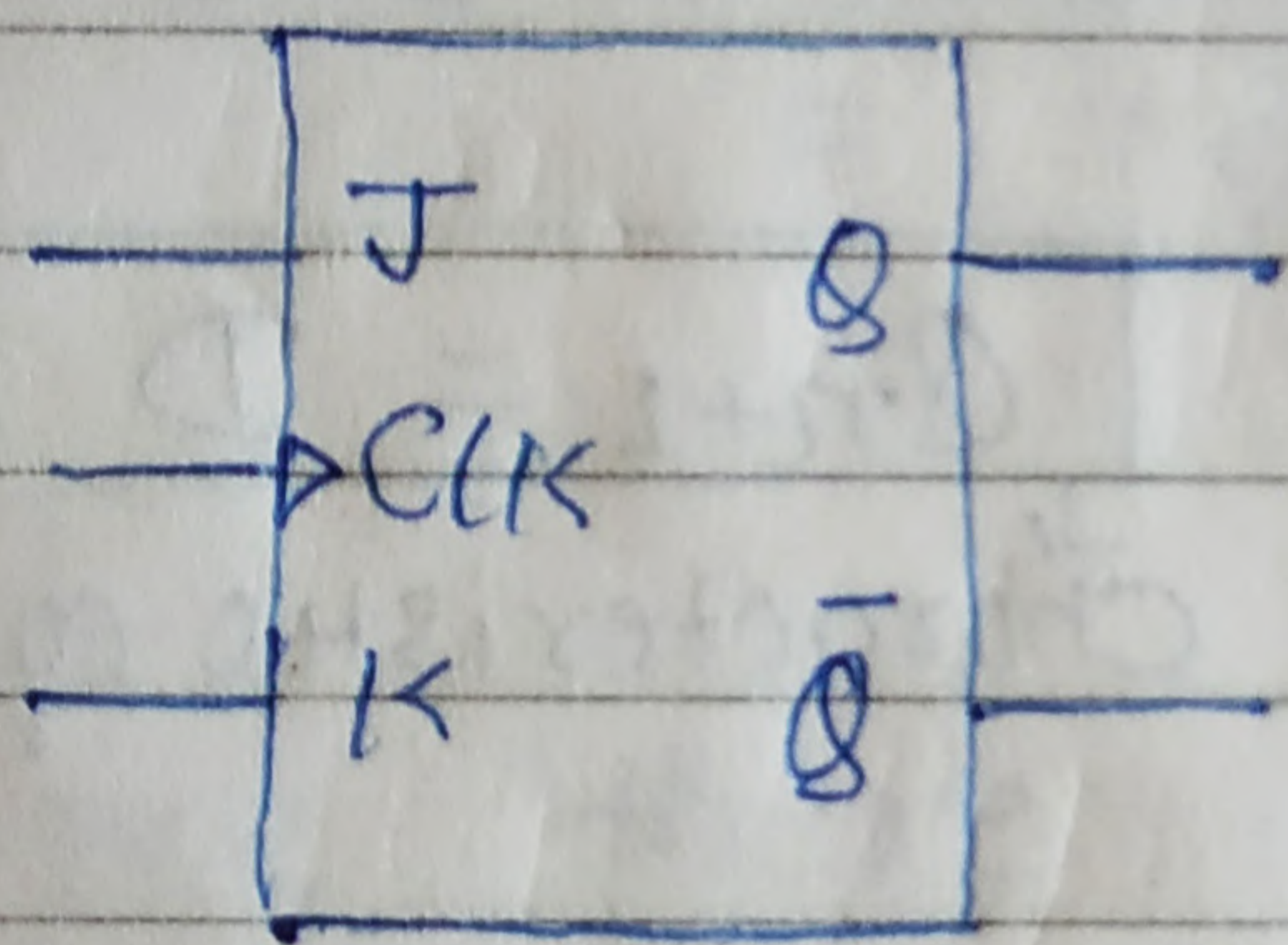


J-K FLIP-FLOP

A J-K flip-flop has a characteristic similar to that of an S-R flip-flop. The indeterminate condition of the S-R flip-flop is permitted in it.

A J-K flip-flop can be obtained from the clocked S-R flip-flop by augmenting two AND gates as given in logic diagram.



