

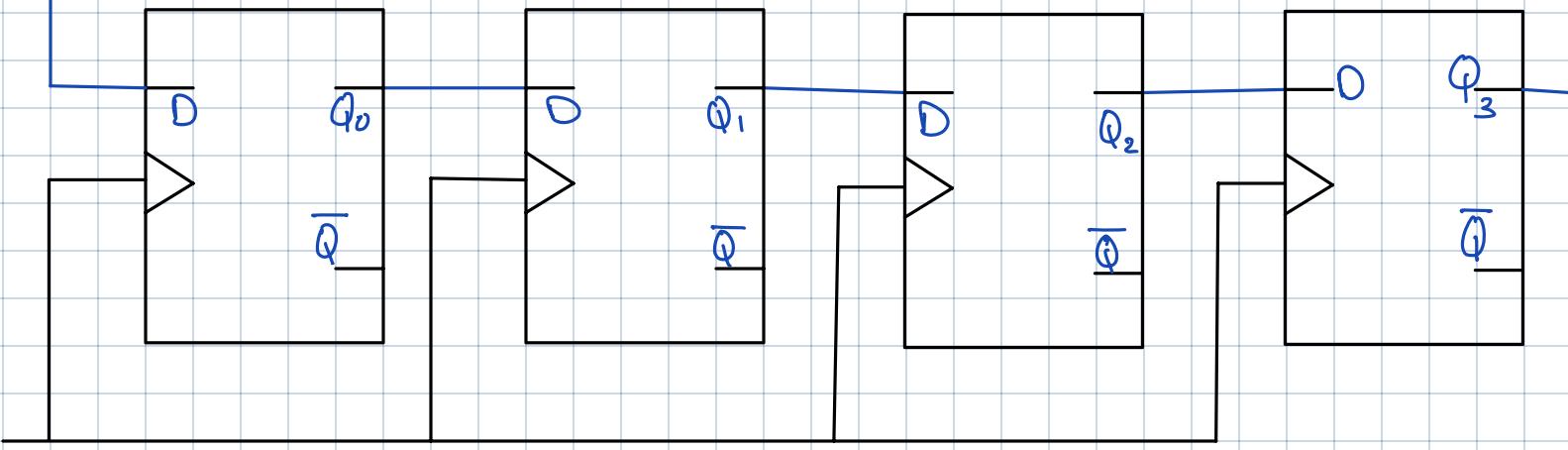
Shift Registers:

↪ It's a memory storage device.

Types:

