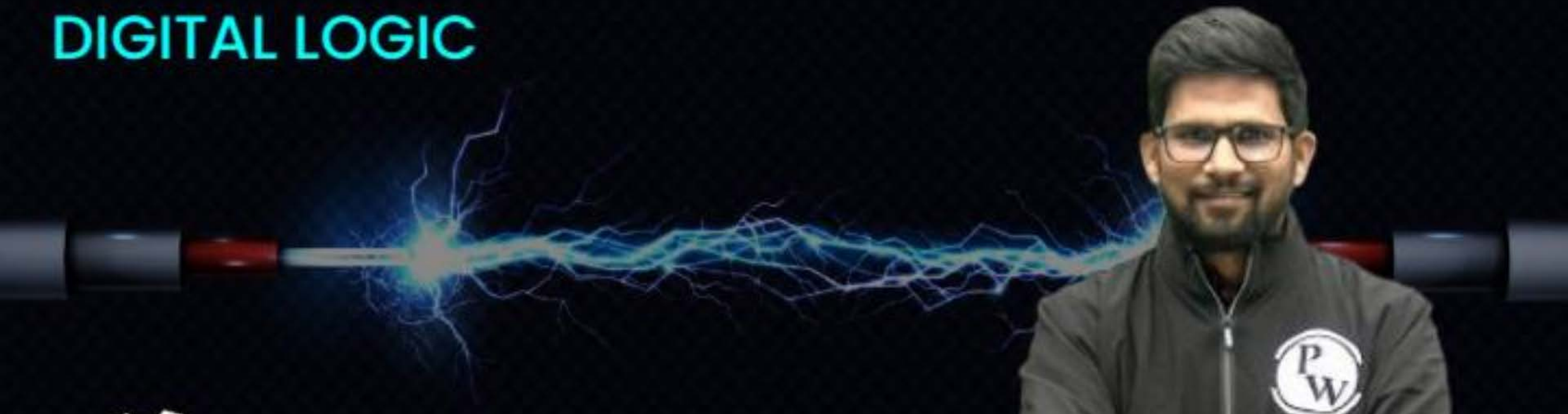
COMPUTER SCIENCE & IT

DIGITAL LOGIC



Lecture No: 02

Sequential Circuit

By- Chandan Gupta Sir

Recap of Previous Lecture

- S-R latch
- S-R FF

J-K FF

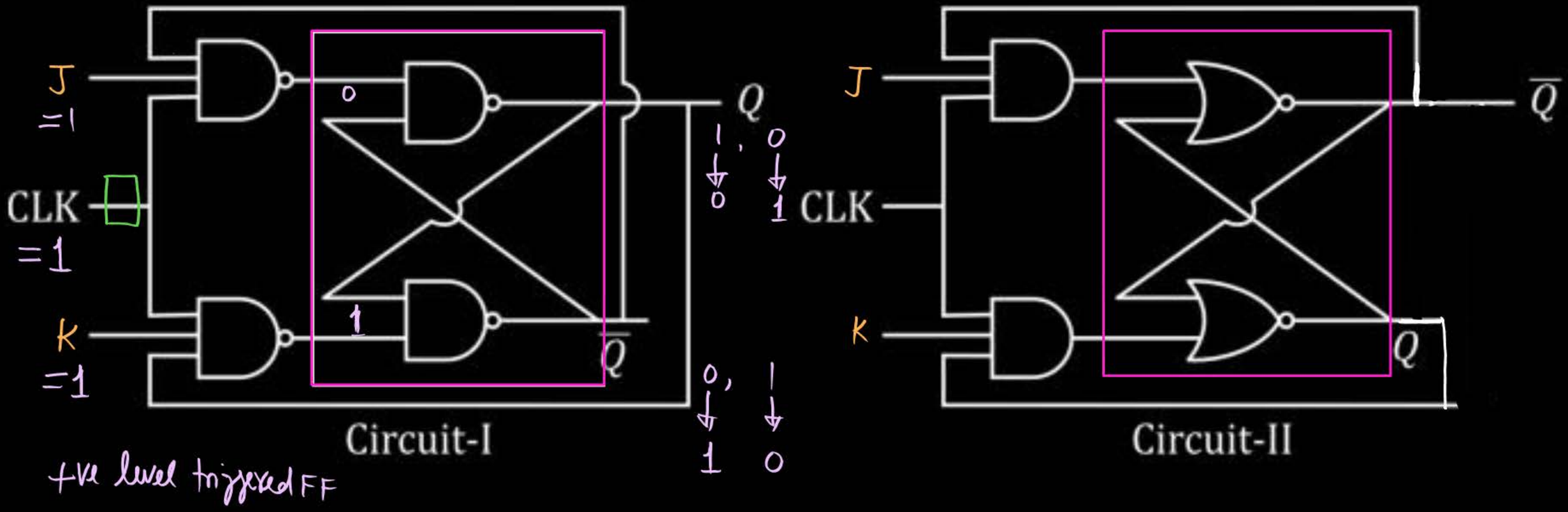
- **Problem with S-R flip-flop :**

$S=R=1$ is invalid state i/p which generates same value of Q & $\bar{Q}$ and this is a problem for circuit designing.

