	0
1	0	0	1	1	1
0	1	0	1	1	0
1	1	0	1	0	0
0	0	1	1	0	0
1	0	1	1	1	1
0	1	1	1	1	0
1	1	1	1	0	1

8 states  
 $J \leftarrow 1$   
flip flop conversion

1) SR flip flop to JK flip flop  
excitation table of JK flip flop.

	J	K	$Q_{m+1}$
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

Conversion table of JK flip flop

$Q_m$	$Q_{m+1}$	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	1	0

4T  $\rightarrow$  output of SR flip flop

$Y \rightarrow$  output of master slave flip flop (JK flip flop)  
 $Q_{m+1} \rightarrow$  output of slave flip flop (JK flip flop)  
N.C.  $\rightarrow$  Not change,  
 $Y = S$   
 $Y = R$

excitation table for conversion

$Q_0 \rightarrow$  present state

DATE \_\_\_\_\_  
PAGE NO. \_\_\_\_\_

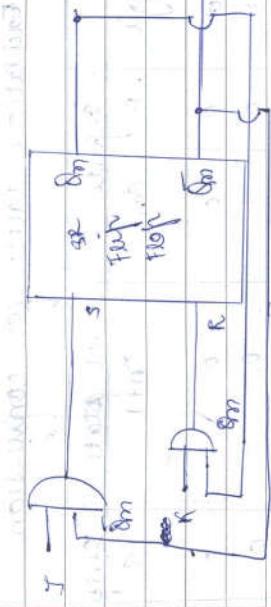
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PAGE NO. \_\_\_\_\_

Inputs	Present State	Next State	Outputs
J R	Q <sub>n</sub>	Q <sub>n+1</sub>	S Q <sub>n</sub>
0 0	0 0	0 0	X
0 0	0 1	1 0	X
0 1	0 0	0 0	X
0 1	1 0	0 0	X
1 0	0 0	0 1	0 0
1 0	1 1	1 0	X 0
1 1	0 1	1 1	1 0
1 1	1 1	0 0	0 1

R map for SR to JK map for R

JK	Q <sub>n</sub>	Q <sub>n+1</sub>	D <sub>n+1</sub>
0 0	0 0	0 1	0 1
0 1	0 1	1 0	0 1
1 0	1 0	0 1	1 1
1 1	1 1	1 1	1 1

$$S = J \bar{Q}_n \quad R = K Q_n$$



SR to JK flip flop

- a) SR flip flop to JK flip flop

SR to JK flip flop



Conversion table of SR flip flop

Q <sub>n</sub>	D <sub>n+1</sub>	Q <sub>n+1</sub>
0 0	0 0	0 1
0 1	0 1	1 0
1 0	1 1	0 1
1 1	1 1	1 1

conversion table of SR flip flop

Q <sub>n</sub>	D <sub>n+1</sub>	Q <sub>n+1</sub>
0 0	0 0	0 1
0 1	1 0	1 0
1 0	0 1	0 0
1 1	1 1	1 1

### Excitation table for conversion

	S	Inputs	New State	Outputs
digit	D	$Q_m$ $Q_{m-1}$	$Q_{m+1}$	S R
0	0	0 0	0 0	X
1	0	1 0	0 0	1 0
2	1	0 0	1 0	0 1
3	1	1 0	1 0	X 0

