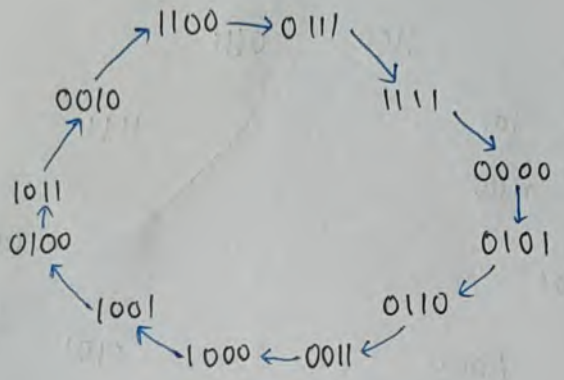
Step-1: State Diagram




Excitation Table of J-k Flip Flop:

| $Q$ | $Q_{next}$ | J | k |
|---|---|---|---|
| 0 | 0 | 0 | x |
| 0 | 1 | 1 | x |
| 1 | 0 | x | 1 |
| 1 | 1 | x | 0 |

Step-2&3: State Table and Flip Flop transition table:

| Present state $Q_3Q_2Q_1Q_0$ | Next state $Q_3Q_2Q_1Q_0$ | $J_0$ | $K_0$ | $J_1$ | $K_1$ | $J_2$ | $K_2$ | $J_3$ | $K_3$ |
|---|---|---|---|---|---|---|---|---|---|
| 1100 | 0111 | 1 | x | 1 | x | x | 0 | x | 1 |
| 0111 | 1111 | x | 0 | x | 0 | x | 0 | 1 | x |
| 1111 | 0000 | x | 1 | x | 1 | x | 1 | x | 1 |
| 0000 | 0101 | 1 | x | 0 | x | 1 | x | 0 | x |
| 0101 | 0110 | x | 1 | 1 | x | x | 0 | 0 | x |
| 0110 | 0011 | 1 | x | x | 0 | x | 1 | 0 | x |
| 0011 | 1000 | x | 1 | x | 1 | 0 | x | 1 | x |
| 1000 | 1001 | 1 | x | 0 | x | 0 | x | x | 0 |
| 1001 | 0100 | x | 1 | 0 | x | 1 | x | x | 1 |
| 0100 | 1011 | 1 | x | 1 | x | x | 1 | 1 | x |
| 1011 | 0010 | x | 1 | x | 0 | 0 | x | x | 1 |
| 0010 | 1100 | 0 | x | x | 1 | 1 | x | 1 | x |

## Step-4: K-Map

| $Q_3Q_2$ \ $Q_1Q_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | 0 | x | 0 |
| 01 | 1 | x | x | 1 |
| 11 | 1 | 0 | x | 0 |
| 10 | 1 | x | x | 0 |

$J_0 = \bar{Q}_1\bar{Q}_0 + \bar{Q}_3Q_2$

| $Q_3Q_2$ \ $Q_1Q_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | x | 0 | 1 | x |
| 01 | x | 1 | 0 | x |
| 11 | x | 0 | 1 | 0 |
| 10 | x | 1 | 1 | 0 |

$K_0 = \bar{Q}_2Q_1Q_0 + Q_3\bar{Q}_2Q_0 + Q_3Q_1Q_0 + \bar{Q}_3Q_2\bar{Q}_1$

| $Q_3Q_2$ \ $Q_1Q_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 0 | 0 | x | x |
| 01 | 1 | 1 | x | x |
| 11 | 1 | 0 | x | 0 |
| 10 | 0 | 0 | x | 0 |

$J_1 = \bar{Q}_3Q_2 + Q_2\bar{Q}_1\bar{Q}_0$

| $Q_3Q_2$ \ $Q_1Q_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | x | 0 | 1 | 1 |
| 01 | x | x | 0 | 0 |
| 11 | x | 0 | 1 | 0 |
| 10 | x | x | 0 | 0 |

