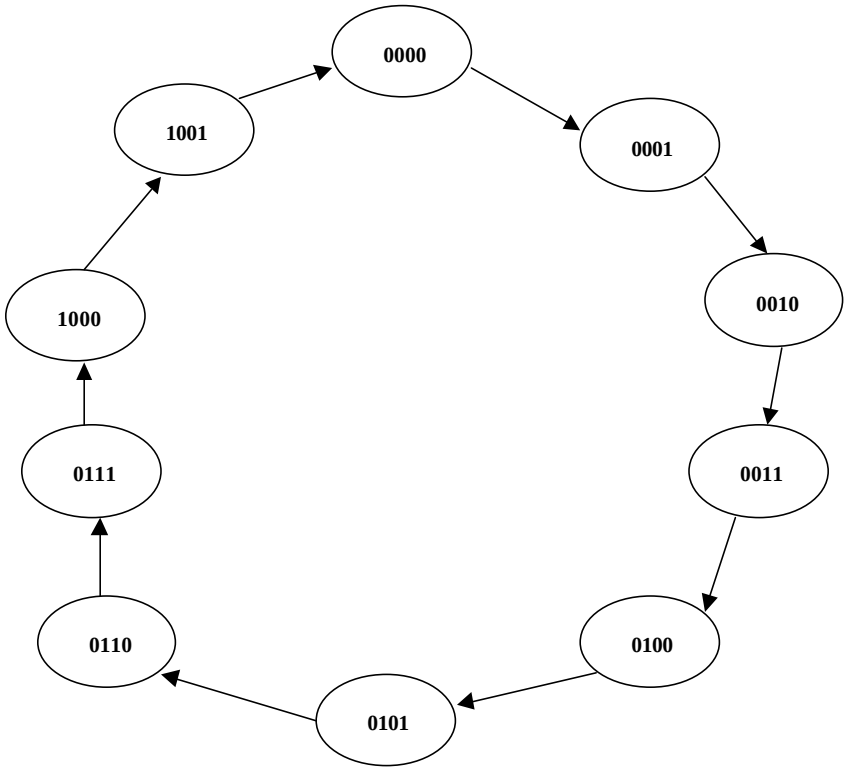
❑ DESIGN PROCEDURE

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**



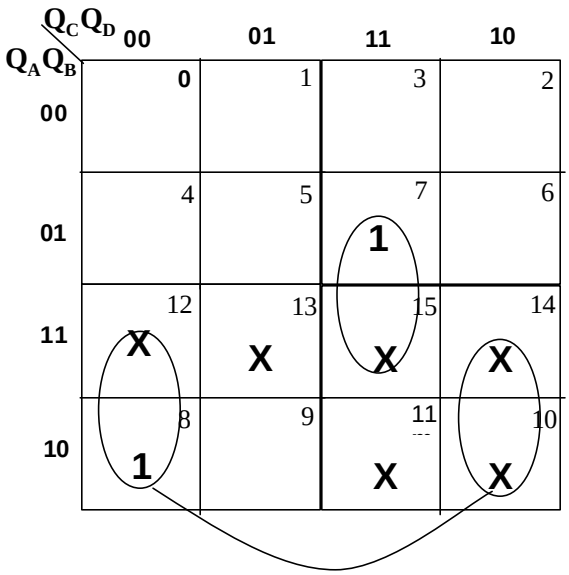
- **D Flip-Flop Excitation Table**

Q(t)	Q(t+1)	D
0	0	0
0	1	1
1	0	0
1	1	1

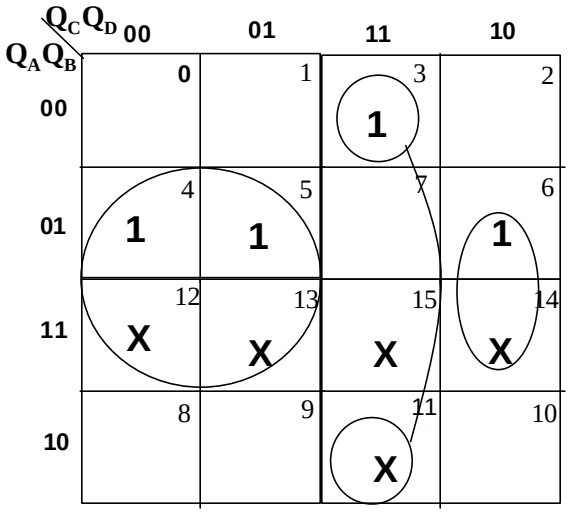
- **State Table**

PRESENT STATE	NEXT STATE				
$Q_AQ_BQ_CQ_D$	$Q_AQ_BQ_CQ_D$	D_A	D_B	D_C	D_D
0000	0001	0	0	0	1
0001	0010	0	0	1	0
0010	0011	0	0	1	1
0011	0100	0	1	0	0
0100	0101	0	1	0	1
0101	0110	0	1	1	0
0110	0111	0	1	1	1
0111	1000	1	0	0	0
1000	1001	1	0	0	1
1001	0000	0	0	0	0
1010	XXXX	X	X	X	X
1011	XXXX	X	X	X	X
1100	XXXX	X	X	X	X
1101	XXXX	X	X	X	X
1110	XXXX	X	X	X	X
1111	XXXX	X	X	X	X