### SR to T flip flop

### Excitation of 7 flip flop

	T	$Q_m$	$Q_{m+1}$
0	0	0	0
1	0	1	0
2	1	0	1

### Conversion table of 8R flip flop

	$Q_m$	$Q_{m+1}$
0	0	0
1	0	1
2	1	0
3	1	1

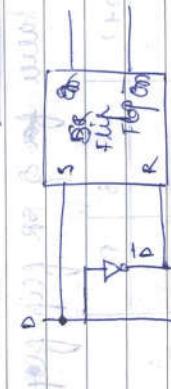
### Excitation table for conversion

	$Q_m$	$Q_{m+1}$	S	R
0	0	0	0	X
1	0	1	1	0
2	1	0	0	1
3	1	1	X	0

### K-map for S and R of 8R flip flop

D	$Q_m$	$Q_{m+1}$	S	R
0	0 0	0 0	1	1
0	0 0	1 1	0	0
1	1 1	0 0	0	1

$$S = D \quad R = D$$



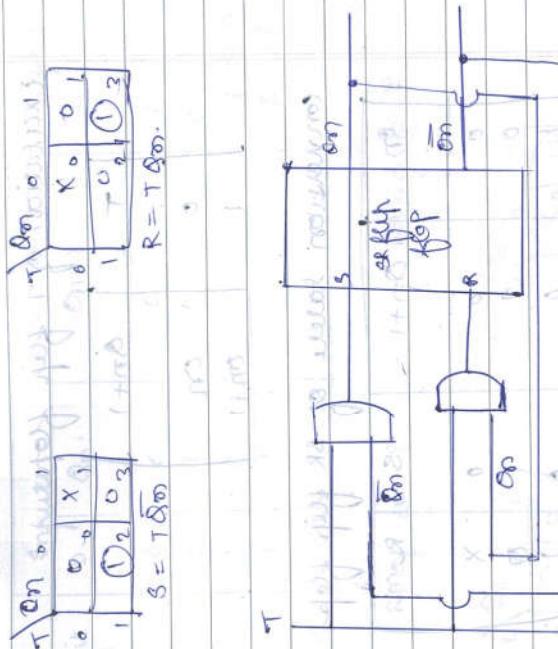
### SR to 1D flip flop

SR to 1D

R map for S  
R map for R

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

$$S = T \oplus Q_n$$



Conversion table of JK flip flop.

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

$$R = T \oplus Q_n$$

Excitation table for conversion

$J$	$K$	$Q_n$	Inputs	Next state	Outputs
0	0	0	0	0	0
0	0	1	0	1	1
1	0	0	1	1	0
1	0	1	1	0	1

\* Map for S  
\* Map for R

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

X

X

X

X

X

X

X

X

X

X

X

X

X

X

X

X

X

X

X

X

JK to T flip flop  
Excitation table of T flip flop

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

\* Map for S  
\* Map for R

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

X

X

X

X

X

X

X

X

X

X

X

X

X

X

X

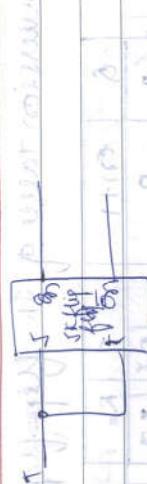
X

X

X

X

X



JK to T flip flop

b) JK to D flip flop

excitation table of a flip flop

	D	J	K	T	Qn+1
A	0	0	0	0	0
	1	0	1	1	1
X	0	1	0	1	0
X	1	1	1	0	1

conversion table of JK flip flop

	JK	Qn+1	J	K
A	00	0	0	0
	01	1	0	1
X	10	0	1	0
X	11	1	1	1

JK to T conversion table

JK = T + JK̄Q̄

JK̄ = T̄ + J̄K̄

Q̄ = JK̄ + J̄K

Q = J + K̄

excitation table of JK flip flop

	Impulses	Input Qn	Output Qn+1	Output
	digit	for 0	for 1	for 0
	0	0	0	0
	1	0	1	x
	2	1	0	1
	3	1	1	x



	Impulses	Input Qn	Output Qn+1	Output
	digit	for 0	for 1	for 0
	0	0	0	0
	1	0	1	x
	2	1	0	1
	3	1	1	x



JK to D conversion table

JK = D + JK̄Q̄

JK̄ = D̄ + J̄K̄

Q̄ = JK̄ + J̄K

Q = J + K̄

6) T flip flop to D flip flop

excitation table of D flip flop

	D	T	Qn+1
X	0	0	0
1	1	0	1
X	1	1	0
0	0	1	1

conversion table of T flip flop

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

excitation table of T flip flop

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

excitation table of D flip flop

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

conversion table of D flip flop

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

K map for T

$$T = D\bar{D} + \bar{D}D$$

$$\begin{array}{c} \text{Qn} \\ \text{Qn+1} \\ \hline 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 0 & 1 & 0 \end{array}$$

K map for T

$$T = D \oplus \bar{D}$$

## Excitation Table for Conversion

digit	Inputs	Next State $Q_{n+1}$	Outputs
0	0 0	0	0
1	0 1	1	1
2	1 0	1	1
3	1 1	0	0

## Counter

Asynchronous | Ripple down counter

Design asynchronous 4 stage down counter using JK flip flop.

Excitation table for JK flip flop.

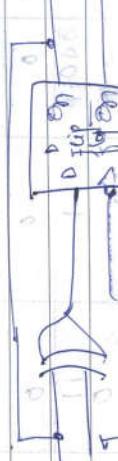
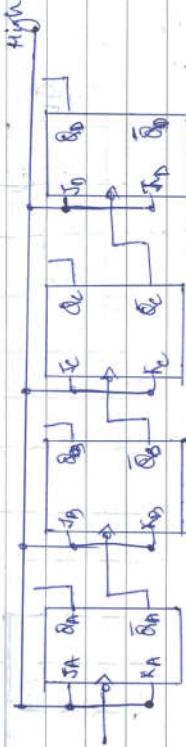
	exc	J	K	Q <sub>n+1</sub>
0	0 0	0	0	0
1	0 1	0	1	1
2	1 0	1	0	0
3	1 1	1	1	1