To remove this invalid state condition we design J-K FF.

J-K Flip-Flop

- Designed to avoid invalid state of S-R Flip-Flop.
- Circuit :



- Truth Table :

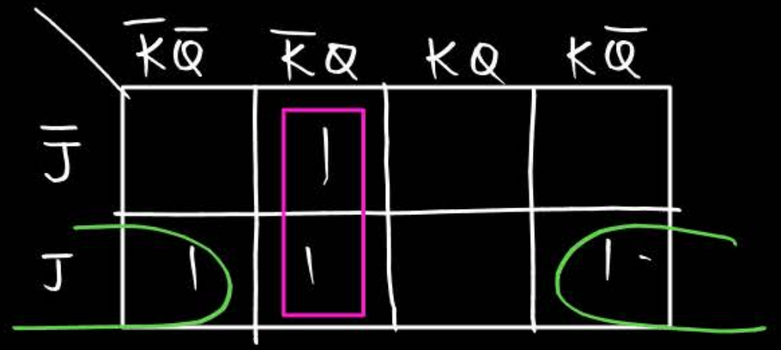
CLK	J	K	$Q(n+1)$
0	X	X	$Q(n)$
1	0	0	$Q(n)$ → Hold state
1	0	1	0
1	1	0	1
1	1	1	$\overline{Q(n)}$ → toggle state

Characteristic Table :

