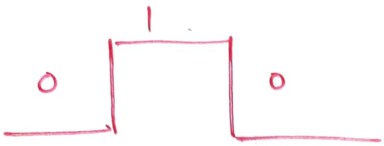
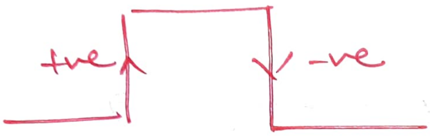
FLIP-FLOP :

we need a clock signal as Flip Flop which is a synchronous device.

Note:

* 

level 0/1 ⇒ Latch

* 

Edge –ve/ve ⇒ Flip-flop

- In synchronous device; the clock is always provided by using AND gate only.

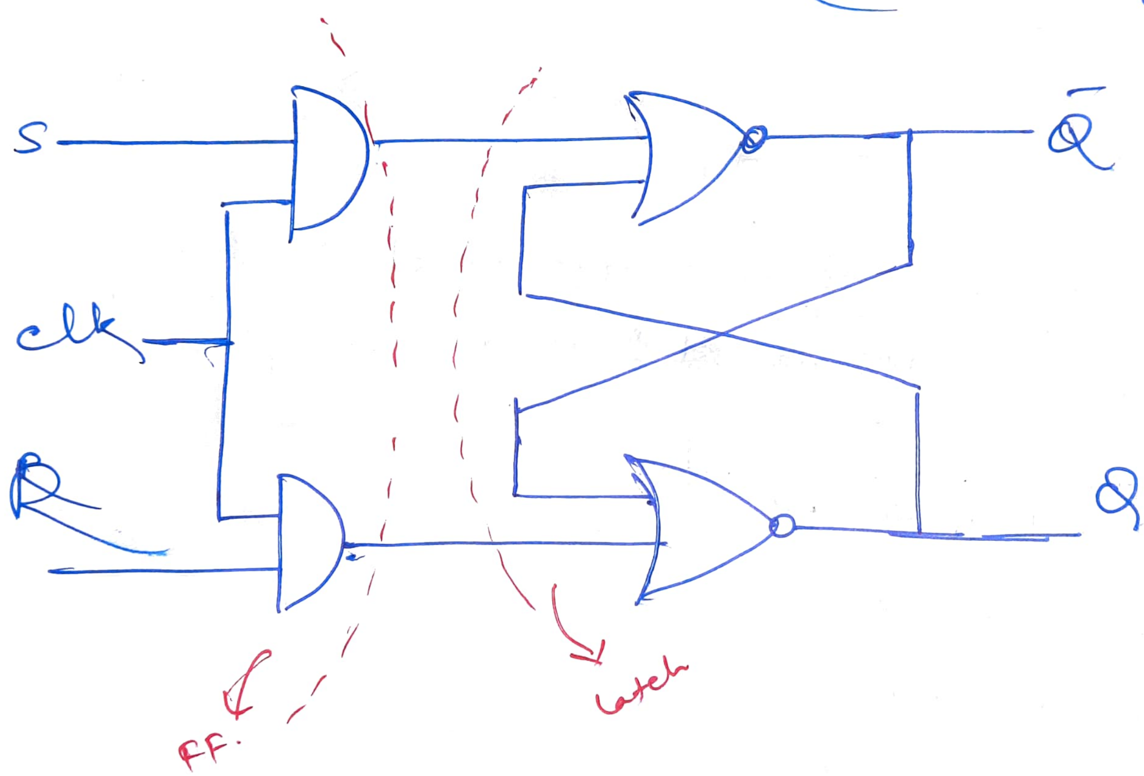
types of flip flop :

i) SR - FF
ii) D - FF
iii) JK - FF
iv) T - FF

I) SR-FF:

It is of two types → SR NOR FF / SR NAND FF

SR-FF (NOR) :- (clk-clock)