K-map for D

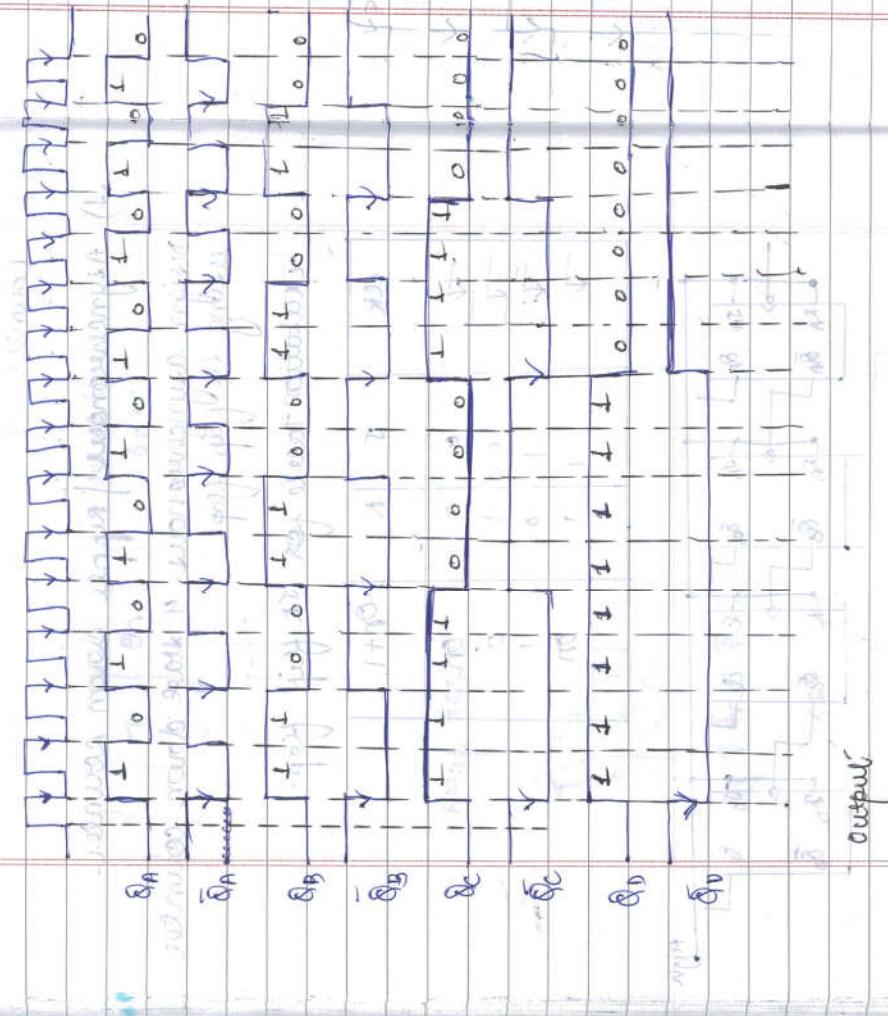
D	0 0	0 1	1 0	1 1
0	0	1	1	0
1	1	0	0	1

$$D = \bar{P} \bar{Q}_1 + \bar{P} Q_2 + P \bar{Q}_2 + PQ_1$$

$$D = T \text{ when } Q_2 = 1$$



D flip flop T.



• 4 bit ripple counter using JK flip-flop.

Initial State	0000
Q1	0
Q2	0
Q3	0
Q4	0
Output	0000

clock

Aynchronous 3 stage up counter (Ripple counter)  
Design 3 stage up counter using JK flip flop

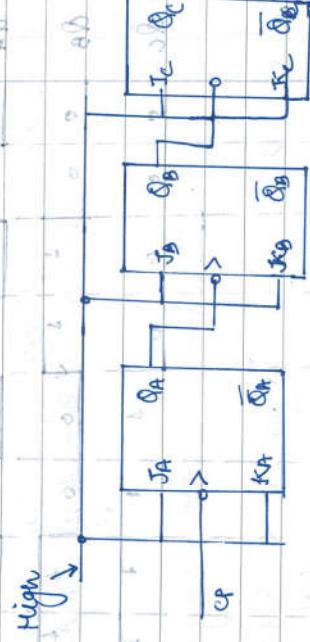


Output

Q<sub>D</sub>    Q<sub>B</sub>    Q<sub>C</sub>    Q<sub>A</sub>  
↓              ↓              ↓              ↓  
M.S.B.    L.F.B.

	Q <sub>A</sub>	Q <sub>B</sub>	Q <sub>C</sub>	Q <sub>D</sub>	Q <sub>A</sub>	Q <sub>B</sub>	Q <sub>C</sub>	Q <sub>D</sub>
0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
2	0	0	1	1	0	0	1	0
3	0	1	1	1	0	1	0	0
4	1	1	1	1	0	1	1	0
5	1	1	0	0	1	0	1	0
6	1	0	0	0	1	0	0	1
7	0	0	0	0	1	1	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0

• Goldgrip & Co. Ltd.  
• Setting up  
• Asynchronous 3 stage up counter (Ripple counter)  
• Design 3 stage up counter using JK flip flop



