CS & IT ENGINEERING

DIGITAL LOGIC

Sequential Circuit

Lecture No. 4

By- CHANDAN SIR

T-FF (Toggle FF)
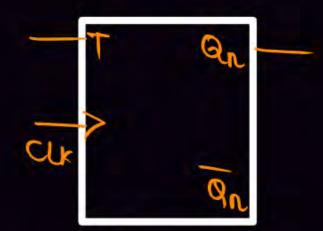
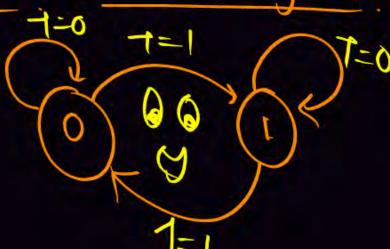## ① Symbol :-

T →
Clk →
Q_n
$\overline{Q_n}$

③ Char. Table

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

⑤ Excitation Table

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

② Truth table

T	Q_{n+1}
0	Q_n
1	$\overline{Q_n}$

④ Characteristic Equation

$$Q_{n+1} = \overline{T}Q_n + T\overline{Q_n}$$

$$Q_{n+1} = T \oplus Q_n$$

⑥ State Diagram

T=0
T=1
T=0
0
1
T=1

SR

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

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

JK

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

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

D-FF

D	Q_{n+1}
0	0
1	1

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

T FF

T	Q_{n+1}
0	Q_n
1	$\bar{Q_n}$

$$Q_{n+1} = T \oplus Q_n$$

Excitation Table
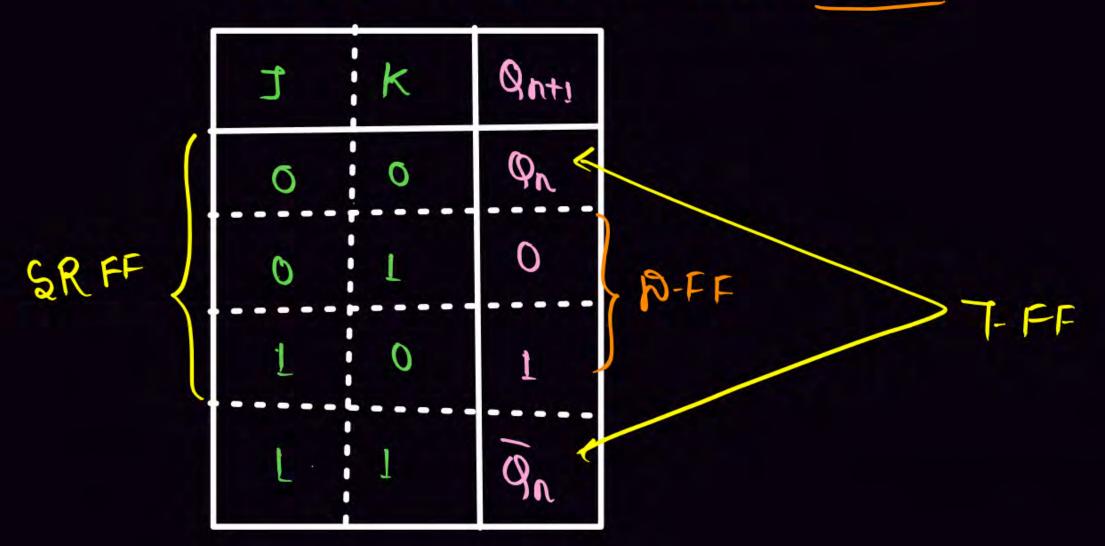
Q_n	Q_{n+1}	S	R	J	K	$\overline{S}$	T
0	0	0	X	0	X	0	0
0	1	1	0	1	X	1	1
1	0	0	1	X	1	0	1
1	1	X	0	X	0	1	0

JK FF is also called universal FF.

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

SR FF

D-FF

T- FF

Designing of Flip-Flop :→

Step 1 :→ Write the characteristic table of desired FF.

Step-2 :→ Write the excitation table of avaliable FF

Step 3. :→ Write the Logical Expression.

