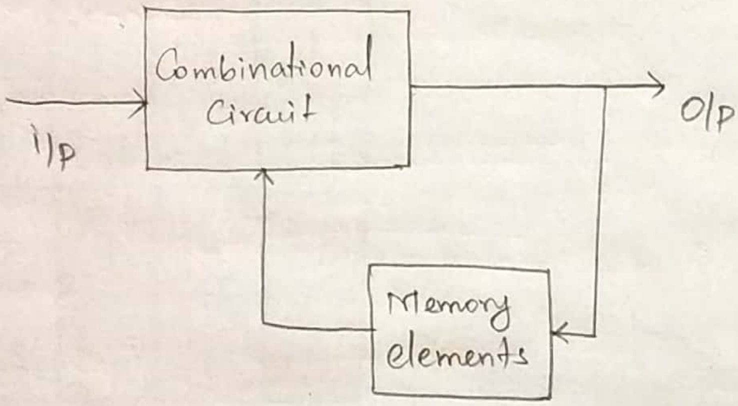
UNIT - III

SYNCHRONOUS SEQUENTIAL CIRCUITS

SEQUENTIAL LOGIC CIRCUITS

The Output of a combinational logic depends on the input levels whereas the output of a Sequential logic depends on Stored levels and also the input levels. A Sequential Circuit consists of a Combinational circuit and a memory element.



The information stored in the memory elements at any given time defines the Present State of the Sequential Circuits. The present State and the inputs determine the next State and the output of the Sequential circuit.

Combinational Circuit	Sequential Circuit
1) The output depends on input only.	1.) The output depends on Present i/p & Past o/p.
2) Memory elements are not required.	2.) Memory elements are required to store the Past outputs.
3.) Combinational Circuits are easy to design.	3.) These circuits are harder to design.
4) These circuits are faster in speed.	4) These circuits are slower than combinational circuits.
5.) Ex: Parallel adder Half Adder	5.) Ex: Counters Shift Registers.

There are 2 types of Sequential Circuits.

Asynchronous Sequential Circuits.

In asynchronous sequential circuit the outputs depend upon the order in which its input variables change and can be affected at any instant of time.

Synchronous Sequential Circuits.

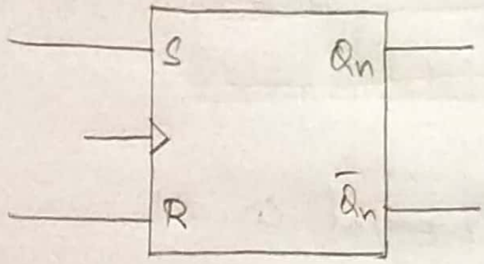
In Synchronous Sequential circuit the outputs depend upon the order in which its input variables change and can be affected at discrete instants of time.

Flip-Flops

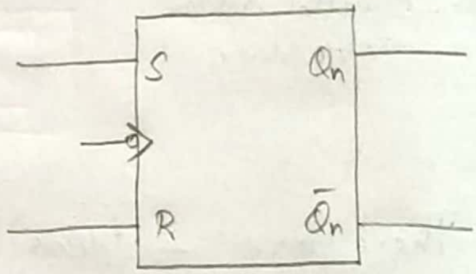
It is a sequential device that normally samples its inputs and changes its output only at times determined by clocking signal.

Flip Flops are bistable elements. The main difference between latches and Flip Flops is in the method used for changing their states.