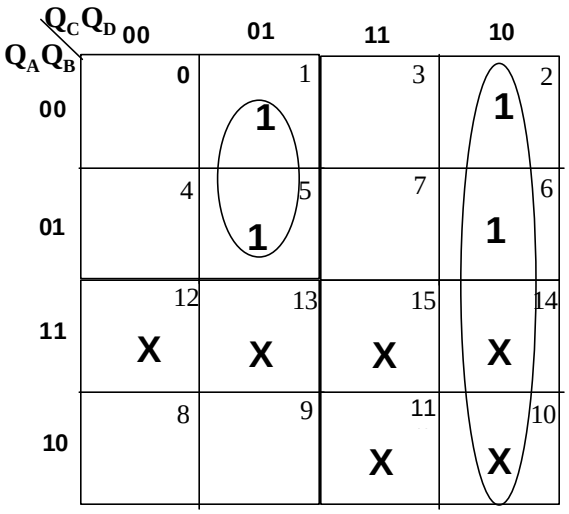
- **Karnaugh Map**



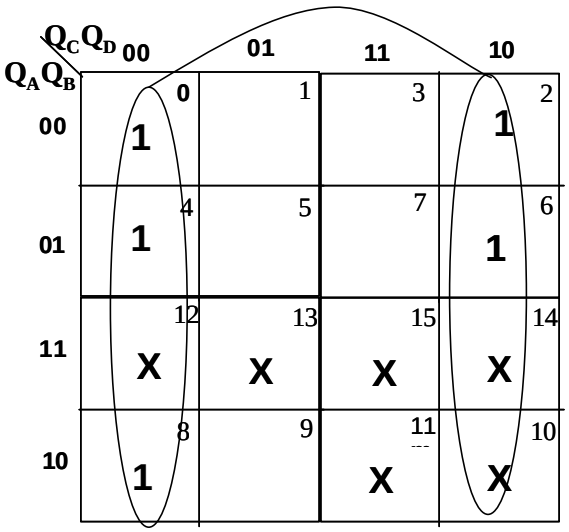
- $D_A = Q_BQ_CQ_D + Q_AQ_D'$



- $D_B = Q_B'Q_CQ_D + Q_BQ_C' + Q_BQ_D'$

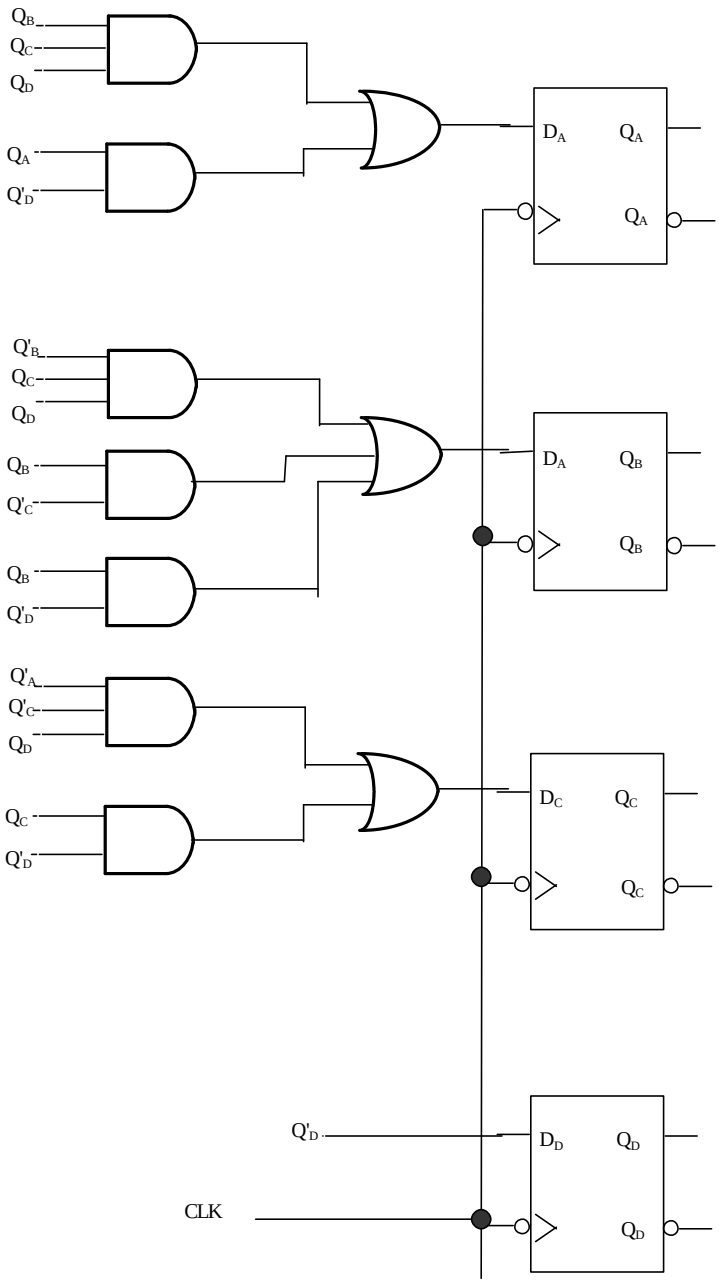


