CS & IT ENGINEERING

DIGITAL LOGIC

Sequential Circuit

Lecture No. 2

By- CHANDAN SIR
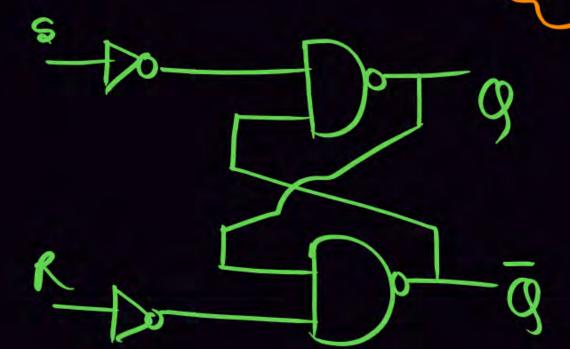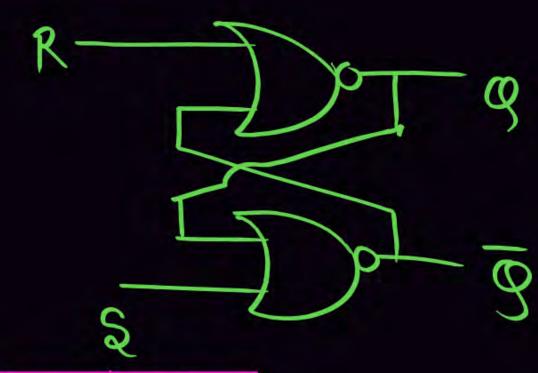
S-R Latch

S	R	Q	$\overline{Q}$
0	0	Q	$\overline{Q}$
0	1	0	1
1	0	1	0
1	1	X	X

X	y	Q	$\overline{Q}$
0	0	1	0
0	1	1	0
1	0	Q	$\overline{Q}$
1	1	1	0

$1 \odot \bar{Q} = \bar{Q}$

$1 \cdot X$

$\bar{Q}$

Q

$Q = \bar{Q}$

$\bar{Q} = Q$

$0 \cdot Y$

$Q \oplus 0 = Q$

X	Y	Q	$\bar{Q}$	
0	0	Q	Q	— Invalid
0	1	Q	$\bar{Q}$	— HOLD
1	0	$\bar{Q}$	Q	— Toggle
1	1	Q	$\bar{Q}$	— Invalid