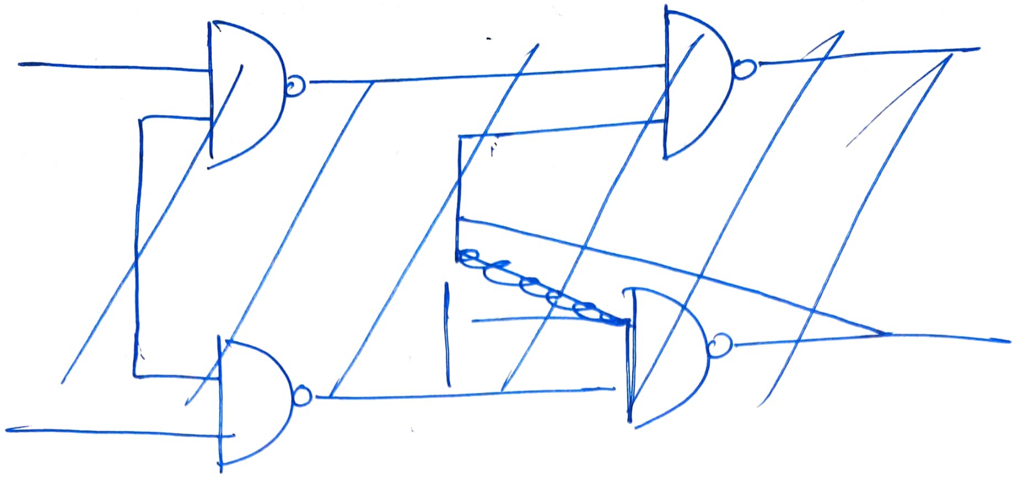
clock	Q_{n-1} (Previous state)	S	R	Q_n	
0	0	0	0	0	Prev. state
↑	0	0	1	0	clear
↑	0	1	0	1	set
↑	0	1	1	X	Invalid
0	1	0	0	1	Prev. state
↑	1	0	1	0	clear
↑	1	1	0	1	set
↑	1	1	1	X	Invalid.

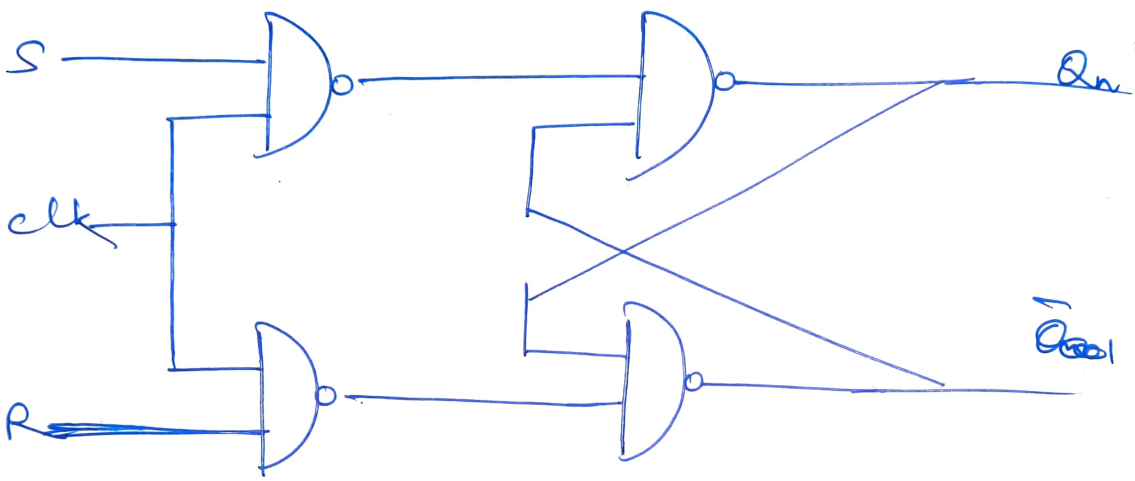
Characteristics eqn of SR-FF:

Q_{n-1} \ SR	$\bar S \bar R$	$\bar S R$	$S R$	$S \bar R$
$\bar Q_{n-1}$	(0)	(1)	(3) X	(2) 1
Q_{n-1}	(4) 1	(5)	(7) X	(6) 1