J	K	$Q(n)$	$Q(n+1)$
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

$Q(n+1)\ [J, K, Q(n)]$

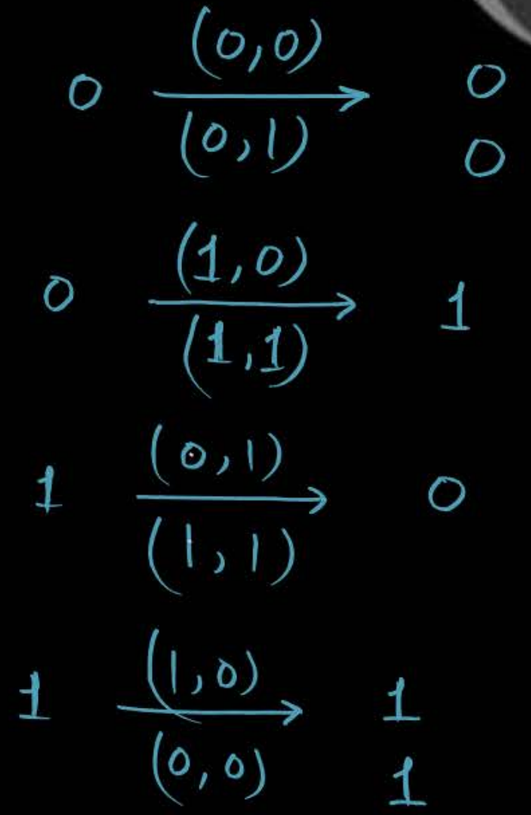
$= \Sigma(1,4,5,6)$



$Q(n+1) = J\bar{Q}(n) + \bar{K}Q(n)$

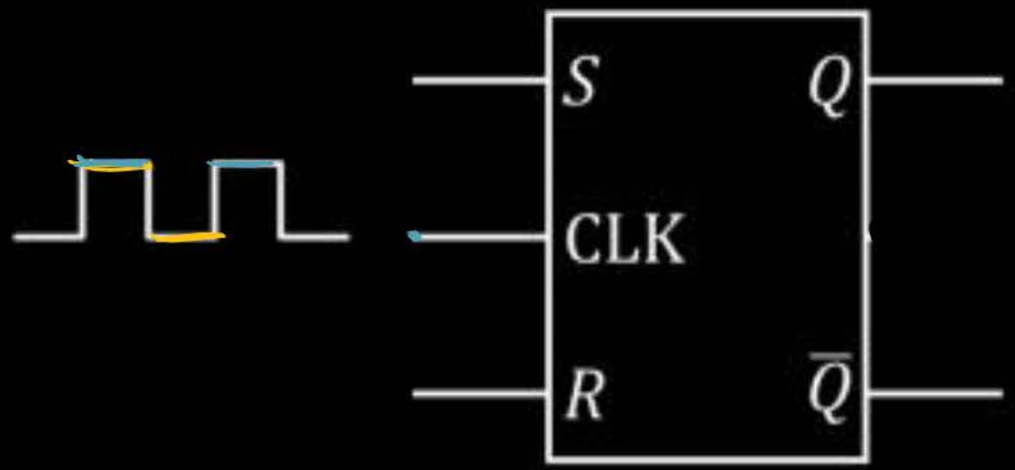
Excitation Table

$Q(n)$	$Q(n+1)$	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

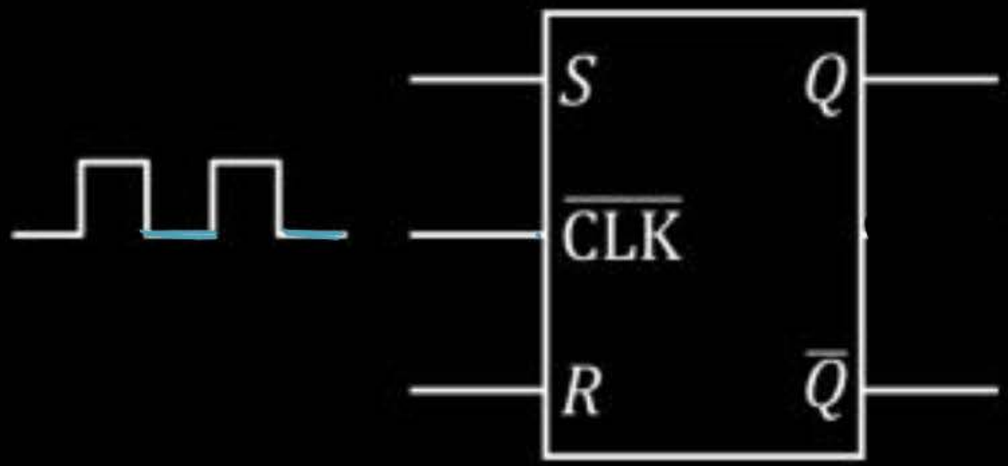


Level Triggered Flip-Flop

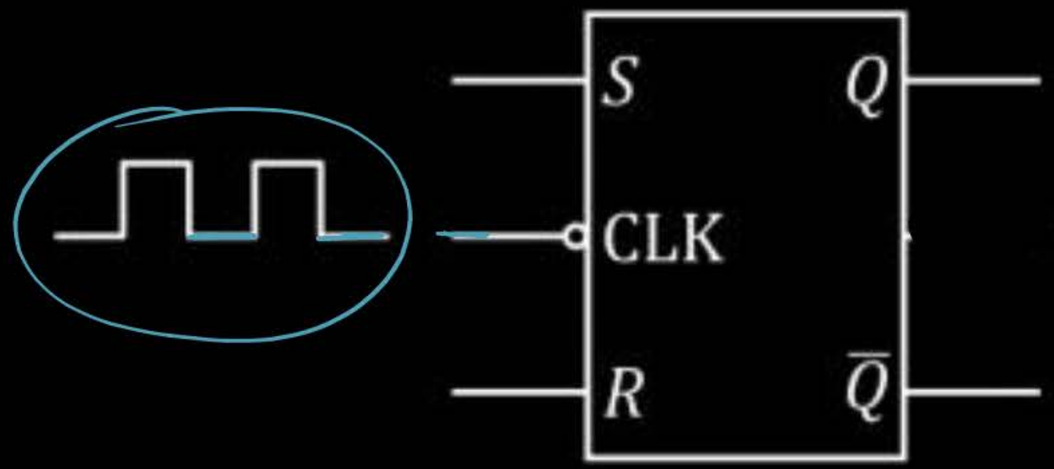
Different representation of level triggered FF's