1. Serial In / Serial Out

Serial In



↪ Start from LSB

2. Parallel In / Parallel out

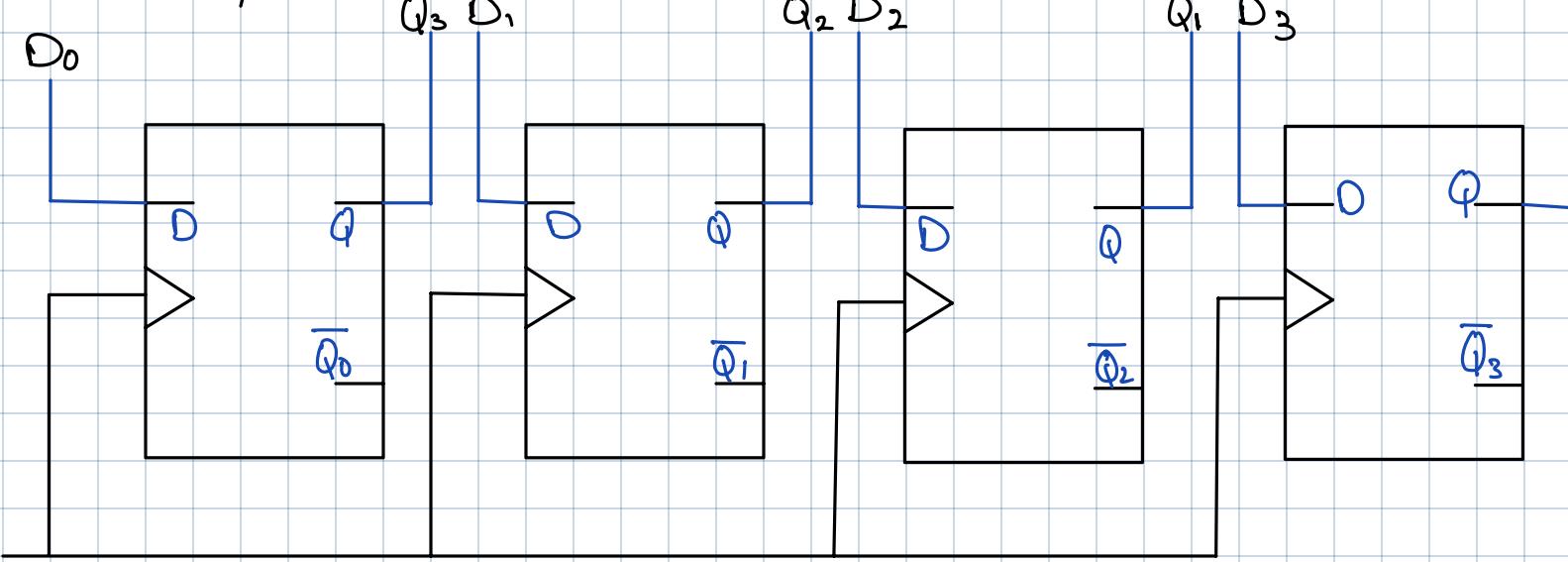
D_0

$Q_3 \ D_1$

$Q_2 \ D_2$

$Q_1 \ D_3$

