

Q. 3 bit Synchronous up-down Counter.

A Step-1

n = 3 bits . Flip-flop - T Flip-flop

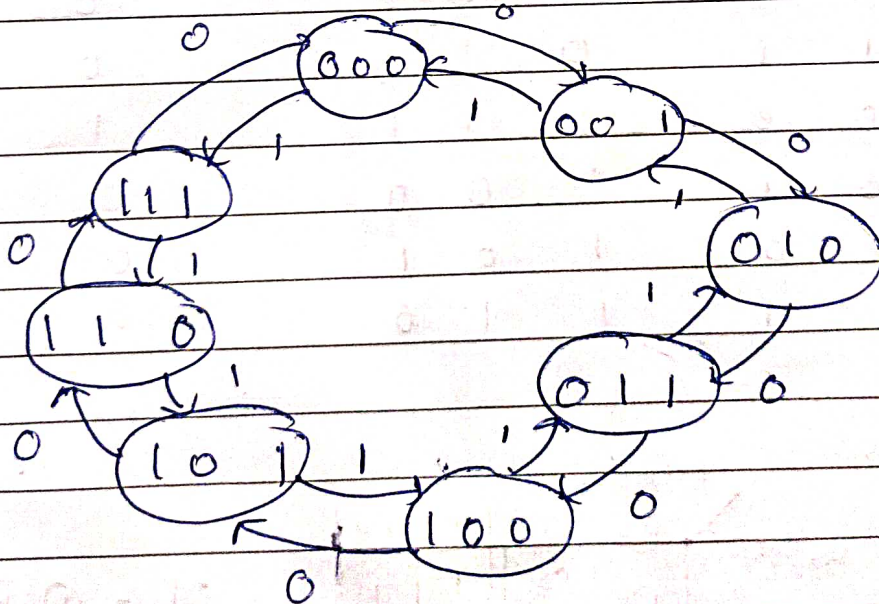
Step-2 . Excitation table

Q_n	Q_{n+1}	T
0	0	0
0	1	1
1	0	1
1	1	0

M = 0 . up counter.

M = 1 . down counter.

Step-3 State diagram.



State table.



M

up
Counter

M	Present state			Next state			input of FF		
	Q ₂	Q ₁	Q ₀	Q ₂ ⁺	Q ₁ ⁺	Q ₀ ⁺	T ₂	T ₁	T ₀
0	0	0	0	0	0	1	0	0	1
0	0	0	1	0	1	0	0	1	1
0	0	1	0	0	1	1	0	0	1
0	0	1	1	1	0	0	1	1	1
0	1	0	0	1	0	1	0	0	1
0	1	0	1	1	1	0	0	1	1
0	1	1	0	1	1	1	0	0	1
0	1	1	1	0	0	0	1	1	1
1	0	0	0	1	1	1	1	1	1
1	0	0	1	0	0	0	0	0	1
1	0	1	0	0	0	1	0	1	1
1	0	1	1	0	1	0	0	0	1
1	1	0	0	0	1	1	1	1	1
1	1	0	1	1	0	0	0	0	1
1	1	1	0	1	0	1	0	1	1
1	1	1	1	1	1	0	0	0	1

T₀ = 1

T₁ =

		M Q ₂			
		00	01	11	10
Q ₁ Q ₀	00	0	0	1	1
	01	1	1	0	0
	11	1	1	0	0
	10	0	0	1	1

T₁ = Q₀ M̄ + Q̄₀ M

T_2 MQ_2

$Q_1 Q_0$	00	01	11	10
00	0	0	1	1
01	0	0	0	0
11	1	1	0	0
10	0	0	0	0

$$T_2 = Q_1 Q_0 \bar{M} + \bar{Q}_1 \bar{Q}_0 M$$

