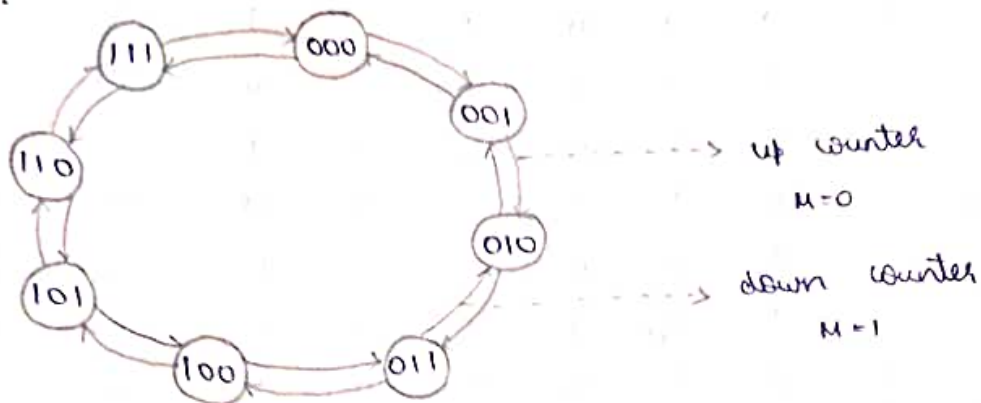


5) 3 bit up/down synchronous counter using TFF.

Soln: State Diagram:

Step 1:



Counting Sequence:

Up Synchronous Counter : M=0

0, 1, 2, 3, 4, 5, 6, 7, ... 0, 1, 2, 3, 4, 5, 6, 7, ...

Down Synchronous Counter : M=1

0, 7, 6, 5, 4, 3, 2, 1, 0 ... 7, 6, 5, 4, 3, 2, 1, 0 ...

Step 2:

Control Input M	Present State			Next State			Required flipflop for T F lip Flop		
	A	B	C	A ⁺	B ⁺	C ⁺	T _A	T _B	T _C
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

0
1
2
3
4
5
6
7
Up Counter

8
9
10
11
12
13
14
15
Down Counter

Control Input M	Present State			Next State			Required for TFF		
	A	B	C	A ⁺	B ⁺	C ⁺	T _A	T _B	T _C
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

K-Map :

For T_A :

MA	BC			
	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{M}\bar{A}$	0 ₀	0 ₁	1 ₂	0 ₃
$\bar{M}A$	0 ₄	0 ₅	1 ₇	0 ₆
MA	1 ₁₂	0 ₁₃	0 ₁₅	0 ₁₄
$M\bar{A}$	1 ₈	0 ₉	0 ₁₀	0 ₁₁

$$T_A = M\bar{B}\bar{C} + \bar{M}BC$$

For T_B :

MA	BC			
	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{M}\bar{A}$	0 ₀	1 ₁	1 ₂	0 ₃
$\bar{M}A$	0 ₄	1 ₅	1 ₇	0 ₆
MA	1 ₁₂	0 ₁₃	0 ₁₅	1 ₁₄
$M\bar{A}$	1 ₈	0 ₉	0 ₁₀	1 ₁₁

$$T_B = \bar{M}C + M\bar{C}$$

$$T_B = M \oplus C$$

For T_c :

	BC	$\overline{B}\overline{C}$	$\overline{B}C$	BC	$B\overline{C}$
$\overline{M}A$	1	1	1	1	1
$\overline{M}A$	1	1	1	1	1
MA	1	1	1	1	1
$M\overline{A}$	1	1	1	1	1

$$T_c = 1$$

Logic Diagram :

