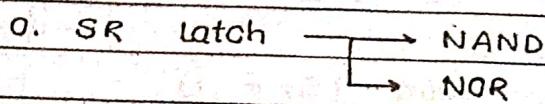


FLIP-FLOP

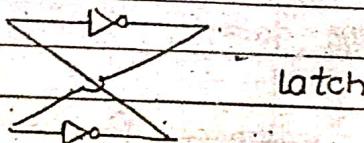
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- ⇒ It is basic memory element.
- ⇒ It can store 1 bit.
- ⇒ FF have two o/p which have complemented to each other.
- ⇒ It have two stable state hence it is known as Bistable multivibrator.

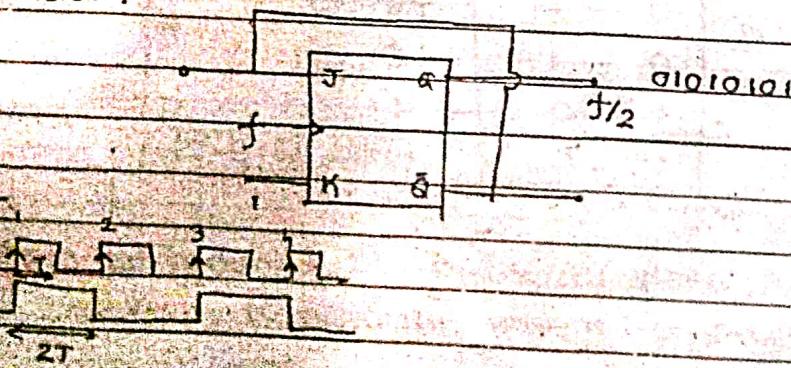
## CONTENT :-



- |          |   |
|----------|---|
| 1. SR FF | ⇒ CKts  |
| 2. JK FF | ⇒ Truth table   |
| 3. D FF  | ⇒ characteristic table  |
| 4. T FF  | ⇒ characteristic equation<br>⇒ Excitation table.<br>⇒ conversion from one to another<br>⇒ simple CKt. |

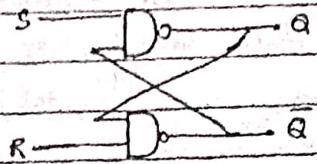


- ⇒ using Not gate the problem is, it have only one I/P then we use NAND or NOR gate instead of NOT gate.
- ⇒ FF is not only used for storing 1 bit but it also used for frequency divider.



## SR Latch using NAND :-

NAND:-



enable - L.

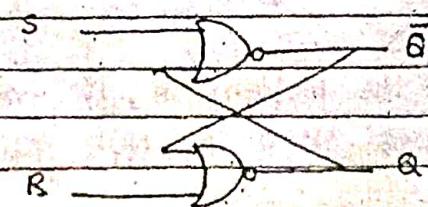
	A	B	Y
00	1		
01	1		
10		1	
11		1	0

Truth table :-

S	R	Q
0	0	Invalid ( $Q = \bar{Q} = 1$ )
0	1	1
1	0	0
1	1	Previous state (no change)

⇒ In SR latch if both gates are enabled o/p remains same previous state and both are disable then o/p remains same invalid state.

## SR latch using NOR gate:-



∴ NAND enable is 1 and disable is 0

and, in NOR - E = 0

⇒ then we change A and Q position

Truth table:-

S	R	Q	AB	Y
0	0	Previous state.	00	1
0	1	0	01	0
1	0	1	10	0
1	1	invalid ( $Q = \bar{Q} = 0$ )	11	0

⇒ SR latch is used to eliminate switch bouncing.