$\bar{Q} \oplus 0 = \bar{Q}$

$Q \oplus 0 = Q$

$Q \oplus 1 = \bar{Q}$

$\bar{Q} \oplus 1 = Q$

$\bar{Q} \odot 0 = Q$

$Q \odot 0 = \bar{Q}$

$Q \odot 1 = Q$

$\bar{Q} \odot 1 = \bar{Q}$

Latch
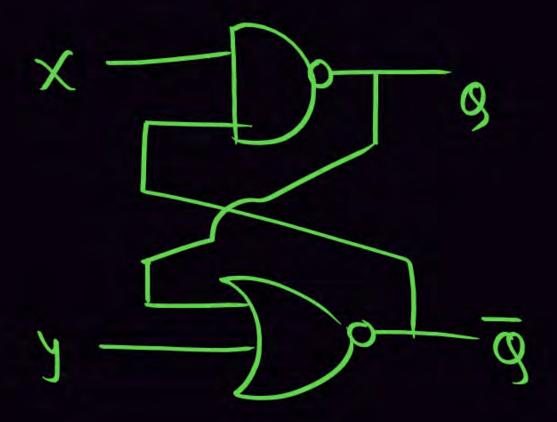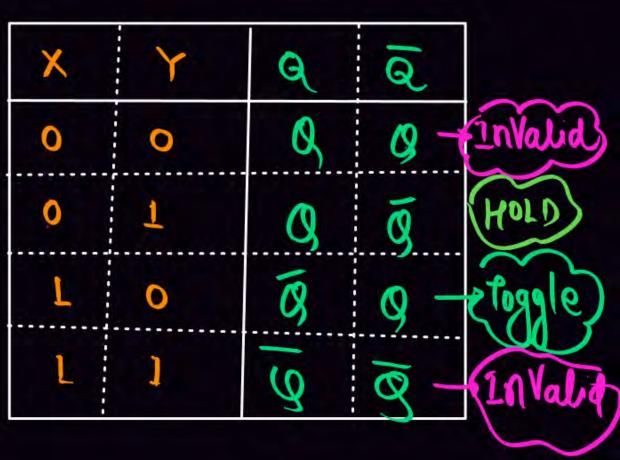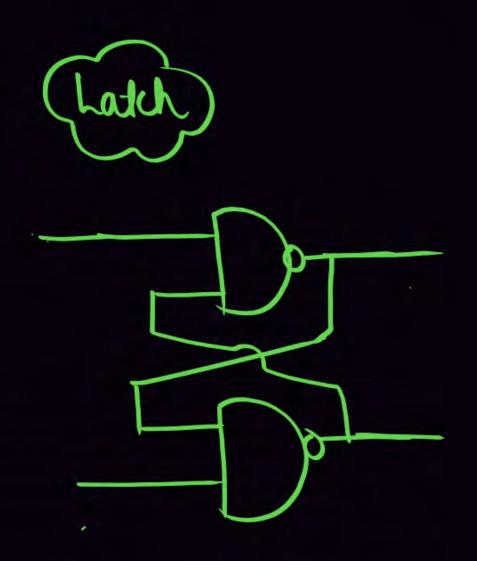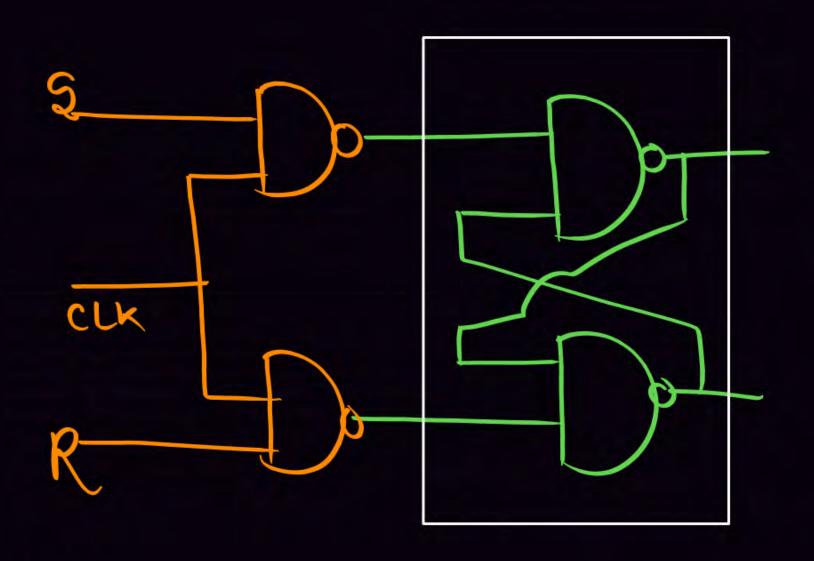
Latches with control phenomena
are called Flip-Flop.

S

CLK

R

CLOCK

$\uparrow$ Q_1 $\uparrow$ Q_2 $\uparrow$ Q_3 $\uparrow$ Q_4 . . . . . . n^{th} $(n+1)^{th}$

