FLIP-FLOPS

CSE-211

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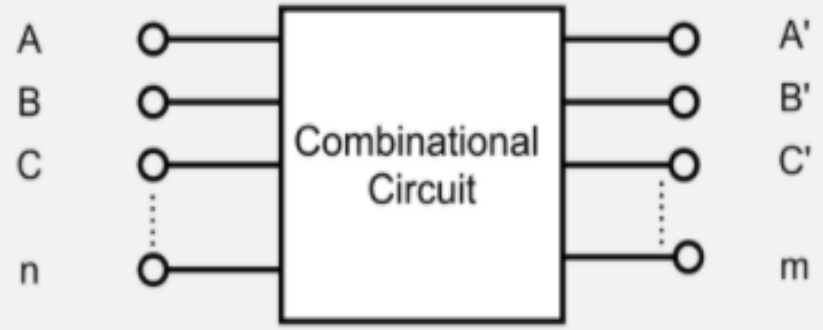
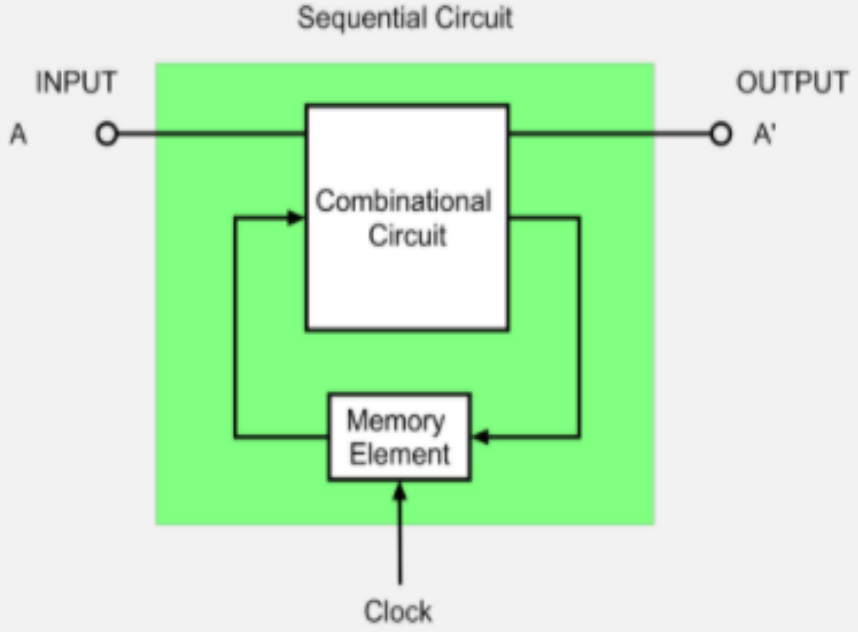
Combinational Vs Sequential Circuits

Diagram



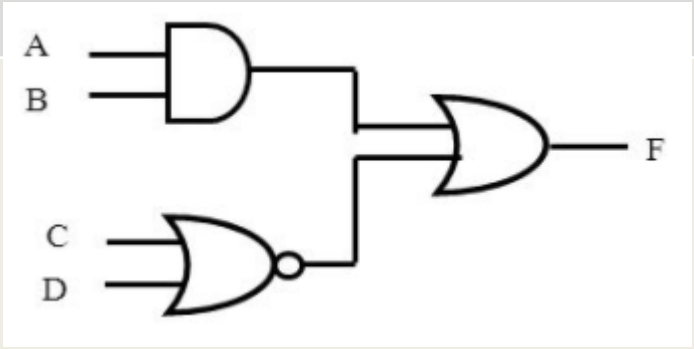
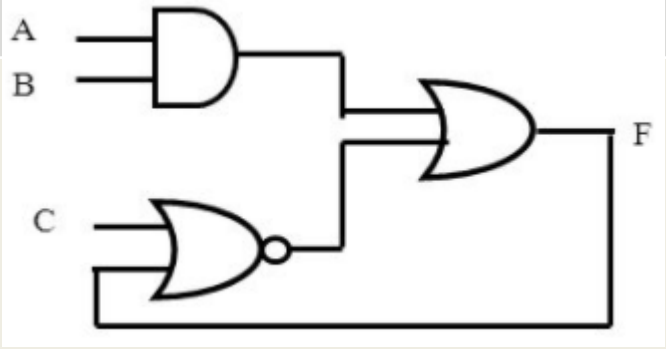
Combinational Circuits

Diagram



Sequential Circuit

Combinational Vs Sequential Circuits

Combinational Circuits	Sequential Circuits
1. Output depends solely on the inputs	1. Output depends upon the inputs and previous outputs
2. Feedback path is not used in Combinational Circuits.	2. Feedback path is used for Sequential circuit.
3. Memory element is not present.	3. Memory element is present.
4. Clock is not used in Combinational circuits.	4. Clock is used in Sequential circuits.
5. Circuit is simple.	5. Circuit is complex.
6. Examples of combinational circuits are adders, subtractors, comparators, multiplexer, de-multiplexer, decoder, encoder, etc.	6. Examples of sequential circuits are : Flip-flops, counters, registers etc.
7. 	7. 