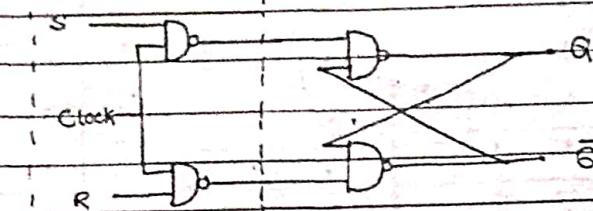
⇒ Bouncing means vibration of switches when ON or OFF

## SR Flip Flop :-

 $S = \text{Set}$  $R > \text{Reset}$ 

This term  
is used only as a inverter

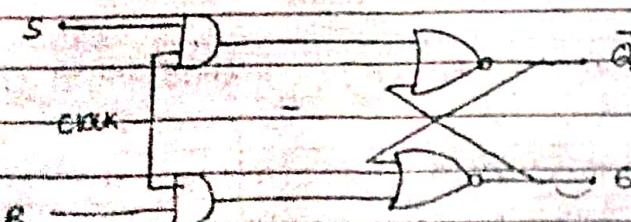
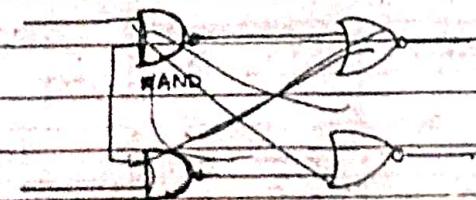
S	Y
0	1
1	1
0	1
1	0



## Truth table :-

	Clock	S R	$Q_{n+1}$	
	0	*	Previous state. ( $Q_n$ )	Hold state
	1	0 0	$Q_n$	
	1	0 1	0	→ Reset
same	1	1 0	1	→ Set
same	1	1 1	invalid.	→ unused

	S R	$Q_{n+1}$	
	0 0	$Q_n$	
	0 1	0	← very imp.
is 1 and	1 0	1	
is 0	1 1	invalid.	



⇒ Truth table is same as for NAND gate GR FF.

## Characteristic table :-

S	R	$Q_n$	$Q_{n+1}$	S	R	$Q_{n+1}$
0	0	0	0	0	0	$Q_n$
0	0	1	1	0	1	0
0	1	0	0	0	1	0
0	1	1	0	1	0	1
1	0	0	1	1	1	invalid
1	0	1	1			
1	1	0	x			
1	1	1	x			
$S \quad R\bar{Q}_n \quad \bar{R}Q_n \quad R\bar{Q}_n \quad R\bar{Q}_n$			$S \quad R \quad PS. \quad NS.$			
0	0	1	0	0	0	0(0)
0	1	0	1	1	0	1(1)
1	0	1	0	1	1	0(1)
1	1	0	1	1	0	0(0)
1	1	1	x	1	1	0(1)

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

$$Q_{n+1} = S + \bar{R}Q_n \quad \text{and} \quad SR = 0 \quad \text{--- (i)}$$

⇒ since  $S=1, R=1$ , the o/p is invalid because  $S.R=1$  not satisfy the above condition.

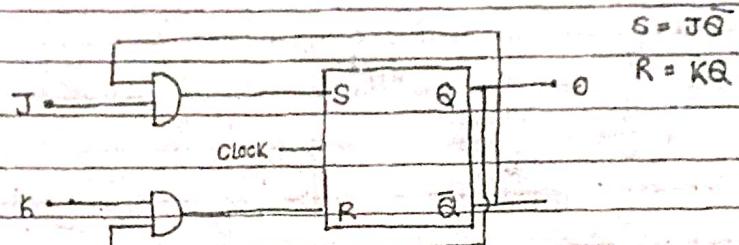
## Excitation table :-

$Q_n$        $Q_{n+1}$       S.R

	$Q_n$	$Q_{n+1}$	S	R
	0	0	0	*
	0	1	1	0
	1	0	0	1
	1	1	x	0

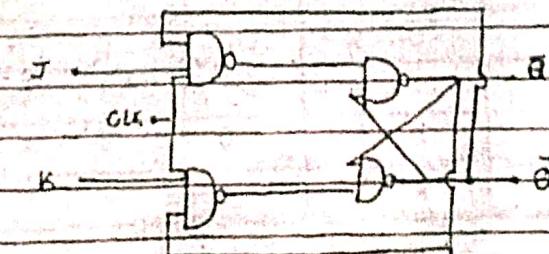
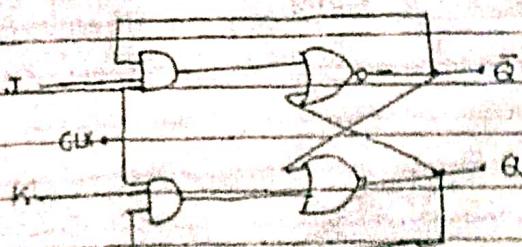
⇒ Disadvantage of SR FF is invalid state present when  $S=1$  and  $R=1$ .

