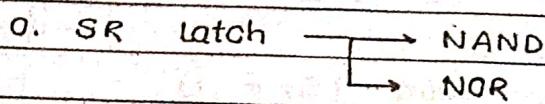


FLIP-FLOP

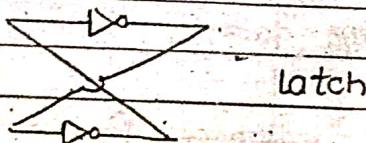
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- ⇒ It is basic memory element.
- ⇒ It can store 1 bit.
- ⇒ FF have two o/p which have complemented to each other.
- ⇒ It have two stable state hence it is known as Bistable multivibrator.

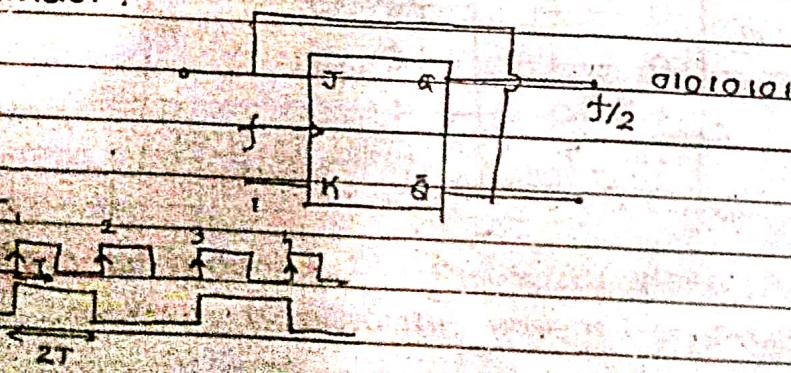
CONTENT :-



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

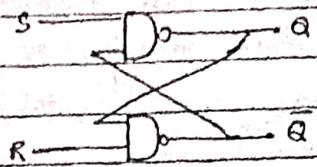


- ⇒ using Not gate the problem is, it have only one I/P then we use NAND or NOR gate instead of NOT gate.
- ⇒ FF is not only used for storing 1 bit but it also used for frequency divider.



SR Latch using NAND :-

NAND:-



enable - L.

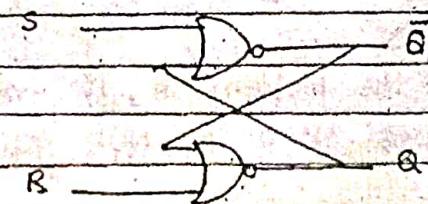
	A	B	Y
00	1		
01	1		
10	1		
11	0		

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.

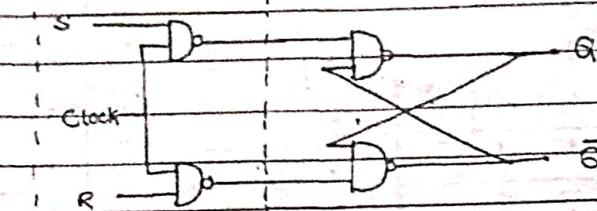
⇒ Bouncing means vibration of switches when ON or OFF

SR Flip Flop :-

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

This term
is used only as a inverter

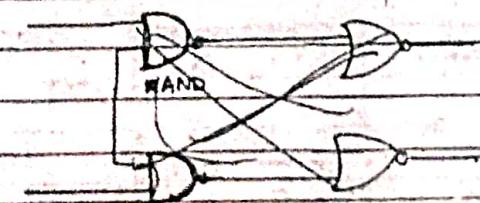
S	Y
0	1
1	1
0	1
1	0



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			
$S \quad R\bar{Q}_n \quad \bar{R}Q_n \quad R\bar{Q}_n \quad R\bar{Q}_n$			$SR \text{ PS. NS. } S \cdot R$			
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 $S \cdot R=1$ not satisfy the above condition.