Flip-Flops

- A computer needs devices which can store information. A **flip flop** is a **binary storage** device. It can store binary bit **either 0 or 1**.
- It has two stable states HIGH and LOW i.e.1 and 0. It has the property to remain in one state indefinitely until it is directed by an input signal to switch over to the other state.
- The **basic function** of a flip flop is to **store data**. They can be used to keep a record or what value of variable (input, output or intermediate).
- Flip flops are also used to exercise control over the functionality of a digital circuit i.e. change the operation of a circuit depending on the state of one or more flip flops.
- It is the basic storage element in a sequential logic.
- These devices are mainly used in situations which require one or more of these three tasks: operations (e.g. counting), storage and sequencing.

Types of Flip-Flops

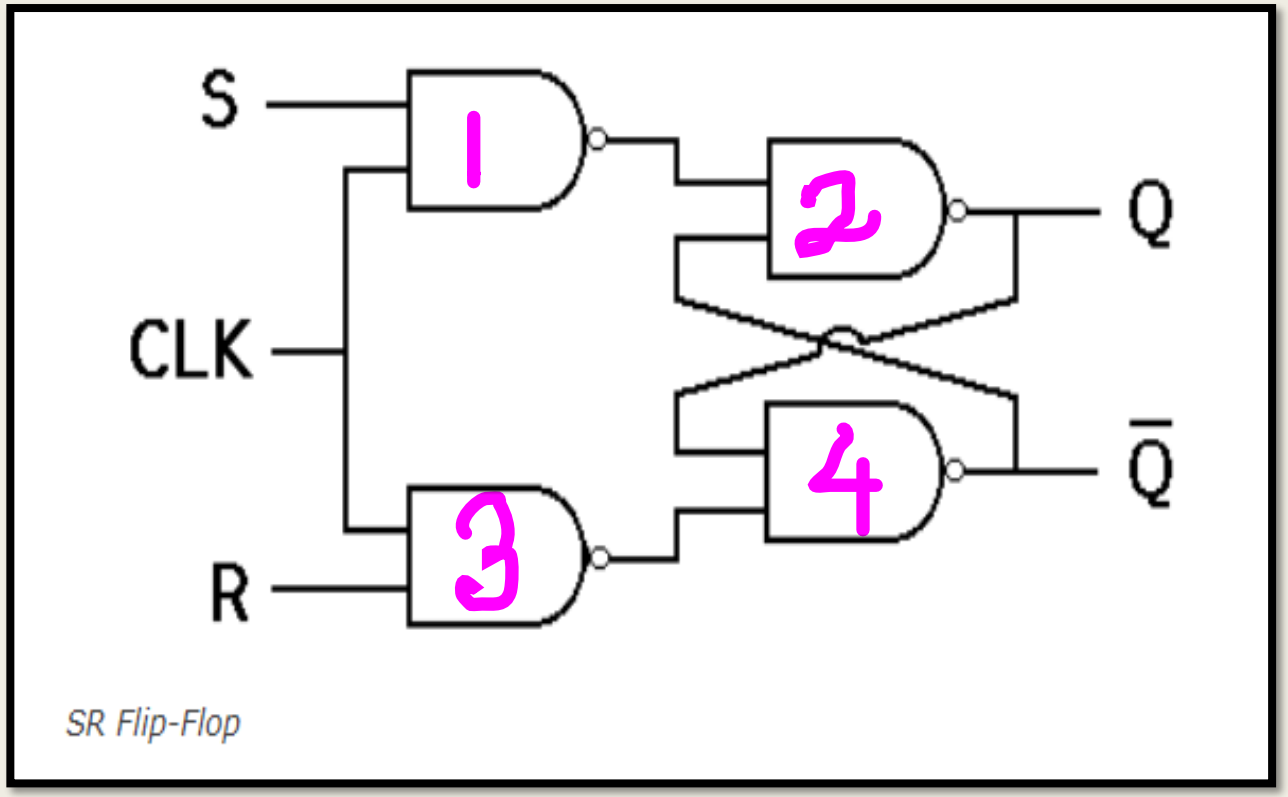
- SR Flip-Flop
- JK Flip-Flop
- D Flip-Flop
- T Flip-Flop

These are the various types of flip-flops being used in digital electronic circuits and these flip-flops are used in the specified devices commonly:

- Counters
- Frequency Dividers
- Shift Registers
- Storage Registers

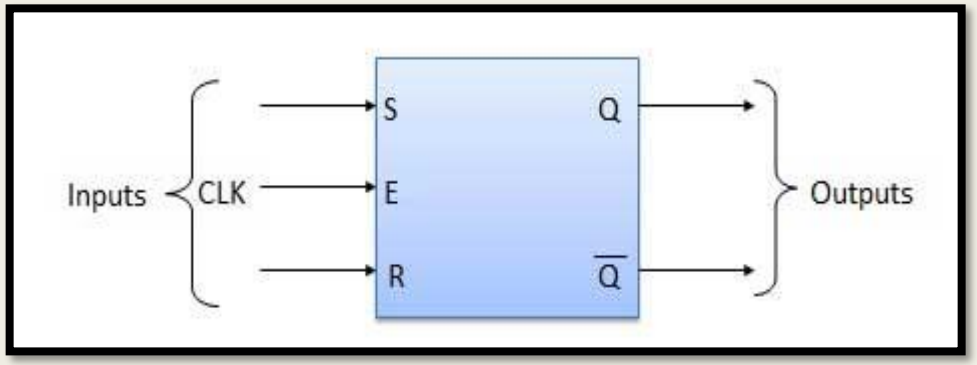
SR Flip-Flop

- In this circuit diagram, the output is changed (i.e. the stored data is changed) only when you give an active clock signal. Otherwise, even if the S or R inputs are present, the data will not change.
- This simple flip flop circuit has a set input (S) and a reset input (R). In addition to control inputs Set (S) and Reset (R), there is the clock input (CLK) also.
- It is very useful to add clock to control precisely the time at which the flip flop changes the state of its output.



Circuit Diagram

Block Diagram



SR Flip-Flop

Truth Table / Characteristic Table

Present Inputs		Present State	Next State
S	R	Q (t)	Q $(t+1)$
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

