Chapter 11
Registers and Counters

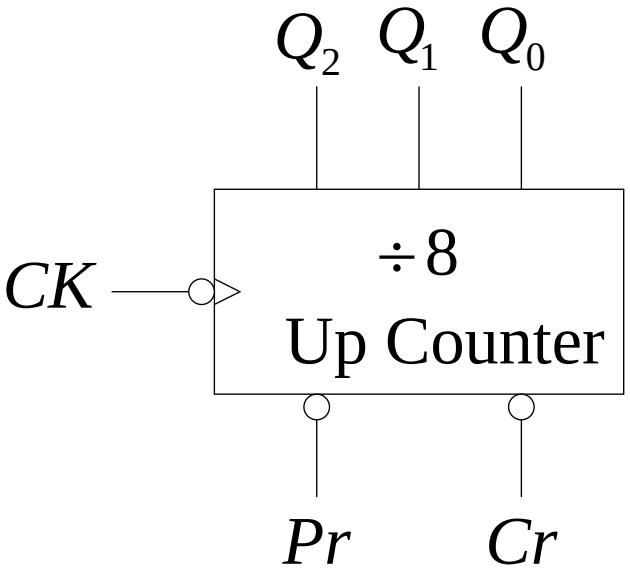
Counters

Counters and Their Classification

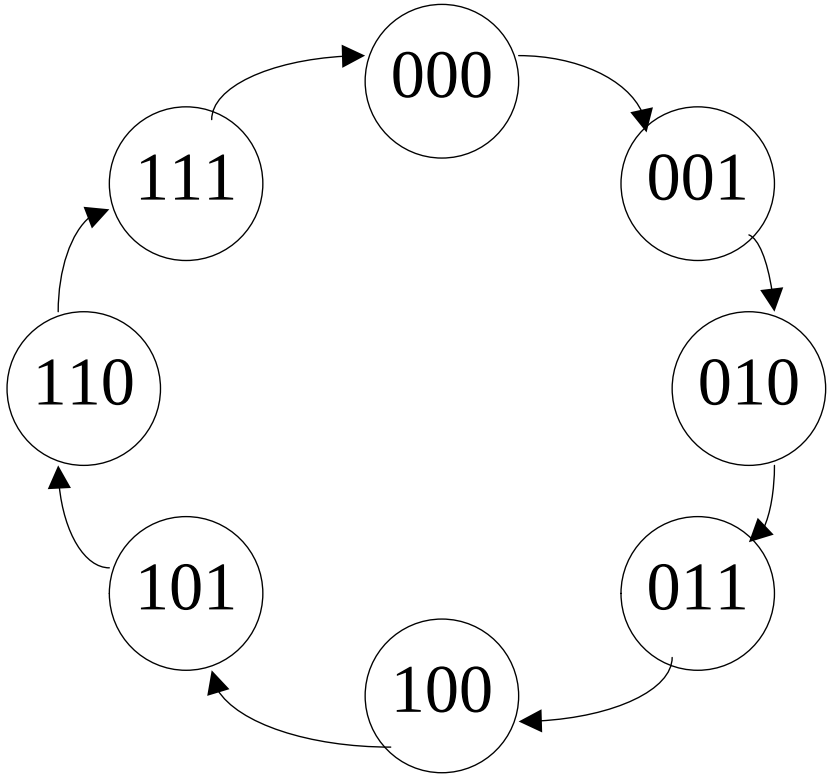
- Based on Count Order
  - Up Counter
  - Down Counter
- Based on Operating Mode
  - Asynchronous Counter (All FFs are not controlled by the same clock)
  - Synchronous Counter (All FFs are controlled by the same clock)