- $D_C = Q_A'Q_C'Q_D + Q_C Q_D'$



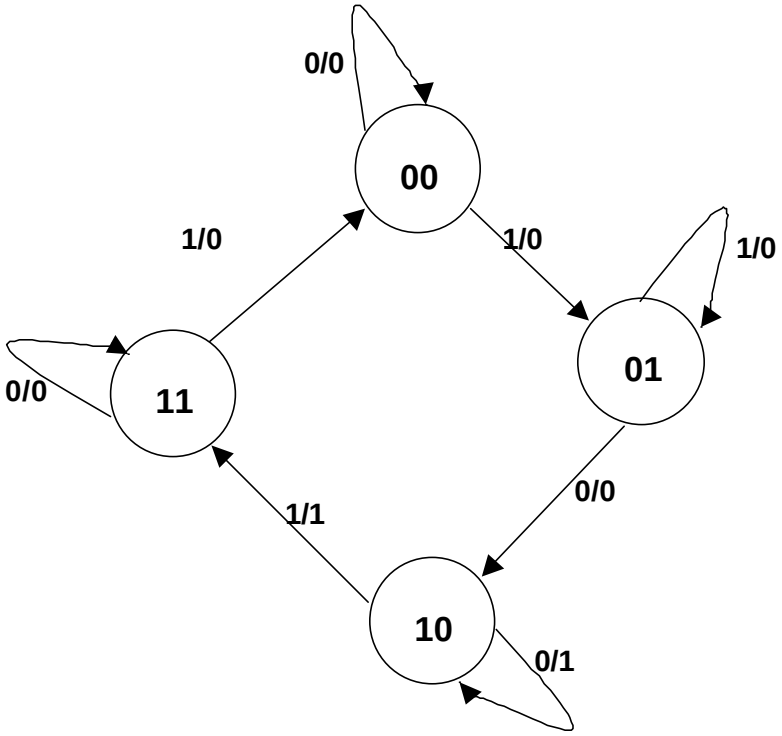
- $D_D = Q_D'$

- **Circuit**


Q_B
Q_C
Q_D
Q_A
Q'_D
D_A
Q_A
Q_A
Q'_B
Q_C
Q_D
Q_B
Q'_C
Q_B
Q'_D
D_A
Q_B
Q_B
Q'_A
Q'_C
Q_D
Q_C
Q'_D
D_C
Q_C
Q_C
Q'_D
D_D
Q_D
CLK
Q_D

