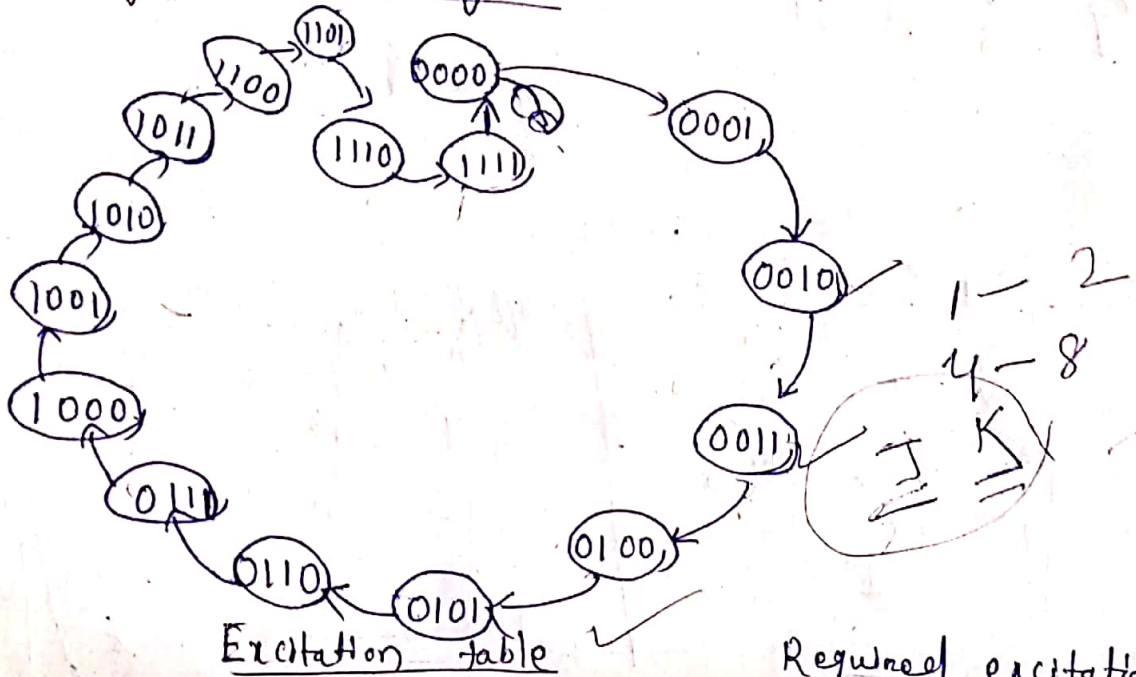


# 4-bit Synchronous up counter using J-K FF

## State Diagram



Excitation table

Required excitations

PS				NS				Required excitations							
Q <sub>4</sub>	Q <sub>3</sub>	Q <sub>2</sub>	Q <sub>1</sub>	Q <sub>4</sub>	Q <sub>3</sub>	Q <sub>2</sub>	Q <sub>1</sub>	J <sub>4</sub>	K <sub>4</sub>	J <sub>3</sub>	K <sub>3</sub>	J <sub>2</sub>	K <sub>2</sub>	J <sub>1</sub>	K <sub>1</sub>
0	0	0	0	0	0	0	1	0	X	0	X	0	X	1	X
0	0	0	1	0	0	1	0	0	X	0	X	1	X	X	1
0	0	1	0	0	0	1	1	0	X	0	X	X	0	1	X
0	0	1	1	0	1	0	0	0	X	1	X	X	1	X	1
0	1	0	0	0	1	0	1	0	X	X	0	0	X	1	X
0	1	0	1	0	1	1	0	0	X	X	0	1	X	X	1
0	1	1	0	0	1	1	1	0	X	X	0	X	0	1	X
0	1	1	1	1	0	0	0	1	X	X	1	X	1	X	1
1	0	0	0	1	0	0	1	X	0	0	X	0	X	1	X
1	0	0	1	1	0	1	0	X	0	0	X	1	X	X	1
1	0	1	0	1	0	1	1	X	0	0	X	X	0	1	X
1	0	1	1	1	1	0	0	X	0	1	X	X	1	X	1
1	1	0	0	1	1	0	1	X	0	X	0	0	X	1	X
1	1	0	1	1	1	1	0	X	0	X	0	1	X	X	1
1	1	1	0	1	1	1	1	X	0	X	0	X	0	1	X
1	1	1	1	0	0	0	0	X	1	X	1	X	1	1	X