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

SR-FF (NAND):





characteristics table:

clk	Q_{n-1}	S	R	Q_n	
↑	0	0	0	0	prev. state
↑	0	0	1	0	clear state/reset
↑	0	1	0	1	set
↑	0	1	1	X	Invalid
↑	1	0	0	1	prev. state
↑	1	0	1	0	clear state / reset
↑	1	1	0	1	set
↑	1	1	1	X	Invalid
0	0	X	X	0	
0	1	X	X	1	

Characteristics equation:

Q_{n-1} \ SR	$\bar{S}\bar{R}$	$\bar{S}R$	SR	$S\bar{R}$
$\bar{Q}_{n-1}$	^{0}	^{1}	X ^{3}	1 ^{2}
Q_{n-1}	1 ^{4}	^{5}	X ^{7}	1 ^{6}

$$\boxed{Q_n = \bar{R}\,Q_{n-1} + S}$$

Note:

* Characteristics table for SR : (for both NAND & NOR)

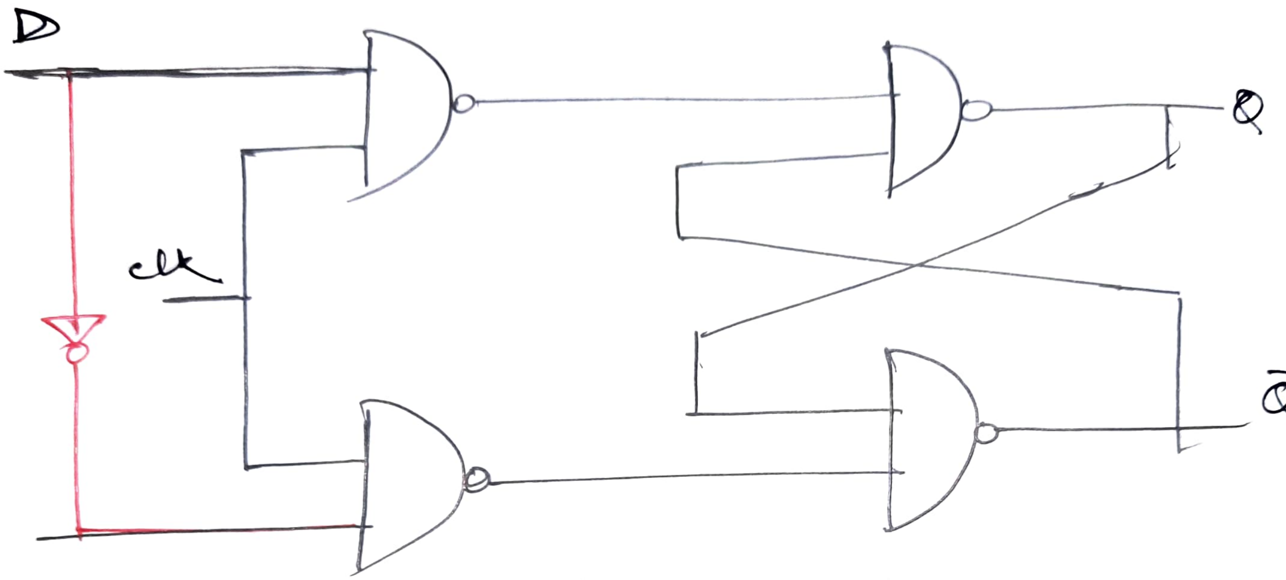
Q_n
prev. state (Q_{n-1})
Reset (0)
set (1)
Invalid (X)

* characteristics eqn for

SR-NOR FF = SR-NAND FF

II) D-FF:

- using NAND gate.
- was used because in SR FF; when clock pulse need to be 0; $Q_a = \bar{Q}$. To avoid this, we use D-flip flop.