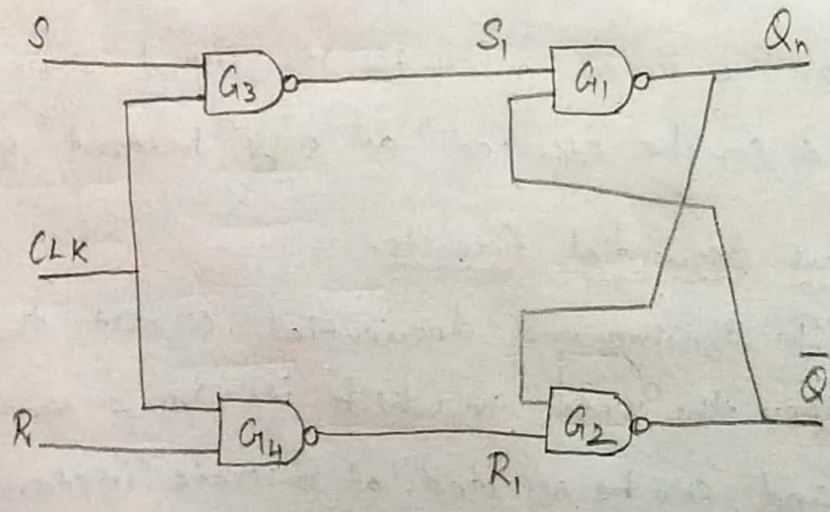
SR Flip-Flops



Positive edge triggered



Negative edge triggered



CLK	S	R	Q_n	Q_{n+1}	State
0	x	x	0	0	Nochange
0	x	x	1	1	
↑	0	0	0	0	Nochange
↑	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	x	Indeterminate
↑	1	1	1	x	

S	R	Q_{n+1}	State
0	0	Q_n	Nochange
0	1	0	Reset
1	0	1	Set.
1	1	x	Indeterminate.

Case(1) when $S=0$ and $R=0$, CLK is +ve.

Assume $Q_n=1$ $\bar{Q}_n=0$

So the inputs G_2 are $Q_n=1$ and $R_1=1$

Hence the o/p of G_2 is 0.

Similarly

Input of G_1 are $S_1=1$ and $\bar{Q}_n=0$

Hence the output of G_1 is 1.

∴ When S & R both are low the output State does not change.

Case(2) when $S=0$ and $R=1$, CLK is +ve.

Assume $Q_n=1$ $\bar{Q}_n=0$

$G_2=1$ $G_1=0$

Case (3): $S=1$, $R=0$ CLK is +ve

Assume $Q_n=1$ $\bar{Q}_n=0$.

$\therefore$ $G_1=1$ $G_2=0$.

Case (4): $S=1$, $R=1$ CLK is +ve

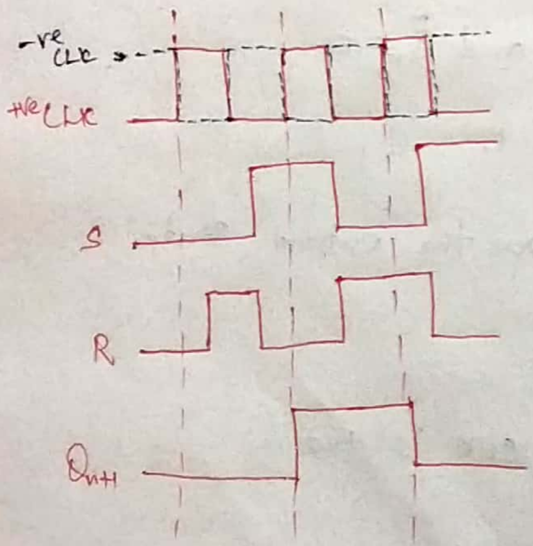
Assume $Q_n=1$ $\bar{Q}_n=0$

$\therefore$ $G_1=1$ $G_2=1$.

Q_{n+1}

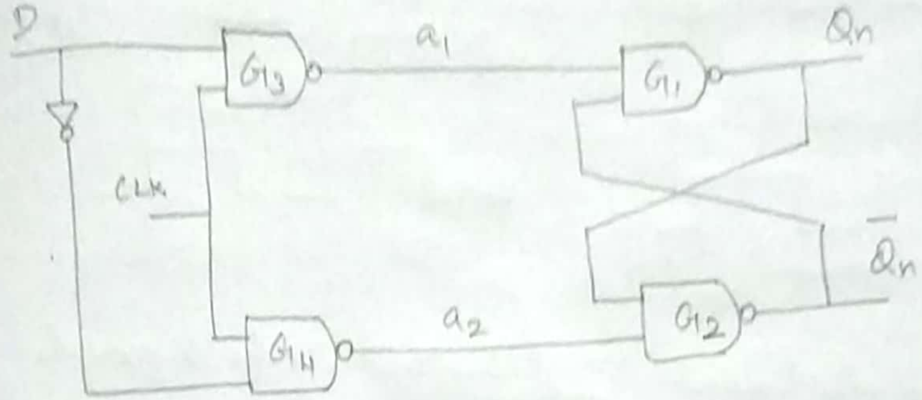
S \ RQ_n	00	01	11	10
0	0	1	0	0
1	1	1	X	X