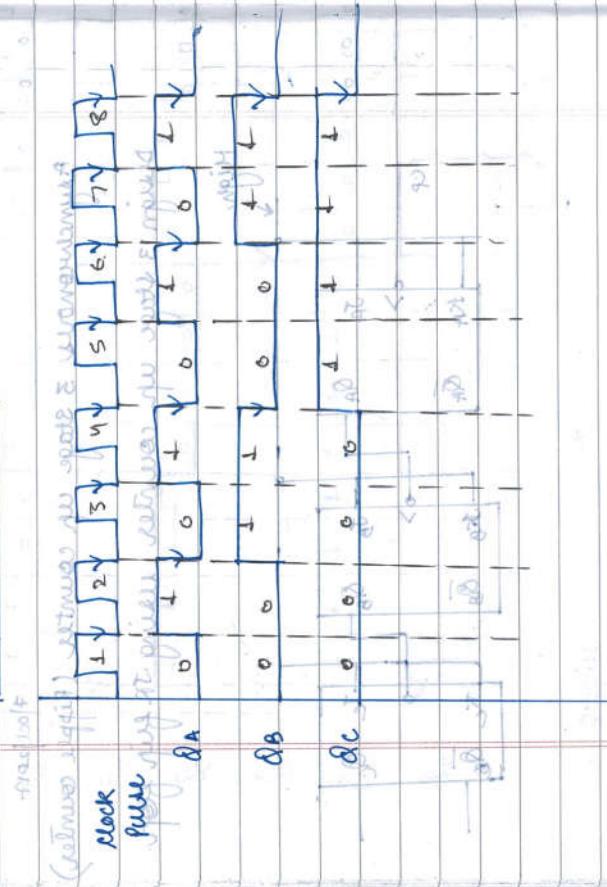
Output

$$\begin{array}{l} Q_D \\ \downarrow \\ M.S.B. \end{array}$$

$$\begin{array}{l} Q_3 \\ \downarrow \\ L.S.B. \end{array}$$

### Excitation Table for JK flipflop.

J	K	R	S	Emt 1
0	0	0	0	0
0	1	1	0	1
1	0	1	0	0
1	1	1	1	1

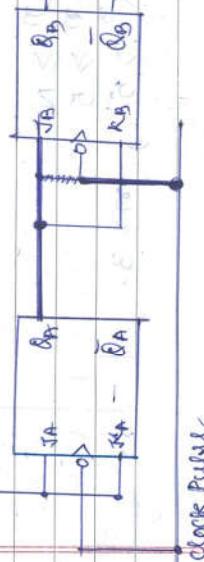


count	Q <sub>C</sub>	Q <sub>B</sub>	Q <sub>A</sub> (Q <sub>B</sub> ) (Q <sub>C</sub> )
0	0	0	0 0 0
1	0	0	0 0 1
2	0	1	0 1 0
3	0	1	0 1 1
4	0	0	0 0 0
5	1	0	0 0 1
6	1	0	0 1 0
7	1	1	0 1 1

In Asynchronous counter all inputs & outputs work at diff. clock pulse so it is  
k/a Asynchronous counter.

(a) Synchronous counter works at same clock pulse.  
i) 2 - stage synchronous counter

High



clock pulse

Transition Table after JK flip flop

J	K	Q <sub>n+1</sub>
0	0	0
0	1	1
1	0	1
1	1	0

Required JK flip flop m=3  
conversion table of JK flip flop.

Q <sub>n</sub>	Q <sub>n+1</sub>	J	K
0	0	0	0
0	1	0	1
1	0	1	0
1	1	1	1

and flip flop working on command clock.

synchonous counter working on command clock.

3) Modular counter

i) Design mod 5 counter using JK flip flop.

$$2^m \geq N \Rightarrow 2^m \geq 5 \quad \Rightarrow m = 3$$

$$\text{Sol} \quad N=5$$

$$\begin{aligned} \Rightarrow 2^m &\geq N \\ \Rightarrow 2^m &\geq 5 \\ \Rightarrow m &= 3 \end{aligned}$$

digit	Present State	Next State	Output - J	Output - K
0	0 0 Q <sub>0</sub> Q <sub>1</sub>	0 0 Q <sub>0</sub> Q <sub>1</sub>	0	1
1	0 1 Q <sub>0</sub> Q <sub>1</sub>	0 1 Q <sub>0</sub> Q <sub>1</sub>	0	0
2	1 0 Q <sub>0</sub> Q <sub>1</sub>	1 0 Q <sub>0</sub> Q <sub>1</sub>	1	0
3	1 1 Q <sub>0</sub> Q <sub>1</sub>	0 0 Q <sub>0</sub> Q <sub>1</sub>	0	0

K map for  $\bar{Q}_A$  (minimized)