The data input J and the output $\bar{Q}$ are applied to the first AND gate, and its output $J\bar{Q}$ is applied to the S input of S-R flip-flop.

Similarly, the data input K and the output Q are connected to the second AND gate and its output KQ is applied to R input of S-R flip-flop.

Let Q_{n+1} = Next state of output Q
 Q_n = Present state of output Q

$$Q_{n+1} = \overline{\{(J \cdot \bar{Q}_n) \cdot CLK\} \cdot \bar{Q}_n}$$

$$= \{(J \cdot \bar{Q}_n) \cdot CLK\} + Q_n$$

$$\bar{Q}_{n+1} = \overline{\{(K \cdot Q_n) \cdot CLK\} \cdot Q_n}$$

$$= \{(K \cdot Q_n) \cdot CLK\} + \bar{Q}_n$$

Case i) $J=0$, $K=0$, $CLK=1$

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

$$\bar{Q}_{n+1} = \bar{Q}_n$$

Case ii) $J=0$, $K=1$, $CLK=1$

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

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

Since $\bar{Q}_{n+1}$ is '1', then $Q_{n+1} = 0$
for $J=0$, $K=1$ and $CLK=1$.

Case iii) $J = 1, K = 0, CLK = 1$

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

Since $Q_{n+1} = 1$, then $\bar{Q}_{n+1} = 0$ for

$$J = 1, K = 0, CLK = 1$$

Case iv) $J = 1, K = 1, CLK = 1$

This case deserves special attention.

~~Q_{n+1}~~ When $J = 1, K = 1$ and the present state ~~i.e. Q_n~~ is SET State i.e. $Q_n = 1, \bar{Q}_n = 0$.

then, $S = J \cdot \bar{Q}_n = 0$ and
 $R = K \cdot Q_n = 1$

i.e. $S = 0, R = 1$, so the flip-flop RESETS on the application of clock pulse i.e.

$$Q_{n+1} = 0 \quad \bar{Q}_{n+1} = 1$$

So the J-K flip flop toggles from SET State to Reset, when $J = 1, K = 1, Q_n = 1, \bar{Q}_n = 0$ and $CLK = 1$

Secondally, $J = 1, K = 1$ and the present state is RESET state i.e. $Q_n = 0$ and $\bar{Q}_n = 1$, then

$$S = J \cdot \bar{Q}_n = 1$$

$$R = K \cdot Q_n = 0$$

i.e $S = 1$, $R = 0$, so the flip flop SETS on the application of clock-pulse i.e

$$Q_{n+1} = 1 \quad \bar{Q}_{n+1} = 0$$

So the J-K flip flop toggles from RESET State to SET State, when $J = 1, K = 1$
 $Q_n = 0$, $\bar{Q}_n = 1$ and $clk = 1$.

We see that when $J = 1, K = 1$, JK flip-flop toggles. Toggle means to switch to the opposite state.

Based on above analysis, results can be tabulated to form characteristic table of JK flip flop

Truth Table

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

Characteristic Table.