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



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

D- FLIP FLOP



CLK	D	Q_n	Q_{n+1}	State
0	X	0	0	No change
0	X	1	1	
↑	0	0	0	Reset
↑	0	1	0	
↑	1	0	1	Set
↑	1	1	1	

D	Q_{n+1}	State
0	0	Reset
1	1	Set

Case 1: When $D=0$, CLK is +ve

Assume $Q_n=1$ $\bar{Q}_n=0$

$G_1 = Q_n = 0$ $\quad G_2 = \bar{Q}_n = 1$

Case 2: When $D=1$, CLK is +ve

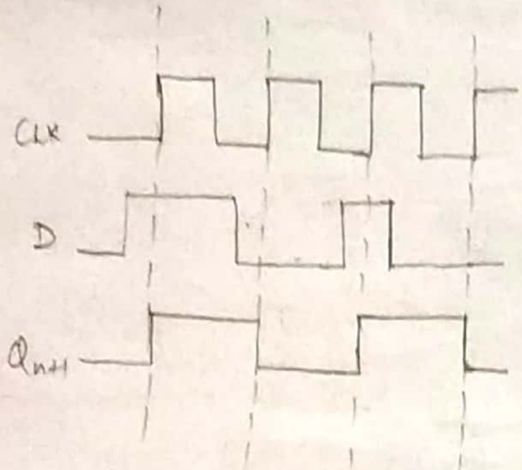
Assume $Q_n=1$ $\bar{Q}_n=0$

$G_1 = Q_n = 1$ $\quad G_2 = \bar{Q}_n = 0$

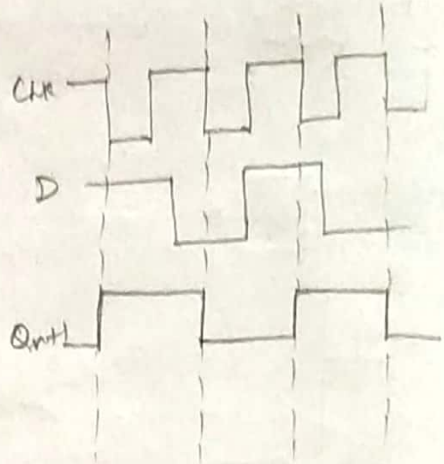
Negative Edge Triggered

Same Truth table.

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



Positive edge triggered

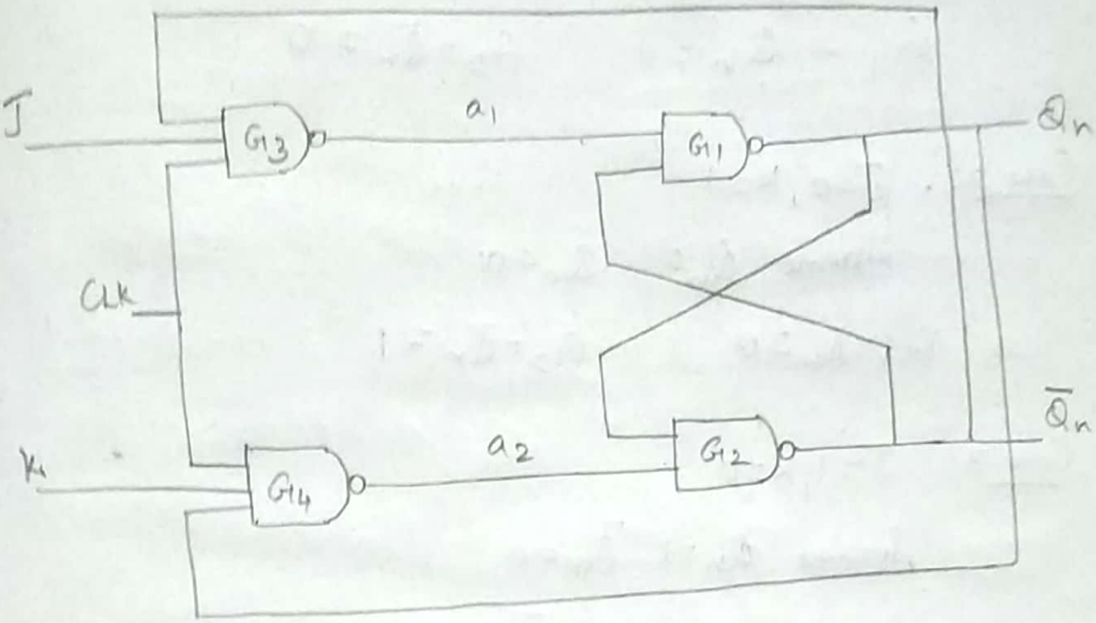


Negative edge triggered.