❑ **Example #2:**

1. State diagram



2. Use JK flip flops

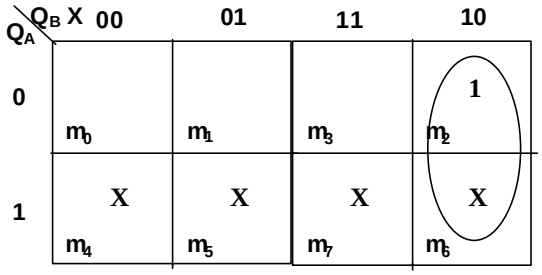
3. Flip flop Excitation Table

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

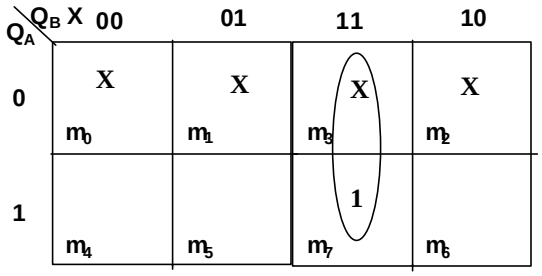
4. State Table

PRESENT STATE	INPUT	NEXT STATE	FLIP-FLOP INPUTS				OUTPUT
$Q_A\,Q_B$	X	Q_AQ_B	J_A	K_A	J_B	K_B	Z
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