⇒ To avoid this JK FF is used.

JK Flip Flop :-

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

	J	K	$Q_{n+1}$	
	0	0	$Q_n$	Hold
	0	1	0	Reset
	1	0	1	Set
	1	1	$\bar{Q}_n$	Toggle.

J-K FF using NAND gate :-J-K FF using NOR gate :-

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JK FF 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

Logical Expression:-

minimization:-

$J$	$K$	$\bar{K}Q_n$	$\bar{K}Q_n$	$KQ_n$	$KQ_n$
		$\bar{K}Q_n$	$\bar{K}Q_n$	$KQ_n$	$KQ_n$
$\bar{J}$					
	$J$	1	1		1

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

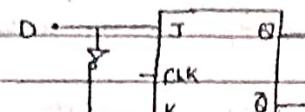
$$Q_{n+1} = JQ_n + KQ_n$$

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

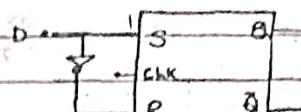
→ Drawback in JK ff is Race around condition which is eliminated in D flipflop.

## D-Flip Flop :-



$$J = D$$

$$JK = \bar{D}$$



$$S = D$$

$$R = \bar{D}$$

Truth table :-

CLK	D	$Q_{n+1}$	D	$Q_{n+1}$
0	*	$Q_n$	0	0
1	0	0	1	1
1	1	1		

Characteristic table :-

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

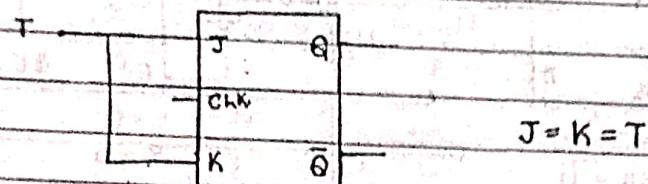
$$Q_{n+1} = D \Rightarrow \text{Therefore it is also called transparent latch}$$

Excitation table :-

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

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**T Flip-Flop (Toggle) :-****Truth table :-**

CLK	J	K	T	$Q_{n+1}$	T	$Q_{n+1}$
0	*	*	X	$Q_n$	0	$Q_n$
1	0	0	0	$Q_n$	1	$\bar{Q}_n$
1	1	1	1	$\bar{Q}_n$		

**Characteristic table :-**

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

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

**Excitation table :-**

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

Important :-

		J	K	$Q_{n+1}$	
SR-FF	0	0		$Q_n$	
	0	1		0	D-FF
	1	0		1	T-FF
	1	1		$Q_n$	

$\Rightarrow$  All tables are inside JK FF therefore it is also called as JK FF universal flip flop.

Excitation table :-

$Q_n$	$Q_{n+1}$	S	R	J	K	D	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	

FF  $\rightarrow$  Flip Flop - one bit storing element.