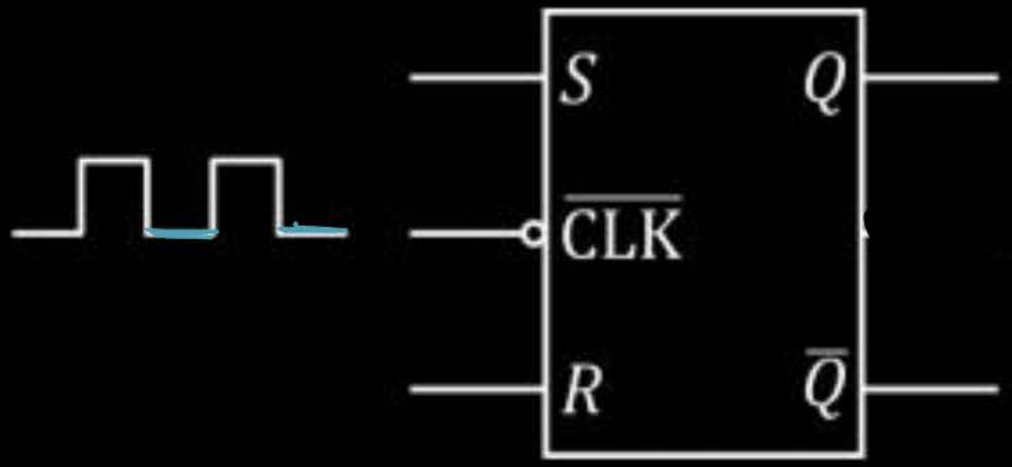
+ve level triggered



−ve level triggered

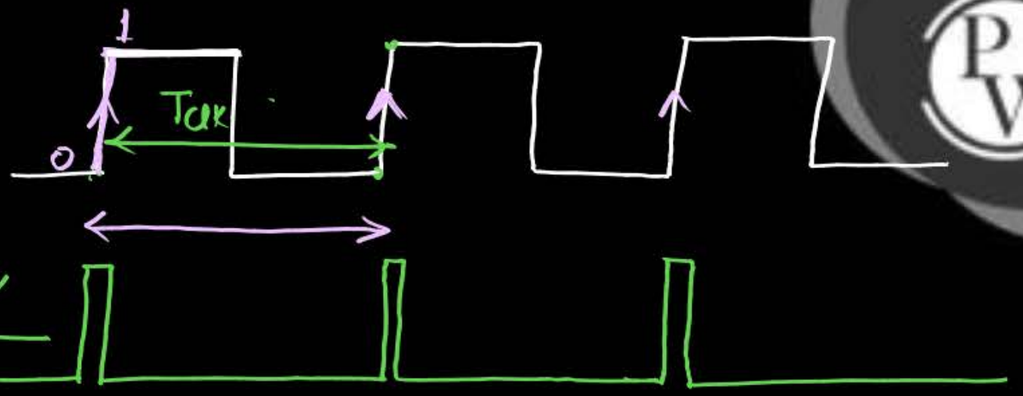


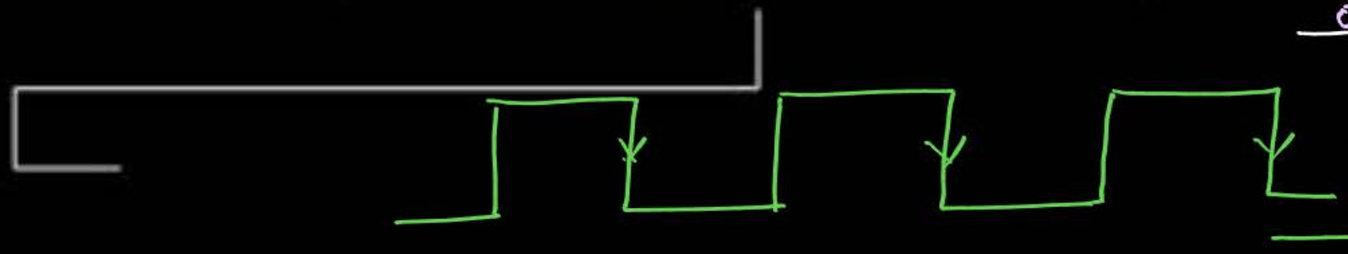
– ve level triggered

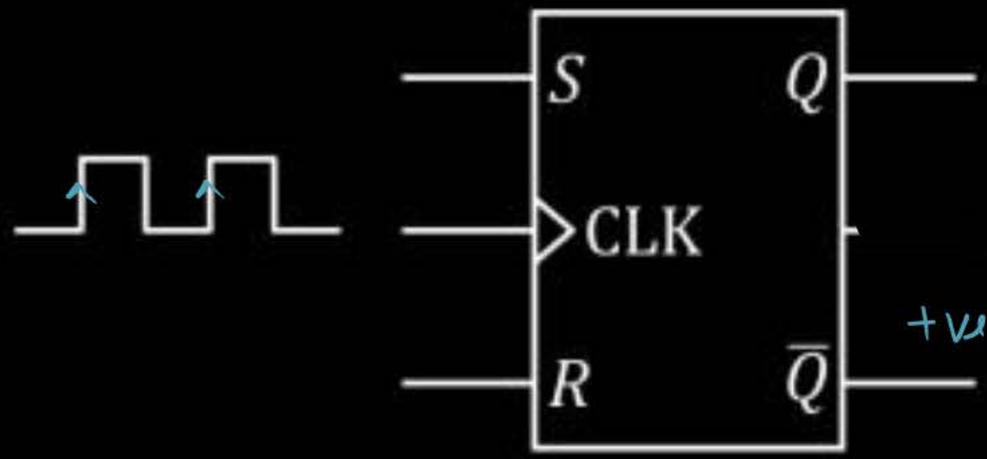


– ve level triggered