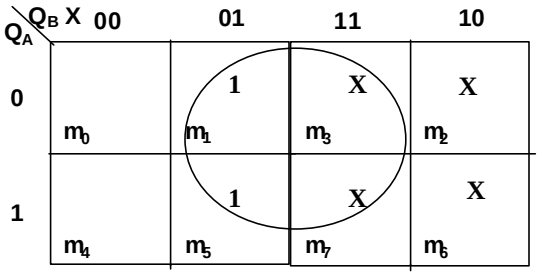
5. Karnaugh Map



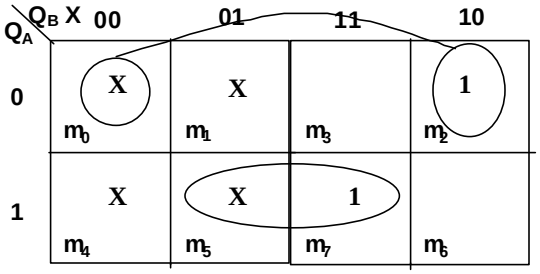
- $J_A = Q_B\,X'$



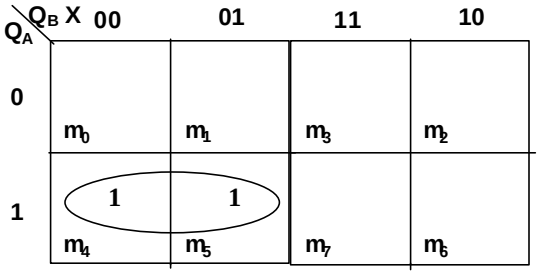
- $K_A = Q_B\,X$



- $J_B = X$

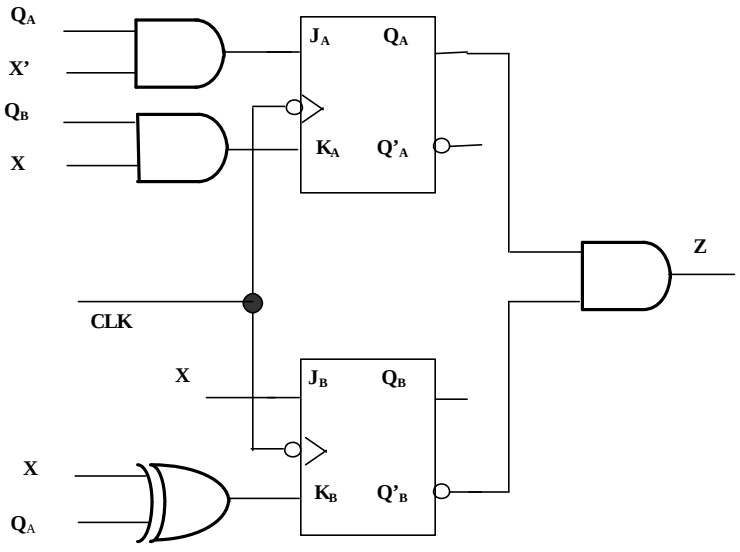


- $K_B = Q_A\ X' + Q'_A\ X = Q_A \oplus X$



- $Z = Q_A\ Q'_B$

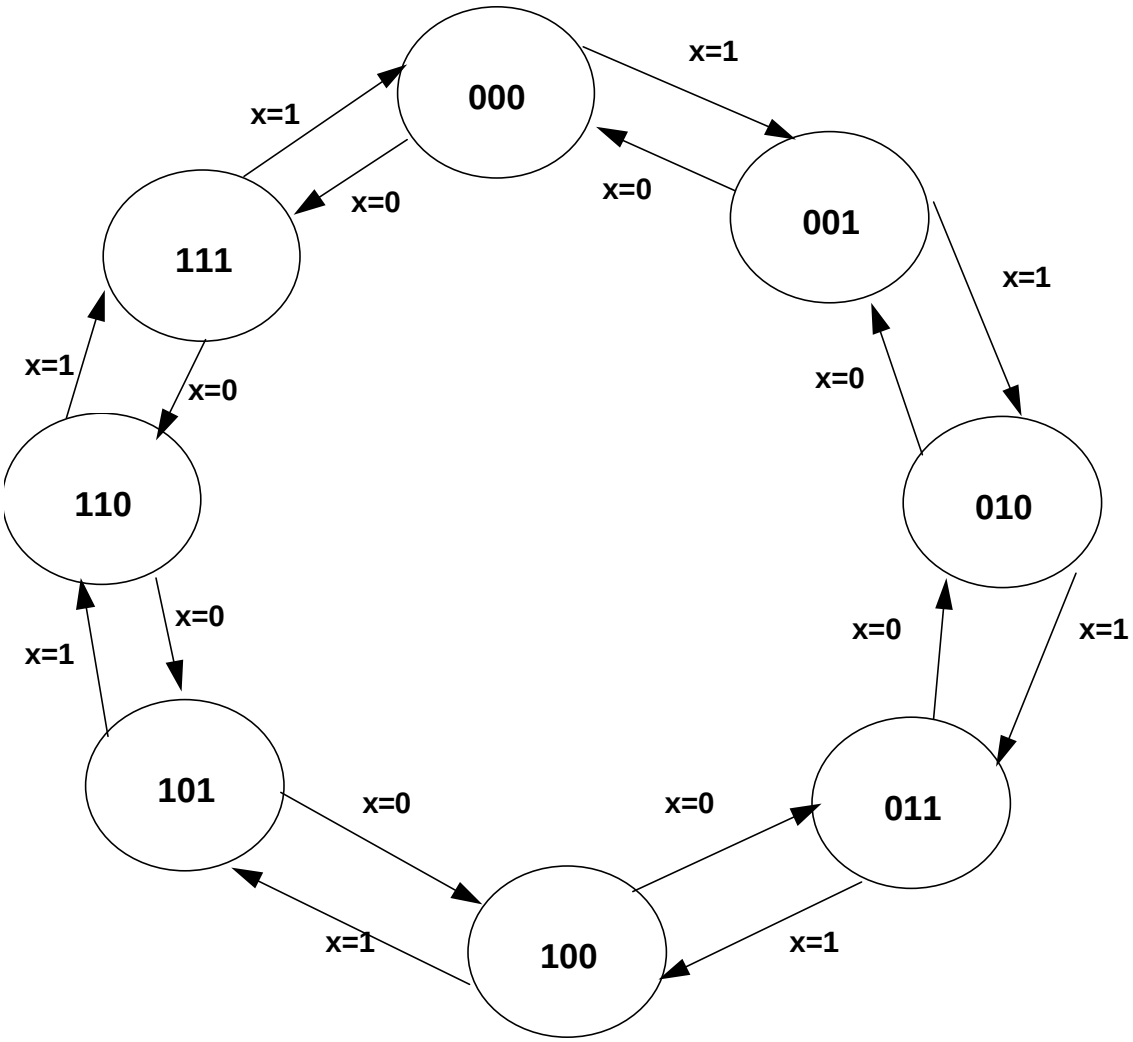
6. Schematic



❑ **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**

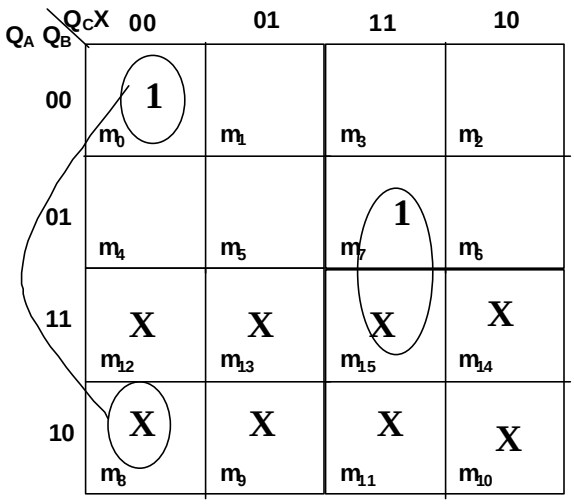
- **Flip flop Excitation Table**

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

