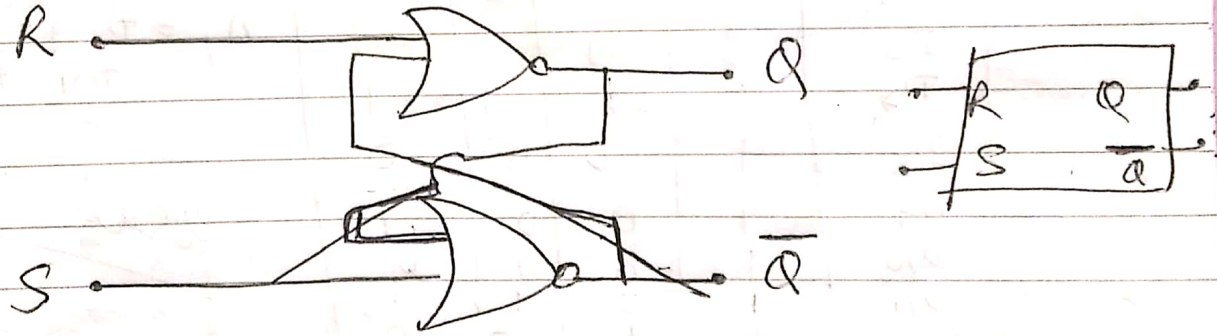
10. Sequential circuits

(1) Latch :-

S-R Latch :- Using NOR

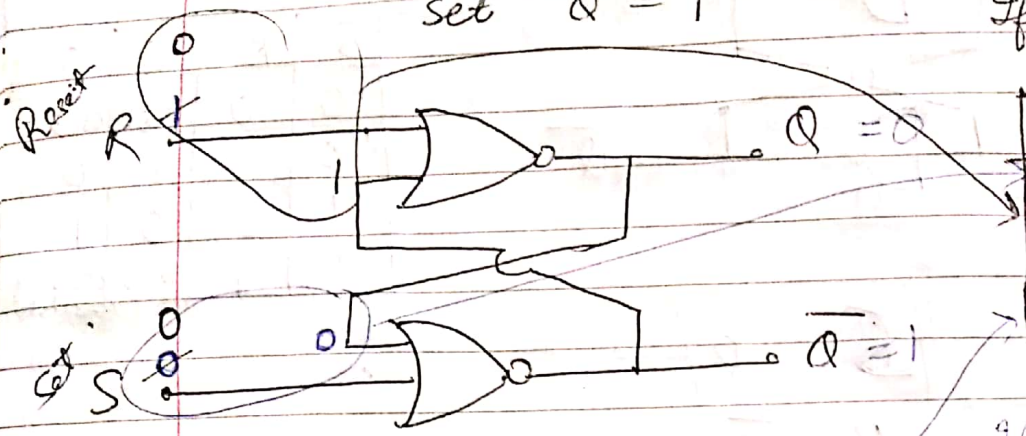


Reset $Q = 0$

Set $Q = 1$

If $R = 1$ Output = 0

If $S = 1$ output = 1



NOR

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

If Input = 1 output is 0

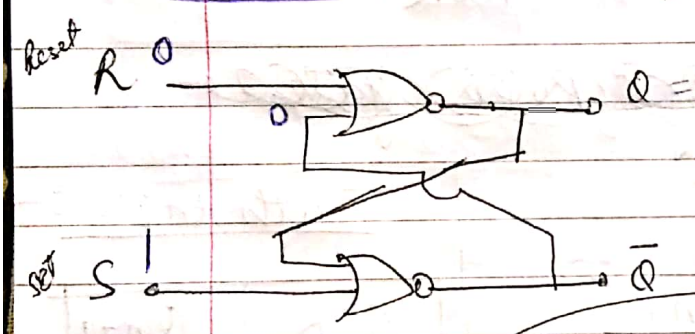
Case I :- $S = 0$, $R = 1$

$Q = 0$, $\bar{Q} = 1$

Memory as we have the previous output.

