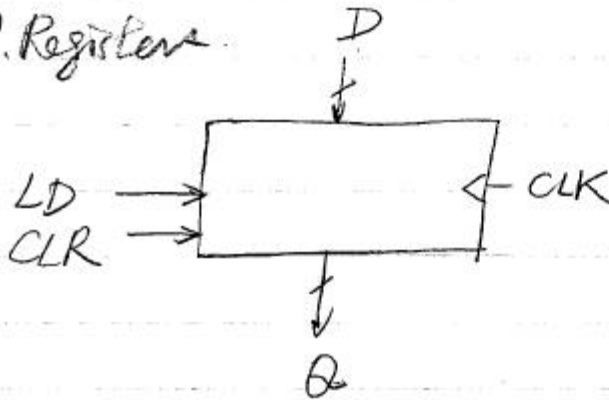


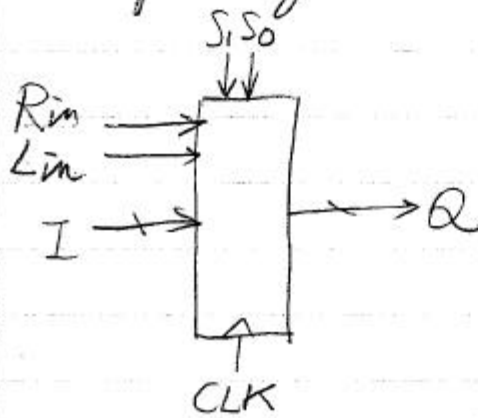
Standard Sequential Modules

1. Registers

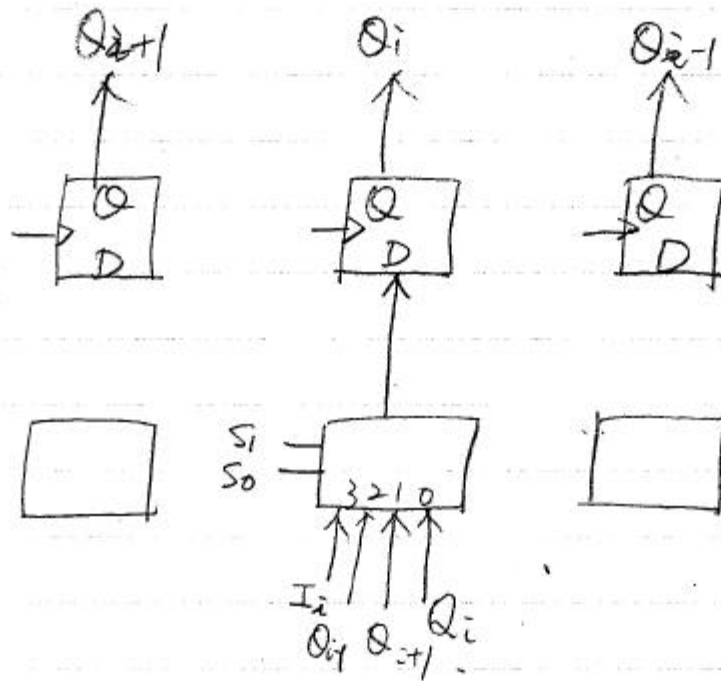


$$\begin{aligned} Q(t+1) &= (0, 0, \dots, 0) && \text{if } CLR=1 \\ &= D && \text{if } LD=1 \text{ and } CLR=0 \\ &= Q(t) && \text{if } LD=0 \text{ and } CLR=0. \end{aligned}$$

2. Shift Register

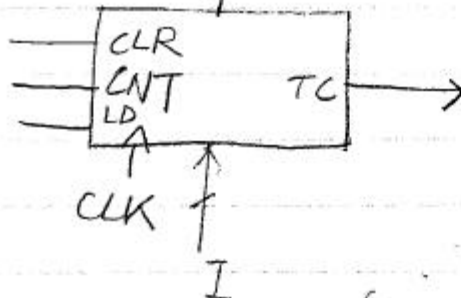


	$S_1 S_0$	
Hold	00	$Q(t+1) = Q(t)$
Shift right	01	$Q(t+1) = (Rin, Q(t), \dots, Q_1(t))$
Shift left	10	$Q(t+1) = (Q_{n-2}(t), \dots, Q_0(t), Lin)$
Load	11	$Q(t+1) = I$



9W1

Counter (modulo-n counter)

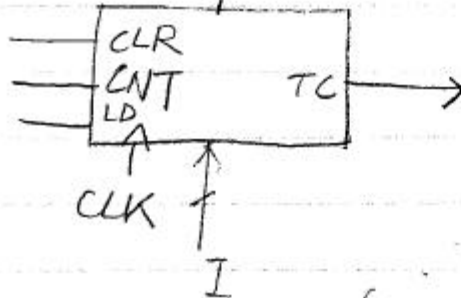


$$Q(t+1) = \begin{cases} (0, 0, \dots, 0) & \text{if } CLR=1 \\ I & \text{if } CLR=0, LD=1 \\ (Q(t)+1) \bmod n & \text{if } CLR=0, LD=0, CNT=1 \\ Q(t) & \text{if } CLR=0, LD=0, CNT=0 \end{cases}$$

$$TC = \begin{cases} 1 & \text{if } Q(t) = n-1 \text{ and } CNT=1 \\ 0 & \text{otherwise} \end{cases}$$