Q_n Q_{n+1}

F/F

Clk

(FF)
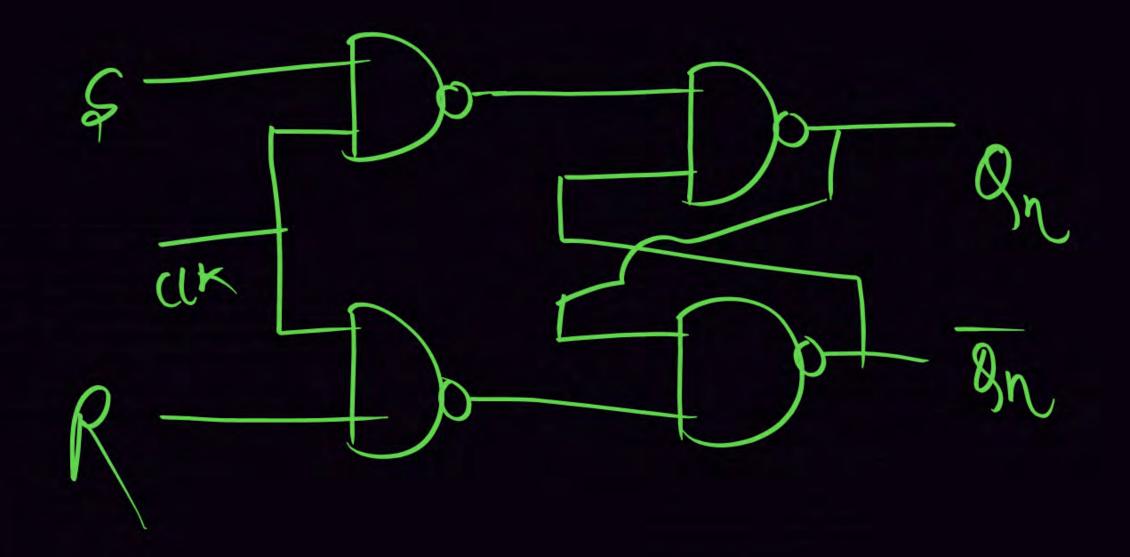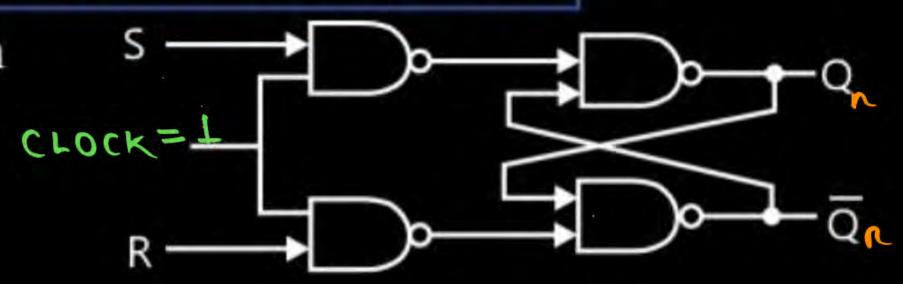
1. Circuit Diagram
2. Truth table
3. Characteristic Table
4. Characteristic Equation
5. Excitation Table
6. State Diagram

(1) SR FLIP-FLOP [SET RESET FF]

1. Circuit Diagram

CLOCK = 1

Q_n

$\overline{Q}_n$

2. Truth Table

S	R	Q_{n+1}	$\overline{Q}_{n+1}$	
0	0	Q_n	$\overline{Q}_n$	→ HOLD / Previous state / Memory
0	1	0	1	→ RESET
1	0	1	0	→ SET
1	1	X	X	→ InValid

(1) SR FLIP-FLOP [SET RESET FF]
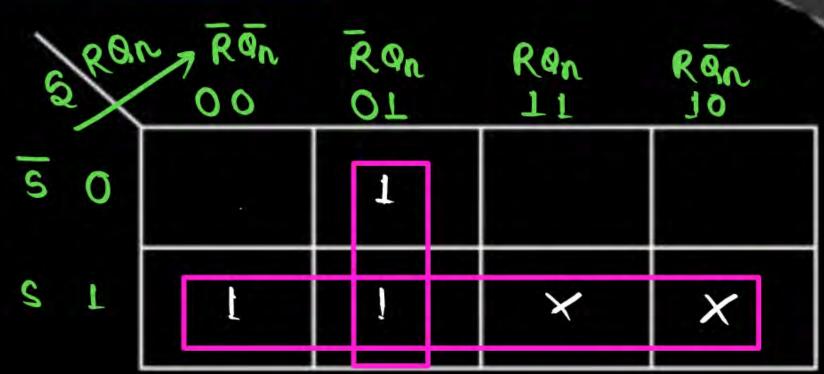
3. Characteristics Table