Q_0



↪ Transmit data synchronously

3. Serial In / Parallel Out

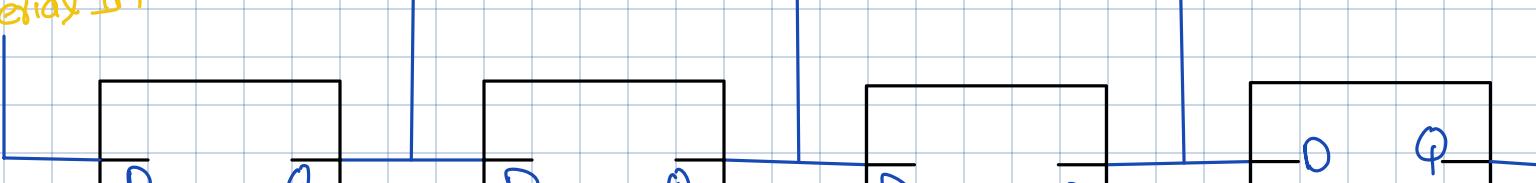
Serial In

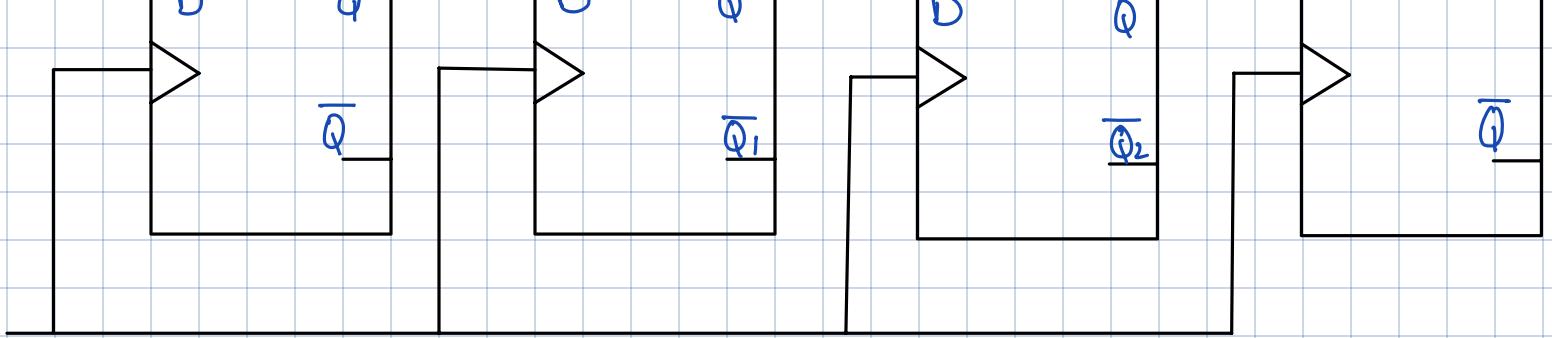