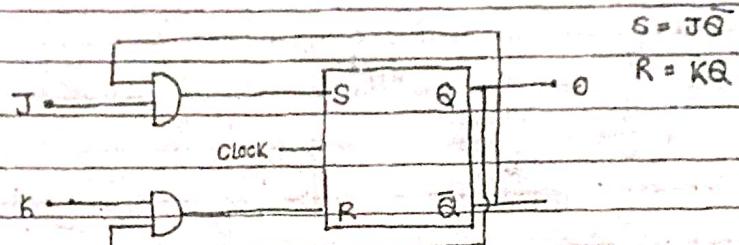
Excitation table :-

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

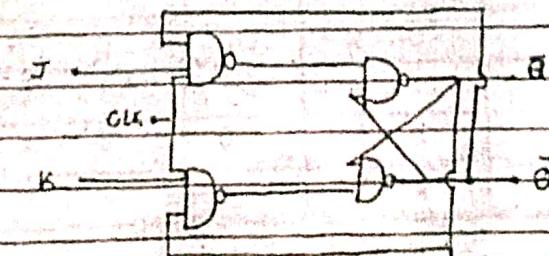
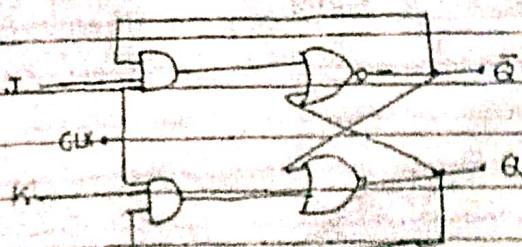
⇒ Disadvantage of SR FF is invalid state present when $S=1$ and $R=1$.

⇒ 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

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

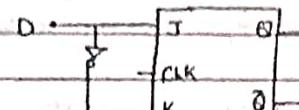
$$Q_{n+1} = JQ_n + KQ_n$$

Exitation table :-

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

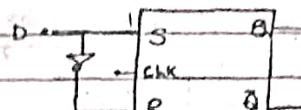
→ Drawback in JK ff is Race around condition which is eliminated in D flipflop.

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

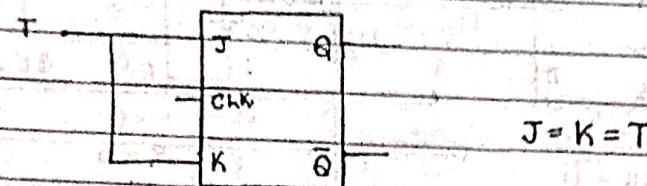
$$Q_{n+1} = D \Rightarrow \text{Therefore it is also called transparent latch}$$

Excitation table :-

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

This

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.

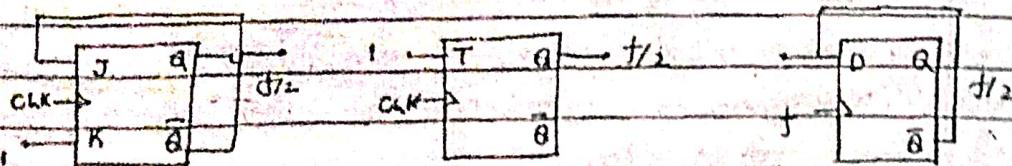
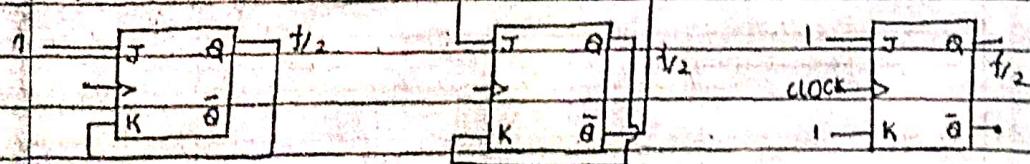
$$Q_{n+1} = S + \bar{R} Q_n \Rightarrow SR = \text{Set Reset}$$

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

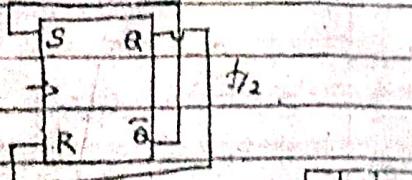
$$Q_{n+1} = D \Rightarrow D = \text{Delay element.}$$