Binary Asynchronous Counters

Binary Asynchronous ÷8 Up Counter



(a) Block diagram



(b) Transition diagram

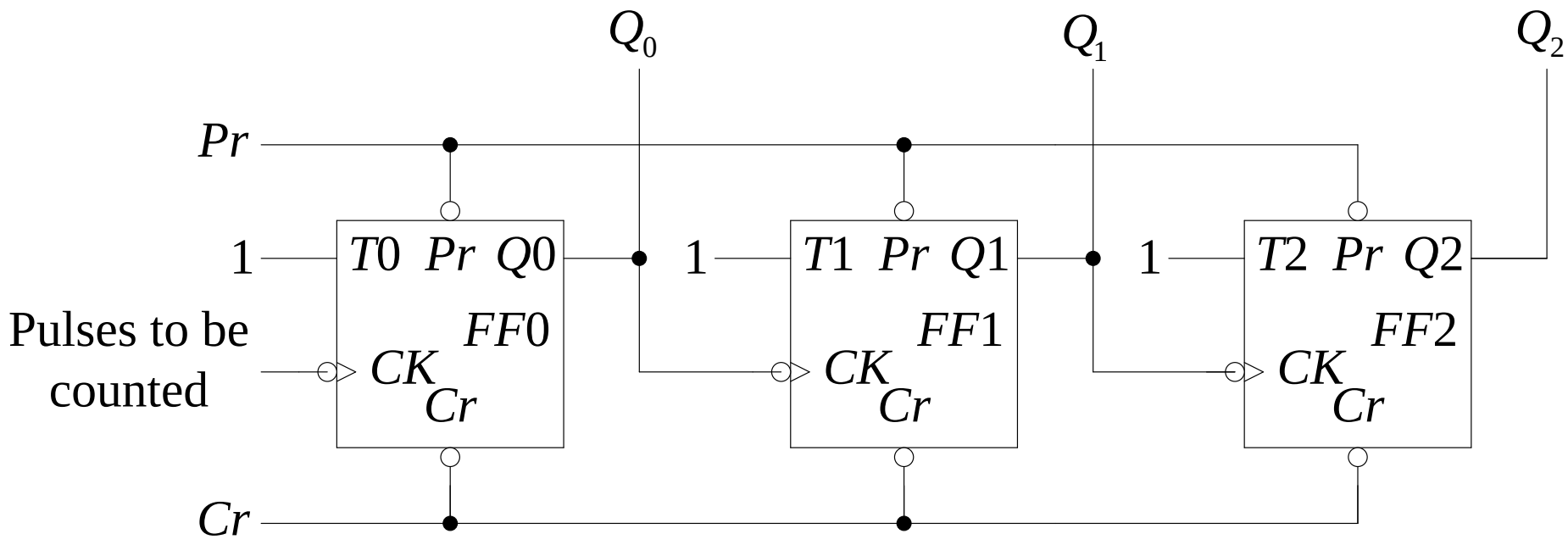
Count Sequence

Q_2	Q_1	Q_0
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1
0	0	0

Binary Asynchronous Counters (Contd.)

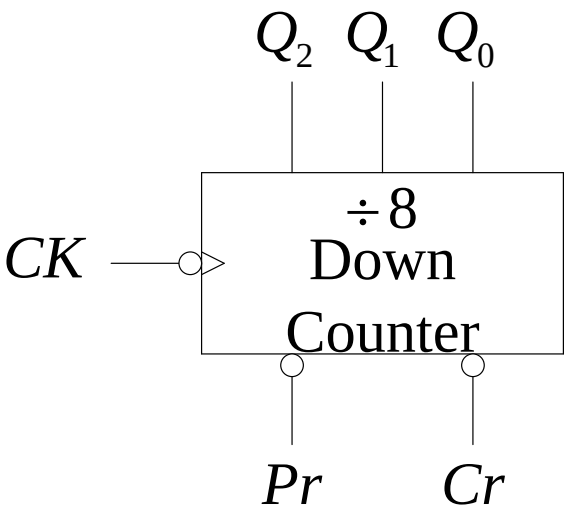
Count Sequence

Q_2	Q_1	Q_0
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1
0	0	0

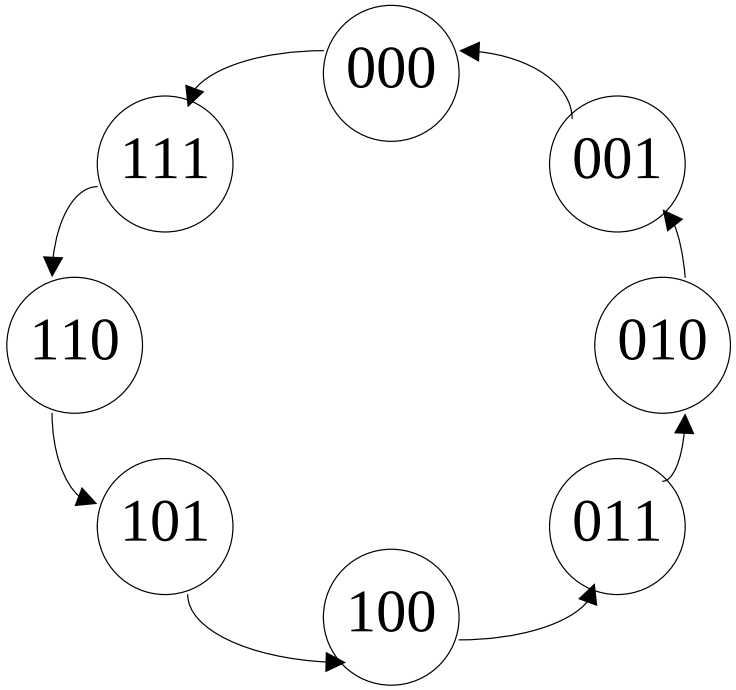


Binary Asynchronous Counters (Contd.)