	S	R	Q_n	Q_{n+1}
0	0	0	0	0
①	0	0	1	1
②	0	1	0	0
③	0	1	1	0
④	1	0	0	1
⑤	1	0	1	1
⑥	1	1	0	X
⑦	1	1	1	X
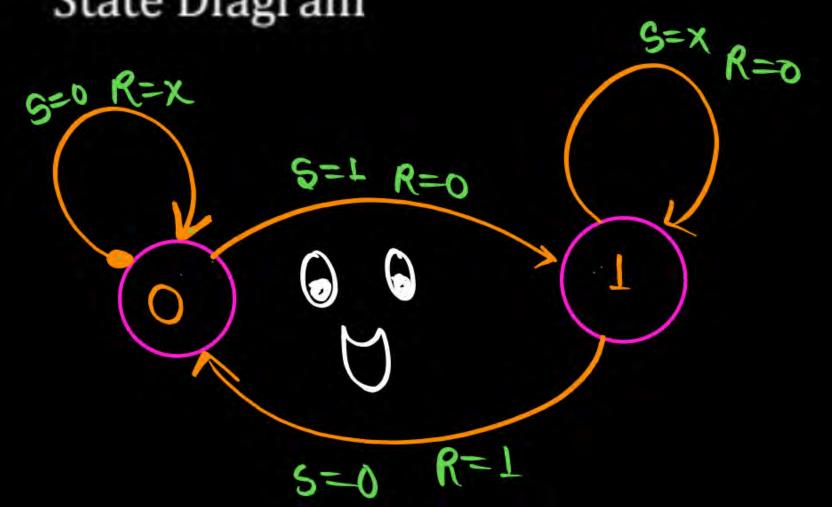
$$Q_{n+1}(S, R, Q_n) = \Sigma m(1,4,5) + \Sigma d(6,7)$$

4. **Characteristics Equation**

$S \backslash RQ_n$	$\bar{R}\bar{Q}_n$ 00	$\bar{R}Q_n$ 01	RQ_n 11	$R\bar{Q}_n$ 10
$\bar{S}$ 0		1		
S 1	1	1	$\times$	$\times$

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

5. Excitation Table

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

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

6. State Diagram

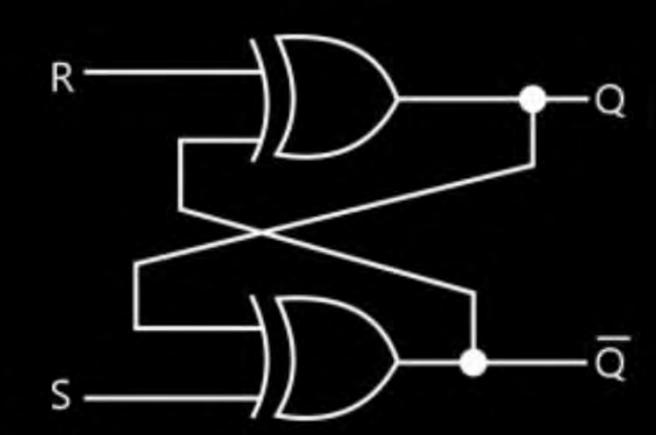| Q_n	Q_{n+1}	S	R
0	0	0	X
0	1	1	0
1	0	0	1
1	1	X	0

Which of the following will be correct for the given sequential circuit?

A The circuit would hold the previous state for S=0, R=0

B The circuit would hold the previous state for S=0, R=1

C The circuit would hold the previous state for S=1, R=1

D The circuit would never be able to hold the previous state under any condition

$\underline{Q}$ Truth

C	J	Q_{n+1}
0	0	$\overline{Q_n}$
0	1	Q_n
1	0	1
1	1	0

Characteristic Table

Characteristic Equation

Excitation Table

State Diagram

Which of the following will be correct for the given sequential circuit?