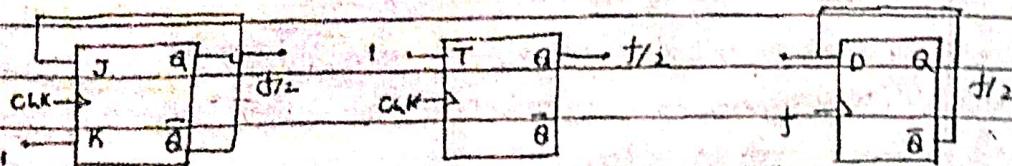
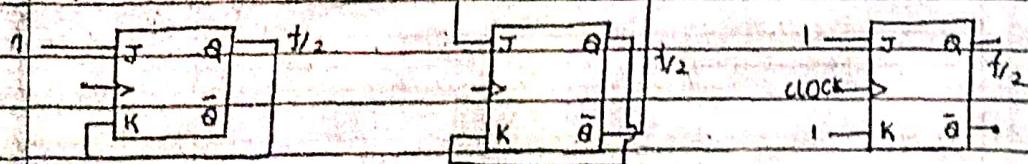
$$Q_{n+1} = S + \bar{R} Q_n \Rightarrow SR = \text{Set Reset}$$

$$Q_{n+1} = J Q_n + \bar{K} Q_n \Rightarrow JK = \text{name of person who give the IC's}$$

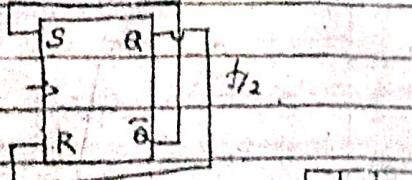
$$Q_{n+1} = D \Rightarrow D = \text{Delay element.}$$

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

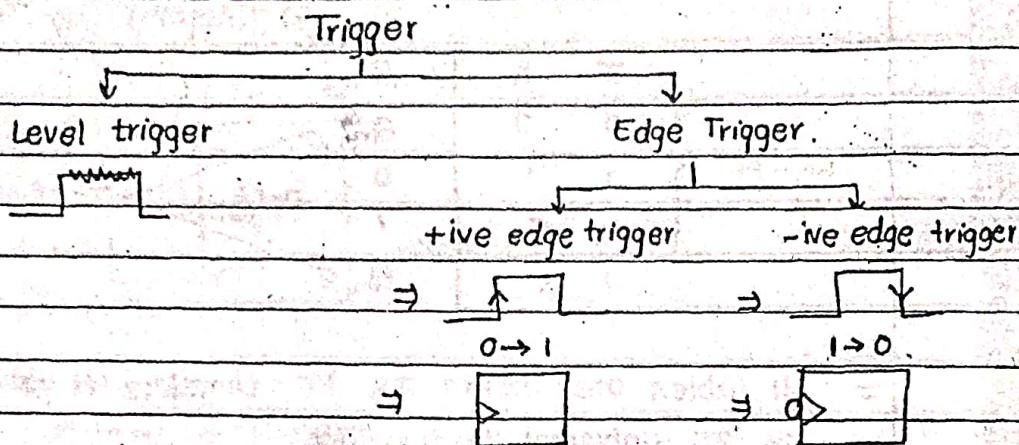
Toggle mode of JK :-



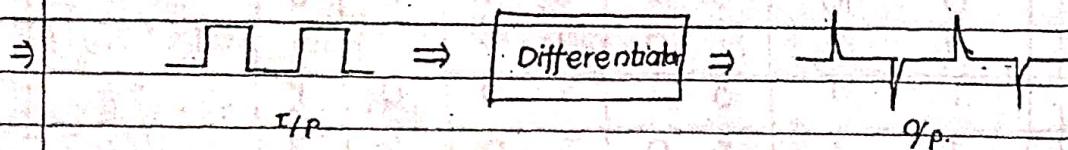
All 7 diagrams are in Toggle mode



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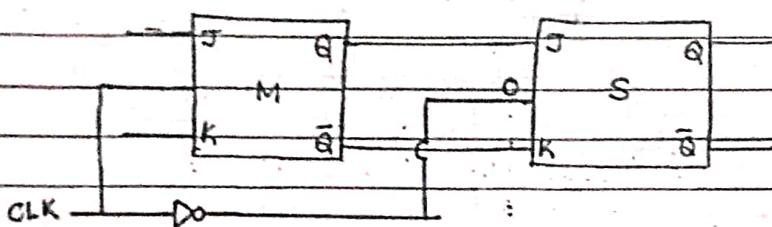


- ⇒ In level trigger ckt, o/p may changes many time in single clock
- ⇒ In edge trigger, o/p may change only ones in single pulse.