characteristics table:

clk	Q_{n-1}	D	Q_n
↑	0	0	0
↑	0	1	1
↑	1	0	0
↑	1	1	1
↓ 0	0	0	0
↓ 0	0	1	0
↓ 0	1	0	1
↓ 0	1	1	1

} prev. state

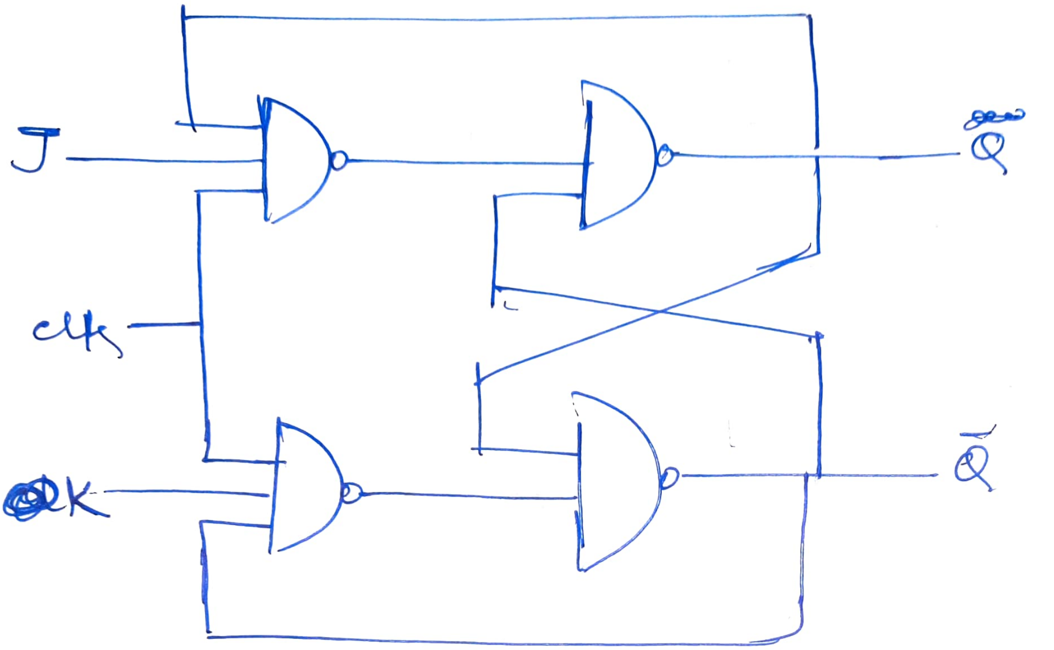
characteristics eqn :