$\bar{Q}_C$	00	01	11	10
0	1	X <sub>4</sub>	X <sub>3</sub>	X <sub>2</sub>
1	0	X <sub>5</sub>	X <sub>7</sub>	X <sub>6</sub>

$$J_A = \bar{Q}_C$$

K map for  $Q_A$

$\bar{Q}_C$	00	01	11	10
0	X <sub>4</sub>	1	1	X <sub>2</sub>
1	X <sub>5</sub>	X <sub>3</sub>	X <sub>7</sub>	X <sub>6</sub>

$$J_C = Q_A$$

K map for  $J_C$

$\bar{Q}_C$	00	01	11	10
0	0	0	1	X <sub>2</sub>
1	0	0	X <sub>3</sub>	X <sub>4</sub>

$$J_C = Q_A$$

K map for  $J_B$

$\bar{Q}_C$	00	01	11	10
0	0	0	1	X <sub>2</sub>
1	0	0	X <sub>3</sub>	X <sub>4</sub>

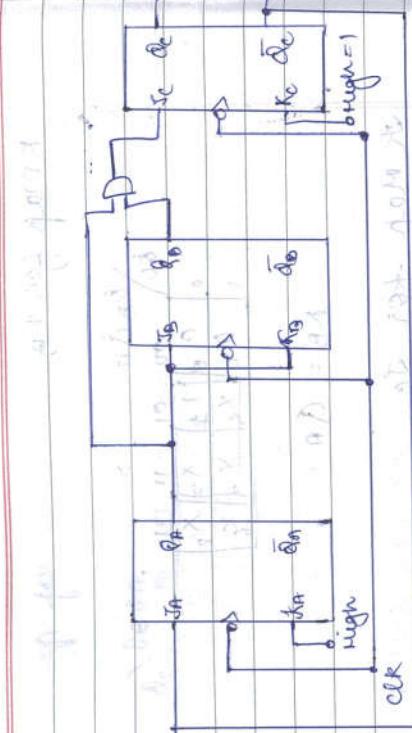
$$J_B = Q_A$$

K map for  $J_C$

$\bar{Q}_C$	00	01	11	10
0	0	0	1	X <sub>2</sub>
1	0	0	X <sub>3</sub>	X <sub>4</sub>

K map for  $J_B$

$\bar{Q}_C$	00	01	11	10
0	0	0	1	X <sub>2</sub>
1	0	0	X <sub>3</sub>	X <sub>4</sub>



$Q_1$	$Q_2$	$Q_3$	$Q_4$	$Q_{\bar{1}}$	$Q_{\bar{2}}$	$Q_{\bar{3}}$	$Q_{\bar{4}}$	$D_{in}$	$Q_{out1}$	$T$	$Q_{out2}$
0	0	0	0	1	1	1	1	0	0	1	0
0	0	0	1	1	1	1	1	1	1	1	1
1	0	0	1	1	1	1	1	1	1	1	1

digit	Present State.				Next State.				Output			
	$Q_1$	$Q_2$	$Q_3$	$Q_4$	$Q_{\bar{1}}$	$Q_{\bar{2}}$	$Q_{\bar{3}}$	$Q_{\bar{4}}$	$Q_{out1}$	$Q_{out2}$	$T_c$	$T_b$
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1	0	1	0	0
2	0	0	1	0	0	0	0	1	1	1	1	1
3	0	0	1	1	0	0	0	0	0	0	0	0
4	0	1	0	0	1	0	1	0	1	0	0	1
5	0	1	0	1	1	0	1	1	0	1	0	1
6	0	1	1	0	0	1	0	0	1	0	0	1
7	0	1	1	1	1	0	0	1	1	1	1	1
8	1	0	0	0	0	1	0	0	0	0	0	0
9	1	0	0	0	1	0	0	1	0	0	0	1
10	1	0	0	1	0	0	1	0	0	0	0	0
11	1	0	0	1	1	0	0	1	0	0	0	1
12	1	0	0	1	1	0	0	1	0	0	0	1

4. Synchronous decade counter using T flip flop or Mod 10 counter.

Sol. Synchronous decade counter = Mod 10 counter

$$N=10$$

$$2^n \geq 10$$

$$2^4 \geq 10$$

$$n=4$$

$\Rightarrow$  Required T flip flop = 4

Conversion tables for T flip flop  
Conversion tables for T flip flop

13	1	1	0	1	X	X	X	X	X
14	1	1	1	0	X	X	X	X	X
15	1	1	1	1	X	X	X	X	X
					1	1	1	1	1

K-map  $T_c$

		Q <sub>B</sub> Q <sub>C</sub>							
00	01	0	1	1	0	1	1	0	1
01	00	0	0	0	0	0	0	1	0
11	10	0	1	0	0	0	1	0	0

$T_c = Q_A \bar{Q}_B$ .

K-map  $T_d$

		Q <sub>B</sub> Q <sub>C</sub>							
00	01	0	1	0	1	0	1	1	0
11	10	0	0	0	0	0	0	0	0

$T_d = Q_c \bar{Q}_A + \bar{Q}_B Q_B$ .

