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Lecture : 7

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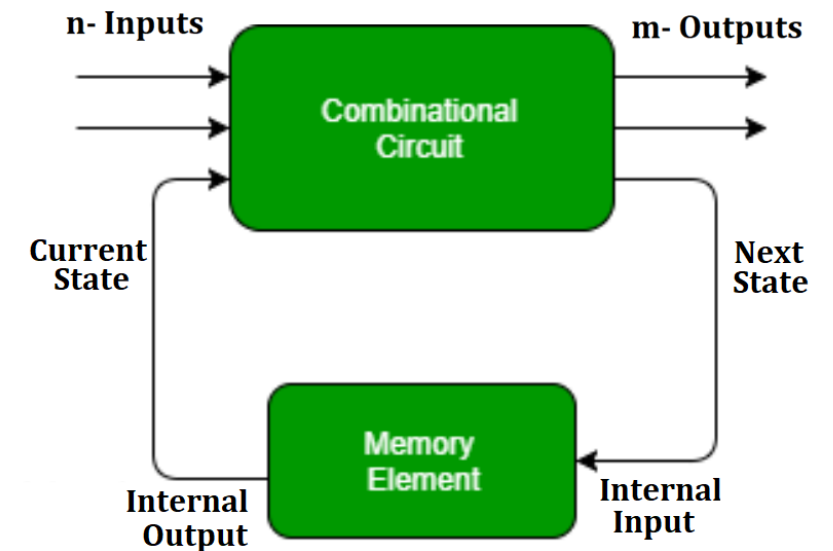
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Combinational Circuits : The Output is determined by the combination of current input, regardless of the output or the prior combination of input

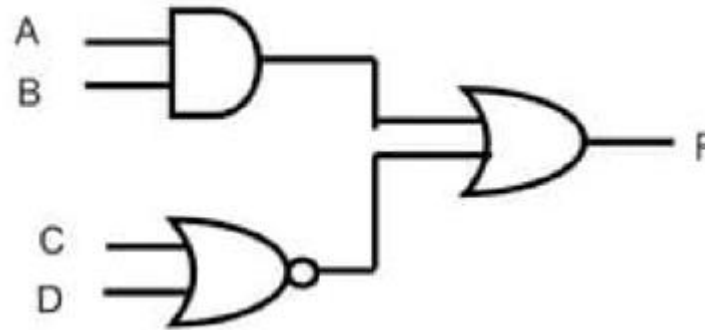


Sequential Circuits: The Output is determined not only by the combination of inputs but also the prior outputs. The circuit also contains memory element to store the information.

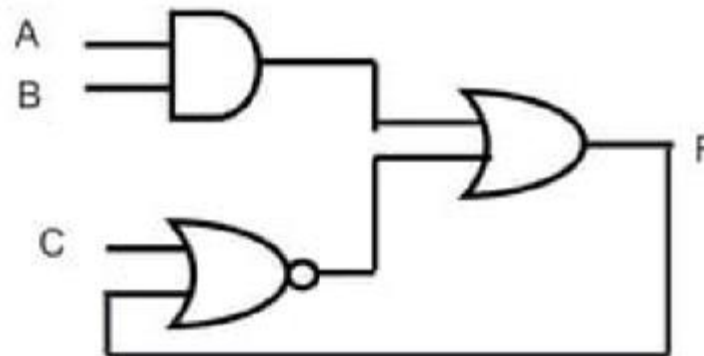


Example

Combinational Circuits



Sequential Circuits



Latches

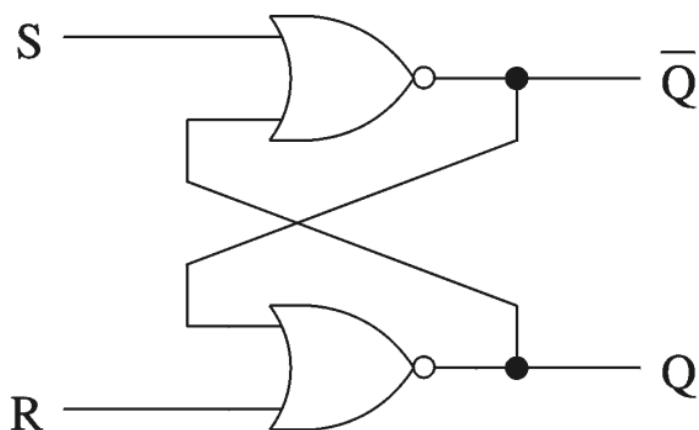
Latches are digital circuits that store a single bit of information and hold its value until it is updated by new input signals. They are used in digital systems as temporary storage elements to store binary information.

Types Of Latches

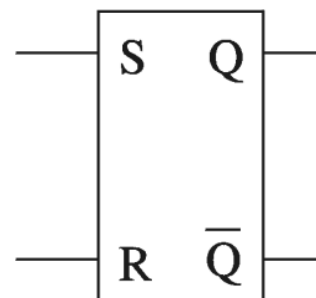
1. S-R (Set-Reset) Latches
2. D (Data) Latches

SR - Latch

S-R latches are the simplest form of latches and are implemented using two inputs: S (Set) and R (Reset). The S input sets the output to 1, while the R input resets the output to 0.