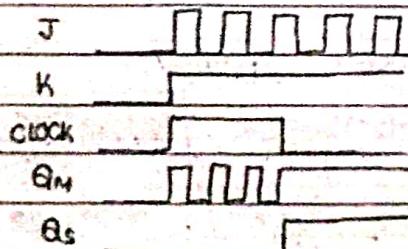


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## Master slave Flip Flop :-



- ⇒ Since the I/p of slave never go to (1,1) therefore in Master-Slave the Race around condition is removed.
- ⇒ Since I/p of slave is  $J=Q$  and  $K=\bar{Q}$  therefore it is always (1,0) or (0,1).
- ⇒ since race around condition occurs only when the I/p is (1,1).



- ⇒ In M-S FF, o/p is change only when slave o/p is changing
- ⇒ In M-S FF, Master is level triggered and edge is slave is edge triggered.

## Conversion of one FF to other FF :-

Procedure:-

- ⇒ Required FF characteristic table.
- ⇒ Available FF excitation table.
- ⇒ Write logical expression for excitation.

## (i) JK-Flip Flop to D-Flip Flop :-

D	$\bar{Q}_{n-1}$	Q <sub>n-1</sub>	J	K
0	0	0	0	X
0	1	0	X	1
1	0	1	1	X
1	1	1	X	0

⇒ write the logical expression for J and K :-

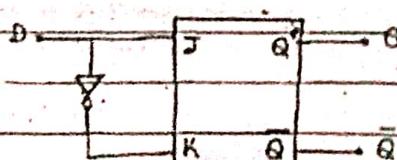
D \ $\bar{Q}_{n-1}$	
J =	K =
D	X
D	I X

$$J = D$$

D \ $\bar{Q}_{n-1}$	
J =	K =
D	X
D	I

$$K = \bar{D}$$

⇒ Implementation :-



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(ii) JK FF to SR FF :-

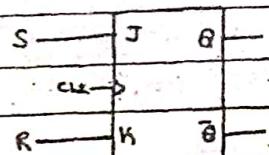
S	R	Q <sub>n</sub>	Q <sub>n+1</sub>	J	K
0	0	0	0	0	X
0	0	1	1	X	0
0	1	0	0	0	X
0	1	1	0	X	1
1	0	0	1	I	X
1	0	1	1	X	0
1	1	0	X	X	X
1	1	1	X	X	X

1	0	0	d	x
0	1	1	0	B
1	0	X	1	
1	1	X	0	

S	R <sub>n</sub>				
J :-	$\bar{S}$	X	X	X	X
S	[I]	X	X	X	X

K = R.

implementation:-



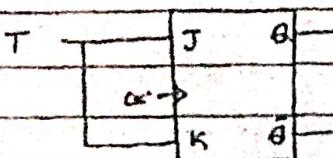
(iii) JK FF to T FF :-

T	Q <sub>n</sub>	Q <sub>n+1</sub>	J	K
0	0	0	0	X
0	1	1	X	0
1	0	1	I	X
1	1	0	X	I

T	Q <sub>n</sub>	Q <sub>n+1</sub>	T	Q <sub>n</sub>
J :-	$\bar{T}$	X	$\bar{T}$	X
T	[I]	X	T	[X]

J = T, K = T

implementation:-



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(iv) SR to JK FF :-

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

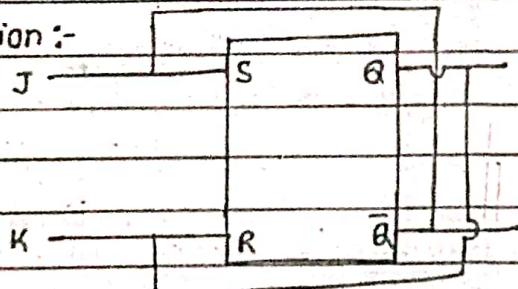
J	R	$Q_n$	$Q_{n+1}$	S R
0	0	0	0	0 X
0	0	1	1	X 0
0	1	0	0	0 X
0	1	1	0	0 1
1	0	0	1	1 0
1	0	1	1	X 0
1	1	0	1	1 0
1	1	0 1	0	0 1