$J_4$

$Q_3 \backslash Q_2 Q_1$	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

$J_4 = Q_3 Q_2 Q_1$

$K_4$

$Q_3 \backslash Q_2 Q_1$	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

$K_4 = Q_3 Q_2 Q_1$

$J_3$

$Q_2 \backslash Q_1$	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

$J_3 = Q_2 Q_1$

$K_3$

$Q_2 \backslash Q_1$	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

$K_3 = Q_2 Q_1$

$J_2$

$Q_1$	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

$J_2 = Q_1$

$K_2$

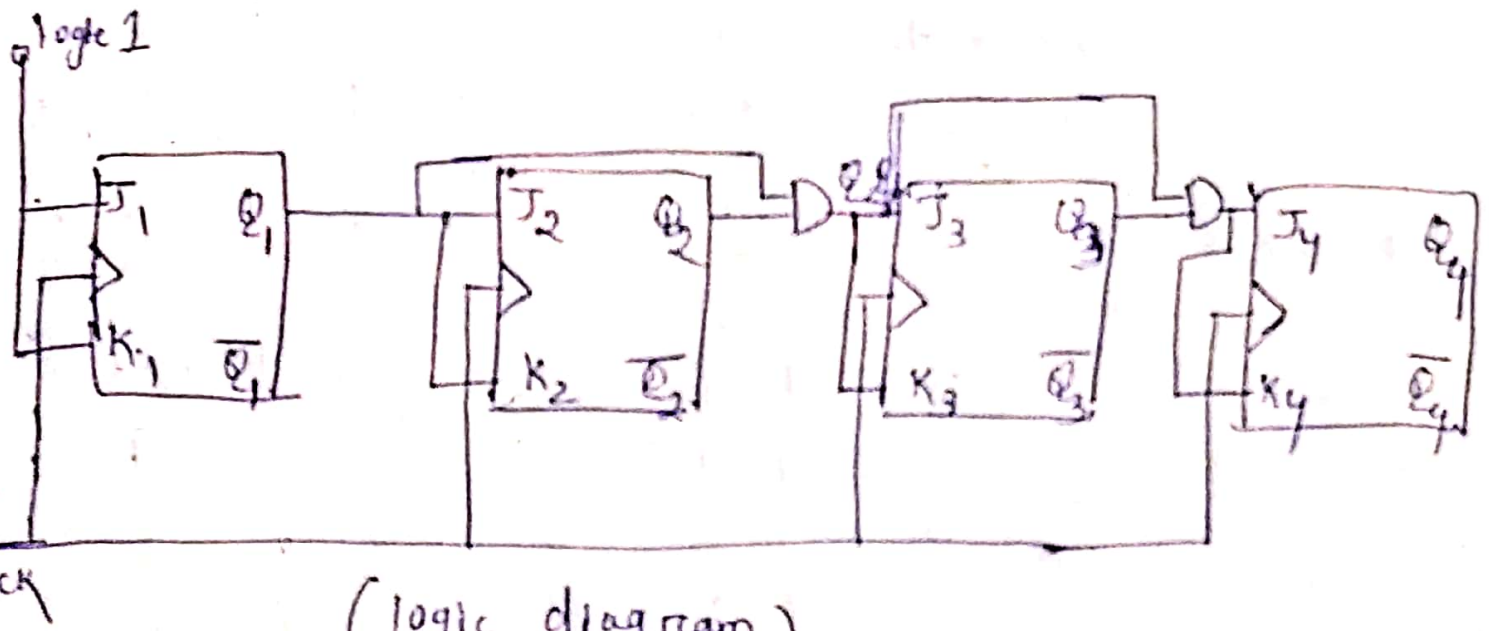
$Q_1$	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

