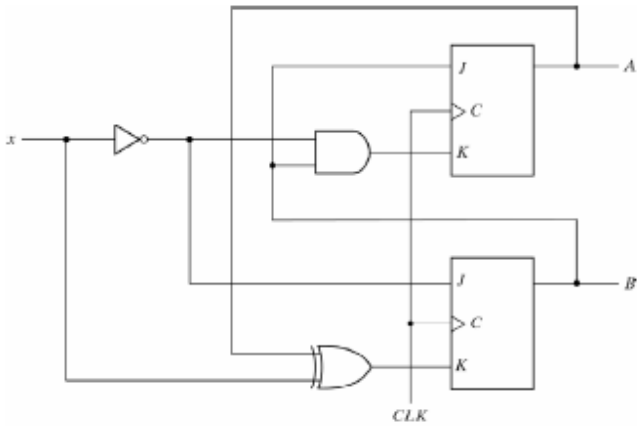
ANALYSIS OF SEQUENTIAL CIRCUITS

The next state values of a sequential circuit that uses *JK* or *T* flip-flops can be derived from:

- The characteristic table, or
- The characteristic equation.
- Determine the flip-flop input equations in terms of the present state and input variables.
- List the binary values of each equation.
- Use the flip-flop characteristic table to find the next state values in the state table.

As an example consider the following circuit:



The circuit can be specified by the flip-flop input equations:

$$J_A = B \qquad K_A = Bx'$$
$$J_B = x' \qquad K_B = A'x + Ax' = A \oplus x$$

The state table is:

Present State		Input	Next State		Flip-Flop Inputs			
A	*B*	*x*	*A*	*B*	J_A	K_A	J_B	K_B
0	0	0	0	1	0	0	1	0
0	0	1	0	0	0	0	0	1
0	1	0	1	1	1	1	1	0
0	1	1	1	0	1	0	0	1
1	0	0	1	1	0	0	1	1
1	0	1	1	0	0	0	0	0
1	1	0	0	0	1	1	1	1
1	1	1	1	1	1	0	0	0

The next state of each flip-flop is determined from the corresponding *J* and *K* inputs and the characteristic table of the *JK* flip-flop listed below:

JK Flip-Flop			
J	*K*	$Q(t+1)$	
0	0	$Q(t)$	No change
0	1	0	Reset
1	0	1	Set
1	1	$Q'(t)$	Complement

- Determine the flip-flop input equations in terms of the present state and input variables.
- Substitute the input equations into the flip-flop characteristic equation to obtain the state equations.
- Use the corresponding state equations to determine next state values in the state table.

Again the input equations for the two flip-flops are:

$$J_A = B \qquad K_A = Bx'$$
$$J_B = x' \qquad K_B = A'x + Ax' = A \oplus x$$

The characteristic equations for the flip-flops are obtained are obtained by substituting *A* or *B* for the name of the flip-flop instead of *Q*:

$$A(t+1) = JA' + K'A$$

$$B(t+1) = JB' + K'B$$

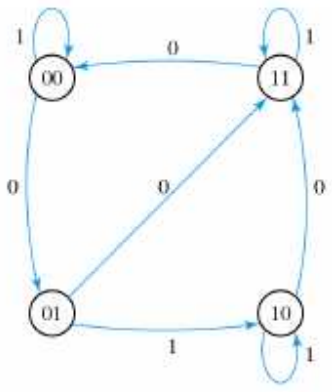
Substituting the values of *JA* and *KA* from the input equations, the state equation for *A* is obtained

$$A(t+1) = BA' + (Bx')'A = A'B + AB' + Ax$$

Similarly, the state equation for flip-flop *B* can be derived from the characteristic equation by substituting the values of J_B and K_B:

$$B(t+1) = x'B' + (A \oplus x)'B = B'x + ABx + A'Bx'$$

The above state equation provides the bit values for the column under “next state” in the state table. The state diagram of the sequential circuit is as follows:



Note that since the circuit has no outputs, the directed lines out of the circles are marked with one binary number only to denote the value of input *x*.