J		$K_Q$	$\bar{K}_Q$	K		J		$K_Q$	$\bar{K}_Q$
$\bar{J}$		X				R = J	X	1 1	X
S :- J	1	X		1 1		$\bar{J}$		1 1	

$$S = \bar{J} \bar{Q}_n$$

$$R = \bar{J} K Q_n$$

Implementation :-



(v) SR FF to D FF :-

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

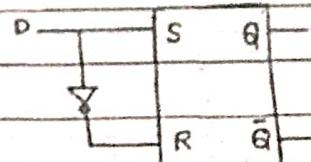
D		$Q_n$	$Q_{n+1}$	D	
B				B	X
S :- D	1	X		R :- D	1

$$S = D$$

$$R = B$$

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Implementation :-



vii) SR to TFF :-

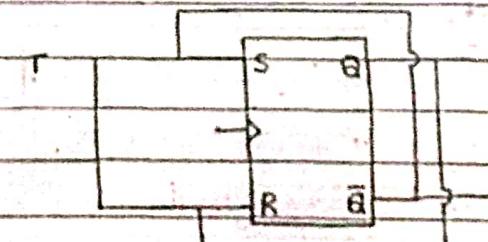
T	$Q_n$	$\bar{Q}_{n+1}$	S	R
0	0	0	0	X
0	1	1	X	0
1	0	1	1	0
1	1	0	0	1

T $Q_n$ $\bar{Q}_n$ $\bar{Q}$				$T \bar{Q}_n \bar{\bar{Q}}_n \bar{Q}_n$			
S :-		$\bar{T}$	X	R :-		$\bar{T}$	X
T	1			T	1		UD

$$S = T\bar{Q}_n$$

$$R = TQ_n$$

Implementation :-



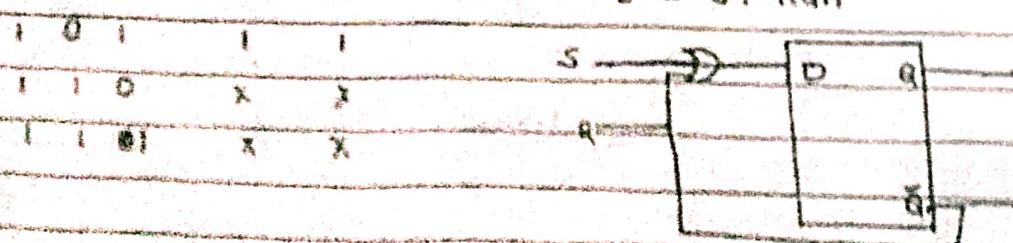
viii) D FF to SR FF :-

S	R	$Q_n$	$\bar{Q}_{n+1}$	D
0	0	0	0	0
0	0	1	1	1
0	1	0	0	0
0	1	0	0	1
1	0	0	1	1
1	0	1	1	1
1	1	X	X	X
1	1	0	X	X

$Q_n$	$\bar{Q}_{n+1}$	D
*	*	*
*	1	1
1	0	0
1	1	1

D :		$\bar{S}$	$\bar{R}$	$Q_n$
S	R	1	1	1
1	1	1	1	1
1	1	1	1	X
1	1	1	1	X

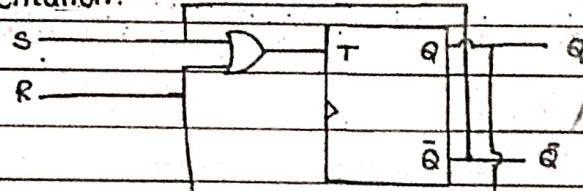
$$D = S + R\bar{Q}_n$$



(X) T FF to SR FF :-

S	R	$Q_n$	$Q_{n+1}$	T						
0	0	0	0	0						
0	0	1	1	0	S	$\bar{R}Q$	$\bar{R}\bar{Q}$	$\bar{R}Q$	$RQ$	$R\bar{Q}$
0	1	0	0	0	T :-	$\bar{S}$			$\bar{T}$	
0	1	1	0	1	S	0	X	X		
1	0	0	1	1						
1	0	1	1	0						
1	1	0	X	X						
1	1	1	X	X						