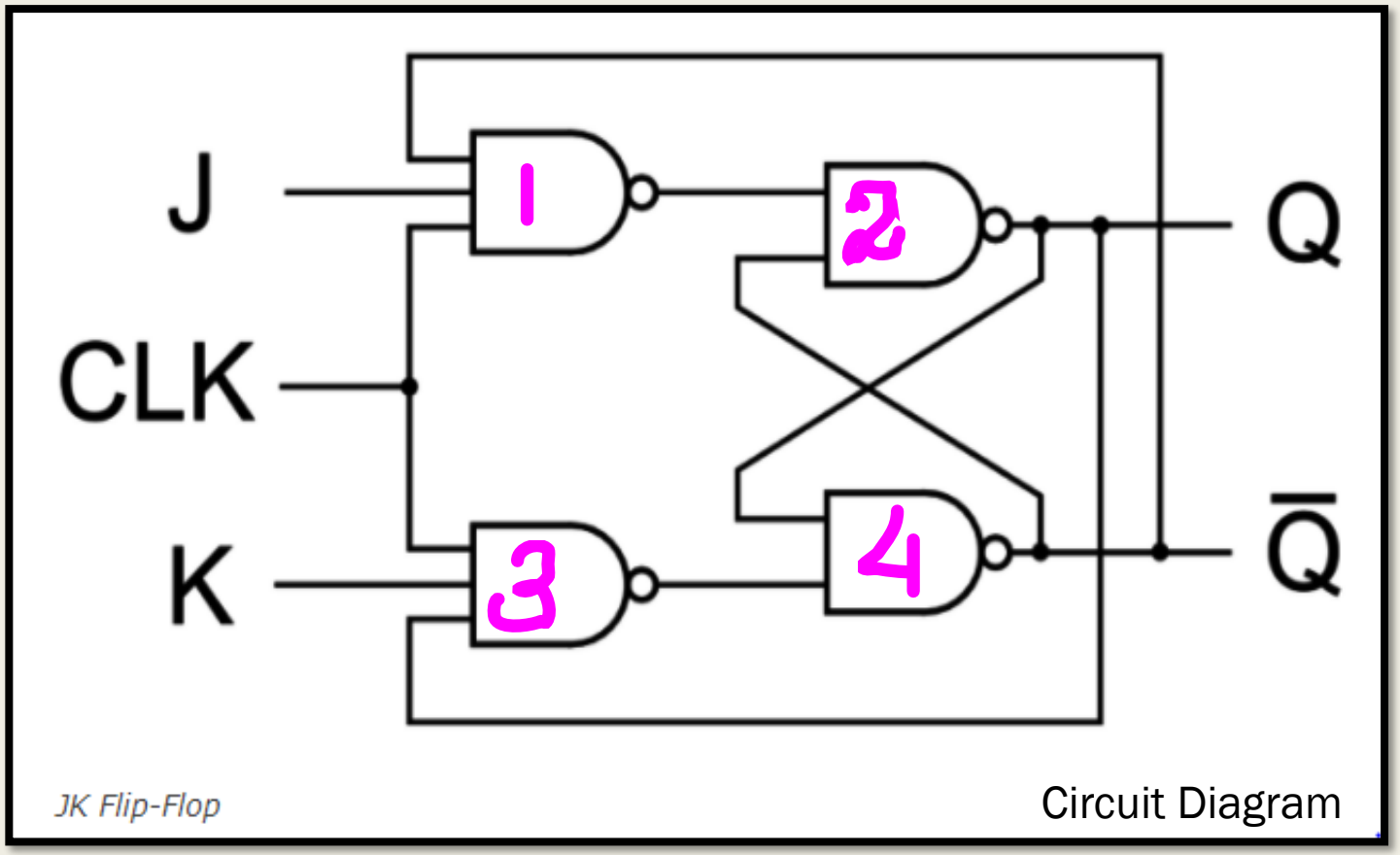
State Table

S	R	Q (t + 1)
0	0	No Change
0	1	Reset (0)
1	0	Set (1)
1	1	Indeterminate

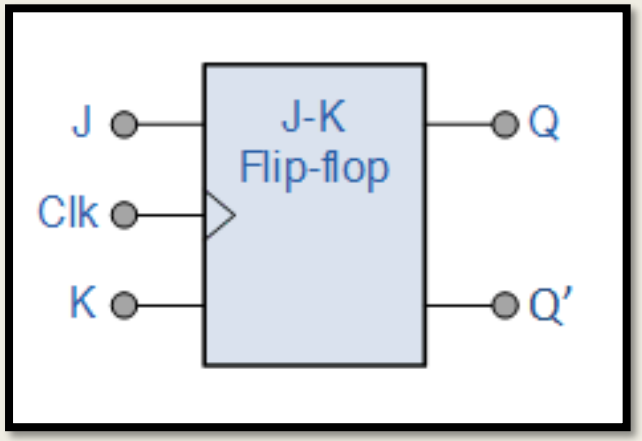
JK Flip-Flop

Due to the undefined state in the SR flip flop, another flip flop is required in electronics.

The JK flip flop is an improvement of the SR flip flop where the problem when S=R=1 is resolved.



Circuit Diagram



Block Diagram

JK Flip-Flop

Present Inputs		Present State	Next State
J	K	Q t	Q $t+1$
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

Truth/Characteristic Table

State Table

J	K	Q $t+1$
0	0	Q t No change/Hold
0	1	Reset/Clear 0
1	0	Set 1
1	1	Toggle Q t '

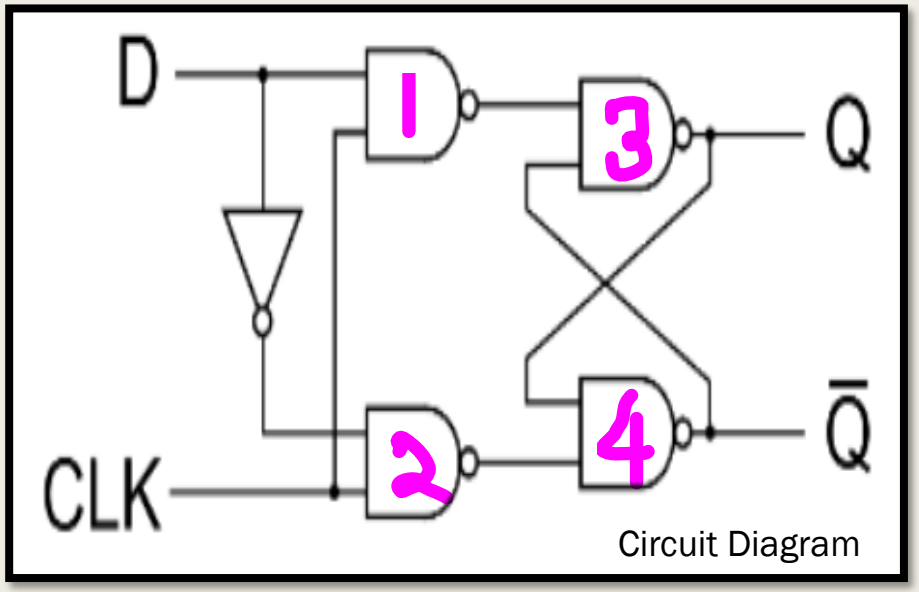
JK Flip-Flop

One of the most useful and versatile flip flop is the JK flip flop. The unique features of a JK flip flop are:

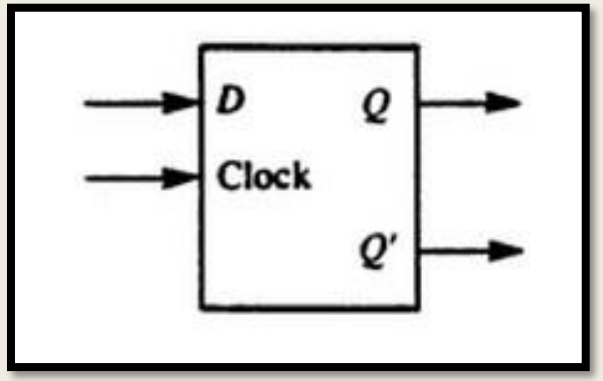
- If the J and K input are both at 1 and the clock pulse is applied, then the output will change state, regardless of its previous condition.
- There is no indeterminate condition, in the operation of JK flip flop i.e. it has no ambiguous state.
- That is, if J and K are both high at the clock edge then the output will toggle from one state to the other.
- If J and K data input are different (i.e. high and low) then the output Q takes the value of J at the next clock edge.
- If J and K are both low then no change occurs. If both J and K inputs are at 0 and the clock pulse is applied there will be no change in the output.
- JK Flip Flop can function as Set or Reset Flip flop

D Flip-Flop

- D flip flop is a better alternative that is very popular with digital electronics. They are commonly used for counters, shift-registers and input synchronization.
- A D type (Data flip flop) has a single data input in addition to the clock input as shown in the Figure below.
- The output can be only changed at the clock edge, and if the input changes at other times, it will be unaffected.
- That means, change of state of the output is dependent on the rising edge of the clock.
- The output (Q) is same as the input, i.e. when D = 0, the output is also 0 and when D = 1, the o/p is 1



Circuit Diagram



Block Diagram

D Flip-Flop

Basically, such type of flip flop is a modification of clocked SR flip flop. The **D input goes directly** to **S input** and **its complement** through NOT gate, is **applied to the R input**.

The **truth table** for such a flip flop is as follows:

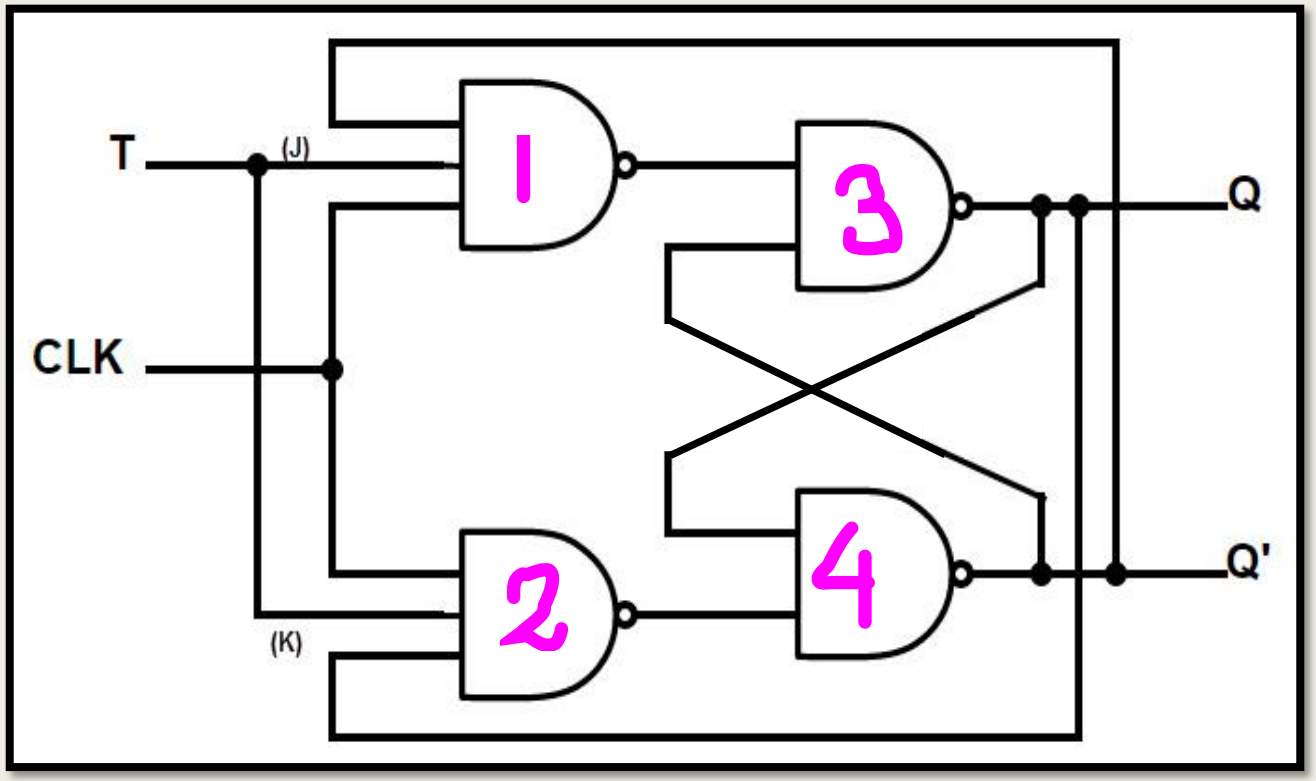
D flip-flop input	Present State	Next State
D	Q t	Q $t+1$
0	0	0
0	1	0
1	0	1
1	1	1