Step 4 :→ Minimization

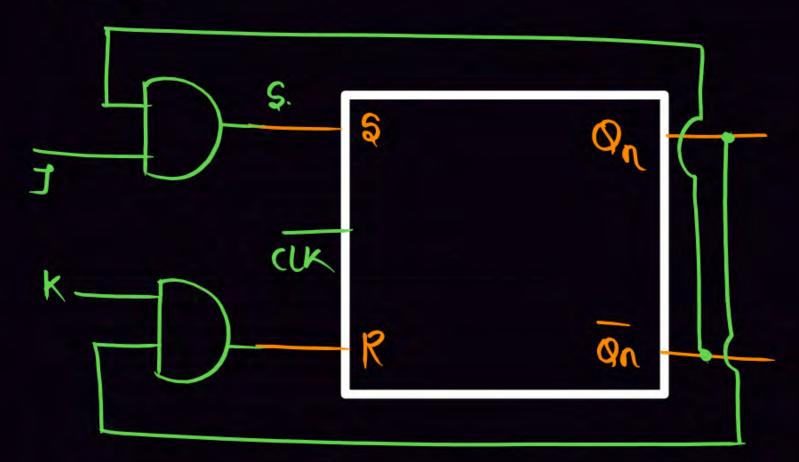Step 5 :→ Hardware Implementation.

Q Design a JK FF by using SR FF.

Desired: JK FF | available: SR FF

Step 1:→

& Step-2.

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

Step 3:→ $S(J,K,Q_n) = \Sigma m(4,6) + \Sigma d(1,5)$

$R(J,K,Q_n) = \Sigma m(3,7) + \Sigma d(0,2)$

Step 4 Minimization.

$S = J\overline{Q_n}$

S⇒

$JK \backslash Q_n$	00	01	11	10
0		X		
1	1	X		1

$R = KQ_n$

R⇒

$JK \backslash Q_n$	00	01	11	10
0	X		1	X
1			1	

$$S = J\overline{Q_n} \qquad R = KQ_n$$

Steps.

$$S = J\bar{Q}n \qquad R = KQn$$

Steps.

S.

J

K

CLK

Qn

$\bar{Q}n$

Q Design a D-FF by using S.R.FF?

Step 1:→

& Step 2.

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

$S = D$ $R = \bar{D}$

Steps: ✓

D

S Q_n

$\overline{Clk}$

R $\bar{Q}_n$

Step 3.

Step 4: S→

D \ Q_n	0	1
0		
1	1	X

$S = D$

R⟹

D \ Q_n	0	1
0	X	1
1		

$R = \bar{D}$

Q Design a T-FF by using SR FF?

Step 1
& step-2

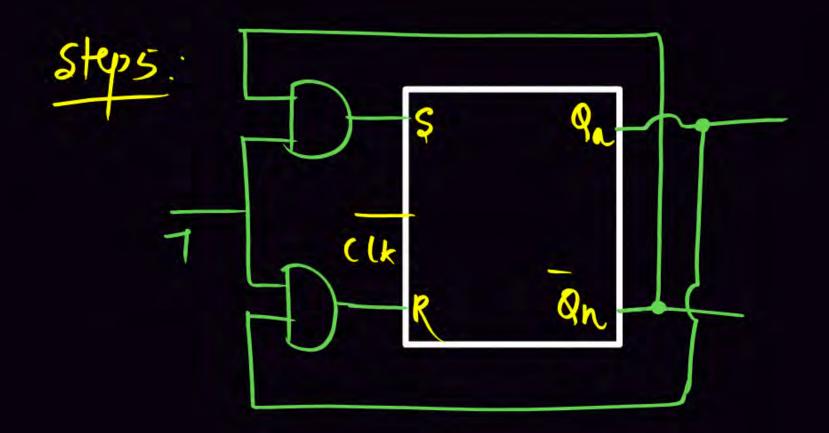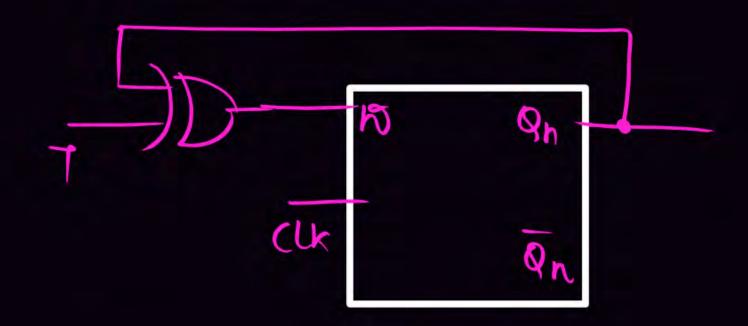| T	Q_n	Q_{n+1}	S	R
0	0	0	0	X
0	1	1	X	0
1	0	1	1	0
1	1	0	0	1