9W1

Counter (modulo-n counter)



$$Q(t+1) = \begin{cases} (0, 0, \dots, 0) & \text{if } CLR=1 \\ I & \text{if } CLR=0, LD=1 \\ (Q(t)+1) \bmod n & \text{if } CLR=0, LD=0, CNT=1 \\ Q(t) & \text{if } CLR=0, LD=0, CNT=0 \end{cases}$$

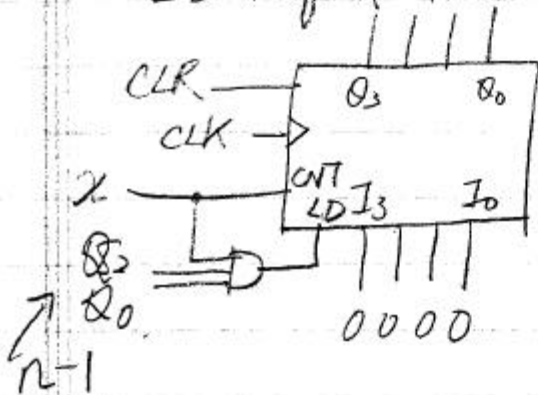
$$TC = \begin{cases} 1 & \text{if } Q(t)=n-1 \text{ and } CNT=1 \\ 0 & \text{otherwise} \end{cases}$$

Modulo-16 counter

(a). Given a mod-16 counter, construct a mod- n counter ($1 \leq n \leq 16$) with AND, OR, NOT gates.

$LD=1$ if $X=1$ & $Q(t)=b$, $I(t)=0$.

Ex. $n=6$.



$LD=1$ if $X=1$ and $Q(t)=0101$

$Q(t)$ 0 1 2 3 4 5 0

LD 0 0 0 0 0 1 0

(b). Construct an a-to-b counter ($0 \leq a, b \leq 15$)

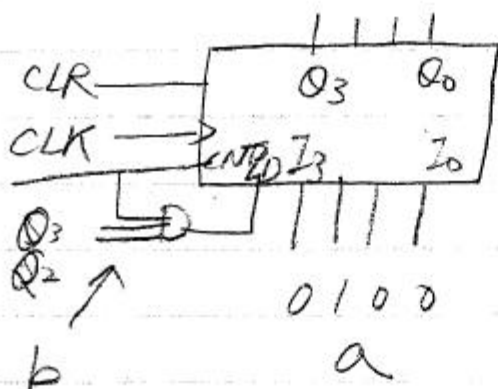
$LD=1$ if $X=1$ & $Q(t)=b$, $I(t)=a$

Ex. $a=4$, $b=10$.

$LD=1$ if $X=1$ & $Q(t)=10$.

$Q(t)$ 4 5 6 7 8 9 10 4 5

LD 0 0 0 0 0 0 1 0 0



(c), Given a mod-8 counter, construct a counter with sequence
0 1 5 6 2 3 7

Load = 1 I = 5 if $Q(1) = 1$
 1 2 6
 1 7 3

LD 0 1 5 6 2 3 7
 0 1 0 1 0 1 0
 - 5 - 2 - 7 -

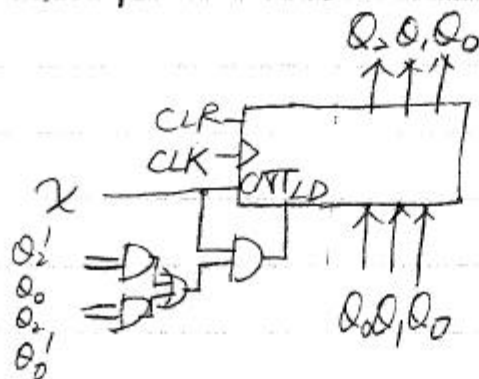
Q_2, Q_1, Q_0	Load	I_2, I_1, I_0
0 0 0	0	—
1 0 1	1	1 0 1
0 1 0	0	—
0 1 1	1	1 1 1
1 0 0	—	—
1 0 1	0	—
1 1 0	1	0 1 0
1 1 1	0	—

K-Map $LD = Q_2'Q_0 + Q_2Q_0'$

$I_2 = Q_0$

$I_1 = Q_1$

$I_0 = Q_0$



Sequence 0 2 3 4 5 7 6

LD=1 I=2 if $Q(t)=0$
 1 7 5
 1 6 7
 1 0 6

$Q_2(t) Q_1(t) Q_0(t)$ LD $I_2 I_1 I_0$

0	0	00	1	0	10
1	0	01	—	—	—
2	0	10	0	—	—
3	0	11	0	—	—
4	1	00	0	—	—
5	1	01	1	1	11
6	1	10	1	0	00
7	1	11	1	1	10