Binary Asynchronous ÷8 Down Counter



(a) Block diagram



(b) Transition diagram

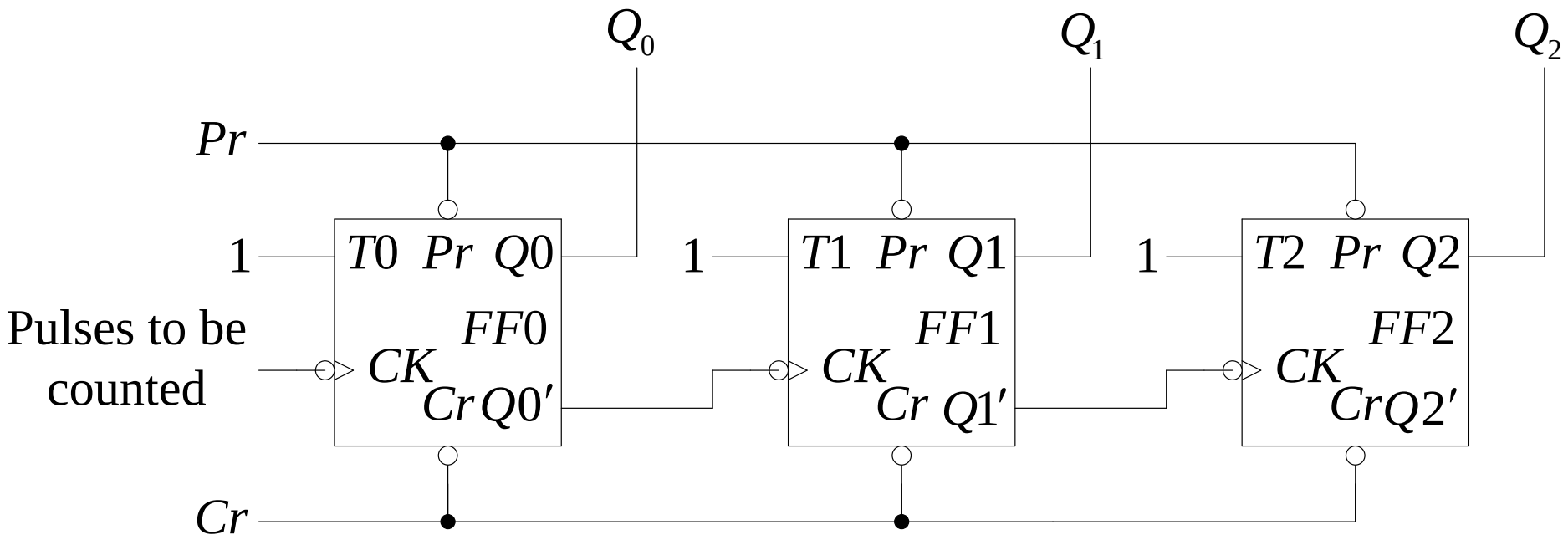
Count Sequence

Q_2	Q_1	Q_0
1	1	1
1	1	0
1	0	1
1	0	0
0	1	1
0	1	0
0	0	1
0	0	0
1	1	1

Binary Asynchronous Counters (Contd.)

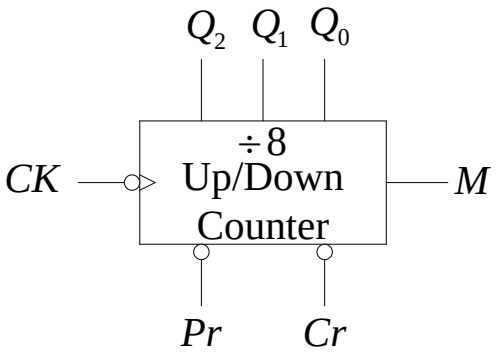
Count Sequence

Q_2	Q_1	Q_0
1	1	1
1	1	0
1	0	1
1	0	0
0	1	1
0	1	0
0	0	1
0	0	0
1	1	1

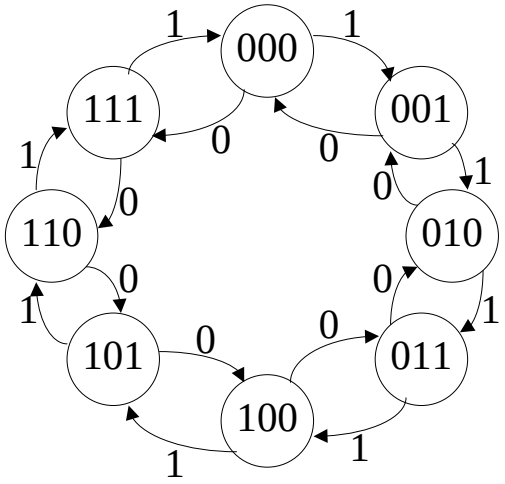


Binary Asynchronous Counters (Contd.)

