State Tables and State Diagrams

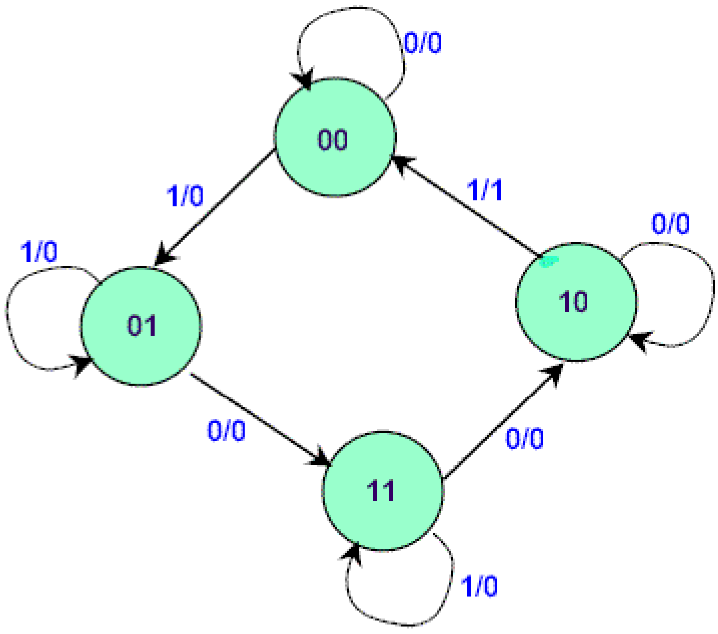
In this model the effect of all previous inputs on the outputs is represented by a state of the circuit. Thus, the output of the circuit at any time depends upon its current state and the input. These also determine the next state of the circuit. The relationship that exists among the inputs, outputs, present states and next states can be specified by either the **state table** or the **state diagram**.

State Table

The state table representation of a sequential circuit consists of three sections labelled *present state*, *next state* and *output*. The present state designates the state of flip-flops before the occurrence of a clock pulse. The next state shows the states of flip-flops after the clock pulse, and the output section lists the value of the output variables during the present state.

State Diagram

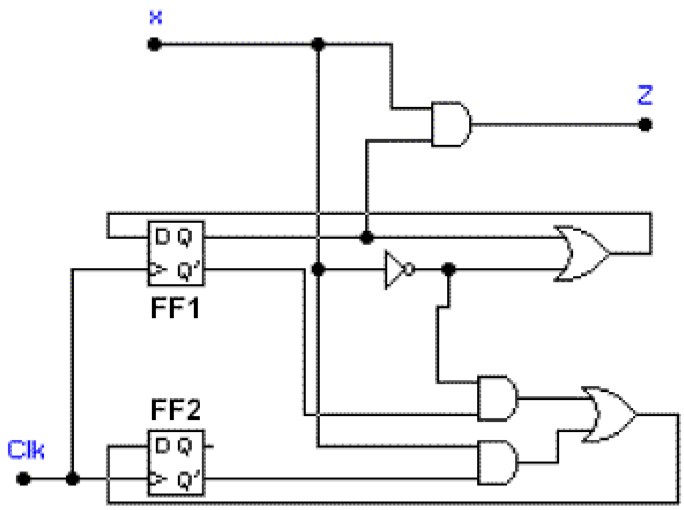
In addition to graphical symbols, tables or equations, flip-flops can also be represented graphically by a state diagram. In this diagram, a state is represented by a circle, and the transition between states is indicated by directed lines (or arcs) connecting the circles. An example of a state diagram is shown in Figure 3 below.



State Diagram

The binary number inside each circle identifies the state the circle represents. The directed lines are labelled with two binary numbers separated by a slash (/). The input value that causes the state transition is labelled first. The number after the slash symbol / gives the value of the output. For example, the directed line from state 00 to 01 is labelled 1/0, meaning that, if the sequential circuit is in a present state and the input is 1, then the next state is 01 and the output is 0. If it is in a present state 00 and the input is 0, it will remain in that state. A directed line connecting a circle with itself indicates that no change of state occurs. The state diagram provides exactly the same information as the state table and is obtained directly from the state table.

Consider a sequential circuit shown in Figure 4. It has one input x, one output Z and twostate variables Q1Q2 (thus having four possible present states 00, 01, 10, 11).