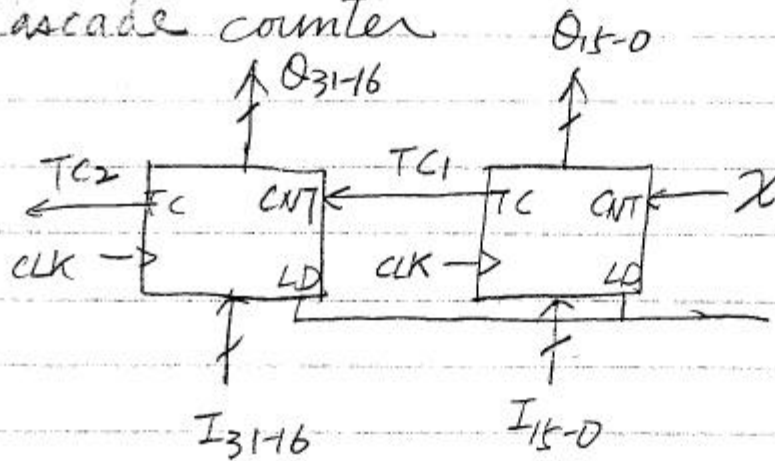
$$LD = Q_2'Q_1' + Q_2Q_0 + Q_2Q_1$$

$$I_2 = Q_0$$

$$I_1 = Q_1' + Q_0$$

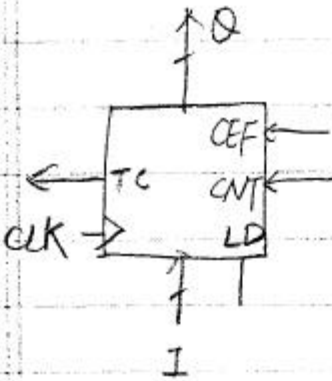
$$I_0 = Q_1'Q_0$$

(d) Cascade counter



$(Q_7 Q_6 Q_5 Q_4)$ 0 1 2 ... 14 15 0 1 2 ... 14 15 0 1 2
 TCI 0 0 0 0 1 0 0 0 0 1 0 0 0

$(Q_7 Q_6 Q_5 Q_4)$ 0 0 0 0 0 1 1 1 1 1 2 2 2

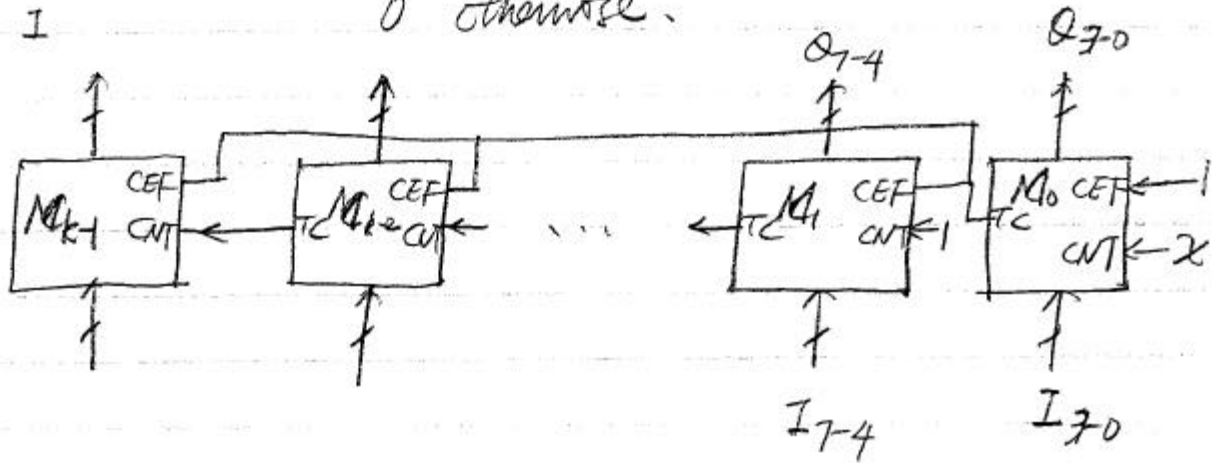


$$Q(t+1) = Q(t) + 1 \text{ mod } n \text{ if } CNT=1 \text{ \& } CEP=1$$

$$= Q(t) \text{ otherwise}$$

$$TC = 1 \text{ if } Q(t) = n-1 \text{ \& } CNT=1$$

$$0 \text{ otherwise.}$$



	M_{k-1}	M_{k-2}	M_3	M_2	M_1	M_0
$Q(t)$	0	0	0	0	0	0
TC	0	0	0	0	0	0
CEP	0	0	0	0	0	1
CNT	0	0	0	0	1	1
	0	0	0	0	0	15
	0	0	0	0	0	1
	0	0	0	0	1	1
	0	0	0	0	1	1
$Q(t)$	0	15	15	15	14	
TC	0	1	1	1	0	
CEP	0	0	0	0	1	
CNT	1	1	1	1	1	