State Table

D	Q (t+1)	State
0	0	Reset
1	1	Set

T Flip-Flop

- A T flip flop is like a JK flip-flop. These are basically a **single input version** of JK flip flops. This modified form of JK flip-flop is obtained by connecting both inputs J and K together. This flip-flop has only one input along with the clock input.
- These flip-flops are called T flip-flops because of their ability to complement its state (i.e.) Toggle, hence the name Toggle flip-flop.



T Flip-Flop

- When the T input is low, then the next sate of the T flip flop is same as the present state.
- T = 0 and present state = 0 then the next state = 0
- T = 0 and present state = 1 then the next state = 1
- When the T input is high and during the positive transition of the clock signal, the next state of the T flip – flop is the inverse of present state.
- T = 1 and present state = 0 then the next state = 1
- T = 1 and present state = 1 then the next state = 0

Generally T flip flop ICs are not available. It can be constructed using JK, RS or D flip flop.

Figure 6 shows the relation of T flip flop using JK flip flop.

Figure 6: T Flip Flop Using JK Flip Flop

T Flip-Flop

- The truth table for a T flip flop is as given table.

T flip-flop input	Present State	Next State
T	Q t	Q $t+1$
0	0	0
0	1	1
1	0	1
1	1	0

- State Table of a T flip flop:

T	Q (t+1)	State
0	Q(t)	No change/Hold
1	Q'(t)	Complement /Toggle

Excitation Tables

Reference

- Explanation - Section 7.7 of “Modern Digital Electronics” by R.P Jain

Table 7.6 ***Excitation Table of* FLIP-FLOPs**

Present State	Next State	*S–R* FF		*J–K* FF		*T-FF*	*D-FF*
		S_n	R_n	J_n	K_n	T_n	D_n
0	0	0	×	0	×	0	0
0	1	1	0	1	×	1	1
1	0	0	1	×	1	1	0
1	1	×	0	×	0	0	1

Conversion of Flip-Flops

Follow these steps for converting one flip-flop to the other.

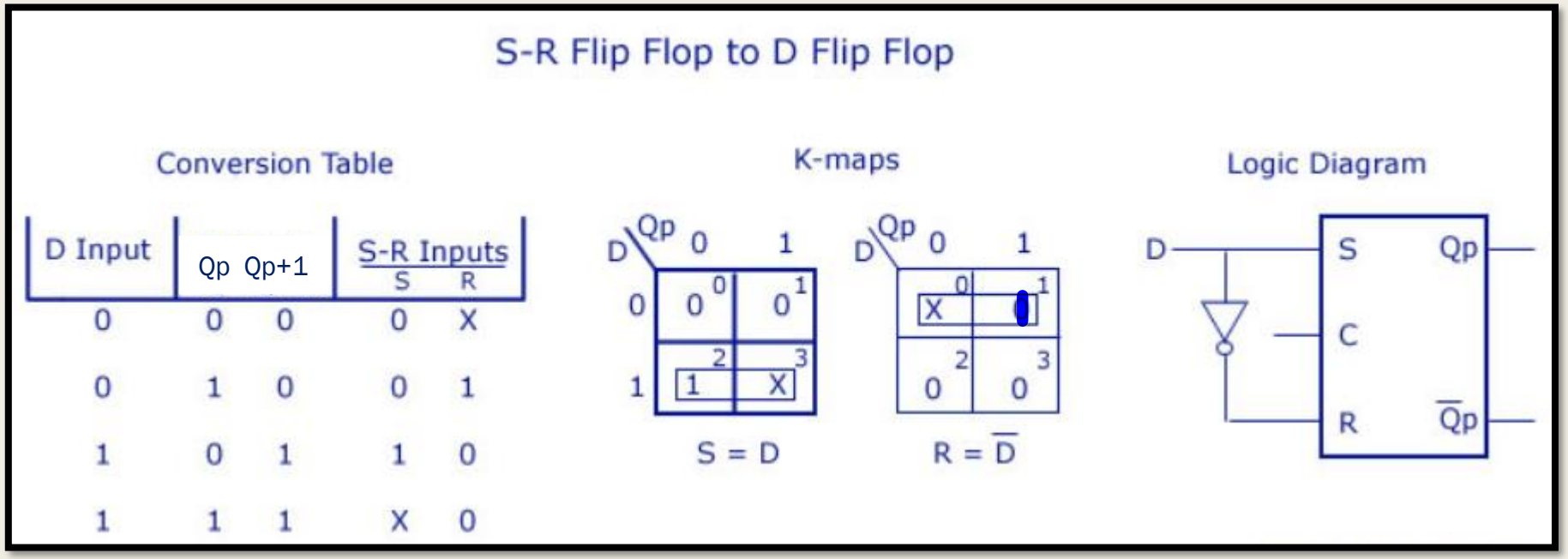
- Consider the **characteristic table** of the desired flip-flop.
- Fill the **excitation values inputs** of **given flip-flop** for each combination of present state and next state.
- Get the **simplified expressions** for each excitation input. If necessary, use Kmaps for simplifying.
- Draw the **circuit diagram** of desired flip-flop according to the simplified expressions using given flip-flop and necessary logic gates.