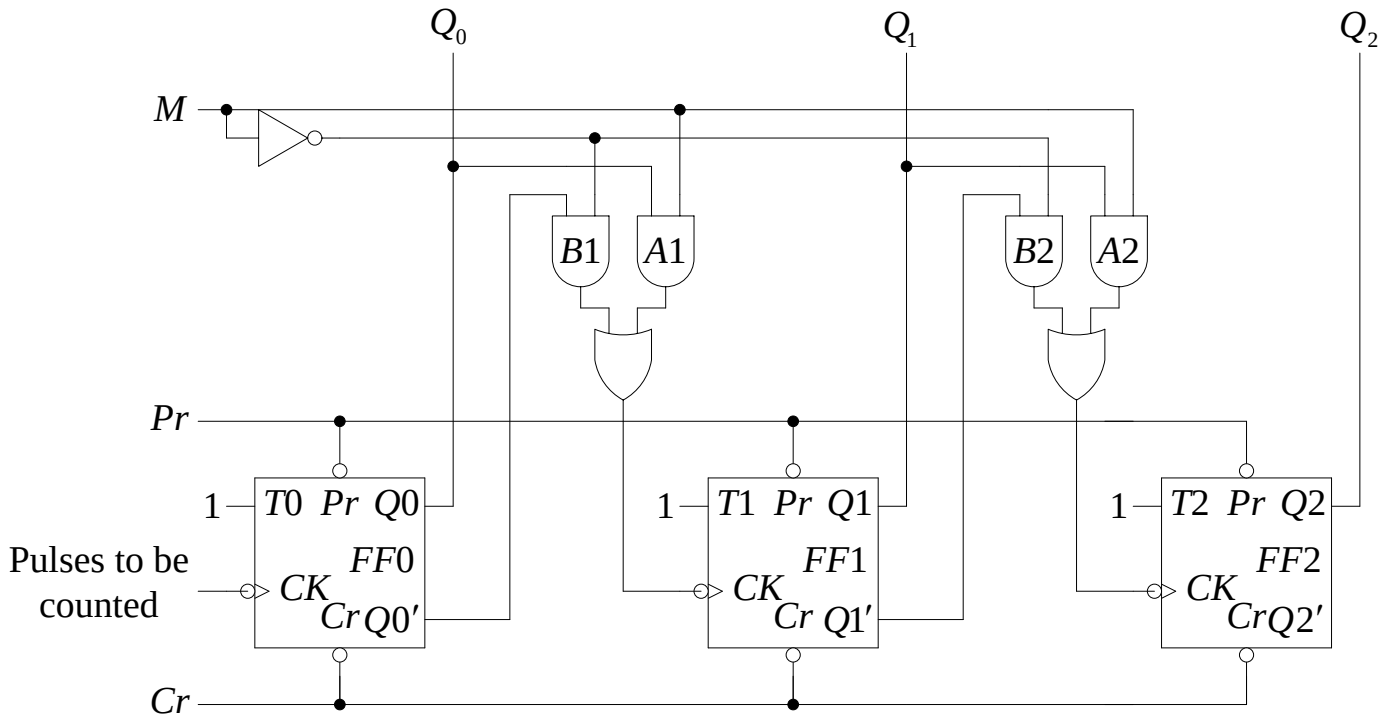
Binary Asynchronous ÷8 Up/Down Counter



(a) Block diagram



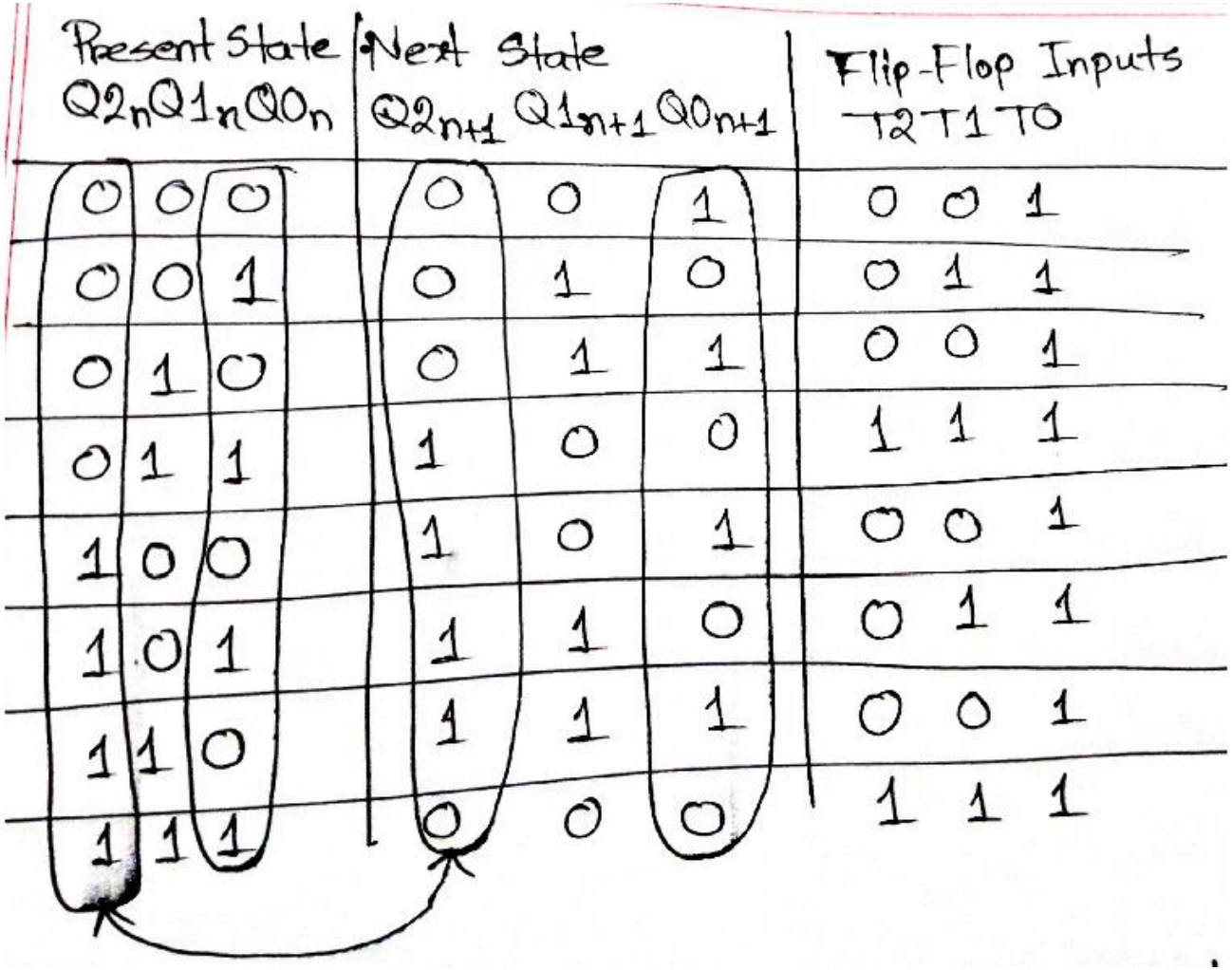