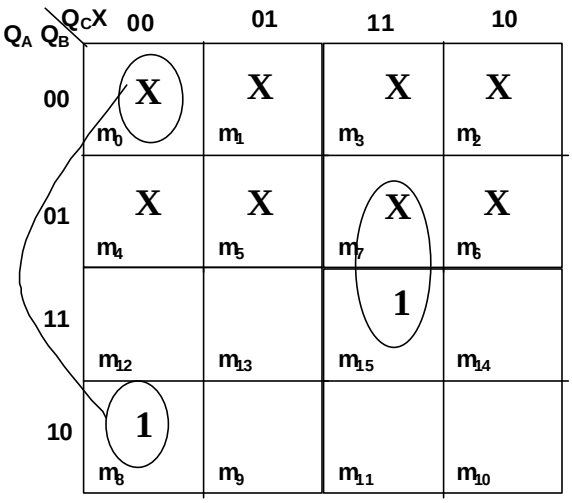
- **State Table**

PRESENT STATE	INPUT	NEXT STATE						
$Q_AQ_BQ_C$	X	$Q_AQ_BQ_C$	J_A	K_A	J_B	K_B	J_C	K_C
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

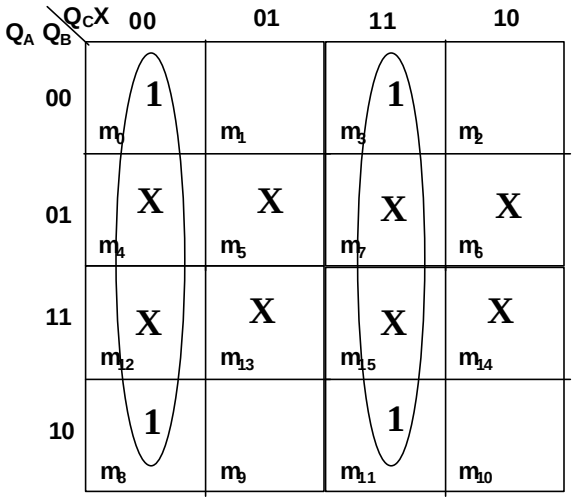
- **Karnaugh Map**



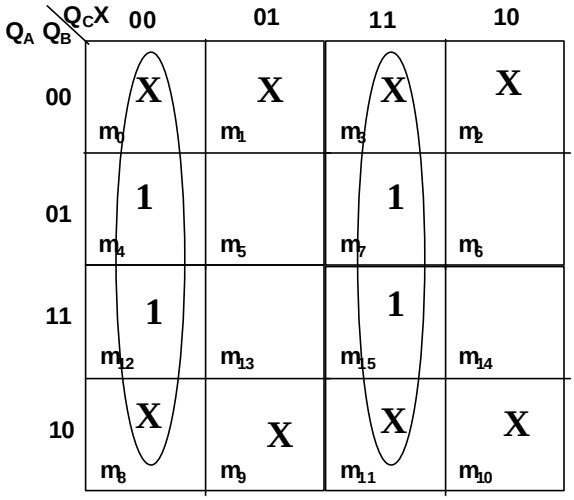
- $J_A = Q'_B\, Q'_C\, X' + Q_B\, Q_C\, X$



- $K_A = Q'_B\, Q'_C\, X' + Q_B\, Q_C\, X$



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



- $K_B = Q'_C\ X' + Q_C X = Q_C \odot X$
- $J_C = 1$
- $K_C = 1$

- **Schematic**