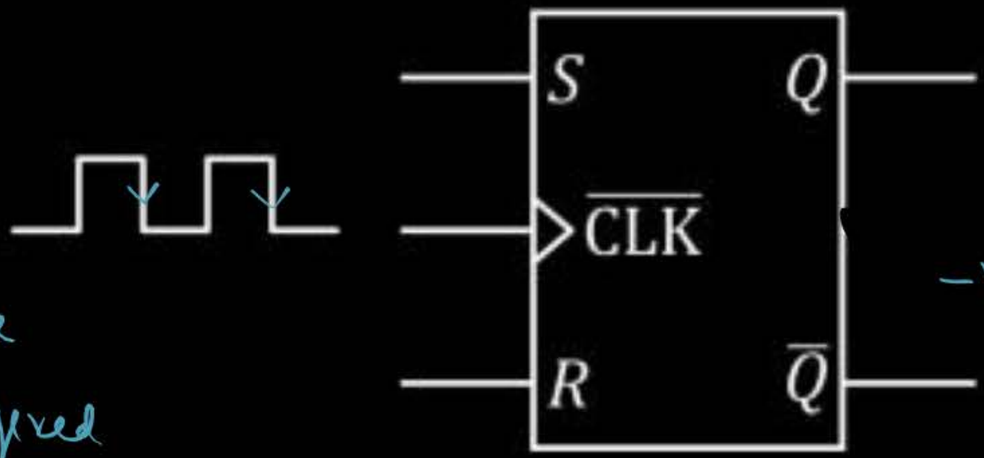
Edge Triggered FF







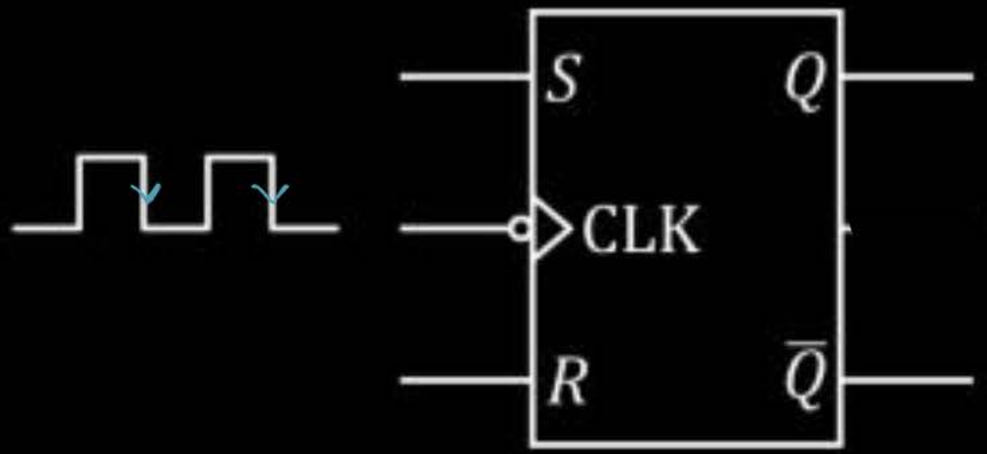
+ve edge triggered



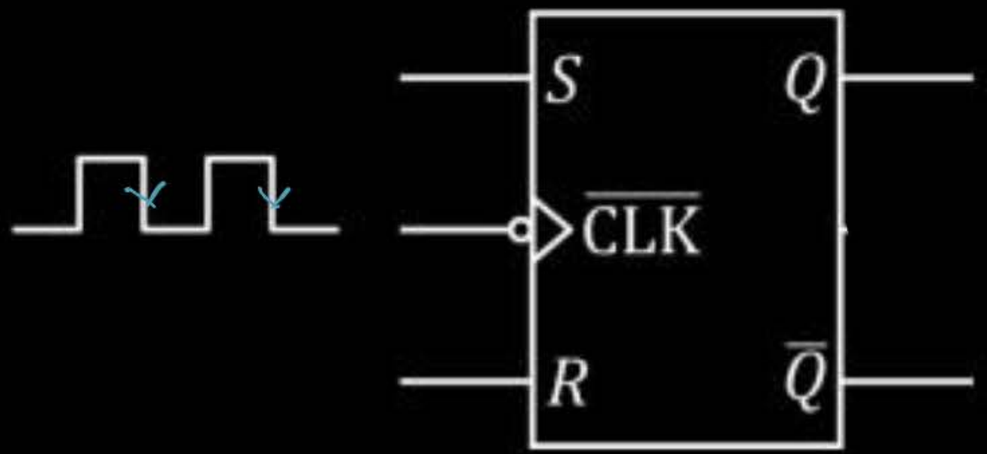
-ve edge triggered

+ve edge triggered → FF is triggered when clock is taking transition from (0 → 1) +ve edge.