$S = 0$, $R = 0$, $Q = 0$ & $\bar{Q} = 1$

Case II :- $S = 1$, $R = 0$, $Q = 1$ & $\bar{Q} = 0$



$S = 0$, $R = 0$, $Q = 1$, $\bar{Q} = 0$

Memory.

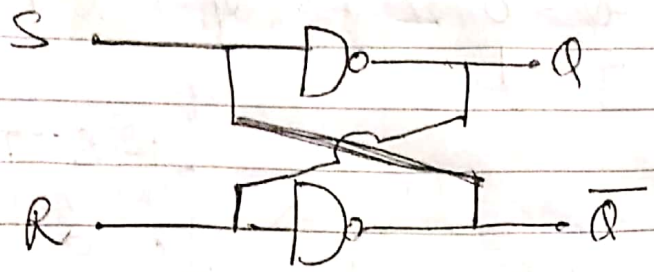
Case III :- $S = 1$, $R = 1$, $Q = 0$, $\bar{Q} = 0$

Not used $S = 0$, $R = 0$, $Q = 0$ & $\bar{Q} = 1$

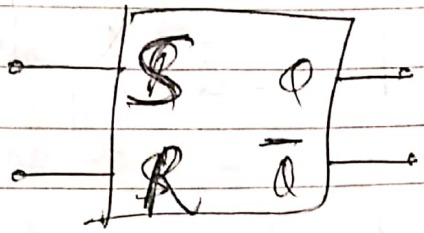
$Q = 1$ & $\bar{Q} = 0$

S	R	Q $\bar{Q}$
0	0	Memory as before / No change.
0	1	0 1
1	0	1 0
1	1	Not used / Invalid condⁿ.

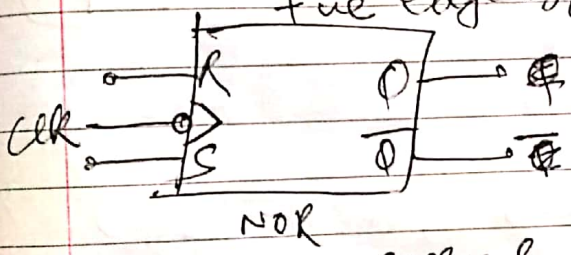
SR - Latch - using NAND

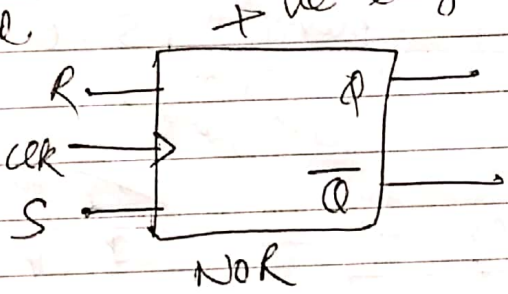


S	R	Q	$\bar{Q}$
0	0	Not used	
0	1	1	0
1	0	0	1
1	1	Memory state	



Flip flop





1. S-R flipflop

Characteristic table:

CLK	S	R	Qn	Qn+1	
↑	0	0	0	0	no change.
↑	0	0	1	1	
↑	0	1	0	0	Reset condition
↑	0	1	1	0	
↑	1	0	0	1	set condition
↑	1	0	1	1	
↑	1	1	0	X	invalid
↑	1	1	1	X	
↓	anything			No change.	