SR Flip-Flop to other Flip-Flop Conversions

Following are the three possible conversions of SR flip-flop to other flip-flops.

- SR flip-flop to D flip-flop
- SR flip-flop to JK flip-flop
- SR flip-flop to T flip-flop ✖

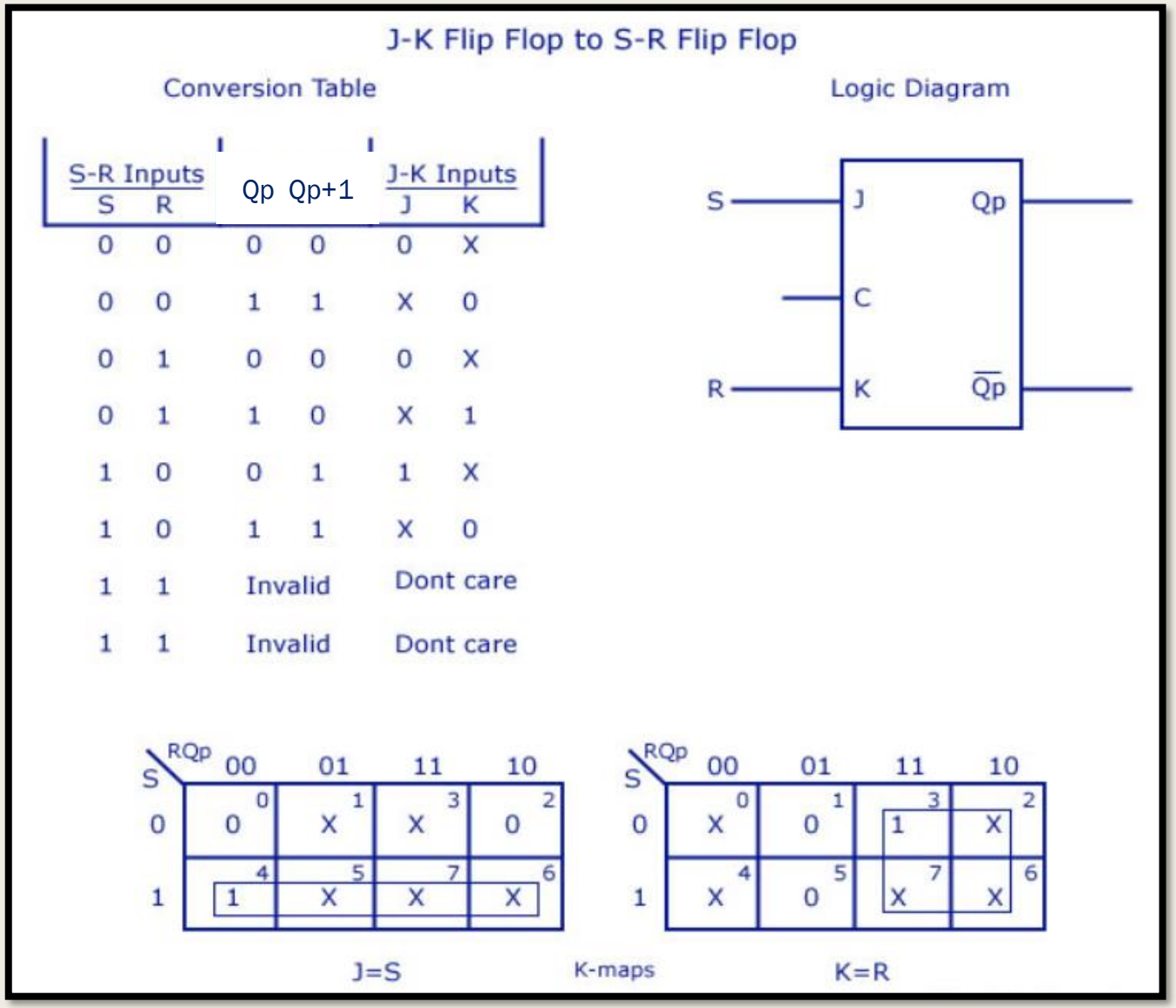
SR flip-flop to D flip-flop conversion is shown below:



JK Flip-Flop to other Flip-Flop Conversions

Following are the **three** possible conversions of JK flip-flop to other flip-flops.

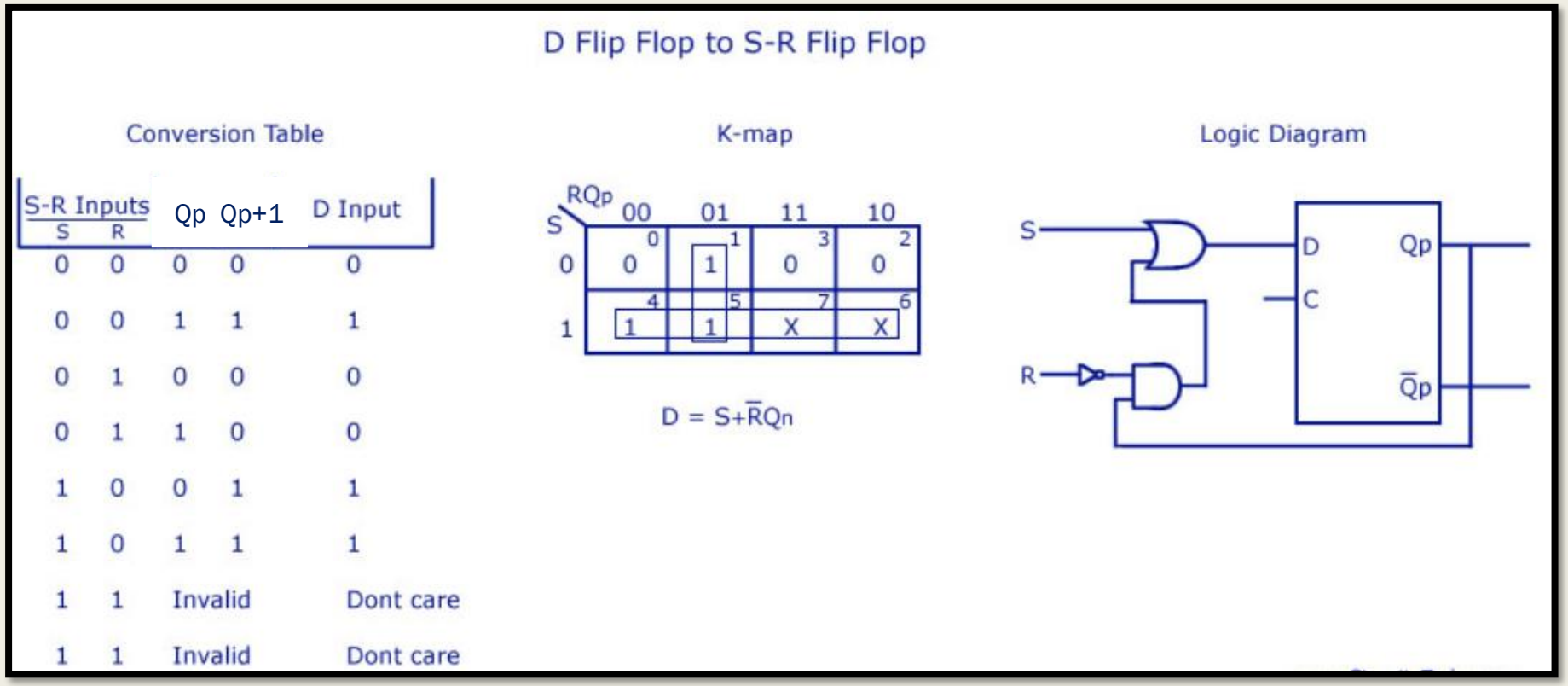
- JK flip-flop to SR flip-flop
- JK flip-flop to T flip-flop
- JK flip-flop to D flip-flop



D Flip-Flop to other Flip-Flop Conversions

Following are the **three possible** conversions of D flip-flop to other flip-flops.

- D flip-flop to SR flip-flop
- D flip-flop to JK flip-flop
- D flip-flop to T flip-flop ✖



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