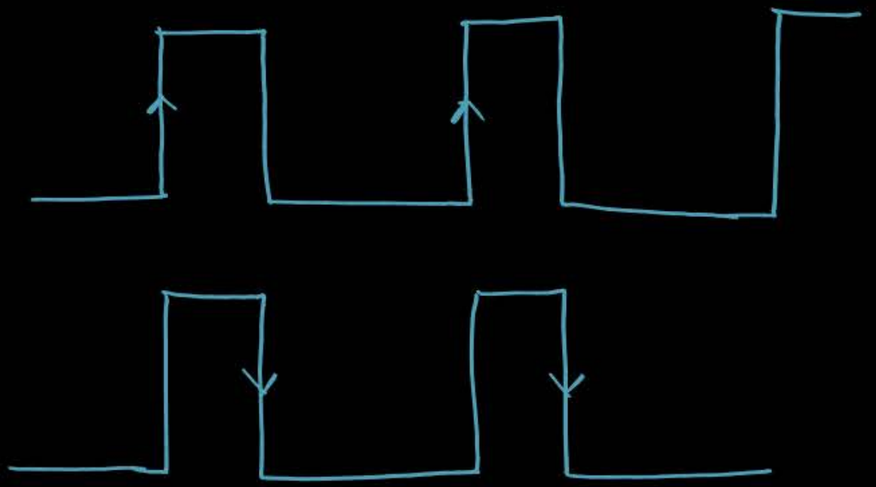
-ve edge triggered → FF is triggered when clock is taking transition from (1 → 0) → -ve edge.



-ve edge triggered



-ve edge triggered.

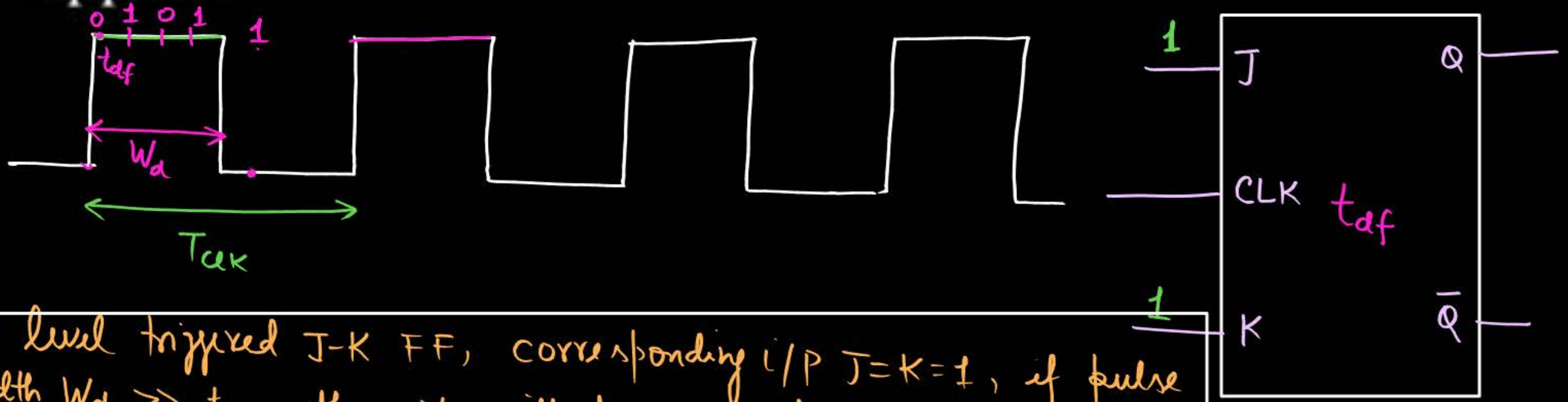


- IMP points about level triggered and edge triggered :

In case of level triggered FF O/P may change more than once in a single clock time period while in case of edge triggered FF O/P will change only once in a single clock time period.

Race Around Condition

- Lets understand what is Race-around condition and when it can happen :



On level triggered J-K FF, corresponding I/P J=K=1, if pulse width $W_d \gg t_{df}$ then O/P will change more than once in single clock and this condition is called as race around condition.

- **Final condition for Race Around Condition :**

Race around condition happens when all the condition written below will be satisfied :