A $X Q(t)' + Y' Q(t)$

B $X + Y' Q(t)$

C $X Q(t) + Y' Q(t)'$
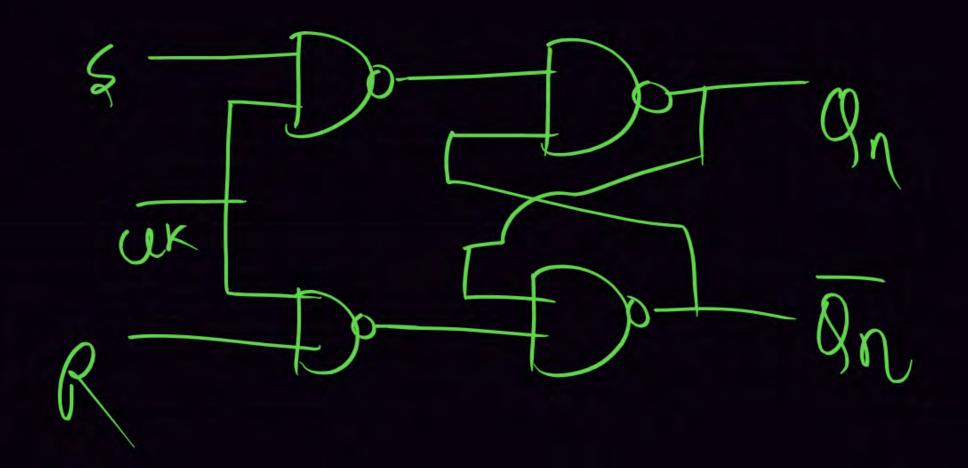
D $X + Y' Q(t)'$

X	Y	Q(t)	Q(t + 1)
0	×	0	0
0	1	0	1
1	0	1	0
×	1	1	1
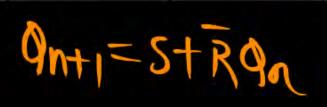
X	Y	Q_n	Q_{n+1}
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	
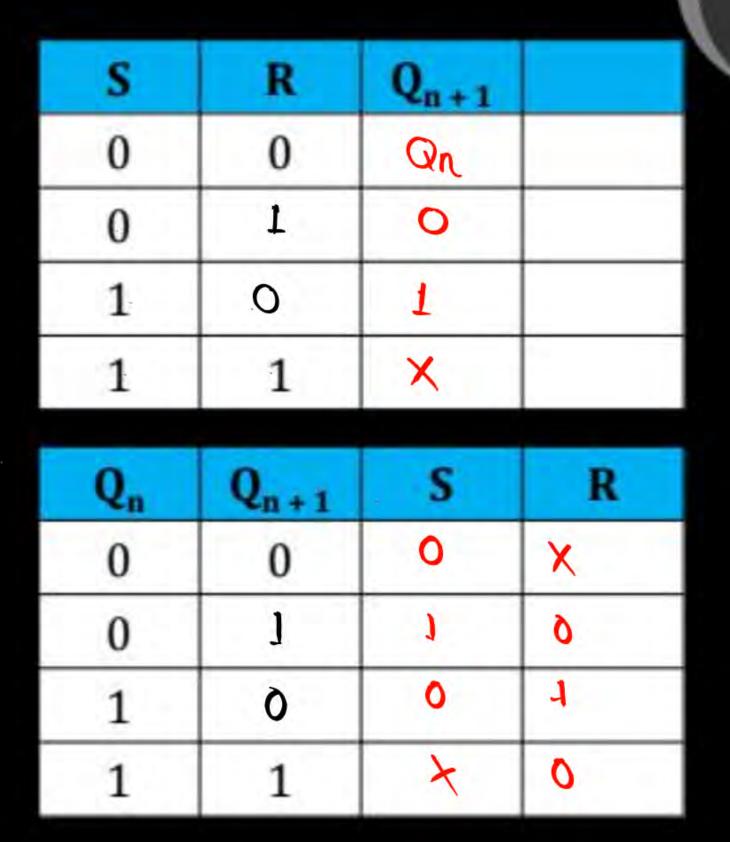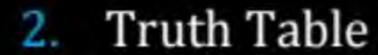
S	R	Q_n	Q_{n+1}
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	X
1	1	1	X

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

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

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

1. Symbol

$$J \longrightarrow \boxed{\begin{array}{c} J\text{-}K \\ \text{flip flop} \end{array}} \longrightarrow Q_n$$