(a) Circuit diagram

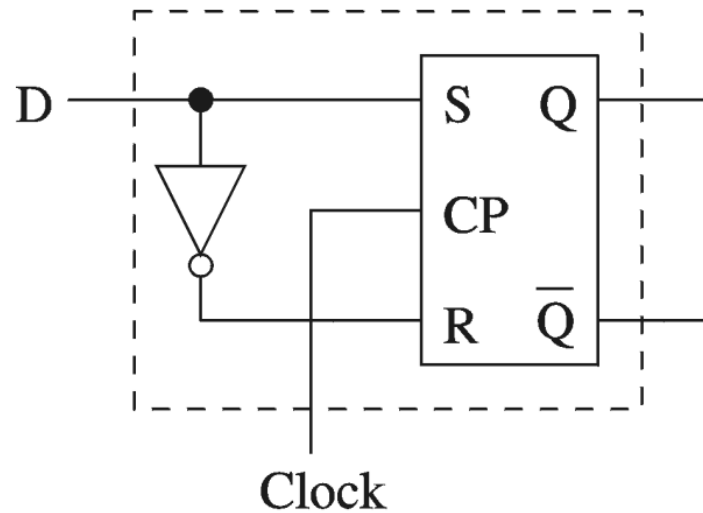


(b) Logic symbol

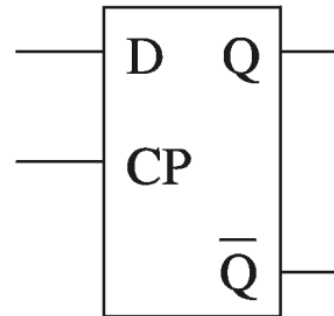
S	R	Q_{n+1}
0	0	Q_n
0	1	0
1	0	1
1	1	0

(c) Truth table

D Latch



Circuit Diagram



Logic Symbol

D	Q_{n+1}
0	0
1	1

Truth table



Flip-Flops

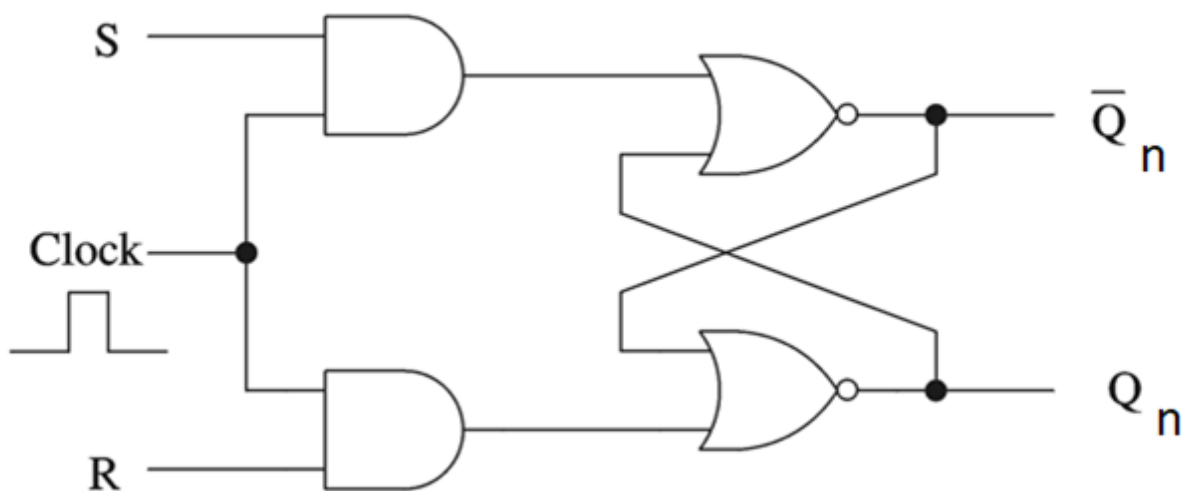
Flip-flop is a circuit that maintains a state until directed by input to change the state. A basic flip-flop can be constructed using four-NAND or four-NOR gates. Latches controlled by a clock transition are flip-flops.

Types of Flip-flops

1. SR Flip Flop
2. JK Flip Flop
3. D Flip Flop
4. T Flip Flop

SR Flip Flop

Logic Circuit



State Table

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

SR Flip Flop

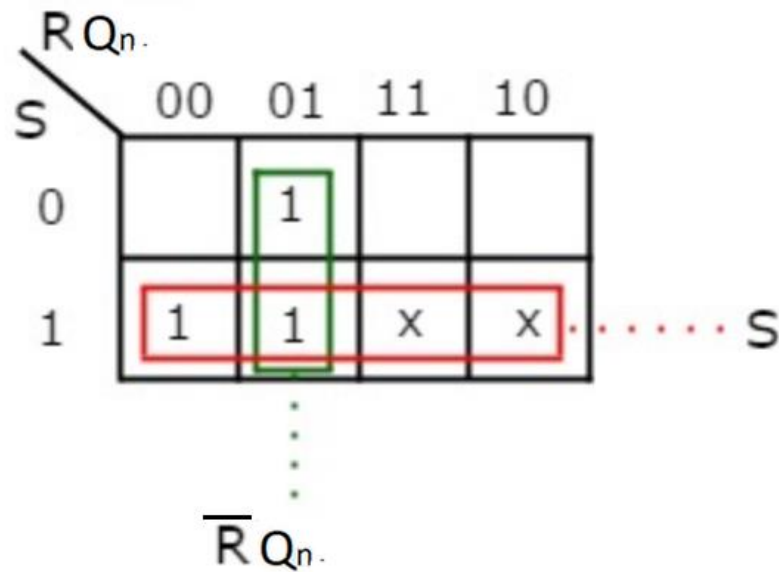
State Table

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

Excitation Table

Present Inputs		Present State	Next State
S	R	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	x
1	1	1	x

SR Flip Flop



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

Excitation Table

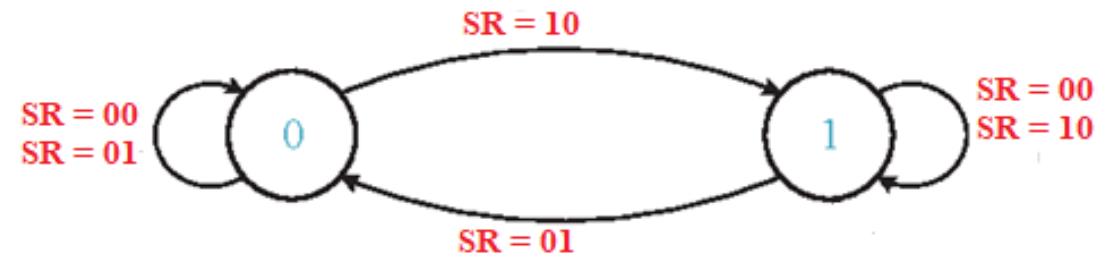
Present Inputs		Present State	Next State
S	R	Q_n	Q_{n+1}
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	x
1	1	1	x

Excitation Table

SR Flip Flop

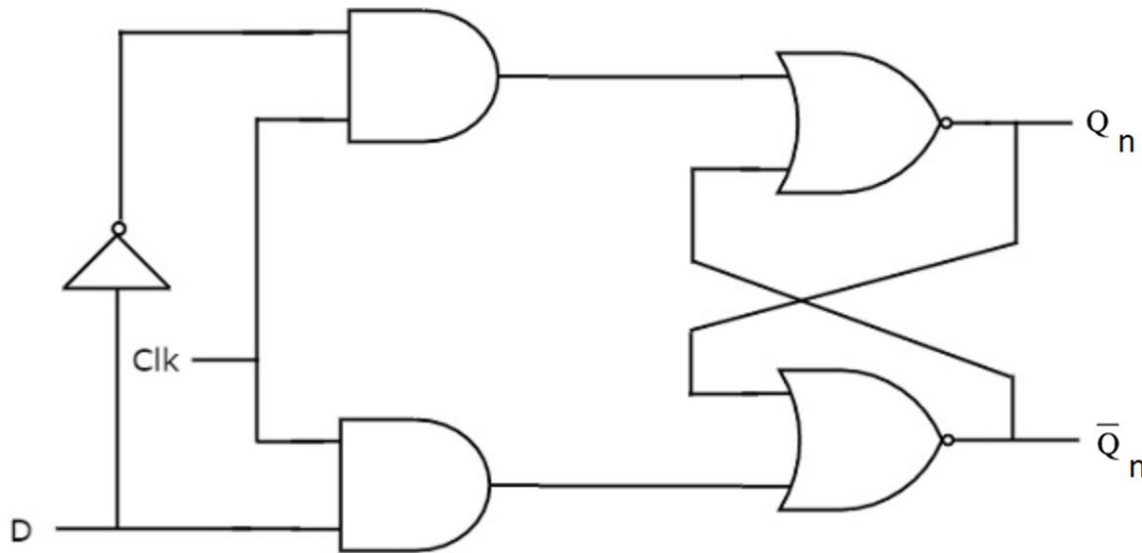
Present Inputs		Present State	Next State
S	R	Q_n	Q_{n+1}
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	x
1	1	1	x

