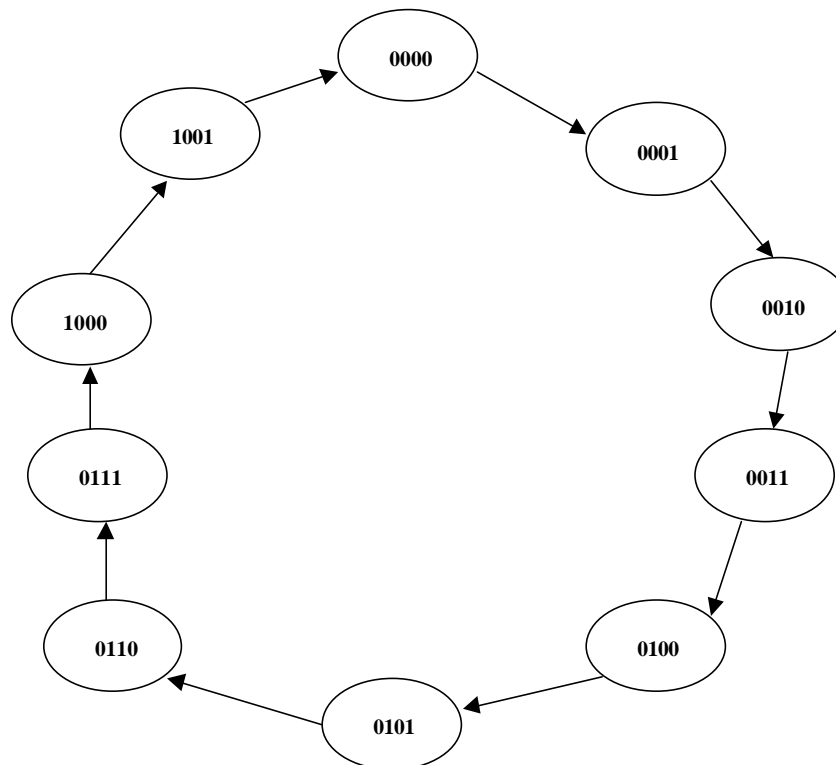


□ **DESIGN PROCEDURE**

1. Word description.
2. State diagram.
3. Assign binary values.
4. Decide on type of flip flops.
5. Excitation table for the flip flop.
6. State table.
7. Generate simplified logic equations for flip flop inputs and system outputs.
8. Draw logic diagram.

- **Example #1: Using D flip-flops, design a 0 to 9 synchronous counter.**

**State diagram**



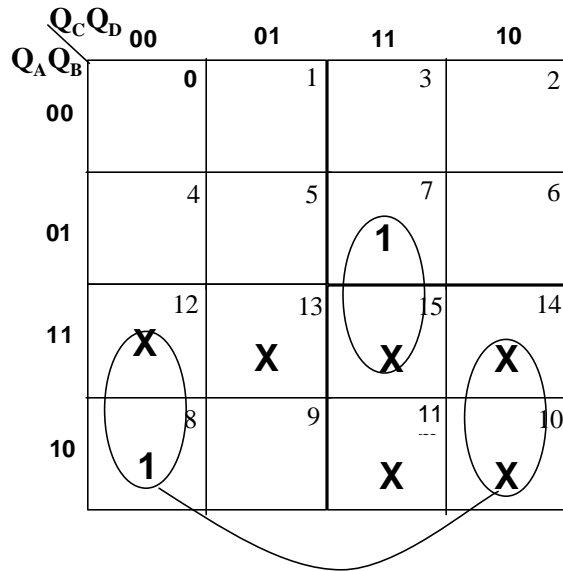
- **D Flip-Flop Excitation Table**

<b>Q(t)</b>	<b>Q(t+1)</b>	<b>D</b>
<b>0</b>	<b>0</b>	<b>0</b>
<b>0</b>	<b>1</b>	<b>1</b>
<b>1</b>	<b>0</b>	<b>0</b>
<b>1</b>	<b>1</b>	<b>1</b>