Q_{n-1} \ D	$\bar{D}$	D
$\overline{Q_{n-1}}$	0	1 1
Q_{n-1}	2	3 1

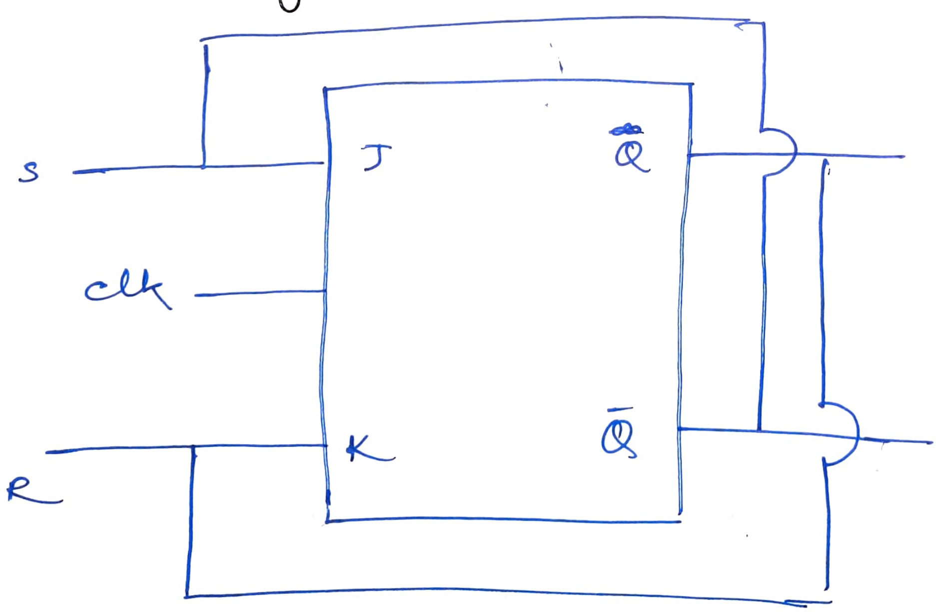
$$\boxed{Q_n = D}$$

III) JK-FF :

It was made to avoid the invalid case developed by SR-FF.



Block diagram :



~~clk Q_{n+1} Q~~

Characteristics table:

clk	Q_{n-1}	J	K	Q_n	
↑	0	0	0	0	No. change (Q_n)
↑	0	0	1	0	Reset
↑	0	1	0	1	set/change
↑	0	1	1	1	Toggle of Q_{n-1}
↑	1	0	0	1	N. change
↑	1	0	1	0	Reset
↑	1	1	0	1	Change
↑	1	1	1	0	Toggle of Q_{n-1}.

Note: Toggle of Q_{n-1} means
if $Q_{n-1} = 0$; then $Q_n = 1$
if $Q_{n-1} = 1$ then $Q_n = 0$

$\Downarrow$

J	K	Q_n
0	0	No change (Q_{n-1})
0	1	Reset (0)
1	0	Set (1)
1	1	$\overline{Q_{n-1}}$

Characteristics Eqn:

$$Q_n = \sum m(2,3,4,6)$$

Q_{n-1} \ JK	$\bar{J}\bar{K}$	$\bar{J}K$	JK	$J\bar{K}$
$\overline{Q_{n-1}}$	^{0}	^{1}	^{3} 1	^{2} 1
Q_{n-1}	^{4} 1	^{5}	^{7}	^{6} 1

$$Q_n = Q_{n-1}\bar{K} + \overline{Q_{n-1}}J$$

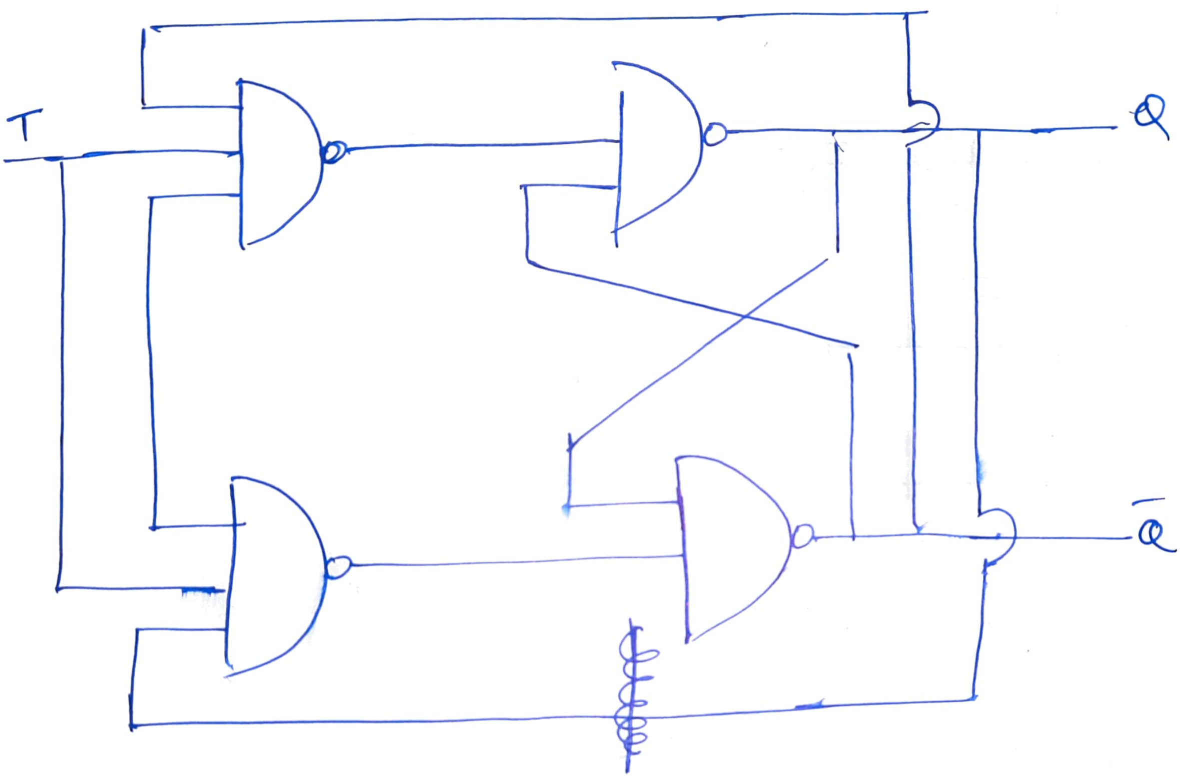
$$\therefore \boxed{Q_n = J\overline{Q_{n-1}} + \bar{K}Q_{n-1}}$$