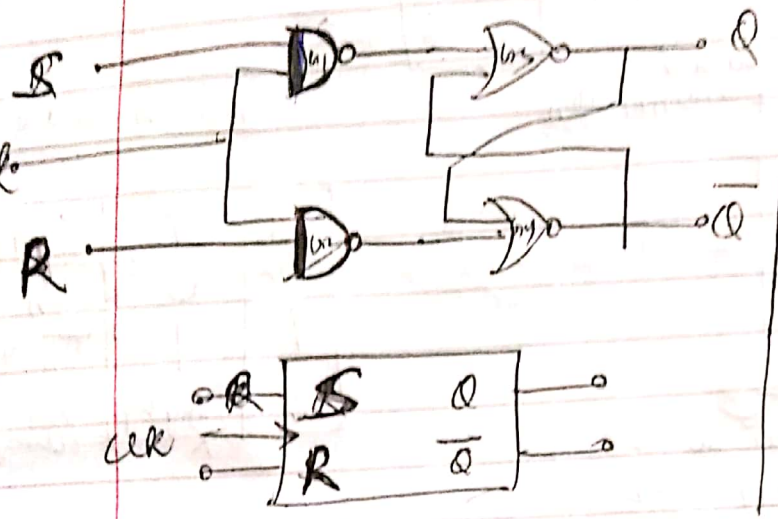
Truth table:-

S	R	Qn+1
0	0	No change (Qn)
0	1	0 (Reset)
1	0	1 (set)
1	1	Invalid (race cond.)

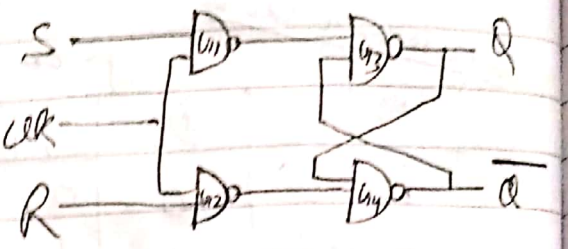
Excitation table

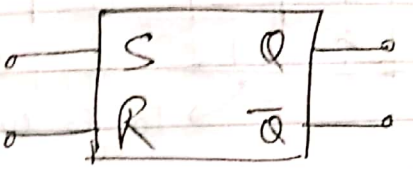
Qn	Qn+1	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

Circuit diag using NOR



Circuit diag using NAND





2° D flip flop :-

Characteristic table

clk	D	Qn	Qn+1
↑	0	0	0
↑	0	1	0
↑	1	0	1
↑	1	1	1
↓	anything		No change

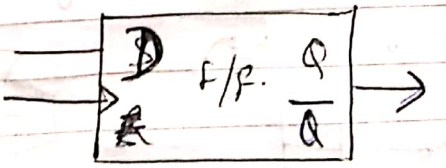
Same

Excitation table

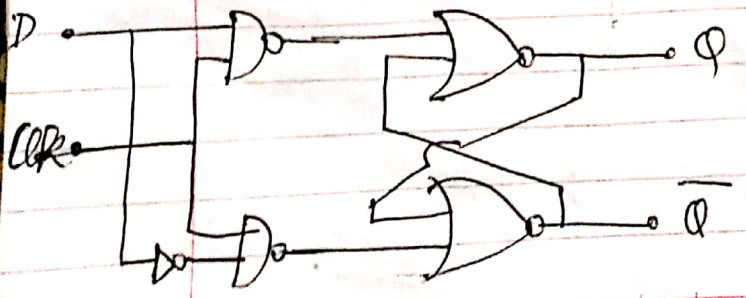
Qn	Qn+1	D
0	0	0
0	1	1
1	0	0
1	1	1

Truth table

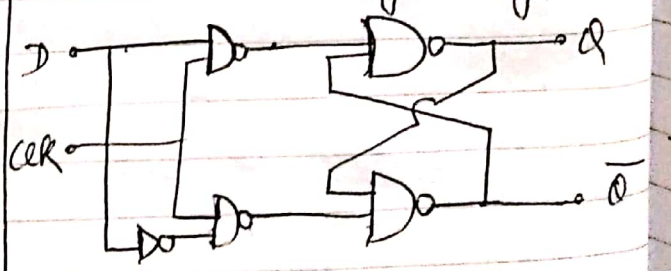
	D	Qn+1
↑	0	0
↑	1	1
↓	anything	No change



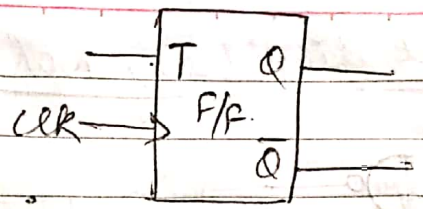
Circuit diagram using NOR



Circuit diag using NAND



(3) T flip flop :-



Characteristic table.