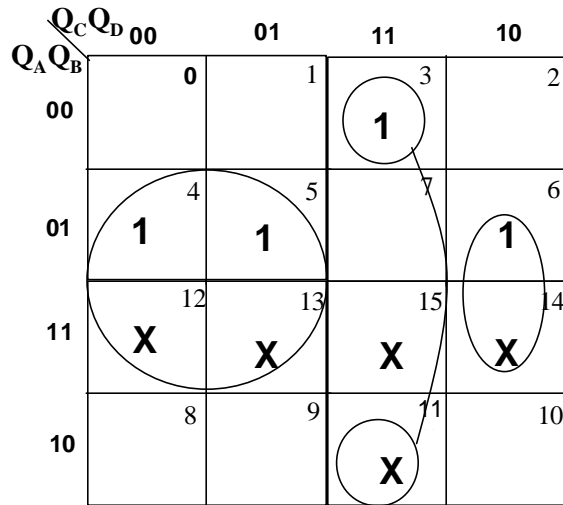
- **State Table**

<b>PRESENT STATE</b>	<b>NEXT STATE</b>				
<b>Q<sub>A</sub>Q<sub>B</sub>Q<sub>C</sub>Q<sub>D</sub></b>	<b>Q<sub>A</sub>Q<sub>B</sub>Q<sub>C</sub>Q<sub>D</sub></b>	<b>D<sub>A</sub></b>	<b>D<sub>B</sub></b>	<b>D<sub>C</sub></b>	<b>D<sub>D</sub></b>
<b>0000</b>	<b>0001</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>1</b>
<b>0001</b>	<b>0010</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>0</b>
<b>0010</b>	<b>0011</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>1</b>
<b>0011</b>	<b>0100</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>0</b>
<b>0100</b>	<b>0101</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>1</b>
<b>0101</b>	<b>0110</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>0</b>
<b>0110</b>	<b>0111</b>	<b>0</b>	<b>1</b>	<b>1</b>	<b>1</b>
<b>0111</b>	<b>1000</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>1000</b>	<b>1001</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>1</b>
<b>1001</b>	<b>0000</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>1010</b>	<b>XXXX</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>1011</b>	<b>XXXX</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>1100</b>	<b>XXXX</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>1101</b>	<b>XXXX</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>1110</b>	<b>XXXX</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
<b>1111</b>	<b>XXXX</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>