State Diagram



D Flip-flop

D flip-flop operates with only positive clock transitions or negative clock transitions.



State Table

D	Q_{n+1}
0	0
1	1

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

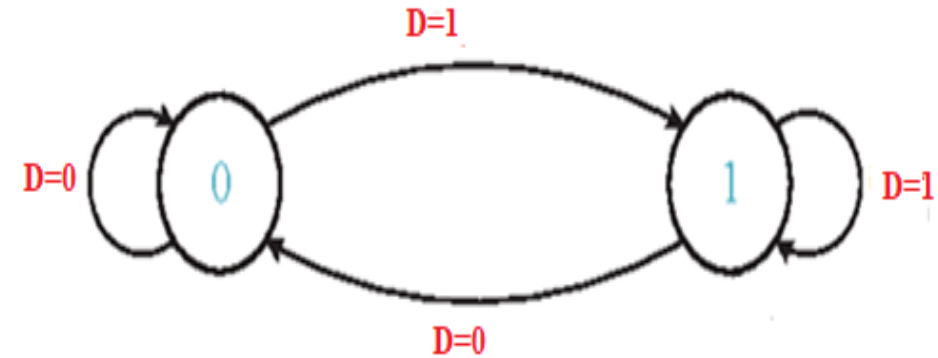


D Flip- flop

State Table

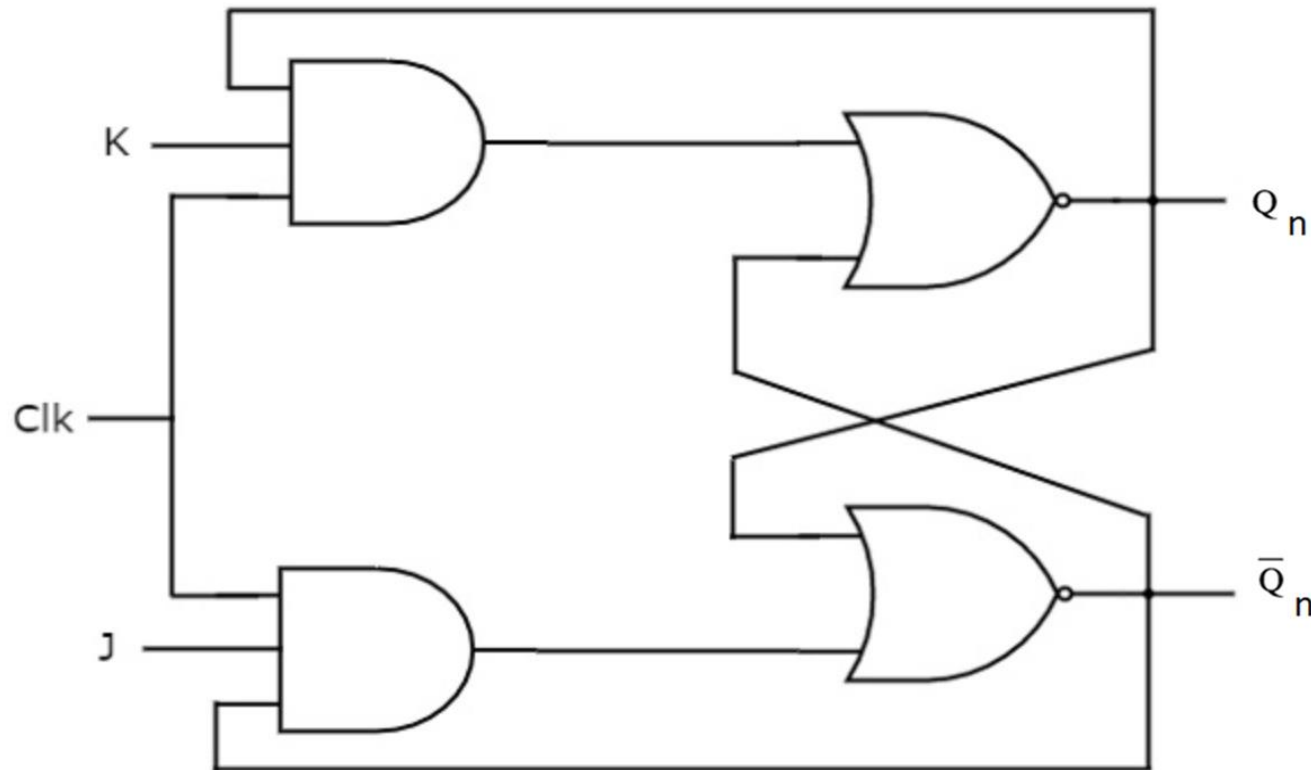
D	Q_{n+1}
0	0
1	1

State Diagram



JK Flip-flop

JK flip-flop is the modified version of SR flip-flop. It operates with only positive clock transitions or negative clock transitions.