A Sequential Circuit

The behaviour of the circuit is determined by the following Boolean expressions:

Z = x*Q1

D1 = x' + Q1

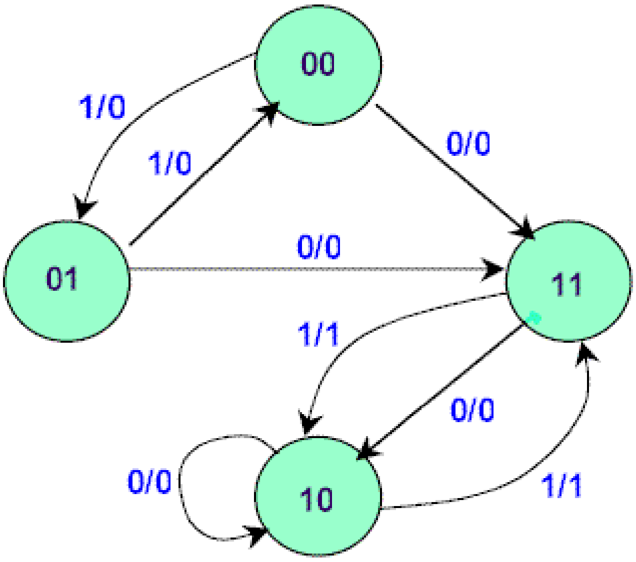
D2 = x*Q2' + x'*Q1'

These equations can be used to form the state table. Suppose the present state (i.e. Q1Q2) = 00 and input x = 0. Under these conditions, we get Z = 0, D1 = 1, and D2 = 1. Thus the next state of the circuit D1D2 = 11, and this will be the present state after the clock pulse has been applied. The output of the circuit corresponding to the present state Q1Q2 = 00 and x = 1 is Z = 0. This data is entered into the state table as shown in Table 2.

Present State Q1Q2	Next State x = 0	x = 1	Output x = 0	x = 1
0 0	1 1	0 1	0	0
0 1	1 1	0 0	0	0
1 0	1 0	1 1	0	1
1 1	1 0	1 0	0	1

State table for the sequential circuit in Figure 4.

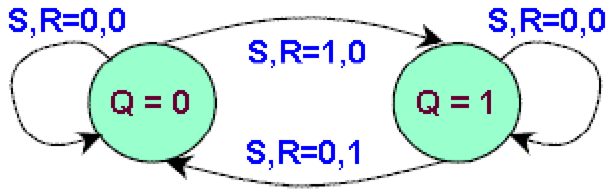
The state diagram for the sequential circuit in Figure 4 is shown in Figure 5.



State Diagram of circuit in Figure 4.

State Diagrams of Various Flip-flops

The state diagrams of the four types of flip-flops.All four flip-flops have the same number of states and transitions. Each flipflop is in the set state when Q=1 and in the reset state when Q=0. Also, each flip-flopcan move from onestate to another, or it can re- enter the same state. The only difference between the four types lies in the values of input signals that cause these transitions. A state diagram is a very convenient way to visualise the operation of a flip-flop or even of large sequential components.

<table>
<tr><th>NAME</th><th>STATE DIAGRAM</th></tr>
<tr><td>SR</td><td>
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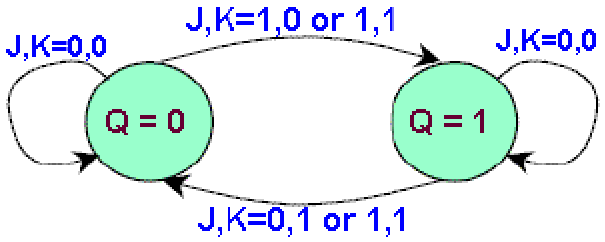
<tr><td>JK</td><td>
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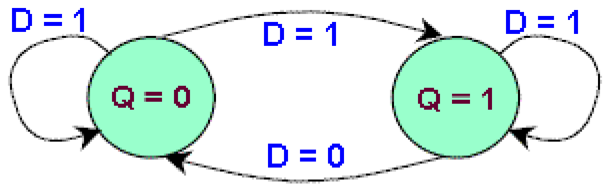
<tr><td>D</td><td>
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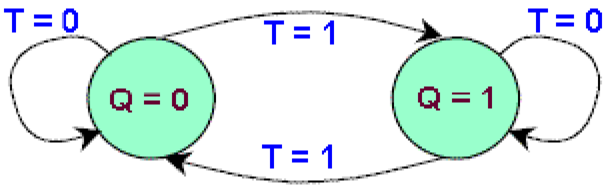
<tr><td>T</td><td>
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