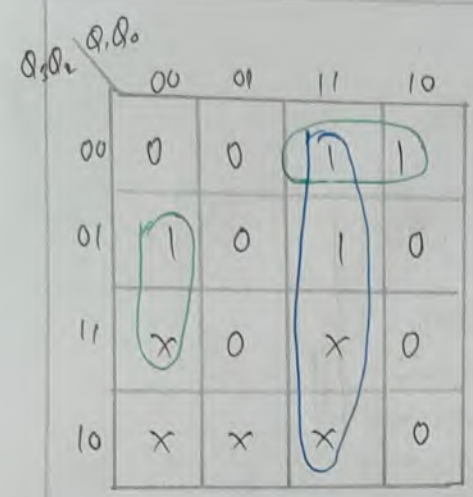
$K_1 = \bar{Q}_3\bar{Q}_2Q_1 + Q_3Q_2Q_1Q_0$

| $Q_3Q_2$ \ $Q_1Q_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 1 | 0 | 0 | 1 |
| 01 | x | x | x | x |
| 11 | x | 0 | x | 0 |
| 10 | 0 | 1 | 0 | 0 |

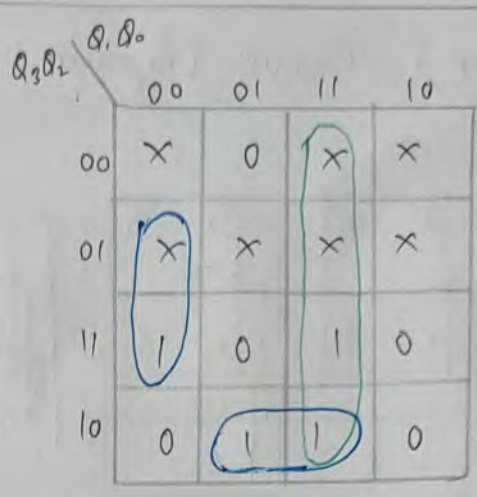
$J_2 = \bar{Q}_3\bar{Q}_0 + Q_3\bar{Q}_2\bar{Q}_1Q_0$

| $Q_3Q_2$ \ $Q_1Q_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | x | 0 | x | x |
| 01 | 1 | 0 | 0 | 1 |
| 11 | 0 | 0 | 1 | 0 |
| 10 | x | x | x | 0 |

$K_2 = \bar{Q}_3\bar{Q}_0 + Q_3Q_1Q_0$



| $Q_3Q_2$ \ $Q_1Q_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | 0 | 0 | 1 | 1 |
| 01 | 1 | 0 | 1 | 0 |
| 11 | x | 0 | x | 0 |
| 10 | x | x | x | 0 |



| $Q_3Q_2$ \ $Q_1Q_0$ | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 00 | x | 0 | x | x |
| 01 | x | x | x | x |
| 11 | 1 | 0 | 1 | 0 |
| 10 | 0 | 1 | 1 | 0 |

$J_3 = Q_1Q_0 + \bar{Q}_3\bar{Q}_2Q_1 + Q_2\bar{Q}_1\bar{Q}_0$ $\quad$ $k_3 = Q_1Q_0 + Q_3\bar{Q}_2Q_0 + Q_2\bar{Q}_1\bar{Q}_0$

Therefore,

Input equations are,

$$J_0 = \bar{Q}_1\bar{Q}_0 + \bar{Q}_3Q_2$$

$$k_0 = \bar{Q}_2Q_1Q_0 + Q_3\bar{Q}_2Q_0 + Q_3Q_1Q_0 + \bar{Q}_3Q_2\bar{Q}_1$$

$$J_1 = \bar{Q}_3Q_2 + Q_2\bar{Q}_1\bar{Q}_0$$

$$k_1 = \bar{Q}_3\bar{Q}_2Q_1 + Q_3Q_2Q_1Q_0$$

$$J_2 = \bar{Q}_3\bar{Q}_0 + Q_3\bar{Q}_2\bar{Q}_1Q_0$$

$$k_2 = \bar{Q}_3\bar{Q}_0 + Q_3Q_1Q_0$$

$$J_3 = Q_1Q_0 + \bar{Q}_3\bar{Q}_2Q_1 + Q_2\bar{Q}_1\bar{Q}_0$$

$$k_3 = Q_1Q_0 + Q_3\bar{Q}_2Q_0 + Q_2\bar{Q}_1\bar{Q}_0$$

## Step-5: Circuit Diagram