Toggle on nahi hai so $Q_{n+1} = Q_n$

clk	T	Q_n	Q_{n+1}
↑	0	0	0
↑	0	1	1
↑	1	0	1
↓	1	1	0

Toggle on hai so Q_{n+1} will be reverse of Q_n

↓ anything no change

Truth table

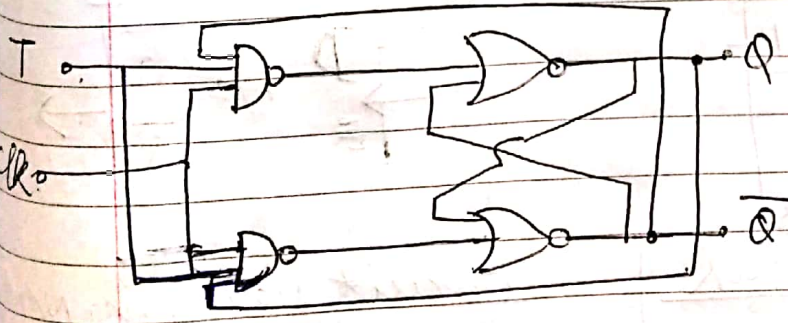
clk	T	Q_{n+1}
↑	0	Q_n no change
↑	1	$\bar{Q}_n$ Toggle
↓	anything ✗	No change

Excitation table

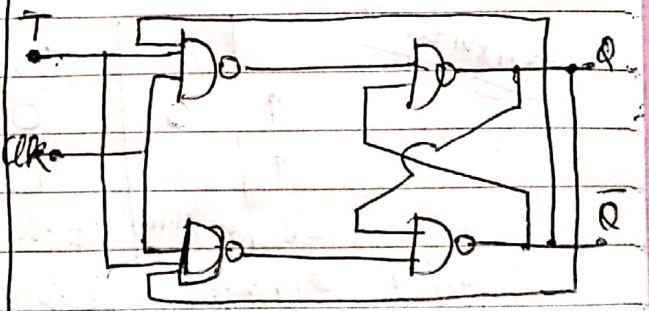
Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

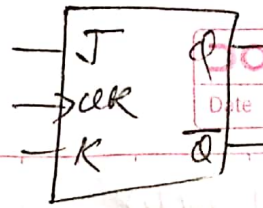
diff input pe

Circuit diag using ~~AND~~ NOR



Circuit diag using NAND





→ prefere over SR.

④ JK flip flop :→

Characteristic table

clk	J	K	Qn	Qn+1	
↑	0	0	0	0	← no change
↑	0	0	1	1	←
↑	0	1	0	0	← Reset
↑	0	1	1	0	←
↑	1	0	0	1	← Set
↑	1	0	1	1	←
↑	1	1	0	1	← Toggle condn
↑	1	1	1	0	←
↓		anything		No change	

→ work as Reset

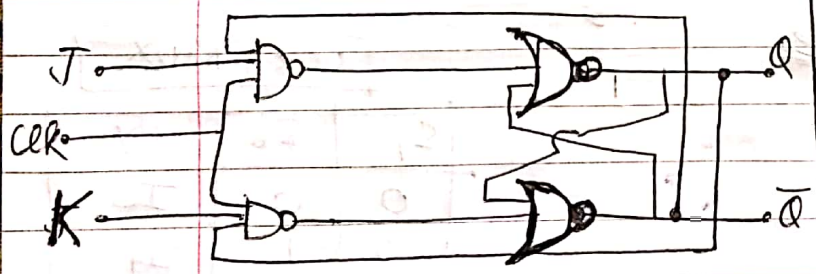
Truth table

clk	J	K	Qn+1
↑	0	0	Qn (no change)
↑	0	1	0 (Reset)
↑	1	0	1 (set)
↑	1	1	$\overline{Q}$n (toggle)
↓	anything		no change.

Excitation table

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

Circuit diagram using NOR



Circuit diagram using NAND