• **Karnaugh Map**



•  $D_A = Q_B Q_C Q_D + Q_A Q_D'$



•  $D_B = Q_B' Q_C Q_D + Q_B Q_C' + Q_B Q_D'$

$Q_A Q_B$		$Q_C Q_D$			
		00	01	11	10
00	0	1	3	2	
01	4	5	7	6	
11	12	13	15	14	
10	8	9	11	10	

		1		1
		1		1
X	X	X	X	X
			X	X

·  $D_C = Q_A' Q_C' Q_D + Q_C Q_D'$

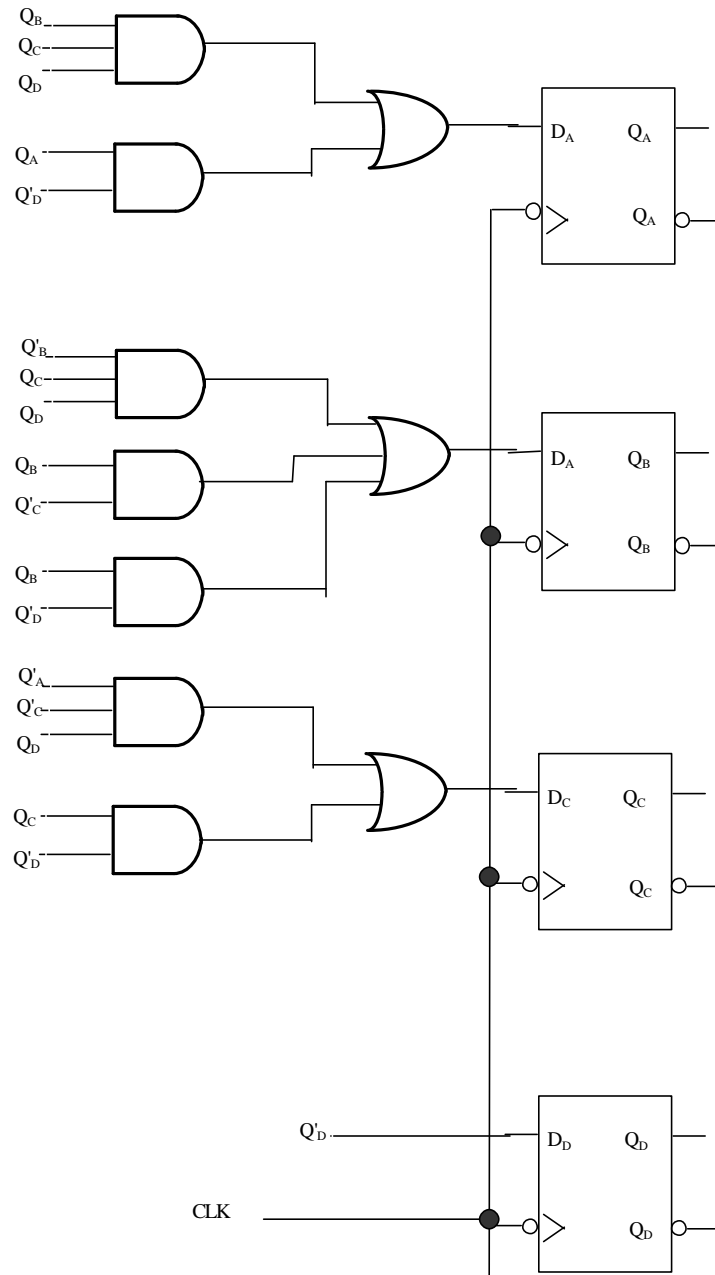
$Q_A Q_B$		$Q_C Q_D$			
		00	01	11	10
00	0	1	3	2	
01	4	5	7	6	
11	12	13	15	14	
10	8	9	11	10	

1			1
1			1
X	X	X	X
1		X	X

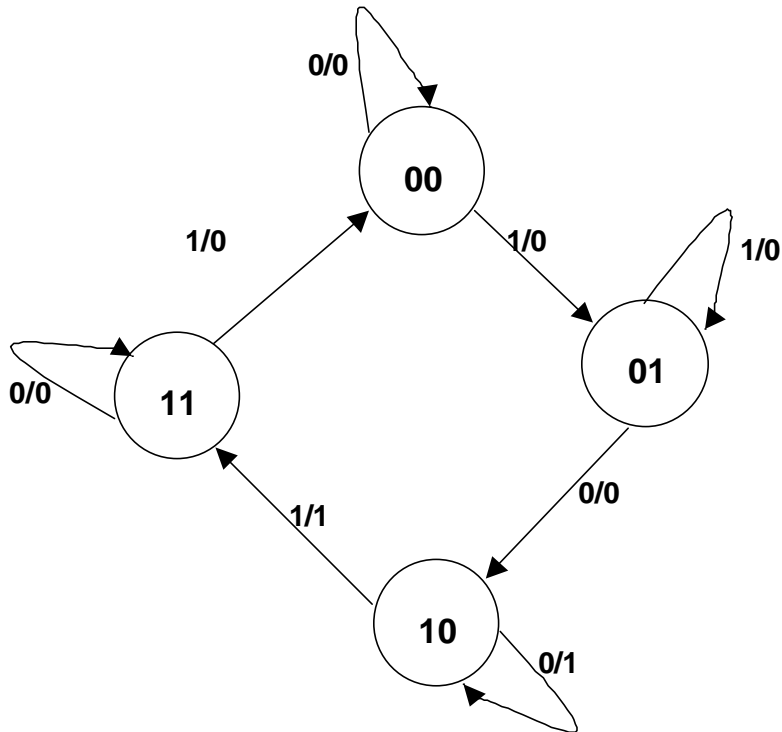
·  $D_D = Q_D'$

- **Circuit**



□ Example #2:

1. State diagram



2. Use JK flip flops

3. Flip flop Excitation Table

PRESENT STATE	NEXT STATE	J	K
Q(t)	Q(t+1)		
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

#### 4. State Table

PRESENT STATE	INPUT	NEXT STATE	FLIP-FLOP INPUTS				OUTPUT
			$Q_A Q_B$	$J_A$	$K_A$	$J_B$	
00	0	00	0	X	0	X	0
00	1	01	0	X	1	X	0
01	0	10	1	X	X	1	0
01	1	01	0	X	X	0	0
10	0	10	X	0	0	X	1
10	1	11	X	0	1	X	1
11	0	11	X	0	X	0	0
11	1	00	X	1	X	1	0

#### 5. Karnaugh Map

	$Q_B X$	00	01	11	10
$Q_A$	0	$m_0$	$m_1$	$m_3$	$m_2$ (1)
1		X	X	X	$m_6$ (X)
		$m_4$	$m_5$	$m_7$	

$$J_A = Q_B X'$$

	$Q_B X$	00	01	11	10
$Q_A$	0	X	X	$m_3$ (X)	X
1				$m_7$ (1)	
		$m_4$	$m_5$	$m_7$	$m_6$

$$K_A = Q_B X$$

$Q_B \backslash X$	00	01	11	10
$Q_A \backslash 0$		1	X	X
	$m_0$	$m_1$	$m_3$	$m_2$
$Q_A \backslash 1$		1	X	X
	$m_4$	$m_5$	$m_7$	$m_6$

·  $J_B = X$

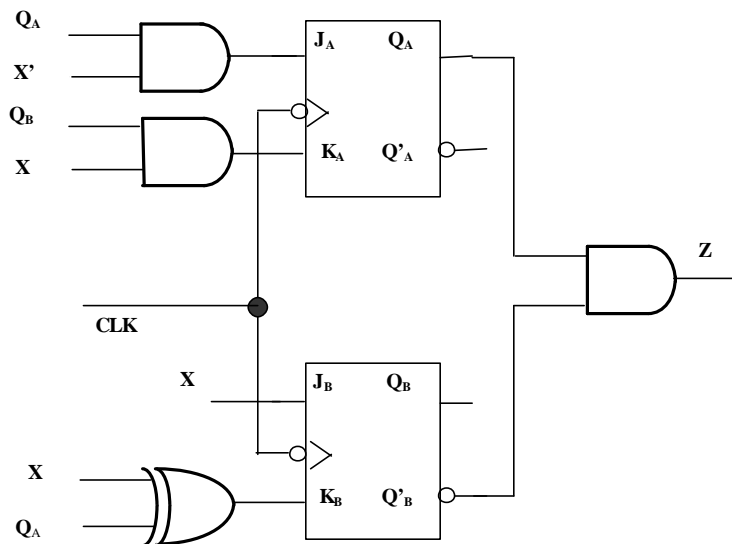
$Q_B \backslash X$	00	01	11	10
$Q_A \backslash 0$	X	X		1
	$m_0$	$m_1$	$m_3$	$m_2$
$Q_A \backslash 1$	X	X	1	
	$m_4$	$m_5$	$m_7$	$m_6$

·  $K_B = Q_A X' + Q_A' X = Q_A \oplus X$

$Q_B \backslash X$	00	01	11	10
$Q_A \backslash 0$				
	$m_0$	$m_1$	$m_3$	$m_2$
$Q_A \backslash 1$	1	1		
	$m_4$	$m_5$	$m_7$	$m_6$