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

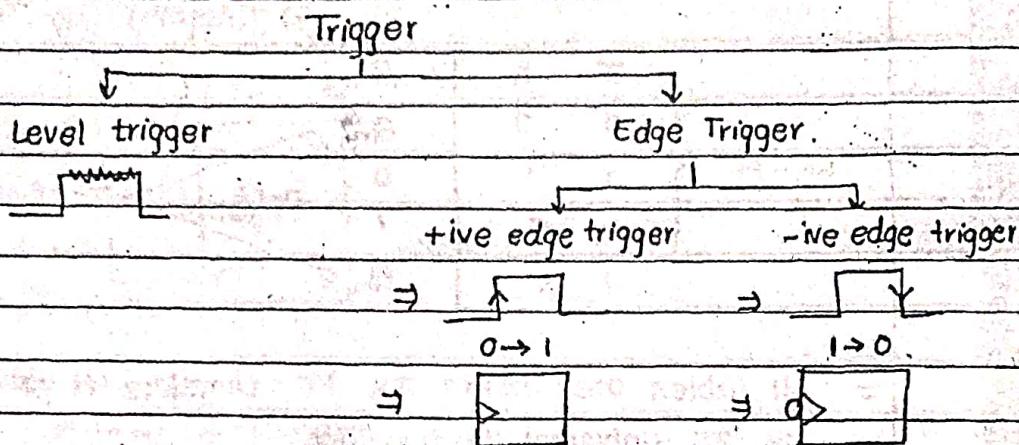
Toggle mode of JK :-



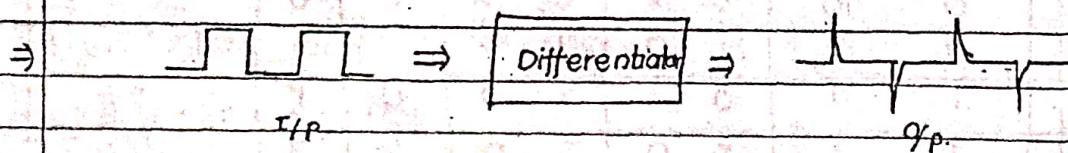
All 7 diagrams are in Toggle mode



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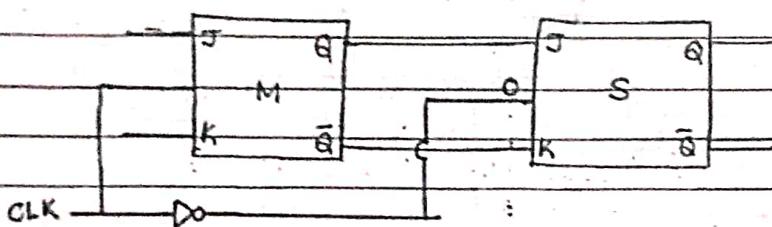
- ⇒ In level trigger ckt, o/p may changes many time in single clock
- ⇒ In edge trigger, o/p may change only ones in single pulse.



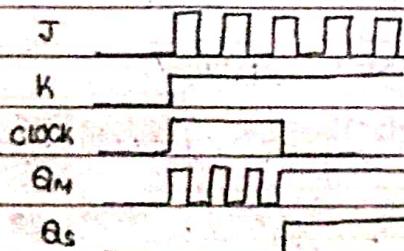
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Master slave Flip Flop :-



- ⇒ 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 _{n-1}	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 :-

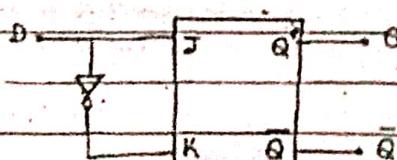
D \ \bar{Q}_{n-1}	
J =	K =
D	X
D	I X

$$J = D$$

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 :-

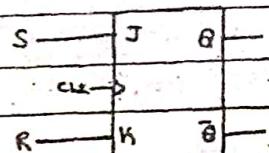
S	R	Q _n	Q _{n+1}	J	K	Q _n	Q _{n+1}	Q _n	Q _{n+1}
0	0	0	0	0	X	0	0	0	X
0	0	1	1	X	0	1	1	1	X
0	1	0	0	0	X	1	0	1	X
0	1	1	0	X	1	1	1	0	X
1	0	0	1	I	X	1	0	1	X
1	0	1	1	X	0	0	1	1	X
1	1	0	X	X	X	1	1	1	X
1	1	1	X	X	X	1	1	1	X

S	Q _n	Q _{n+1}	Q _n	Q _{n+1}	Q _n	Q _{n+1}
J :-	\bar{S}	X	X		X	\bar{S}
S	[I]	X	X	X	X	X

$$J = S$$

$$K = \bar{R}$$

implementation :-



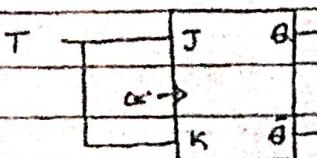
(iii) JK FF to T FF :-

T	Q _n	Q _{n+1}	J	K
0	0	0	0	X
0	1	1	X	0
1	0	1	1	X
1	1	0	X	1

T	Q _n	Q _{n+1}	T	Q _n	Q _{n+1}
J :-	\bar{T}	X	\bar{T}	X	
T	[I]	X	T	X	Y

$$J = T, K = T$$

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

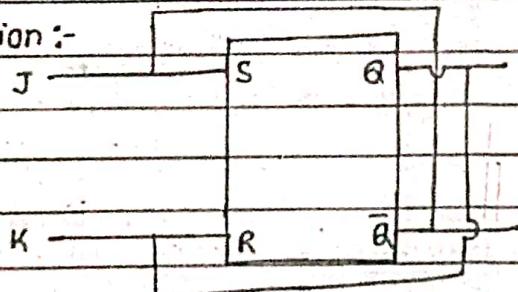
J	R	Q_n	Q_{n+1}	S R
0	0	0	0	0 X
0	0	1	1	X 0
0	1	0	0	0 X
0	1	1	0	0 1
1	0	0	1	1 0
1	0	1	1	X 0
1	1	0	1	1 0
1	1	0 1	0	0 1