K-map for  $T_d$

		Q <sub>B</sub> Q <sub>C</sub>							
00	01	0	0	0	0	0	0	0	0
11	10	0	0	0	0	0	0	0	0

$T_d = Q_c Q_B + Q_B Q_A$ .

K-map for  $T_d$

		Q <sub>B</sub> Q <sub>C</sub>							
00	01	0	0	0	0	0	0	0	0
11	10	0	0	0	0	0	0	0	0

$T_d = Q_A \bar{Q}_C + Q_C Q_B$ .  
Don't care condition  
be taken care.

K-map  $T_e$

		Q <sub>B</sub> Q <sub>C</sub>							
00	01	0	0	0	0	0	0	0	0
11	10	0	0	0	0	0	0	0	0

$T_e = \bar{Q}_B Q_A + Q_A Q_C$ .

K-map  $T_f$

		Q <sub>B</sub> Q <sub>C</sub>							
00	01	0	1	1	0	0	0	0	0
11	10	0	0	0	0	0	0	0	0

$T_e = Q_B \bar{Q}_A + Q_A Q_C$ .

K-map  $T_g$

		Q <sub>B</sub> Q <sub>C</sub>							
00	01	0	0	0	0	0	0	0	0
11	10	0	0	0	0	0	0	0	0

$T_g = \bar{Q}_B Q_A + \bar{Q}_A Q_C$ .

K-map  $T_h$

		Q <sub>B</sub> Q <sub>C</sub>							
00	01	0	0	0	0	0	0	0	0
11	10	0	0	0	0	0	0	0	0

$T_h = Q_A \bar{Q}_C + Q_C Q_B$ .

K-map  $T_i$

		Q <sub>B</sub> Q <sub>C</sub>							
00	01	0	0	0	0	0	0	0	0
11	10	0	0	0	0	0	0	0	0

$T_i = Q_A \bar{Q}_C + \bar{Q}_A Q_C$ .

K-map  $T_j$

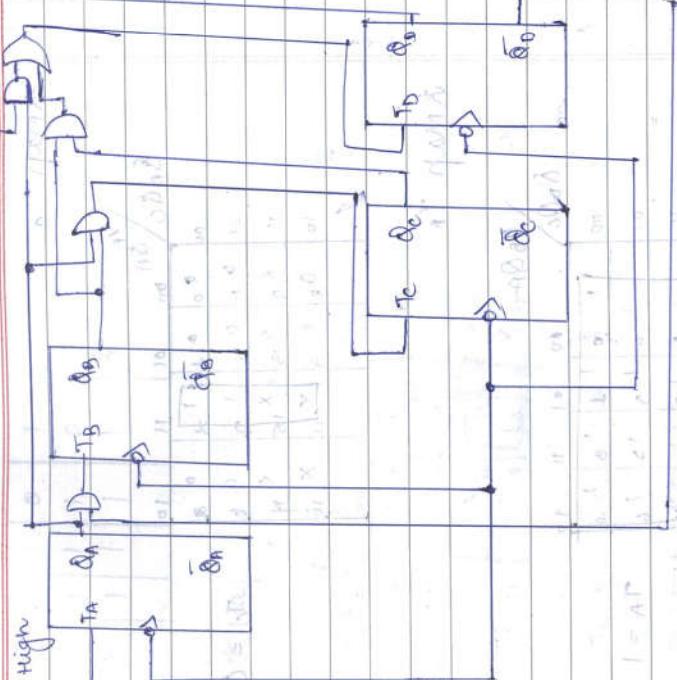
		Q <sub>B</sub> Q <sub>C</sub>							
00	01	0	0	0	0	0	0	0	0
11	10	0	0	0	0	0	0	0	0

$T_j = Q_A \bar{Q}_C + \bar{Q}_A Q_B$ .

K-map  $T_k$

		Q <sub>B</sub> Q <sub>C</sub>							
00	01	0	0	0	0	0	0	0	0
11	10	0	0	0	0	0	0	0	0

$T_k = Q_A \bar{Q}_C + \bar{Q}_A Q_B$ .

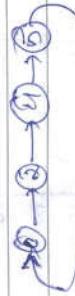


	Adr.	digit	Present state $Q_A$ $Q_B$ $Q_C$	Next state $Q_A$ $Q_B$ $Q_C$	Output
0		0	0 0 0	0 0 0	0 0 1 0
1		1	0 0 1	X X	X X
2		2	0 1 0	0 1 0	1 1 0
3		3	0 1 1	X X	X X
4		4	1 0 0	1 0 1	0 0 1
5		5	1 0 1	0 0 0	1 0 1
6		6	1 1 0	X X	X X
7		7	1 1 1	X X	X X

Sol. Number of state =  $2^3$   
Required T flip flop = 3.

conversion table for T flip flop

Design skipping state counter using T flip flop skipping sequence shown below.