·  $Z = Q_A Q_B'$

### 6. Schematic

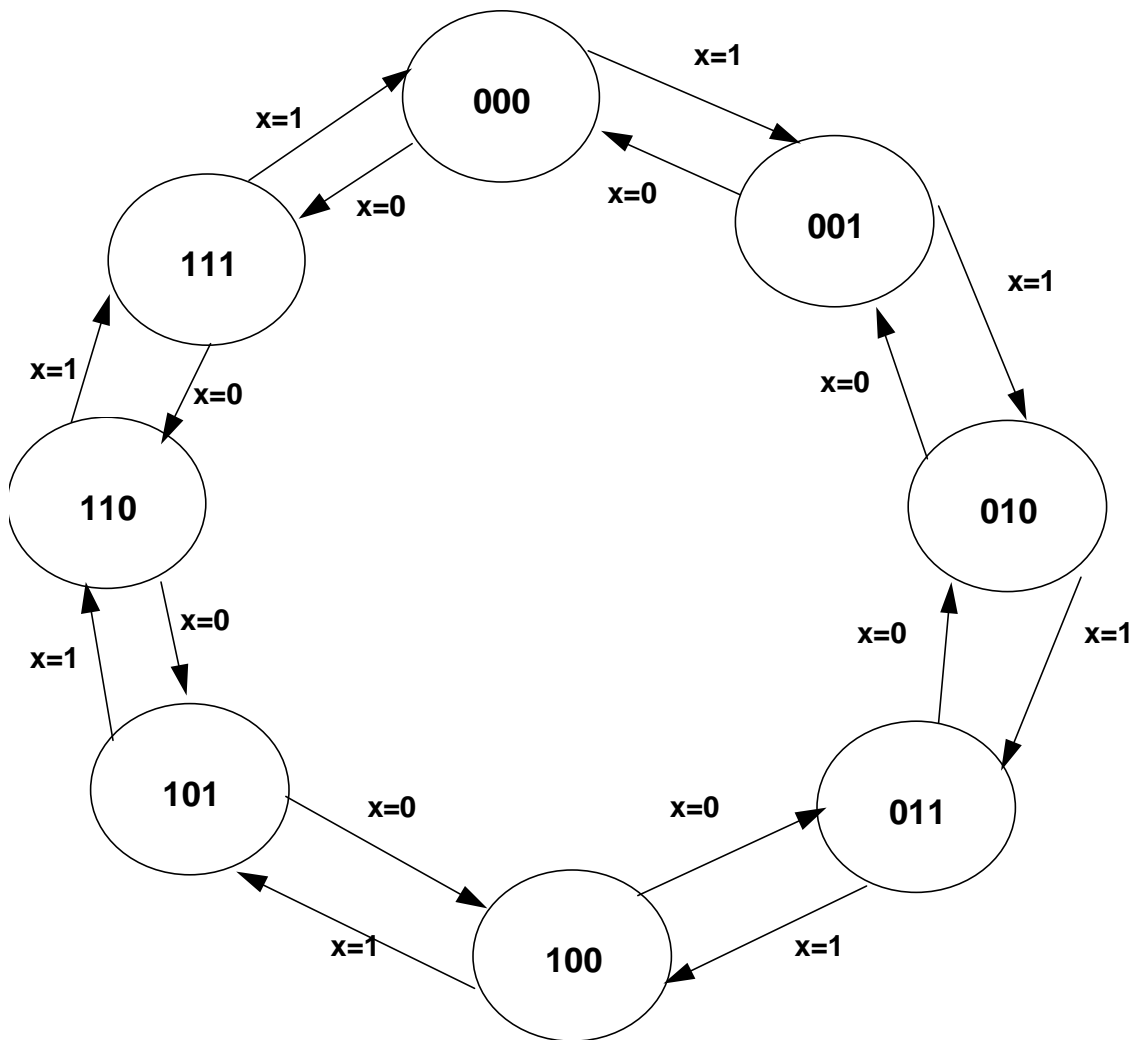




□ **Example #3:**

**Using JK flip-flops, design an up/down synchronous counter as specified below. The counter counts up if input X is 1 and it counts down when X is 0.**