(b) Transition diagram



Binary Synchronous Counters

Binary Synchronous Up Counter

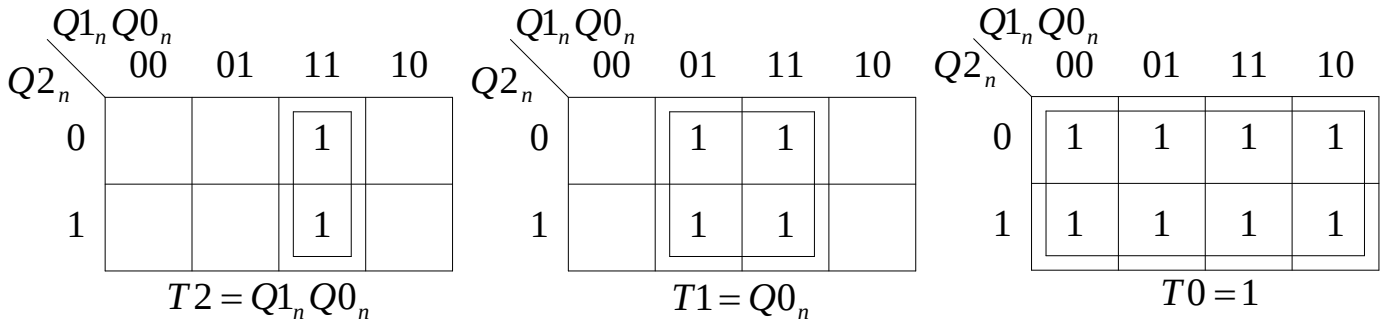
Excitation Table:

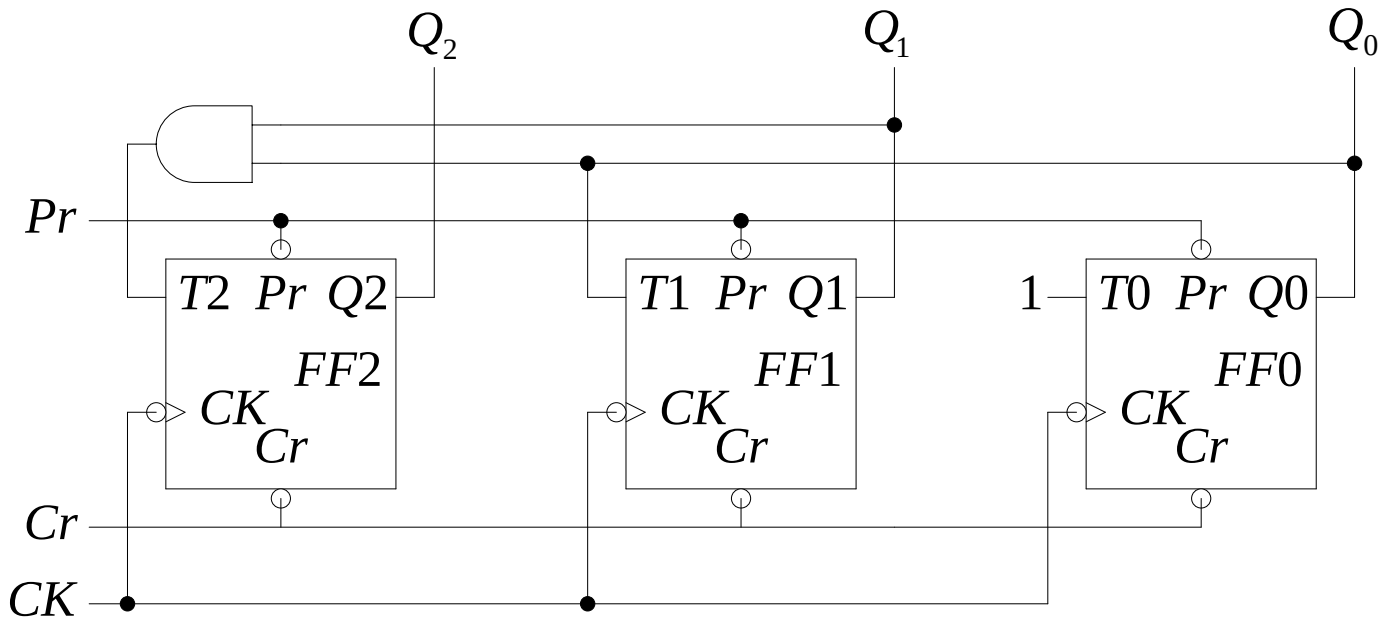


Present State $Q2_nQ1_nQ0_n$	Next State $Q2_{n+1}$ $Q1_{n+1}$ $Q0_{n+1}$	Flip-Flop Inputs T2 T1 T0
0 0 0	0 0 1	0 0 1
0 0 1	0 1 0	0 1 1
0 1 0	0 1 1	0 0 1
0 1 1	1 0 0	1 1 1
1 0 0	1 0 1	0 0 1
1 0 1	1 1 0	0 1 1
1 1 0	1 1 1	0 0 1
1 1 1	0 0 0	1 1 1

Binary Synchronous Counters (Contd.)

Present State $Q2_nQ1_nQ0_n$	Next State $Q2_{n+1}Q1_{n+1}Q0_{n+1}$	Flip-Flop Inputs $T2T1T0$
000	001	001
001	010	011
010	011	001
011	100	111
100	101	001
101	110	011
110	111	001
111	000	111