(i) Level triggered J-K FF

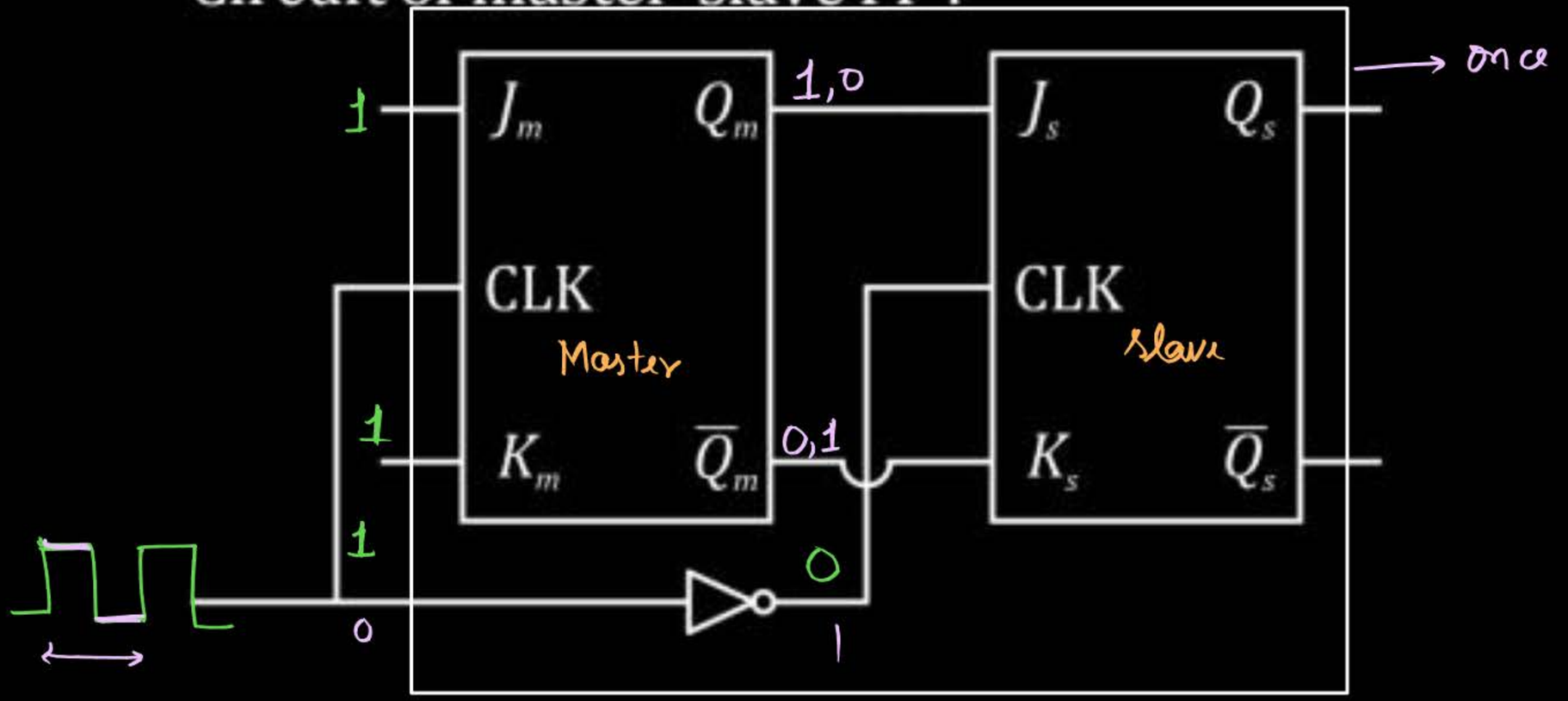
(ii) $J=K=1$

(iii). $W_d >> t_{af}$

Note : Race around condition never happens in edge triggered FF.

How to avoid race around condition using Master slave FF

- Circuit of master-slave FF :



How to avoid race around condition using Master slave FF

- Working :

Only one FF is triggered at a time either Master FF or slave FF.

O/P of Master-slave FF is taken from Slave FF O/P

Master is level triggered and slave is edge triggered.

[Question] (c)

Which of the following is/are true ?

(a) Race around condition occurs when $J = K = 1$ and edge triggered is applied. ✗

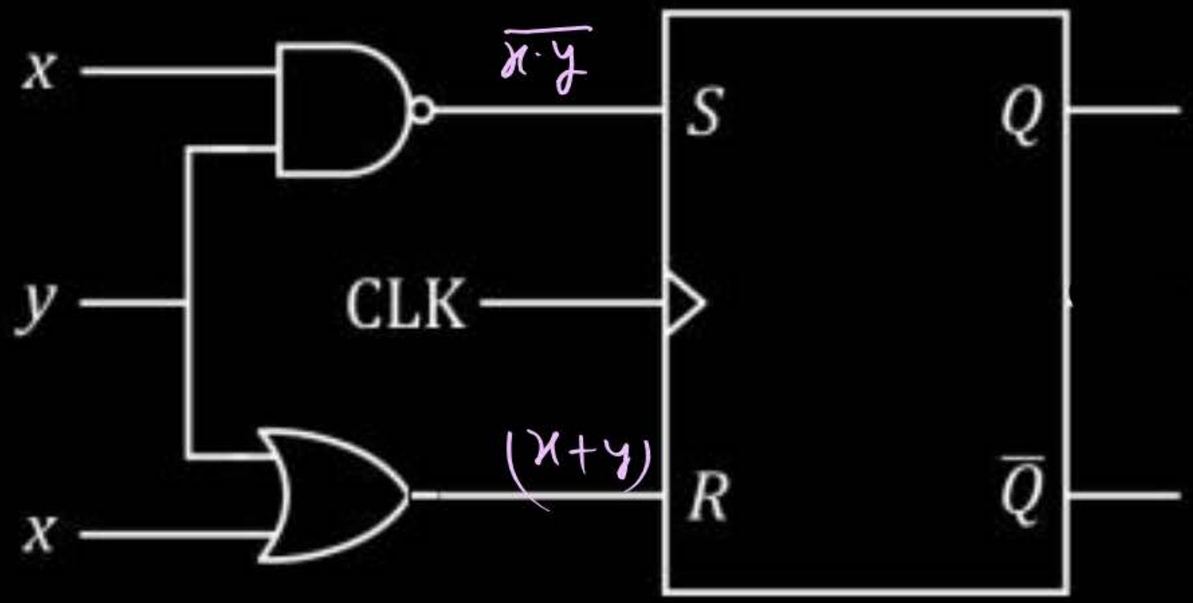
(b) Race around condition occurs when $J = 1, K = 0$ and level triggered is applied. ✗