IV. T-FF:

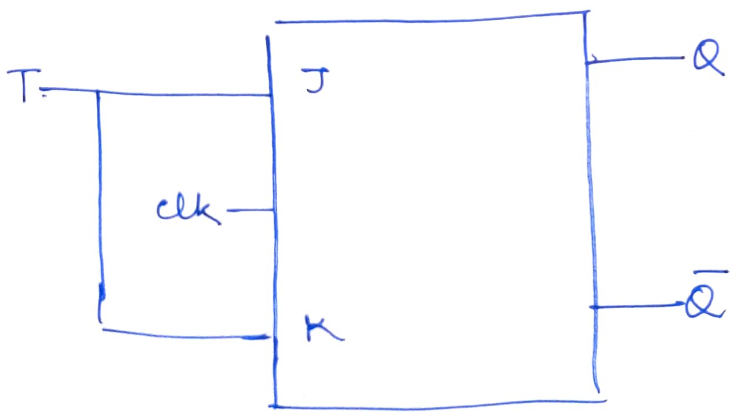
Two I/Ps are connected as a single I/P value re. T.

$T=0$; $J=K=0$; $Q_n = Q_{n-1}$ ✓

$T=1$; $J=K=1$; $Q_n = \overline{Q_{n-1}}$ ✓



Block diagram:



Characteristics table:

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

Characteristics Eq^n:

Q_{n-1} \ T	$\bar{T}$	T
$\overline{Q_{n-1}}$	^{0}	1^{1}
Q_{n-1}	1^{2}	^{3}

$$\boxed{Q_n = Q_{n-1}\bar{T} + \overline{Q_{n-1}}\,T}$$

Note :

I) Pattern of characteristics table of SR-FF:

- Prev. state (No change)
- reset (Q=0)
- set (Q=1)
- Invalid

II) Pattern of characteristics table of JK-FF.

- Prev. state
- reset
- set
- Toggle

III) For D-FF: $Q_n = D$

IV) For T-FF - ~~follows~~ same as XOR truth table.