CLK $\longrightarrow$

K $\longrightarrow$ $\overline{Q}_n$

2. Truth Table

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

3. Characteristics Table

$$Q_{n+1}(J, K, Q_n) = \Sigma m(1, 4, 5, 6)$$
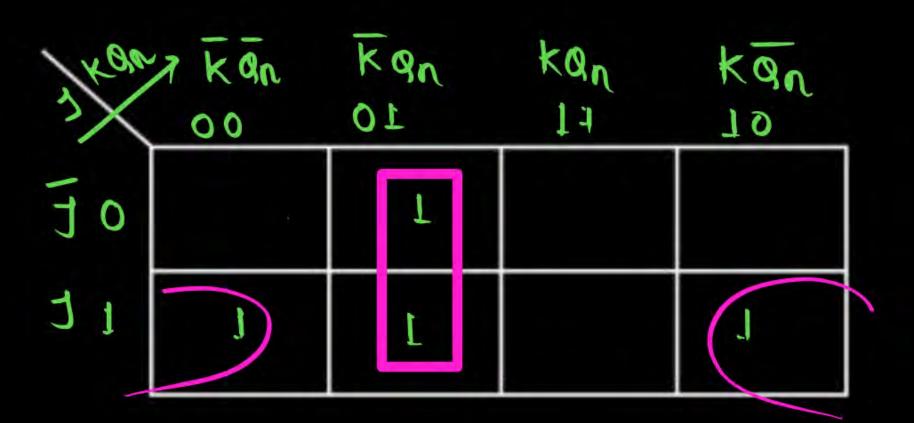
J	K	Q_n	Q_{n+1}
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

4. Characteristics Equation

$J \backslash KQ_n$	$\bar{K}\bar{Q}_n$ 00	$\bar{K}Q_n$ 01	KQ_n 11	$K\bar{Q}_n$ 10
$\bar{J}$ 0		1		
J 1	1	1		1

$$Q_{n+1} = J\bar{Q}_n + \bar{K}Q_n$$
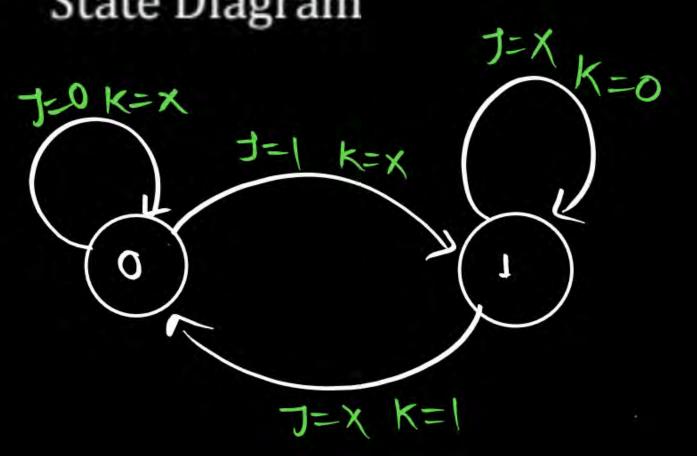
5. Characteristics Equation

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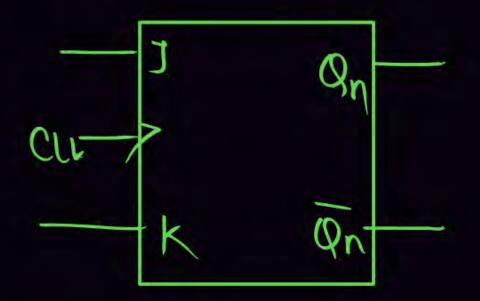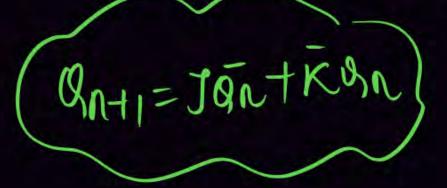
J	K	Q_n	Q_{n+1}
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

6. State Diagram

J=0 K=X

J=X K=0

J=1 K=X

J=X K=1

0 → 1

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

JK Flip-Flop Diagram

Inputs: J, CLK, K → Outputs: Q_n, $\bar{Q}_n$

Characteristic Equation

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

Function Table

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

Truth 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

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

D FLIP-FLOP

3. Characteristics Table

4. Characteristics Equation

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

Table 2 : Characteristic Table of D Flip Flop