(c) Race around condition never occurs in edge triggered J-K FF. ✓

(d) Race around condition occurs in S-R FF with $S = 0, R = 1$ and level triggered is applied. ✗

Question

An S-R FF circuit is as given below :



Characteristic equation of above FF is/are

(a) $\bar{x}$

(b) $\bar{y}$

(c) $\overline{x \cdot y}$

(d) $\overline{x + y}$

Wrong

$Q(n+1) = S + \bar{R}\,Q(n)$, $S \cdot R = 0$

$= \overline{x \cdot y} + \overline{x+y}\,Q(n)$

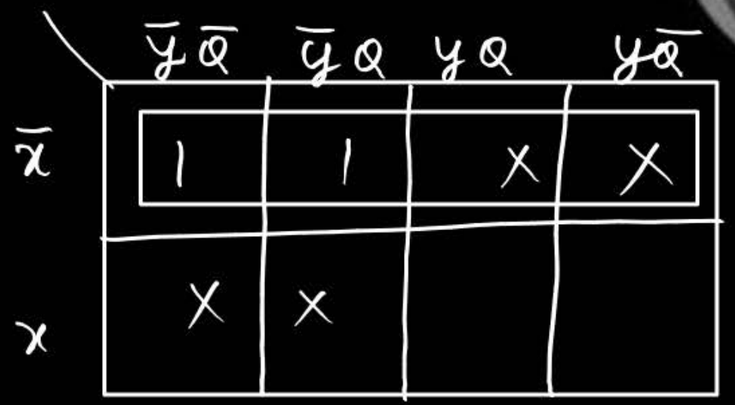
$= \bar{x} + \bar{y} + \bar{x}\bar{y}\,Q(n)$

$= \bar{x}\left[1 + \bar{y}\,Q(n)\right] + \bar{y}$

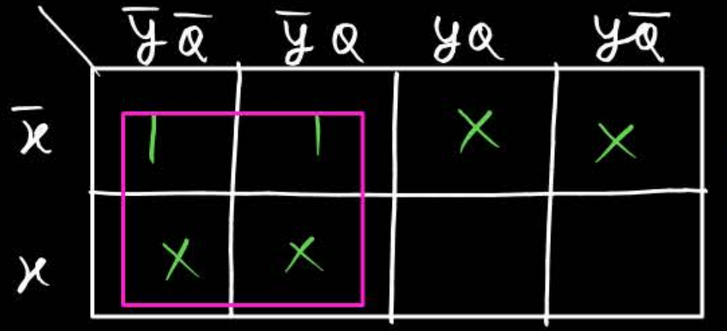
$= \bar{x} + \bar{y}$

$= \overline{x \cdot y}$

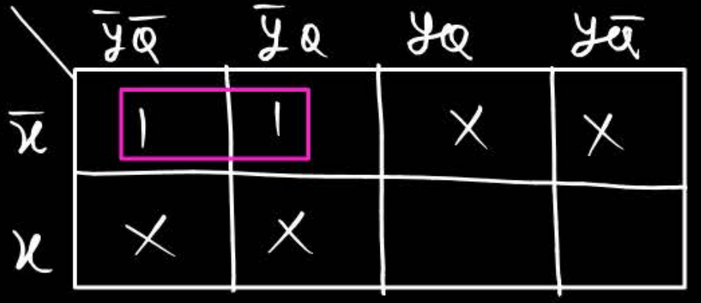
x	y	Q(n)	S	R	Q(n+1)
0	0	0	1	0	1
0	0	1	1	0	1
0	1	0	1	1	X
0	1	1	1	1	X
1	0	0	1	1	X
1	0	1	1	1	X
1	1	0	0	1	0
1	1	1	0	1	0



$Q(n+1) = \bar{x}$



$Q(n+1) = \bar{y}$



$Q(n+1) = \bar{x}\cdot\bar{y}$

$= \overline{x+y}$

Topic : 2 Min Summary

- J-K FF
- Concept of triggering
- Race around condition & Master-slave FF

Thank you

GW

Soldiers !