Q_3

Q_2

Q_1

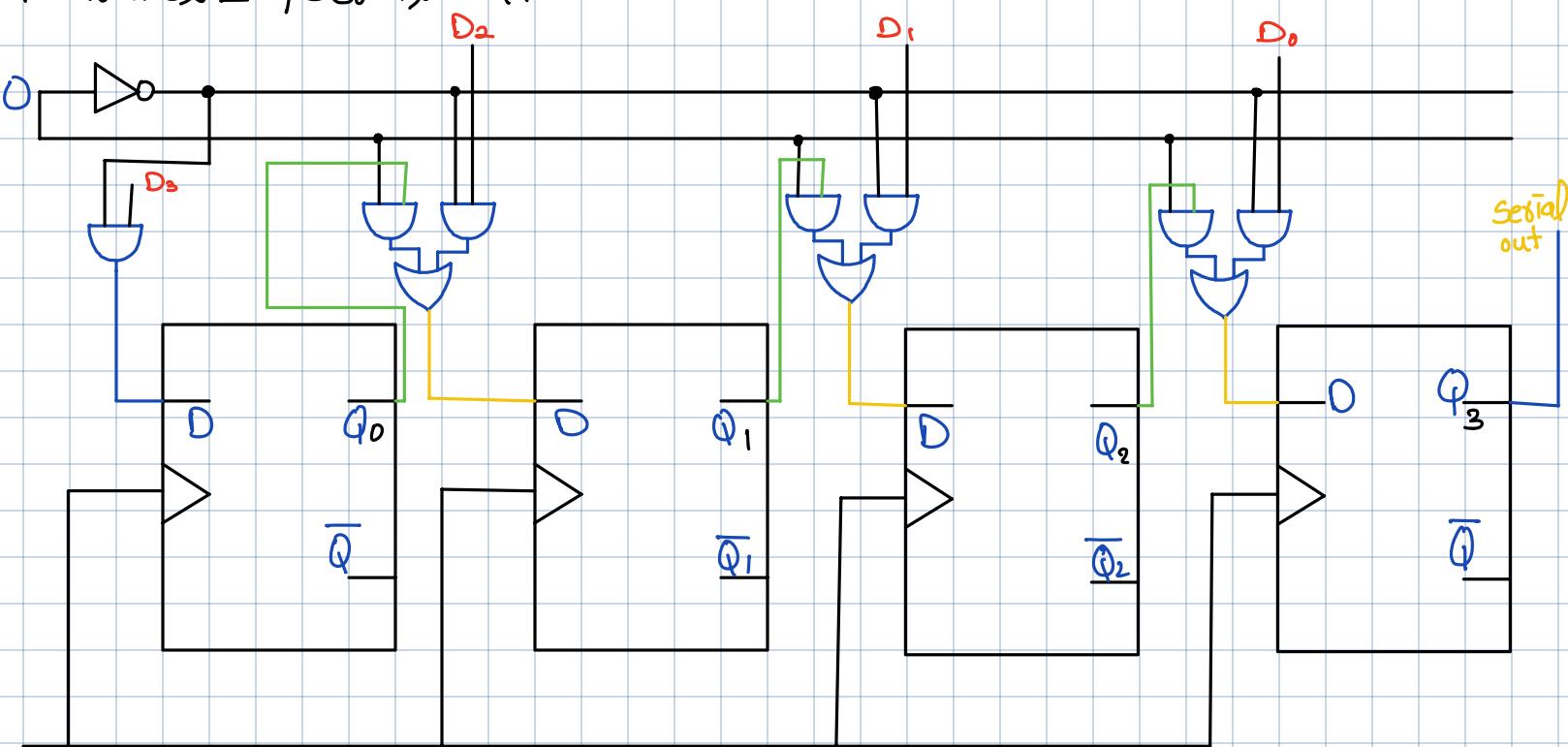
Q_0





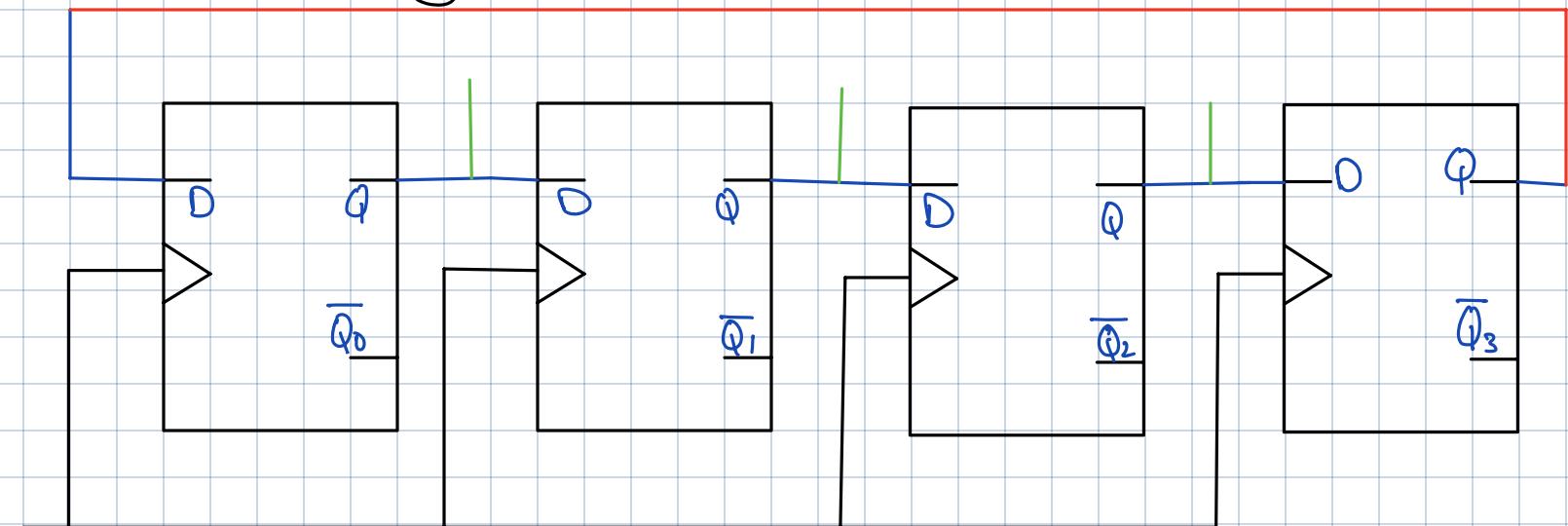
↳ After 4 clock pulses, You can read data without clock pulses