State Table

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

JK Flip- flop

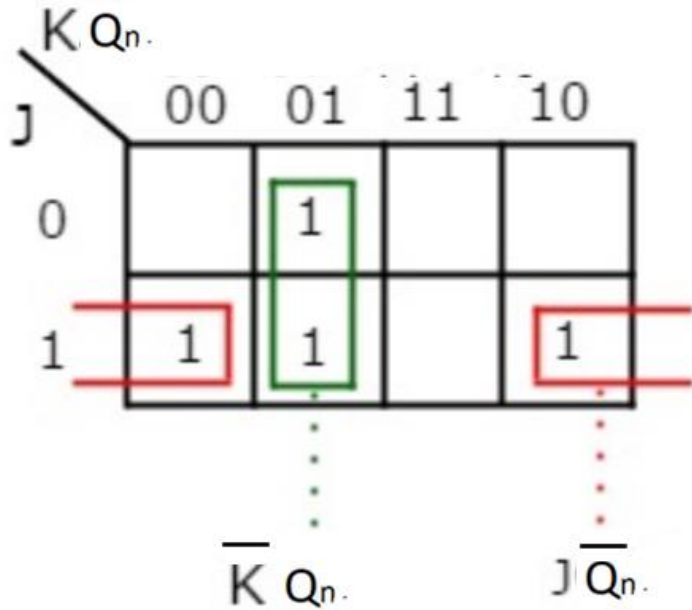
State Table

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

Excitation Table

Present Inputs		Present State	Next State
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

JK Flip Flop



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

Excitation Table

Present Inputs		Present State	Next State
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

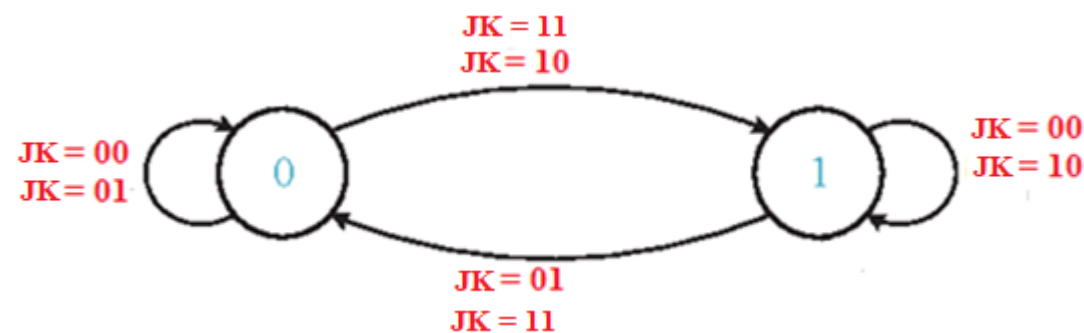


Excitation Table

Present Inputs		Present State	Next State
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

JK Flip Flop

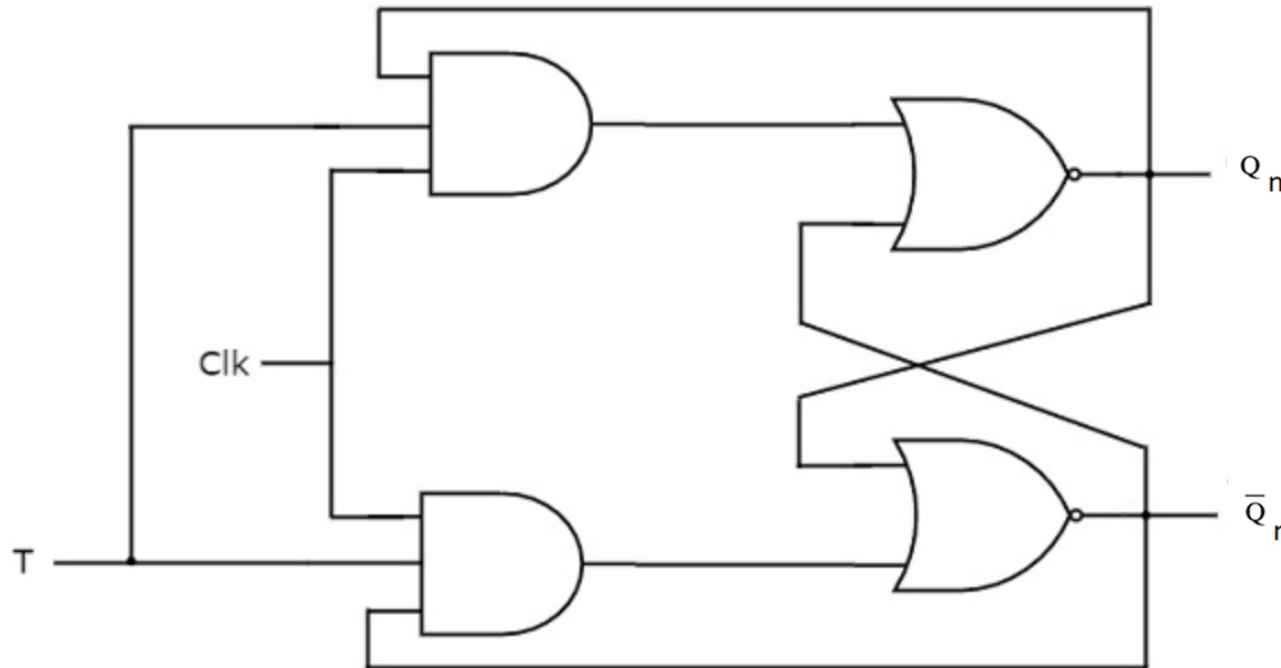
State Diagram



T- Flip Flop

T flip-flop is the simplified version of JK flip-flop. It is obtained by connecting the same input 'T' to both inputs of JK flip-flop.

State Table



Inputs	Present State	Next State
T	Q_n	Q_{n+1}
0	0	0
0	1	1
1	0	1
1	1	0

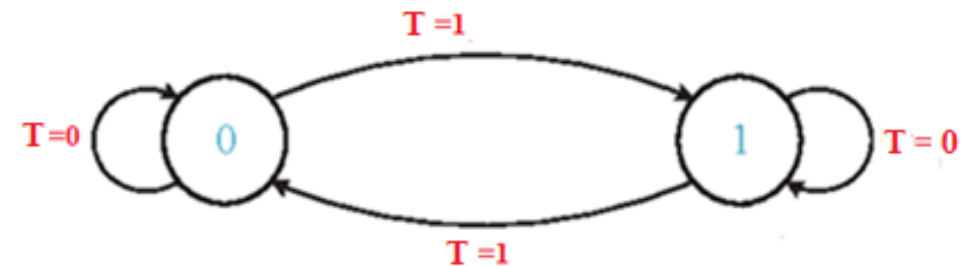
$$Q_{n+1} = T\bar{Q}_n + \bar{T}Q_n$$

T- Flip Flop

State Table

Inputs	Present State	Next State
T	Q_n	Q_{n+1}
0	0	0
0	1	1
1	0	1
1	1	0

State Diagram



Sequential circuit

Latches	Flip flops
Latches are level triggered devices.	Flip flops are edge triggered devices.
No further classification for latches.	Flip flops can be classified as asynchronous and synchronous.
Latches can be clocked or clockless.	Flip flops are always clocked.
Latches are operated only with binary inputs.	Flip flops are worked with both clock and binary inputs.
Latches are faster as compared to flip flops.	Flip flops are slow compared to the latches.
Latches are constructed from logic gates.	Flip flops are constructed from latches along with an additional clock signal.