Step 3
& step 4

$$S = T\,\overline{Q_n}$$
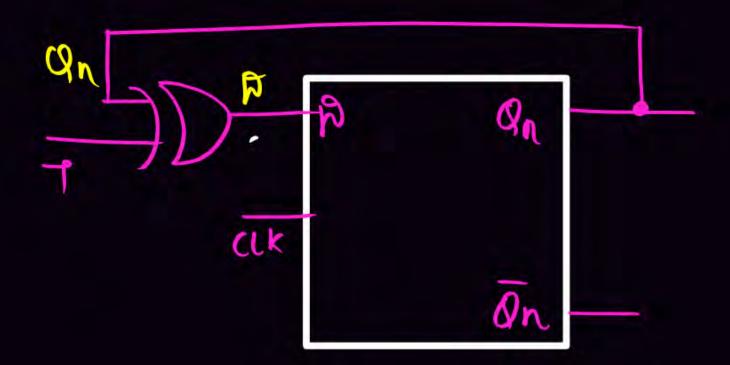
$$R = T\,Q_n$$

Step 5:

Q Design a T-FF by using D-FF?

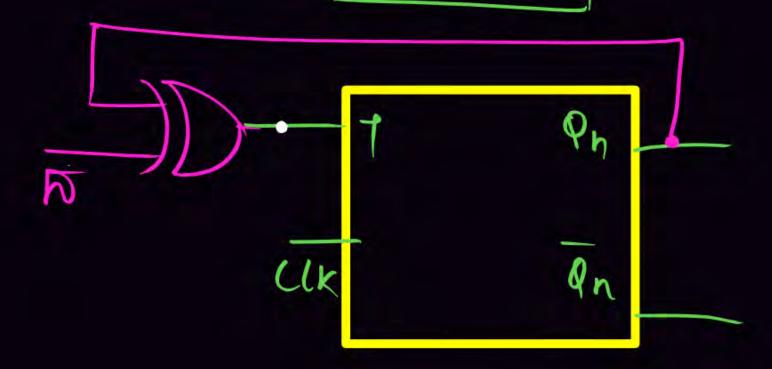| T	Q_n	Q_{n+1}	D
0	0	0	0
0	1	1	1
1	0	1	1
1	1	0	0

$$\overline{D = T \oplus Q_n}$$

Q_n

$\bar{A}$

A

T

$\overline{CLK}$

Q_n

$\overline{Q_n}$

P.FF

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

Method ② $Q_{n+1} = A$ —①

$A = T \oplus Q_n$ —②

Eq② in eq①

$$\boxed{Q_{n+1} = T \oplus Q_n} \checkmark$$

Q Design a D-FF by using T-FF?

$$D = T \oplus Q_n \leftarrow \text{By Previous Question}$$

$$\boxed{T = D \oplus Q_n}$$

$Q_{n+1} = T \oplus Q_n$

$T = D \oplus Q_n$

$Q_{n+1} = (D \oplus Q_n) \oplus Q_n$

$\qquad = D \oplus \underbrace{Q_n \oplus Q_n}_{0}$

$\qquad = D \oplus 0$

$\qquad = D$

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

D-FF

SR   JK   A   T.

$4 \times 3 = 12$

$$\begin{array}{r} 12 \\ -5 \\ \hline 7 \end{array}$$

HW   Design a CJ FF by using T-F.F ?

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