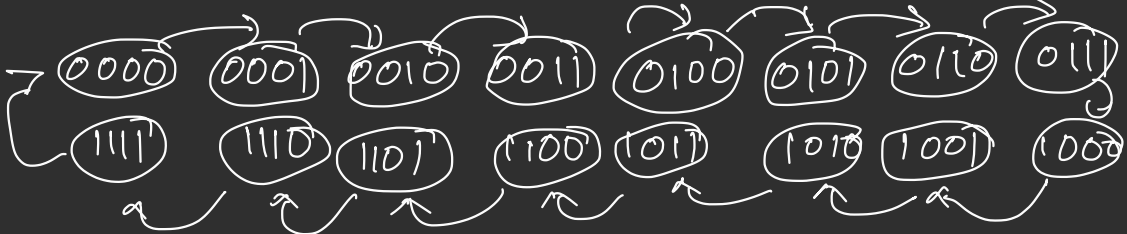
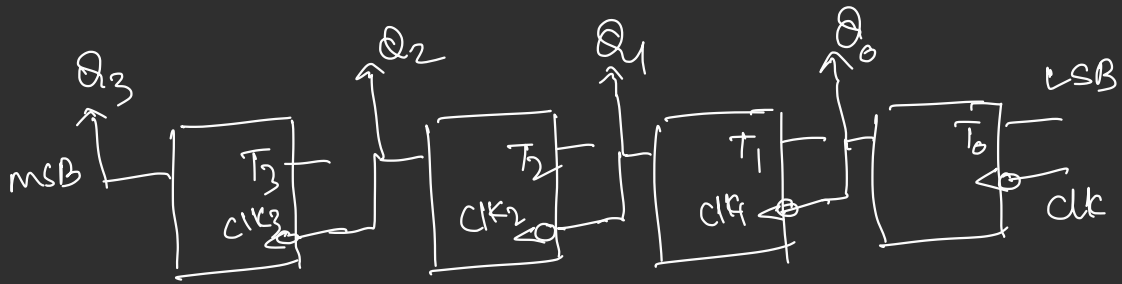
4-bit ripple counter (Asynchronous counter)

modulus = 16





CLK	Q_3	Q_2	Q_1	Q_0
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

Q_0 will change whenever CLK changes

Q_1 will change whenever Q_0 changes from 1 to 0

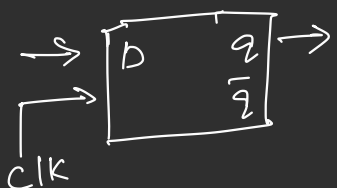
Q_2 will change whenever Q_1 changes from 1 to 0

Q_3 will change whenever Q_2 change from 1 to 0

Q_0 will change whenever CLK change because T FF toggles whenever T = 1 (we used)

To design a 4-bit ripple counter we need to use T-flf which are derived from D-FlF.

D FlF



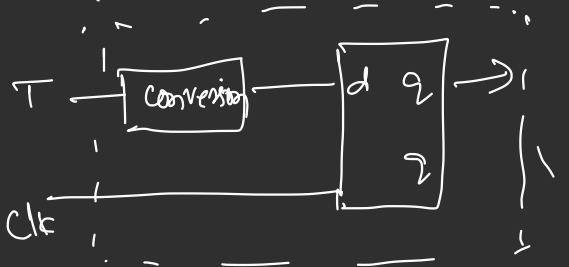
Truth Table

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

Excitation table

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

T-FlF



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

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

DFlF to TFlF :→ Required Given

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

$D = f(T, Q_n)$

$= 1$ if $Q_n = 0$ & $T = 1$

or

$Q_n = 1$, $T = 0$

$D = \bar{Q_n} T + Q_n \bar{T}$

$= T \oplus Q_n$