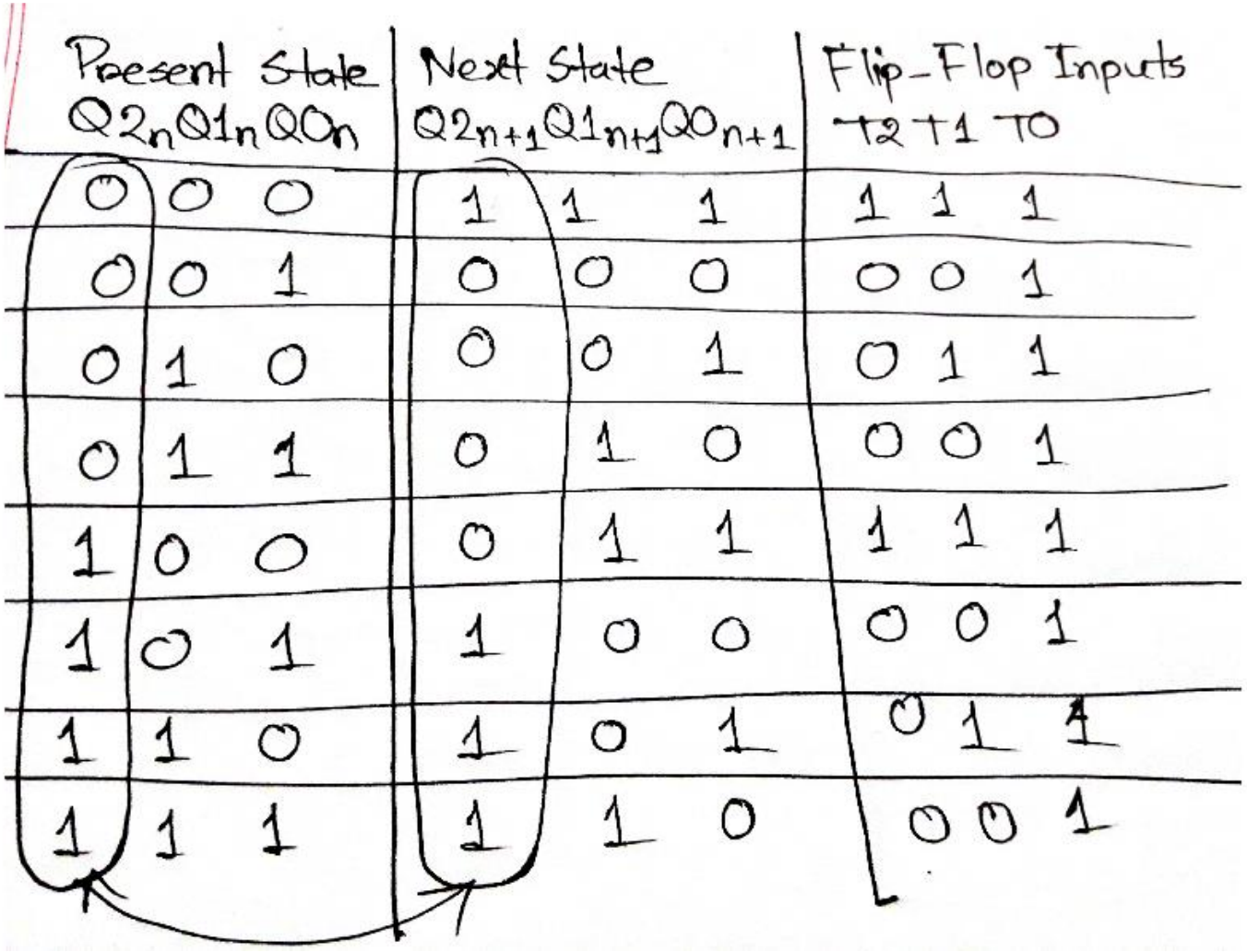




Binary Synchronous Counters (Contd.)

Binary Synchronous Down Counter

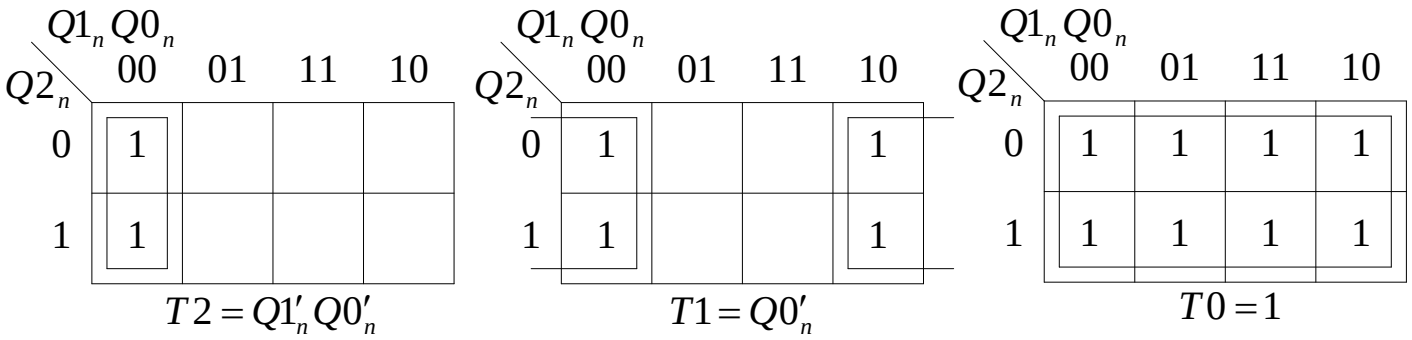
Excitation Table:

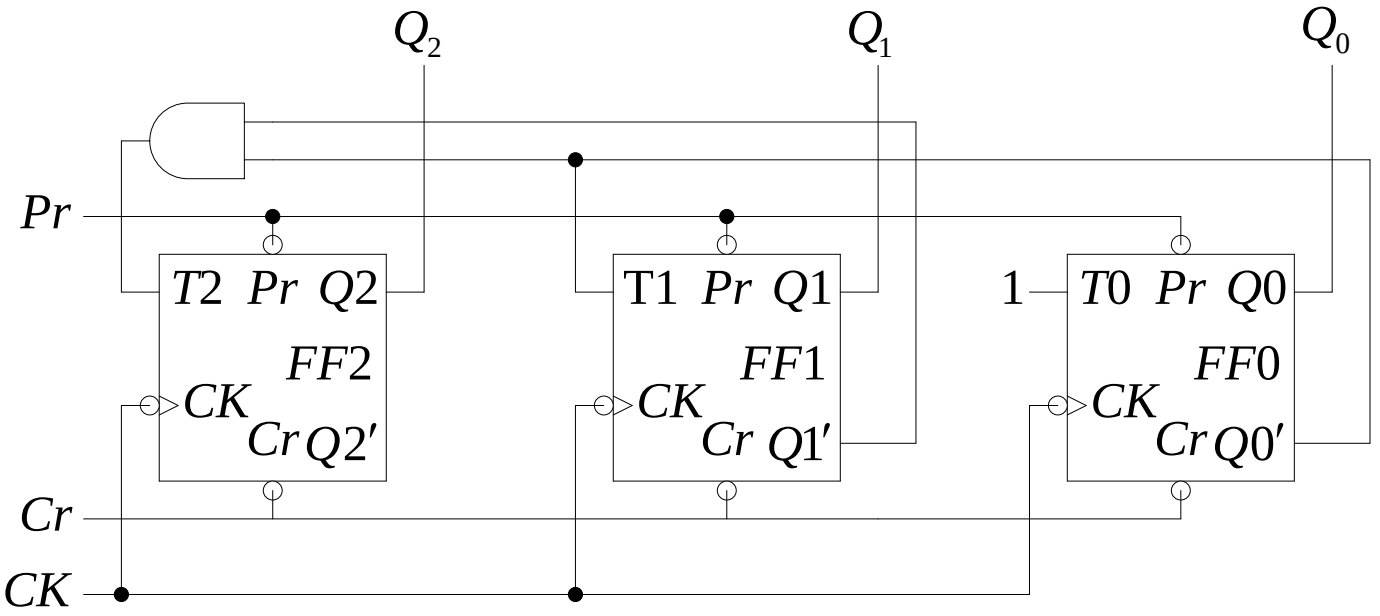


Present State $Q2_nQ1_nQ0_n$	Next State $Q2_{n+1}Q1_{n+1}Q0_{n+1}$	Flip-Flop Inputs T2 T1 T0
0 0 0	1 1 1	1 1 1
0 0 1	0 0 0	0 0 1
0 1 0	0 0 1	0 1 1
0 1 1	0 1 0	0 0 1
1 0 0	0 1 1	1 1 1
1 0 1	1 0 0	0 0 1
1 1 0	1 0 1	0 1 1
1 1 1	1 1 0	0 0 1

Binary Synchronous Counters (Contd.)

Present State $Q2_nQ1_nQ0_n$	Next State $Q2_{n+1}Q1_{n+1}Q0_{n+1}$	Flip-Flop Inputs $T2T1T0$
000	111	111
001	000	001
010	001	011
011	010	001
100	011	111
101	100	001
110	101	011
111	110	001



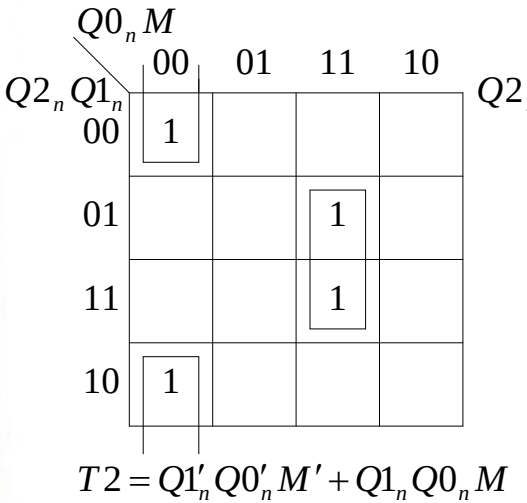


Binary Synchronous Counters (Contd.)

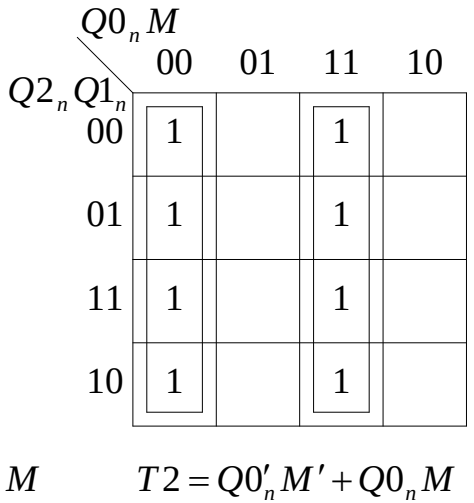
Binary Synchronous Up/Down Counter

Excitation Table of a ÷8 Up/Down Synchronous Counter

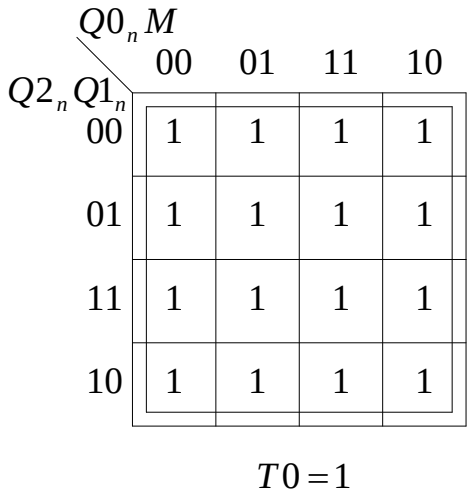
Present State $Q2_nQ1_nQ0_n$	Next State $Q2_{n+1}Q1_{n+1}Q0_{n+1}$		Flip-Flop Inputs T2T1T0	
	M=0	M=1	M=0	M=1
000	111	001	111	001
001	000	010	001	011
010	001	011	011	001
011	010	100	001	111
100	011	101	111	001
101	100	110	001	011
110	101	111	011	001
111	110	000	001	111



$T2 = Q1'_n Q0'_n M' + Q1_n Q0_n M$



$T2 = Q0'_n M' + Q0_n M$



$T0 = 1$

Binary Synchronous Counters (Contd.)