D \ Q_n	0	1
0	0	0
1	1	1

$$Q_{n+1} = D.$$

JK FLIP FLOP



Clk	J	K	Q_n	Q_{n+1}	State
0	x	x	0	0	No change
0	x	x	1	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	Toggles
↑	1	1	1	0	

J	K	Q_{n+1}	State
0	0	Q_n	No change
0	1	0	Reset
1	0	1	Set
1	1	$\bar{Q}_n$	Toggles.

k.map. Q_{n+1}

J \ KQ_n	00	01	11	10
0	0	1	0	0
1	1	1	0	1

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

Case 1: $J=0, k=0$

Assume $Q_n=1$ $\bar{Q}_n=0$.

$G_1 = Q_n = 1$ $G_2 = \bar{Q}_n = 0$

Case 2: $J=0, k=1$

Assume $Q_n=1$ $\bar{Q}_n=0$.

$G_1 = Q_n = 0$ $G_2 = \bar{Q}_n = 1$

Case 3: $J=1, k=0$

Assume $Q_n=1$ $\bar{Q}_n=0$

$G_1 = Q_n = 1$ $G_2 = \bar{Q}_n = 0$

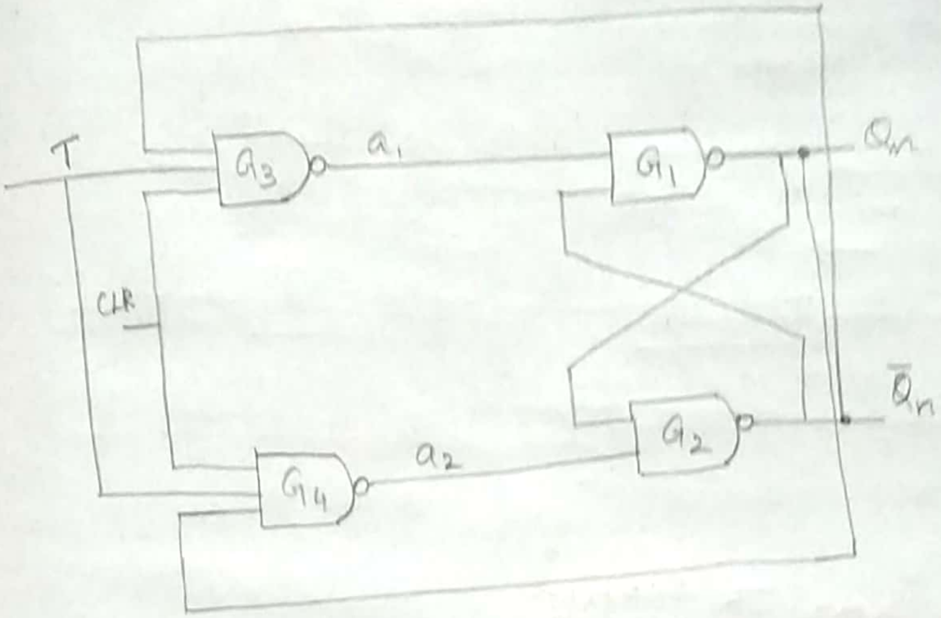
Case 4: $J=1, k=1$

Assume $Q_n=1$ $\bar{Q}_n=0$

$G_1 = Q_n = 0$ $G_2 = \bar{Q}_n = 1$

Q_n	Q_{n+1}	J	k.
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

T- FLIP FLOP



CLK	T	Q_n	Q_{n+1}	State
0	x	0	0	No change
0	x	1	1	
↑	0	0	0	No change
↑	0	1	1	
↑	1	0	1	Toggle
↑	1	1	0	

T	Q_{n+1}	State
0	Q_n	No change
1	$\bar{Q}_n$	Toggle

T \ Q_n	0	1
0	0	1
1	1	0

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

Case (1): $T=0$, $Q_n=1$, $\bar{Q}_n=0$

$G_1 = Q_n = 1$

$G_2 = \bar{Q}_n = 0$

Case (2): $T=1$, $Q_n=1$, $\bar{Q}_n=0$

$G_1 = Q_n = 0$

$G_2 = \bar{Q}_n = 1$

Negative Edge triggered - Same table

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