$Q_m$	$Q_{m+1}$	$T$	$Q_m$
0	0	0	0
1	0	1	1
1	0	0	1

## K map. for T

$$r_0 = \theta_0 + \delta c$$

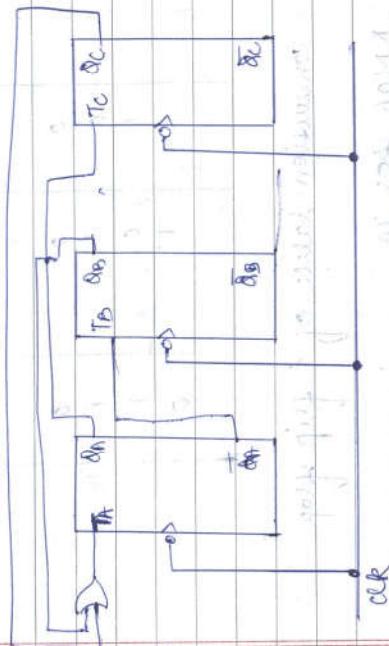
Map for T<sub>B</sub>

$$T_B = \overline{S_A} \oplus M_2(\text{diag}(3, 1, 1, 1))$$

sk map for Tc

	00	01	11	10
00	0	0	X	3
01	0	0	1	X
11	0	0	1	X
10	0	0	1	X

$$T_C = Q_A.$$



17.

design  
3 Zeit synchronous down counter using  
T flip flop.

	$Q_m$	$Q_{m+1}$	$T$
0000	0	0	0
0001	1	1	1
0010	1	0	1
0011	1	1	0

connection table of T flip flop.

i) K-map for  $T_A$

Simplifying Boolean expression	
$Q_m Q_{m+1} \bar{T}_A$	00 01 10 11
$\bar{Q}_m Q_{m+1} T_A$	01 10 00 11
$Q_m \bar{Q}_{m+1} \bar{T}_A$	10 11 00 01
$\bar{Q}_m \bar{Q}_{m+1} T_A$	11 01 01 00

$T_A = 1$ .

ii) K-map for  $T_B$

Simplifying Boolean expression	
$Q_m Q_{m+1} \bar{T}_B$	00 01 10 11
$\bar{Q}_m Q_{m+1} T_B$	01 10 00 11
$Q_m \bar{Q}_{m+1} \bar{T}_B$	10 11 00 01
$\bar{Q}_m \bar{Q}_{m+1} T_B$	11 01 01 00

iii) K-map for  $T_C$

Simplifying Boolean expression	
$Q_m Q_{m+1} \bar{T}_C$	00 01 10 11
$\bar{Q}_m Q_{m+1} T_C$	01 10 00 11
$Q_m \bar{Q}_{m+1} \bar{T}_C$	10 11 00 01
$\bar{Q}_m \bar{Q}_{m+1} T_C$	11 01 01 00

$$T_C = \overline{Q}_B Q_A$$



Design 3-bit counter using D flip-flop

Digit	Present state	New state	Output
0	000	000	0 0 0
1	001	001	0 0 1
2	010	010	0 1 0
3	011	011	0 1 1

## Design - 1

Date \_\_\_\_\_  
Page No. \_\_\_\_\_

Date \_\_\_\_\_  
Page No. \_\_\_\_\_

$Q_1$	$Q_2$	$Q_3$	$Q_4$	$Q_5$	$Q_6$	$Q_7$	$Q_8$
0	0	0	0	1	0	1	0
1	0	1	0	1	1	0	1
0	1	0	1	1	0	0	1
1	1	1	0	0	0	1	1
0	0	0	1	0	0	0	0
1	0	0	0	1	0	0	0
0	1	0	0	0	1	0	0
1	1	0	0	0	0	1	0

connection of T flip flop.

$Q_C$	$Q_{C+1}$	T
0	0	0
0	1	1
1	0	1
1	1	0

Kmap for TA

$Q_B$	$Q_A$	$Q_D$	$Q_C$	$Q_E$	$Q_F$	$Q_G$	$Q_H$
0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	1	0	0	0	0	0
1	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0
1	1	0	0	0	0	0	0
1	1	1	0	0	0	0	0

Kmap for TB

$Q_B$	$Q_A$	$Q_D$	$Q_C$	$Q_E$	$Q_F$	$Q_G$	$Q_H$
0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0
0	1	0	0	0	0	0	0
0	1	1	0	0	0	0	0
1	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0
1	1	0	0	0	0	0	0
1	1	1	0	0	0	0	0

$$T_B = Q_B \oplus Q_C$$

$Q_1$	$Q_2$	$Q_3$	$Q_4$	$Q_5$	$Q_6$	$Q_7$	$Q_8$
0	0	0	0	1	0	1	0
1	0	1	0	1	1	0	1
0	1	0	1	1	0	0	1
1	1	1	0	0	1	1	1
0	0	0	1	0	0	0	0
1	0	0	0	1	0	0	0
0	1	0	0	0	1	0	0
1	1	0	0	0	0	1	0