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

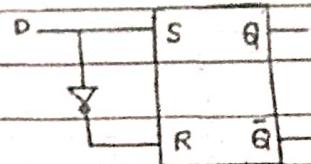
D		Q_n	Q_{n+1}	D	
B				B	X
S :- D	1	X		R :- D	1

$$S = D$$

$$R = B$$

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Implementation :-



vii) SR to TFF :-

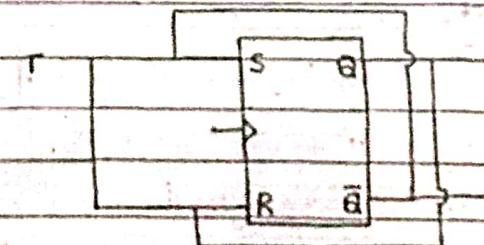
T	Q_n	\bar{Q}_{n+1}	S	R
0	0	0	0	X
0	1	1	X	0
1	0	1	1	0
1	1	0	0	1

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 :-

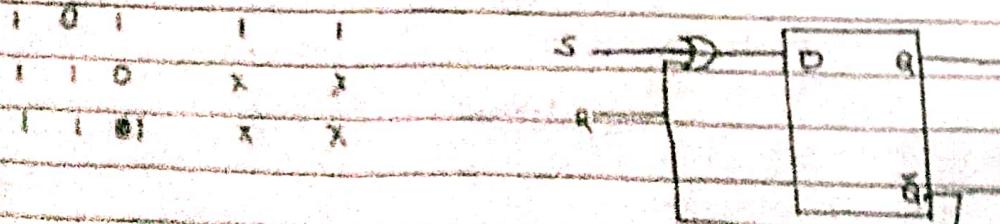


viii) D FF to SR FF :-

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	1	1	-

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

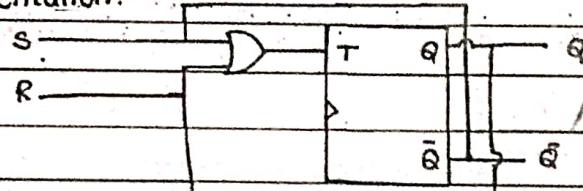
$$D = S + R\bar{Q}_n$$



(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						

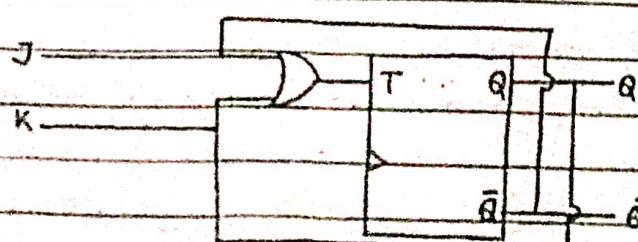
Implementation:-



(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	$\bar{K}Q_n$	$\bar{R}Q$	$\bar{R}\bar{Q}$	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 :-

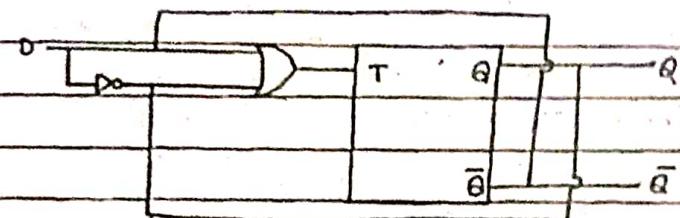


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Q10 T-FF to D-FF :-

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 :-

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
---	---	---	---	---

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

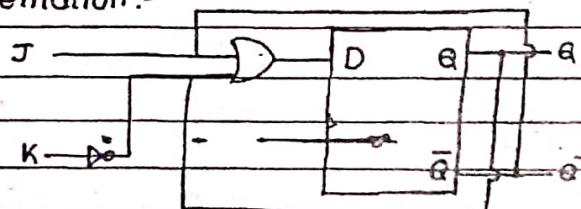
$D = \bar{J}$

$J = \bar{I}$

$\bar{J} = I$

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

Implementation:-



(ix) D-FF to T FF :-

T	Q_n	Q_{n+1}	D	Q_n	\bar{Q}_n	Q
---	-------	-----------	---	-------	-------------	---

0	0	0	0	0	1	Q
---	---	---	---	---	---	---

0	1	1	1	1	0	Q
---	---	---	---	---	---	---

1	0	1	1	1	0	Q
---	---	---	---	---	---	---

1	1	0	0	0	1	Q
---	---	---	---	---	---	---

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

Implementation:-