Shift Registers

- Shift Register is a group of flip flops used to store multiple bits of data. The bits stored in such registers can be made to move within the registers and in/out of the registers by applying clock pulses.
- An n-bit shift register can be formed by connecting n flip-flops where each flip flop stores a single bit of data.

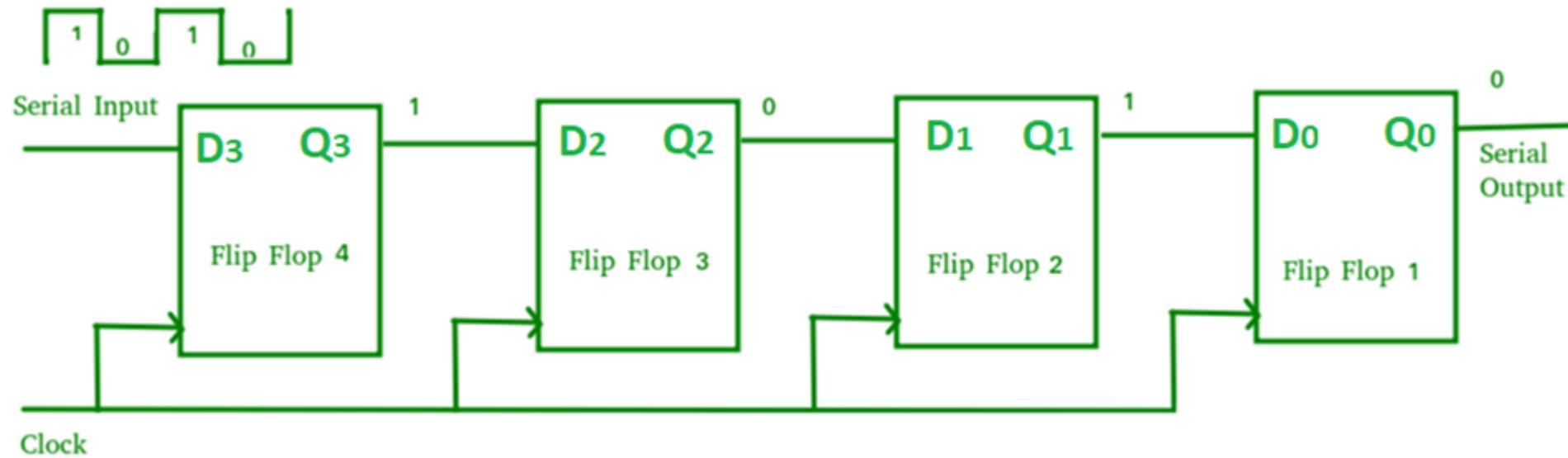


Shift Registers

Shift registers are basically of 4 types. These are:

- Serial In Serial Out shift register
- Serial In parallel Out shift register
- Parallel In Serial Out shift register
- Parallel In parallel Out shift register

Serial-In Serial-Out Shift Register (SISO)

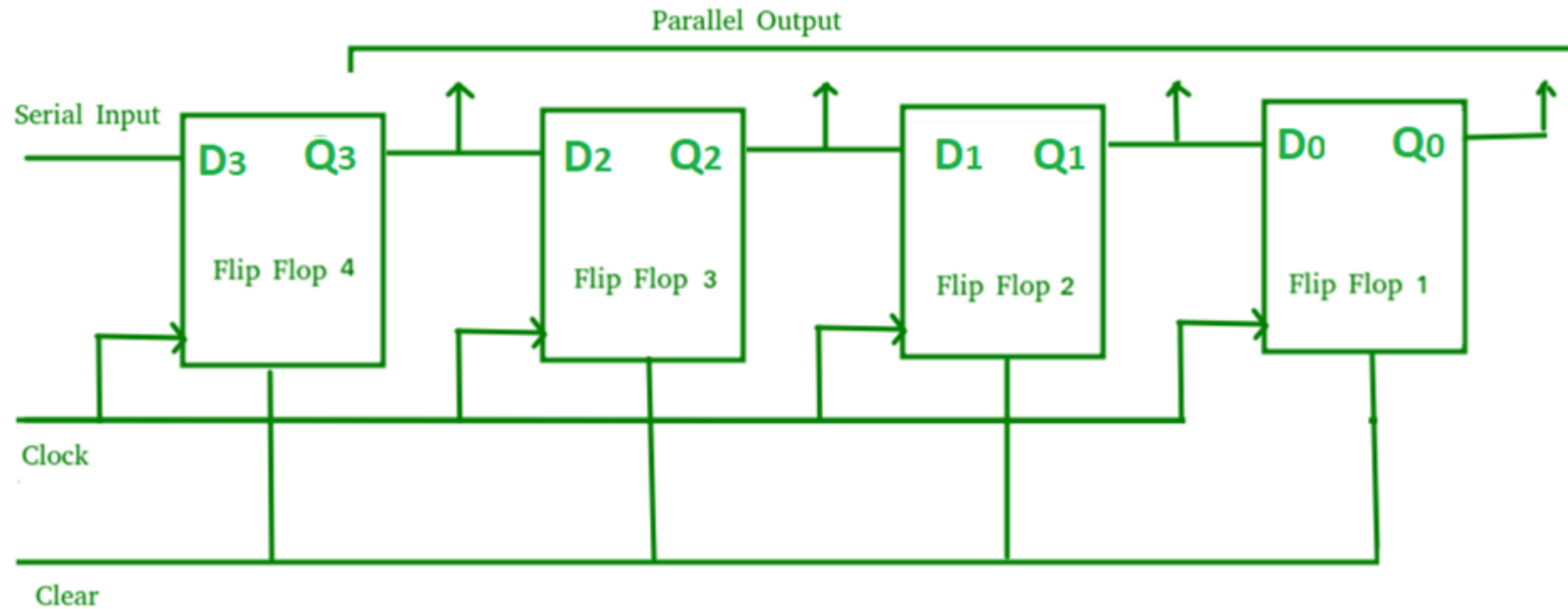


Serial-In Serial-Out Shift Register (SISO)

Example the If the Bits are 1100

Clock	Input	Q_3	Q_2	Q_1	Q_0
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	1	1	0	0	0
4	1	1	1	0	0
5	0	0	1	1	0
6	0	0	0	1	1
7	0	0	0	0	1

Serial-In Parallel-Out shift Register (SIPO)