$K_2 = Q_1$

From the excitation table it is found that

$J_1 = K_1 = 1$

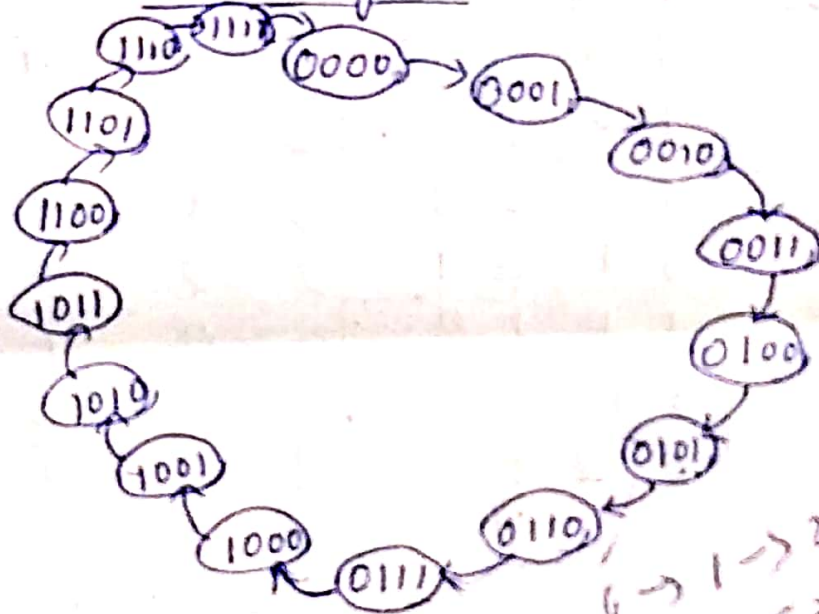




(logic diagram)

4-bit synchronous up counter using T-FF

state diagram



6 → 1 → 2 → 3 → 15  
 15 → 14 → 13 → 12

Excitation table.

$P_s (Q_n)$				$N_s (Q_{n+1})$				<u>Required excitations.</u>			
$Q_4$	$Q_3$	$Q_2$	$Q_1$	$Q_4$	$Q_3$	$Q_2$	$Q_1$	$T_4$	$T_3$	$T_2$	$T_1$
0	0	0	0	0	0	0	1	0	0	0	1
0	0	0	1	0	0	1	0	0	0	1	1
0	0	1	0	0	0	1	1	0	0	0	1
0	0	1	1	0	1	0	0	0	1	1	1
0	1	0	0	0	1	0	1	0	0	0	1
0	1	0	1	0	1	1	0	0	0	1	1
0	1	1	0	0	1	1	1	0	0	0	1
0	1	1	1	1	0	0	0	1	1	1	1
1	0	0	0	1	0	0	1	0	0	0	1
1	0	0	1	1	0	1	0	0	0	1	1
1	0	1	0	1	0	1	1	0	0	0	1
1	0	1	1	1	1	0	0	0	1	1	1
1	1	0	0	1	1	0	1	0	0	0	1
1	1	0	1	1	1	1	0	0	0	1	1
1	1	1	0	1	1	1	1	0	0	0	1
1	1	1	1	0	0	0	0	1	1	1	1

$T_4$

	$Q_2 Q_1$	00	01	11	10
$Q_3 Q_2$	00	0	1	3	2
	01	4	5	7	6
	11	12	13	15	14
	10	8	9	11	10

$T_4 = Q_3 Q_2 Q_1$  ✓

$T_3$

	$Q_2 Q_1$	00	01	11	10
$Q_3 Q_2$	00	0	1	3	2
	01	4	5	7	6
	11	12	13	15	14
	10	8	9	11	10

$T_3 = Q_2 Q_1$  ✓

$T_2$

	$Q_2 Q_1$	00	01	11	10
$Q_3 Q_2$	00	0	1	3	2
	01	4	5	7	6
	11	12	13	15	14
	10	8	9	11	10

$T_2 = Q_1$  ✓

$T_4 = 1$  ✓

Logic Diagram

$0 \rightarrow 15 \rightarrow 17$   
 $\quad \quad \quad 0$