From truth table of J-K flip flop
 • K-map can be solve for Q_{n+1} as

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

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

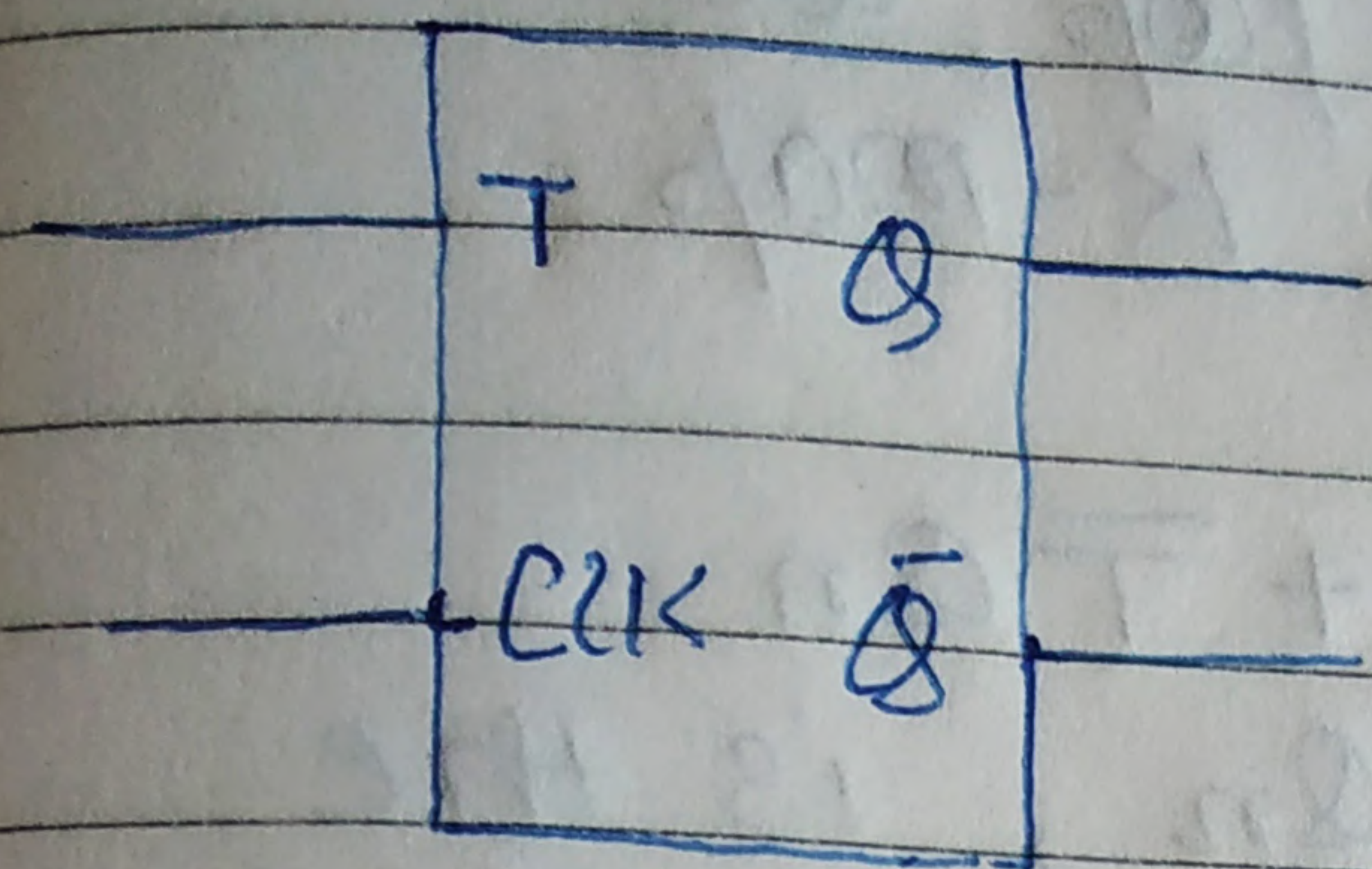
Excitation table can be prepared as

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

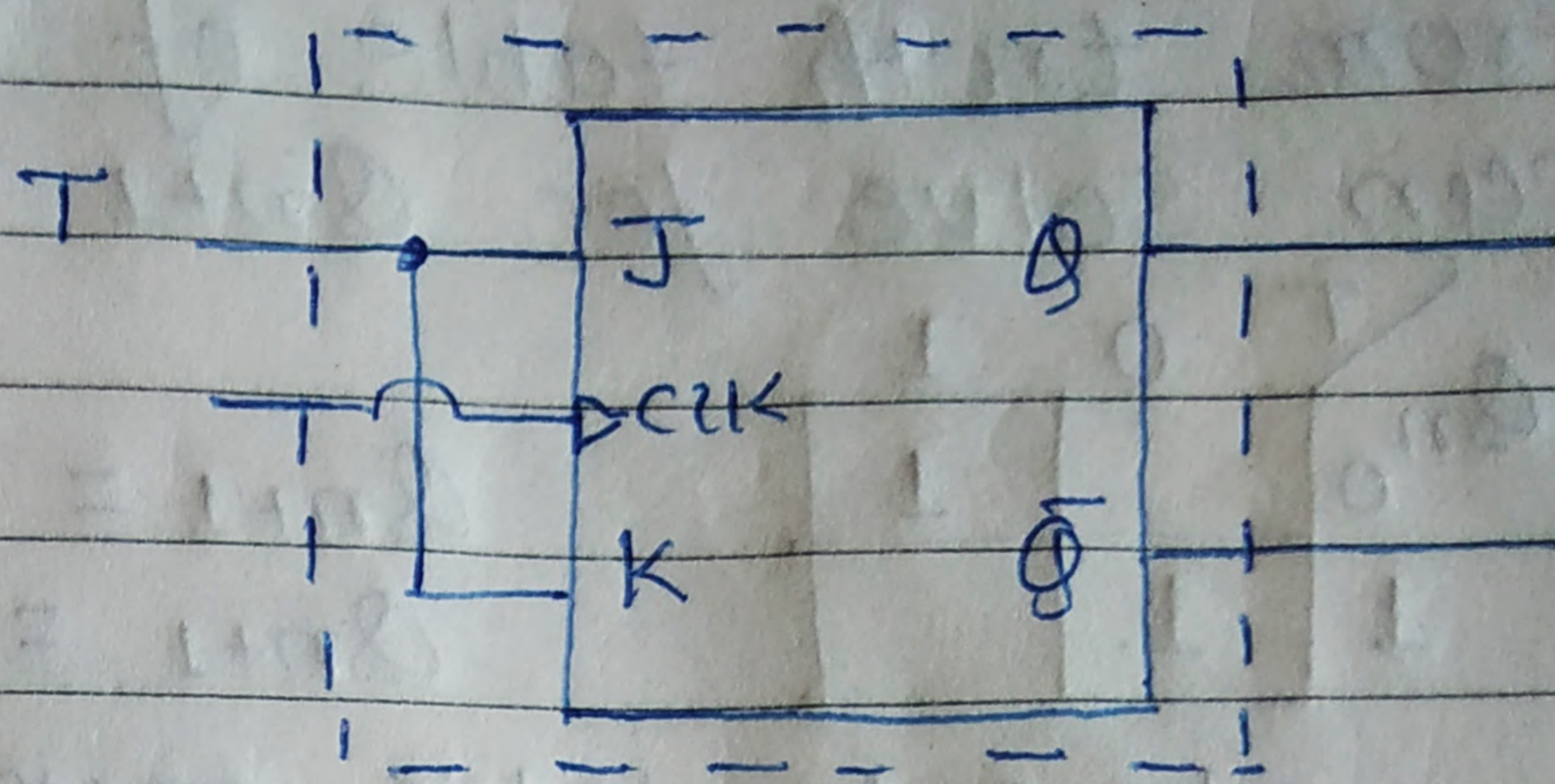
T-FLIP-FLOP

It is another basic flip-flop, its name is trigger or toggle flip-flop. It has only a single data (T) input, a clock input and two output Q and $\bar{Q}$.

T flip-flop is obtained from a J-K flip-flop by connecting its J and K inputs together. The designation T comes from the ability of the flip-flop to "toggle" or complement its state.



Block diagram
of T flip flop



T flip flop using JK
flip flop.

Case i) $T = 0$ $CLK = 1$

when $T = 0$, $J = K = '0'$, So

$$\begin{aligned} Q_{n+1} &= Q_n \\ \bar{Q}_{n+1} &= \bar{Q}_n \end{aligned} \quad \left. \begin{array}{l} \text{from characteristic} \\ \text{table of JK Flip Flop} \end{array} \right\}$$

Case ii) $T = 1$ $CLK = 1$

when $T = 1$, $J = K = '1'$ So

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

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

characteristic table
of T flip-flop

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

truth table of
T flip flop.

From truth table of T-flip flop, we can solve for Q_{n+1} using K-map

$T \backslash Q_n$	0	1
0		1
1	1	

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

$$Q_{n+1} = T \oplus Q_n, \text{ is the}$$

characteristic equation of T flip flop.

Excitation table of T flip-flop can be given as

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

T-flip flop is most often seen in counters and sequential counting networks because of its inherent divide by 2 capability.

Application of FLIP-FLOPS

Flip-Flops find wide application in

- counter circuit
- frequency divider
- Shift and Storage registers