design 8 bit up & down rounder using  
T & flip flop

Control signal		Present state		Next state		Output	
$Q_1$	$Q_2$	$Q_3$	$Q_4$	$Q_5$	$Q_6$	$Q_7$	$Q_8$
0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0*	0	0	0	0	0	0
3	0*	0	0	1	0	0	0
4	0*	0	0	0	0	0	1
5	0*	0	1	0	0	0	1
6	1*	0	1	0	0	0	1
7	0	1	1	1	1	1	1
8	1	1	1	0	0	0	1
9	1	1	0	1	0	0	1
10	1	0	1	1	0	0	1
11	0	1	0	0	1	0	1
12	0	0	1	0	0	1	1
13	0	0	0	1	0	1	1
14	0	0	0	0	1	0	1
15	0	0	0	0	0	1	1

	J <sub>4</sub>	K <sub>4</sub>	J <sub>3</sub> K <sub>3</sub>	J <sub>2</sub>	K <sub>2</sub>	J <sub>1</sub>	K <sub>1</sub>
04	1	1	00	10	10	0	X
05	1	1	01	10	10	1	X
06	1	1	10	11	10	X	1X
07	1	1	11	00	1X	1X	X

Proof for  $f_{cc} = 0$ , when it acts over  
possible random counter. If  $c=0$ ,  
 $c=1$  then it acts as an up  
counter.

Design using state transition

connection table for JK flip flop

Q <sub>n</sub>	Q <sub>n+1</sub>	J	K	Q
1000, 10	0	1	0	0
0111, 00	0	0	1	0
0100, 01	0	1	0	1
1100, 11	1	0	0	1
1110, 00	1	1	0	0
1010, 01	1	0	1	0
0010, 10	0	1	1	0
0110, 11	0	1	1	1

K map for JA = 1

$$JA = \overline{C} \bar{B} \bar{Q}_A + C \bar{B} Q_A$$

K map for RA

C \ B \ Q_A	00	01	10	11
00	00	01	00	01
01	01	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>
10	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>	X <sub>7</sub>
11	00	01	10	11

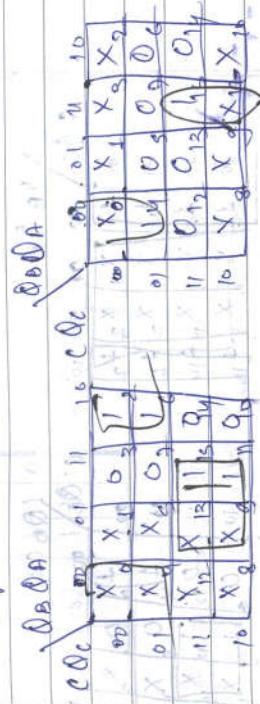
$$JA = \overline{C} \bar{B} \bar{Q}_A + C \bar{B} Q_A \quad RA = 1$$

K map for J<sub>0</sub>

C \ B \ Q_A	00	01	10	11
00	00	01	00	01
01	01	X <sub>1</sub>	X <sub>2</sub>	X <sub>3</sub>
10	00	01	10	11
11	X <sub>4</sub>	X <sub>5</sub>	X <sub>6</sub>	X <sub>7</sub>

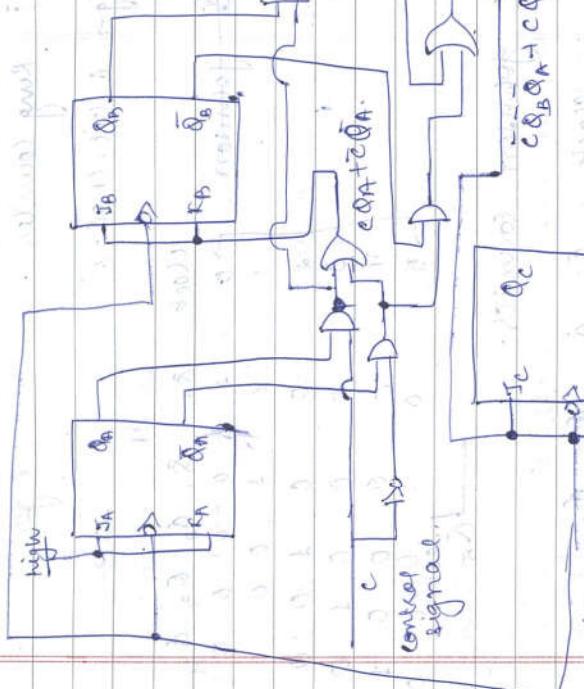
$$J_0 = \overline{C} \bar{B} \bar{Q}_A + C \bar{B} Q_A \quad J_0 = 1$$

K Map for  $R_B$



$$R_B = \bar{C}Q_A + \bar{C}\bar{Q}_A$$

$$R_C = \bar{C}Q_B\bar{Q}_A + CQ_BQ_A$$



$$\bar{C}Q_B\bar{Q}_A + CQ_BQ_A$$

clk pulse.