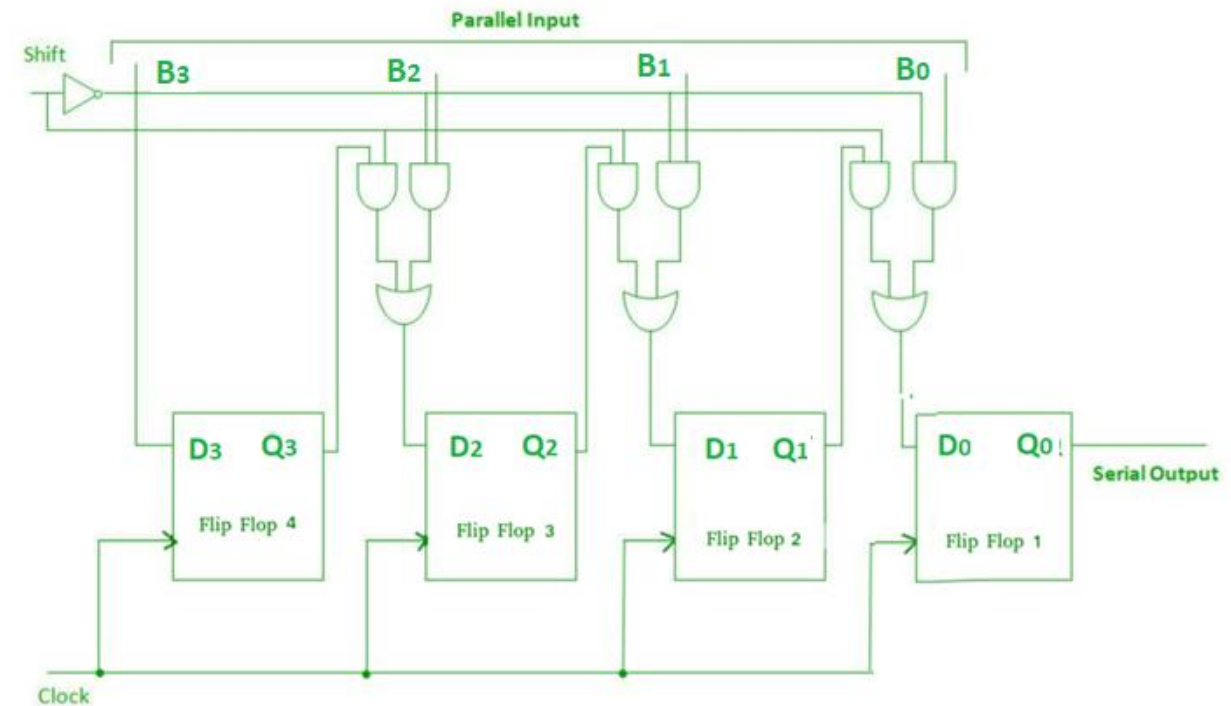
Serial-In Parallel-Out shift Register (SIPO)

Example the If the Bits are 1100

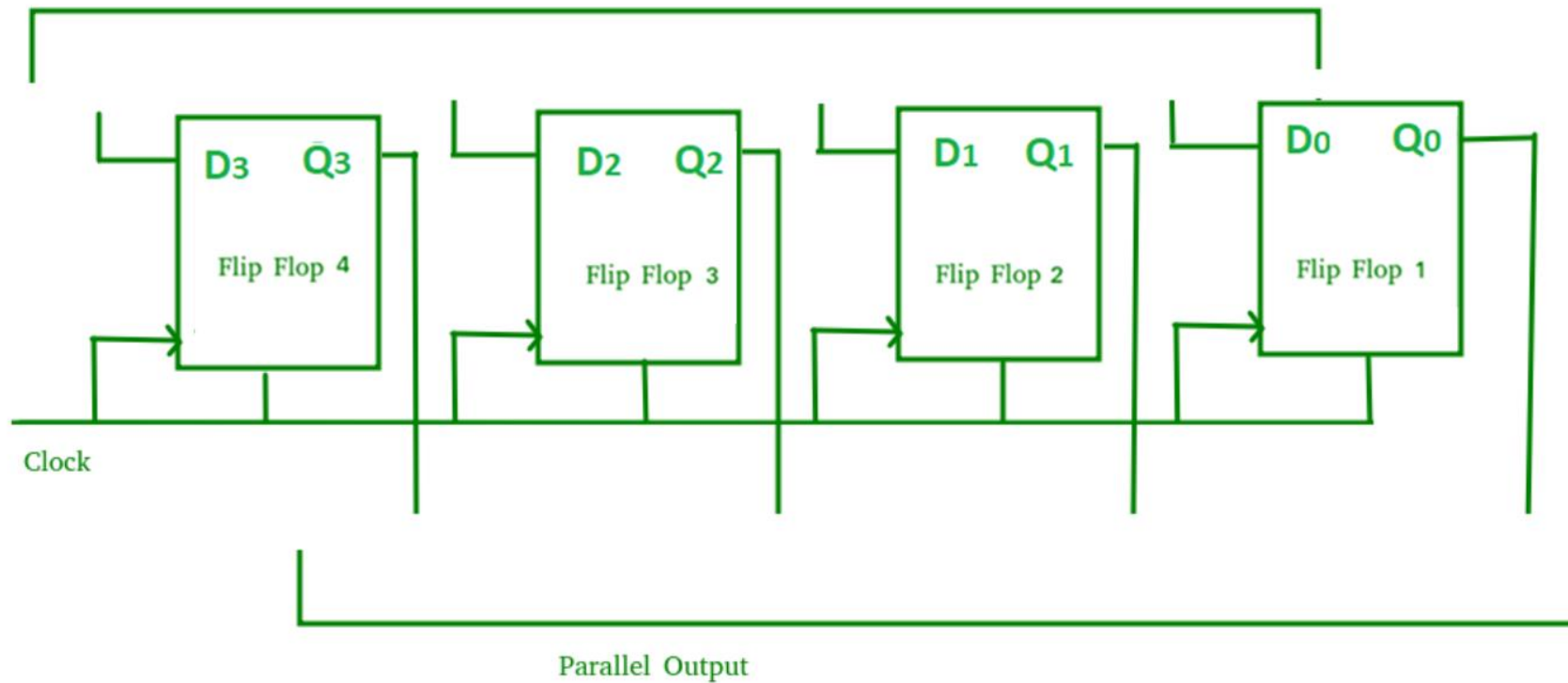
Clock	Input	Q_3	Q_2	Q_1	Q_0
0	0	0	0	0	0
1	0	0	0	0	0
2	0	0	0	0	0
3	1	0	0	0	0
4	1	1	0	0	0
5	0	1	1	0	0

Parallel-In Serial-Out Shift Register (PISO)

- When Shift = 0, it loads the B_3, B_2, B_1, B_0 to the corresponding Flipflops by passing in the NOT Gate
- When Shift = 1, (without NOT Gate) it shifts the butts in serial fashion



Parallel-In Parallel-Out Shift Register (PIPO)



Shift Register Counter

Shift Register Counters are the shift registers in which the outputs are connected back to the inputs in order to produce particular sequences.