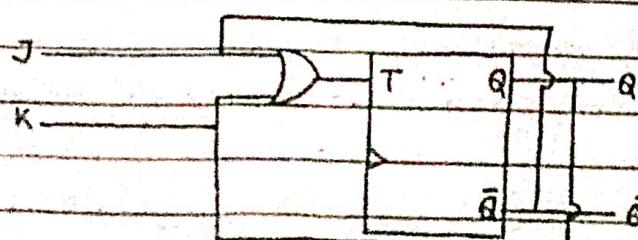
Implementation:-



(X) T FF to JK FF :-

J	K	$Q_n$	$Q_{n+1}$	T						
0	0	0	0	0						
0	0	1	1	0	J	$\bar{K}Q_n$	$\bar{R}Q$	$\bar{K}\bar{Q}$	$KQ$	$K\bar{Q}$
0	1	0	0	0	T :-	$\bar{J}$			$\bar{J}$	
0	1	1	0	1	J	1	1	1	1	1
1	0	0	1	1						
1	0	1	1	0						
1	1	0	1							
1	1	1	0	1						

Implementation :-

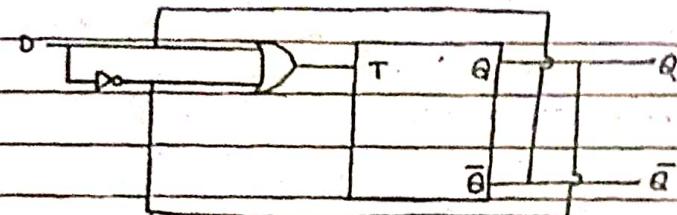


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Q10 T-FF to D-FF :-

D	$Q_n$	$Q_{n+1}$	T	$DQ$	$\bar{D}$	Q
0	0	0	0	T = 0	0	0
0	1	0	1	0	1	1
1	0	1	1			
1	1	1	0	T = $DQ + \bar{D}Q$ .		



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(vi) D FF to JK FF :-

(x)

J	K	$Q_n$	$Q_{n+1}$	D
---	---	-------	-----------	---

0	0	0	0	0
---	---	---	---	---

0	0	1	1	1
---	---	---	---	---

0	1	0	0	0
---	---	---	---	---

0	1	1	0	0
---	---	---	---	---

1	0	0	1	1
---	---	---	---	---

1	0	1	1	1
---	---	---	---	---

1	1	0	1	1
---	---	---	---	---

1	1	1	0	0
---	---	---	---	---

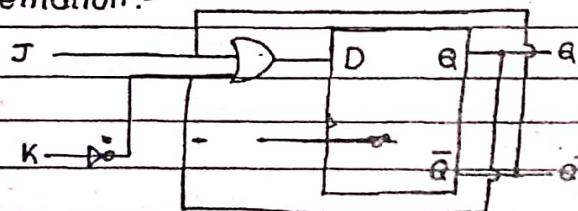
$J \quad K \quad Q_n \quad \bar{Q}_n \quad \bar{Q} \quad Q$

$D = \bar{J} \quad \bar{Q} \quad \bar{Q} \quad Q$

$J \quad \bar{Q} \quad \bar{Q} \quad Q$

$$D = \bar{J}\bar{Q} + \bar{K}Q.$$

Implementation:-



(ix) D-FF to T FF :-

Q.U

T	$Q_n$	$Q_{n+1}$	D
---	-------	-----------	---

0	0	0	0
---	---	---	---

0	1	1	1
---	---	---	---

1	0	1	1
---	---	---	---

1	1	0	0
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$$D = \bar{T}Q + T\bar{Q}$$

Implementation:-