• **State Diagram**



- **Use JK flip flops**

- Flip flop Excitation Table

PRESENT STATE	NEXT STATE		
Q(t)	Q(t+1)	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

- State Table

PRESENT STATE	INPUT	NEXT STATE						
Q <sub>A</sub> Q <sub>B</sub> Q <sub>C</sub>	X	Q <sub>A</sub> Q <sub>B</sub> Q <sub>C</sub>	J <sub>A</sub>	K <sub>A</sub>	J <sub>B</sub>	K <sub>B</sub>	J <sub>C</sub>	K <sub>C</sub>
000	0	111	1	X	1	X	1	X
000	1	001	0	X	0	X	1	X
001	0	000	0	X	0	X	X	1
001	1	010	0	X	1	X	X	1
010	0	001	0	X	X	1	1	X
010	1	011	0	X	X	0	1	X
011	0	010	0	X	X	0	X	1
011	1	100	1	X	X	1	X	1
100	0	011	X	1	1	X	1	X
100	1	101	X	0	0	X	1	X
101	0	100	X	0	0	X	X	1
101	1	110	X	0	1	X	X	1
110	0	101	X	0	X	1	1	X
110	1	111	X	0	X	0	1	X
111	0	110	X	0	X	0	X	1
111	1	000	X	1	X	1	X	1

## Karnaugh Map

$Q_A \backslash Q_B$	$Q_C X$ 00	$Q_C X$ 01	$Q_C X$ 11	$Q_C X$ 10
00	<b>1</b> $m_0$	$m_1$	$m_3$	$m_2$
01	$m_4$	$m_5$	<b>1</b> $m_7$	$m_6$
11	<b>X</b> $m_{12}$	<b>X</b> $m_{13}$	<b>X</b> $m_{15}$	<b>X</b> $m_{14}$
10	<b>X</b> $m_8$	<b>X</b> $m_9$	<b>X</b> $m_{11}$	<b>X</b> $m_{10}$

$$J_A = Q'_B Q'_C X' + Q_B Q_C X$$

$Q_A \backslash Q_B$	$Q_C X$ 00	$Q_C X$ 01	$Q_C X$ 11	$Q_C X$ 10
00	<b>X</b> $m_0$	<b>X</b> $m_1$	<b>X</b> $m_3$	<b>X</b> $m_2$
01	<b>X</b> $m_4$	<b>X</b> $m_5$	<b>X</b> $m_7$	<b>X</b> $m_6$
11	$m_{12}$	$m_{13}$	<b>1</b> $m_{15}$	$m_{14}$
10	<b>1</b> $m_8$	$m_9$	$m_{11}$	$m_{10}$

$$K_A = Q'_B Q'_C X' + Q_B Q_C X$$

$Q_A \backslash Q_B$	$Q_C X$ 00	01	11	10
00	1 $m_7$	$m_1$	1 $m_3$	$m_2$
01	X $m_4$	X $m_5$	X $m_7$	X $m_6$
11	X $m_2$	X $m_{13}$	X $m_5$	X $m_{14}$
10	1 $m_6$	$m_9$	1 $m_{11}$	$m_{10}$

·  $J_B = Q'_C X' + Q_C X = Q_C \odot X$

$Q_A \backslash Q_B$	$Q_C X$ 00	01	11	10
00	X $m_7$	X $m_1$	X $m_3$	X $m_2$
01	1 $m_4$	$m_5$	1 $m_7$	$m_6$
11	1 $m_2$	$m_{13}$	1 $m_5$	$m_{14}$
10	X $m_6$	X $m_9$	X $m_{11}$	X $m_{10}$

·  $K_B = Q'_C X' + Q_C X = Q_C \odot X$

·  $J_C = 1$

·  $K_C = 1$

- Schematic