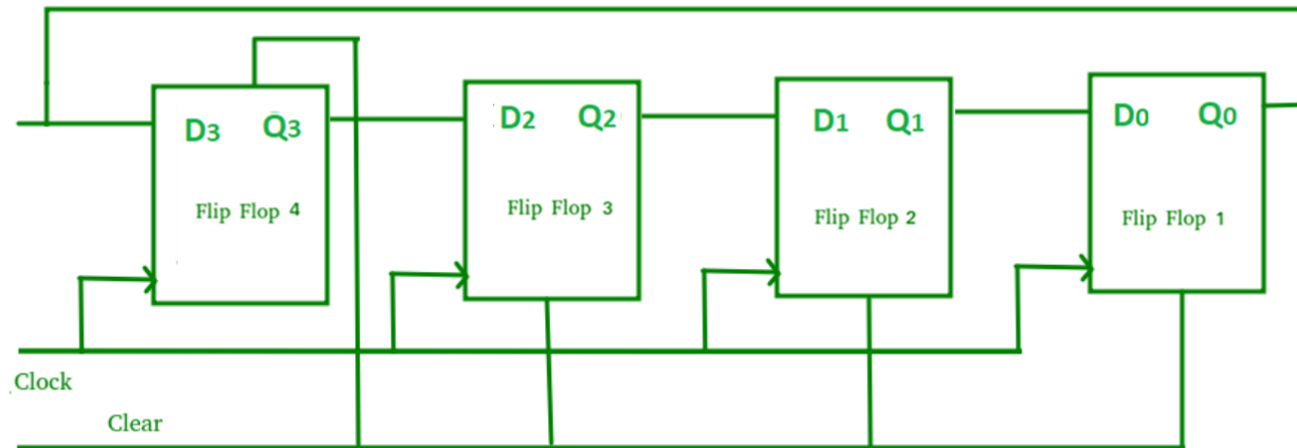
Types

1. Ring Counter – Synchronous Counter
2. Johnson Counter - Synchronous Counter
3. Ripple Counter - Asynchronous Counter

Ring Counter

A ring counter is basically a shift register counter in which the output of the first flip flop is connected to the next flip flop and so on and the output of the last flip flop is again fed back to the input of the first flip flop, thus the name ring counter.

Ring Counter

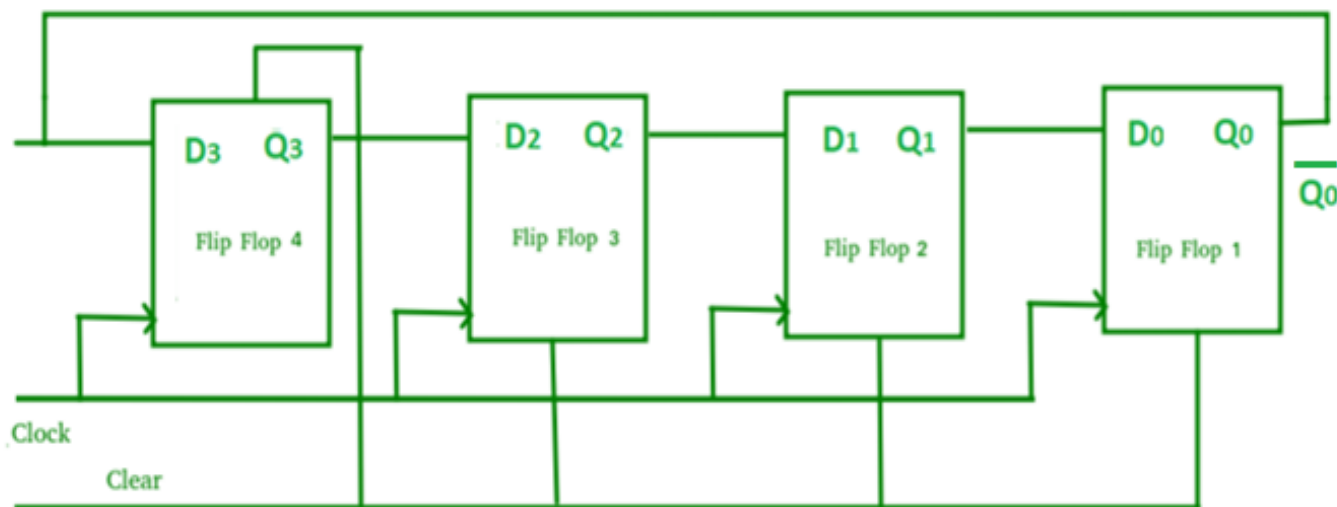


Clock Pulse	Q3	Q2	Q1	Q0
0	1	0	0	1
1	1	1	0	0
2	0	1	1	0
3	0	0	1	1

Johnson Counter

A Johnson counter is basically a shift register counter in which the output of the first flip flop is connected to the next flip flop and so on and the inverted output of the last flip flop is again fed back to the input of the first flip flop. They are also known as twisted ring counters.

Johnson Counter



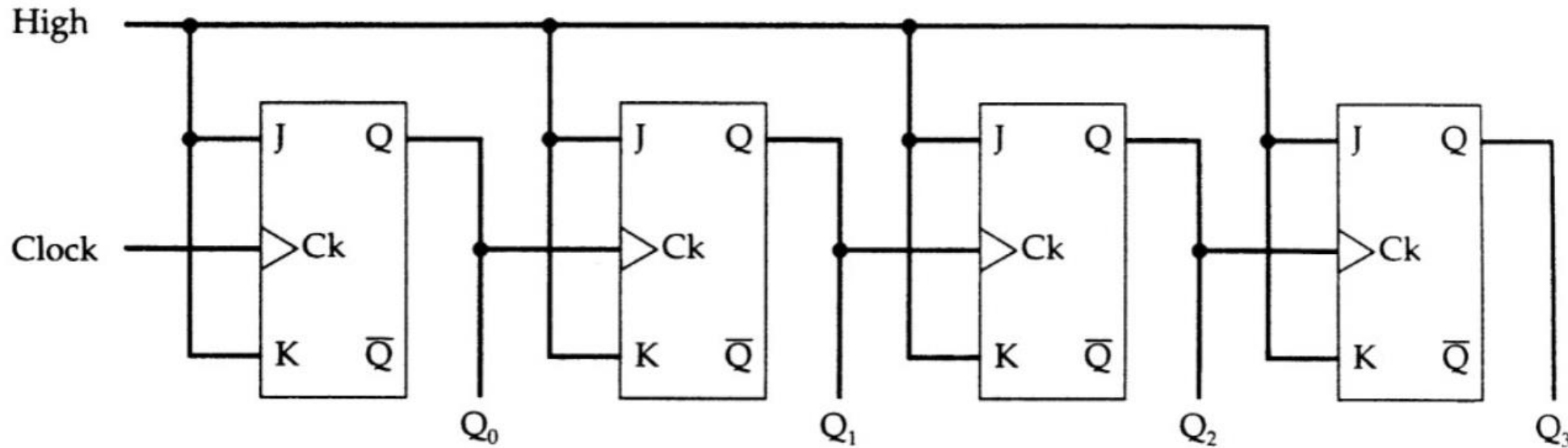
Clock Pulse	Q1	Q2	Q3	Q4
0	0	0	0	1
1	0	0	0	0
2	1	0	0	0
3	1	1	0	0
4	1	1	1	0
5	1	1	1	1
6	0	1	1	1
7	0	0	1	1

Ripple Counter

- The flip-flops are not under the control of a single clock. The clock pulse is applied to the first flip-flop and the successive flip-flop is triggered by the output of the previous flip-flop.
- The first flip-flop switches on the application of a clock pulse and the successive stages change their states in turn causing a ripple through effect of the count pulses.