* SR $\longrightarrow$ $Q_n = S + \bar{R} Q_{n-1}$

D $\longrightarrow$ $Q_n = D$

JK $\longrightarrow$ $Q_n = J \overline{Q_{n-1}} + \bar{K} Q_{n-1}$

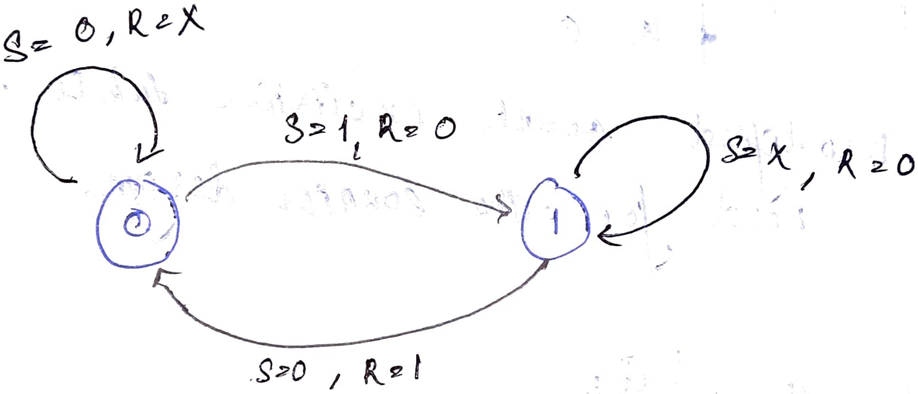
T $\longrightarrow$ $Q_n = Q_{n-1} \bar{T} + \overline{Q_{n-1}} T$.

Excitation table

1) SR - FF

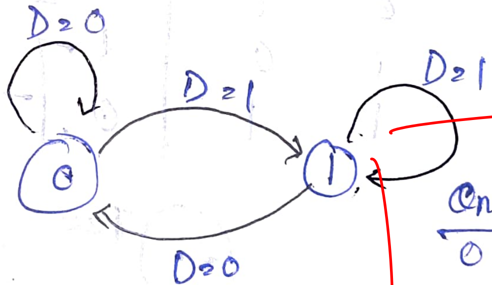
Q_{n-1}	S	R	Q_n	
0	0	0	0	0 to 0
0	0	1	0	
0	1	0	1	→ 0 to 1
0	1	1	x	
1	0	0	1	→ 1 to 1
1	0	1	0	→ 1 to 0
1	1	0	1	
1	1	1	x	

Q_{n-1}	Q_n	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0



2) D - FF

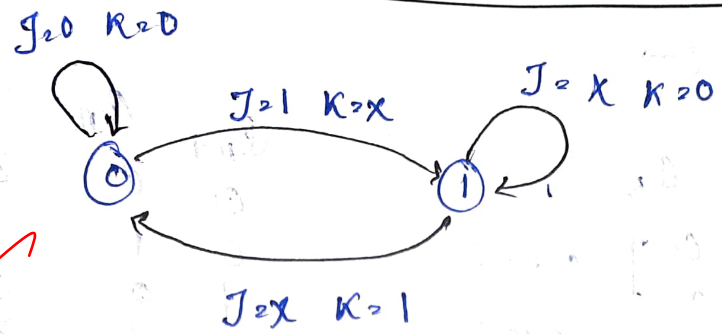
D	Q_{n-1}	Q_n
0	0	0
0	1	0
1	0	1
1	1	1



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

3) JK - FF

J	K	Q_{n-1}	Q_n	
0	0	0	0	→ No change
0	0	1	1	
0	1	0	0	
0	1	1	0	
1	0	0	1	
1	0	1	1	
1	1	0	1	→ Toggle
1	1	1	0	

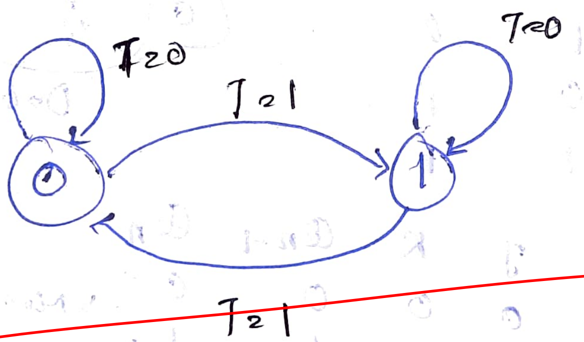


Q_{n-1}	Q_n	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

Modified count. excitation table we need for the counter design.

4) T-FF

T	Q_{n-1}	Q_n	
0	0	0	→ No toggle
0	1	1	
1	0	1	→ Toggle
1	1	0	



Modified Excitation Table

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