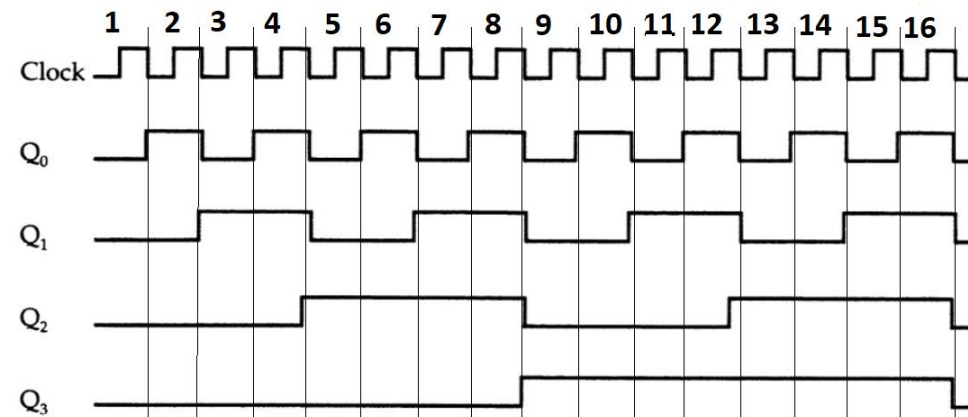


Ripple Counter



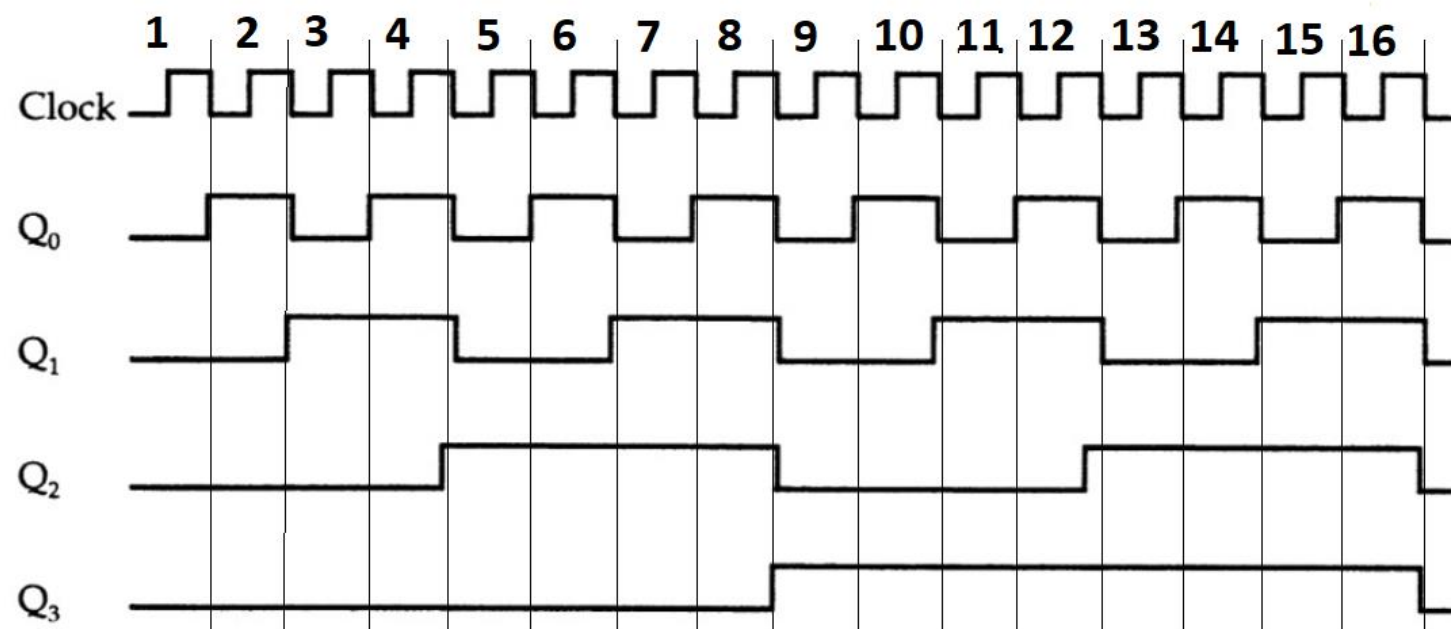
Ripple Counter

- Initially, All Flipflops are Logic 0, when there is no transition of falling edge.
- When the clock is at the transition from 1 to 0, then $Q_0 \rightarrow 0$ to 1
- When $Q_0 \rightarrow 1$ to 0, then $Q_1 \rightarrow 0$ to 1
- When $Q_1 \rightarrow 1$ to 0, then $Q_2 \rightarrow 0$ to 1
- When $Q_2 \rightarrow 1$ to 0, then $Q_3 \rightarrow 0$ to 1
- When $Q_3 \rightarrow 1$ to 0, then $Q_4 \rightarrow 0$ to 1
- This is because, The JK flip flop toggles when the inputs of the flip flops are one, and then the flip flop changes its state from 0 to 1.
- Finally, at the end of 16th clock pulse, all the Flipflops becomes 0.



Clock	State	Q_D	Q_C	Q_B	Q_A
1	0	0	0	0	0
2	1	0	0	0	1
3	2	0	0	1	0
4	3	0	0	1	1
5	4	0	1	0	0
6	5	0	1	0	1
7	6	0	1	1	0
8	7	0	1	1	1
9	8	1	0	0	0
10	9	1	0	0	1
11	10	1	0	1	0
12	11	1	0	1	1
13	12	1	1	0	0
14	13	1	1	0	1
15	14	1	1	1	0
16	15	1	1	1	1
17	0	0	0	0	0

Ripple Counter





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Thank you

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