4. Parallel In / Serial Out

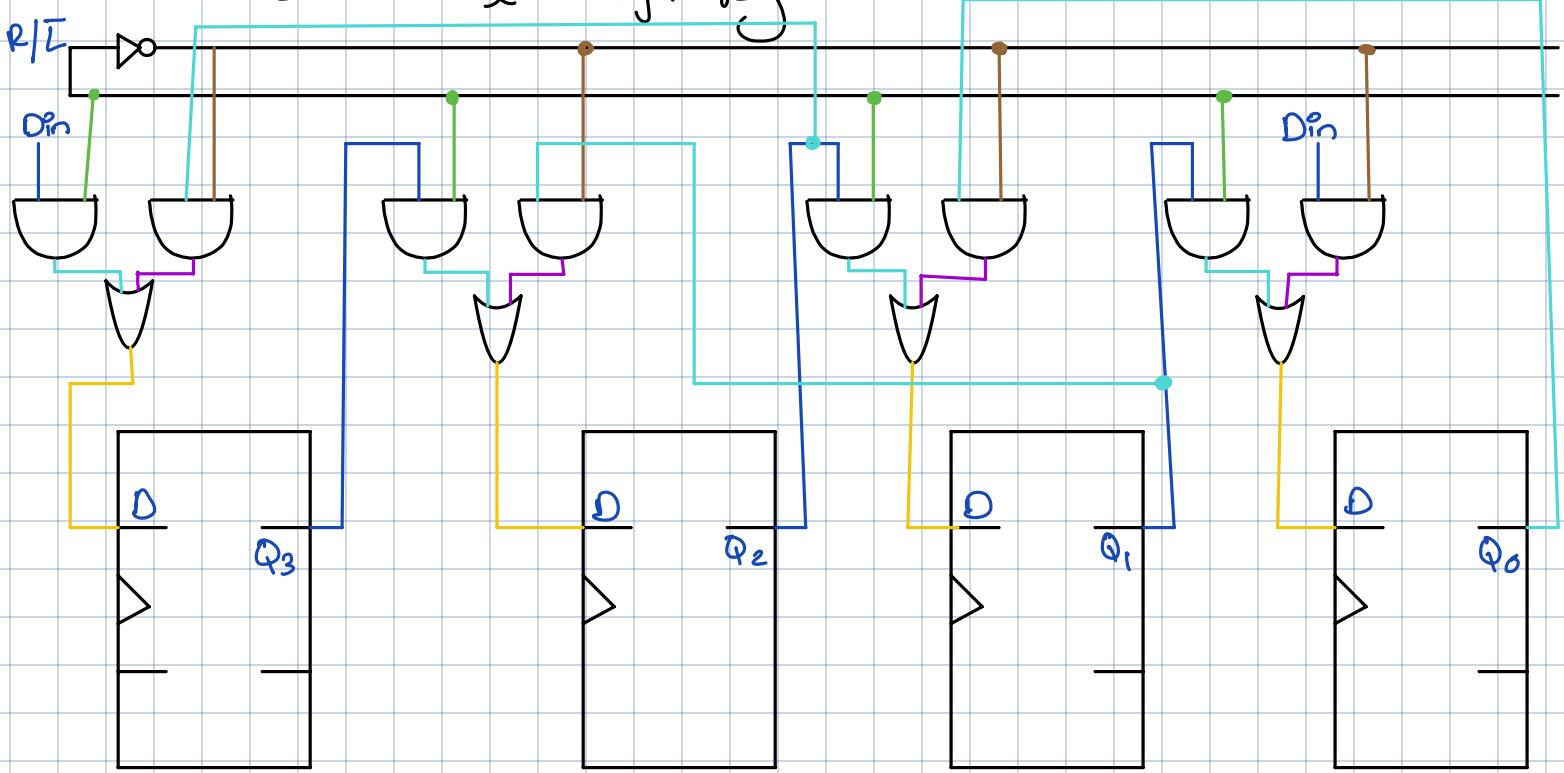


↳ 0 for Loading
↳ 1 for reading

5. Circular Shift Registers:



4 bit bi-directional Shift register:



Mode	Clocks Needed for n-bit Register		
	Loading	Reading	Total
SISO	n	n-1	2n-1
SIPO	n	0	n
PISO	1		n
PIPO	1	0	1

Counters:

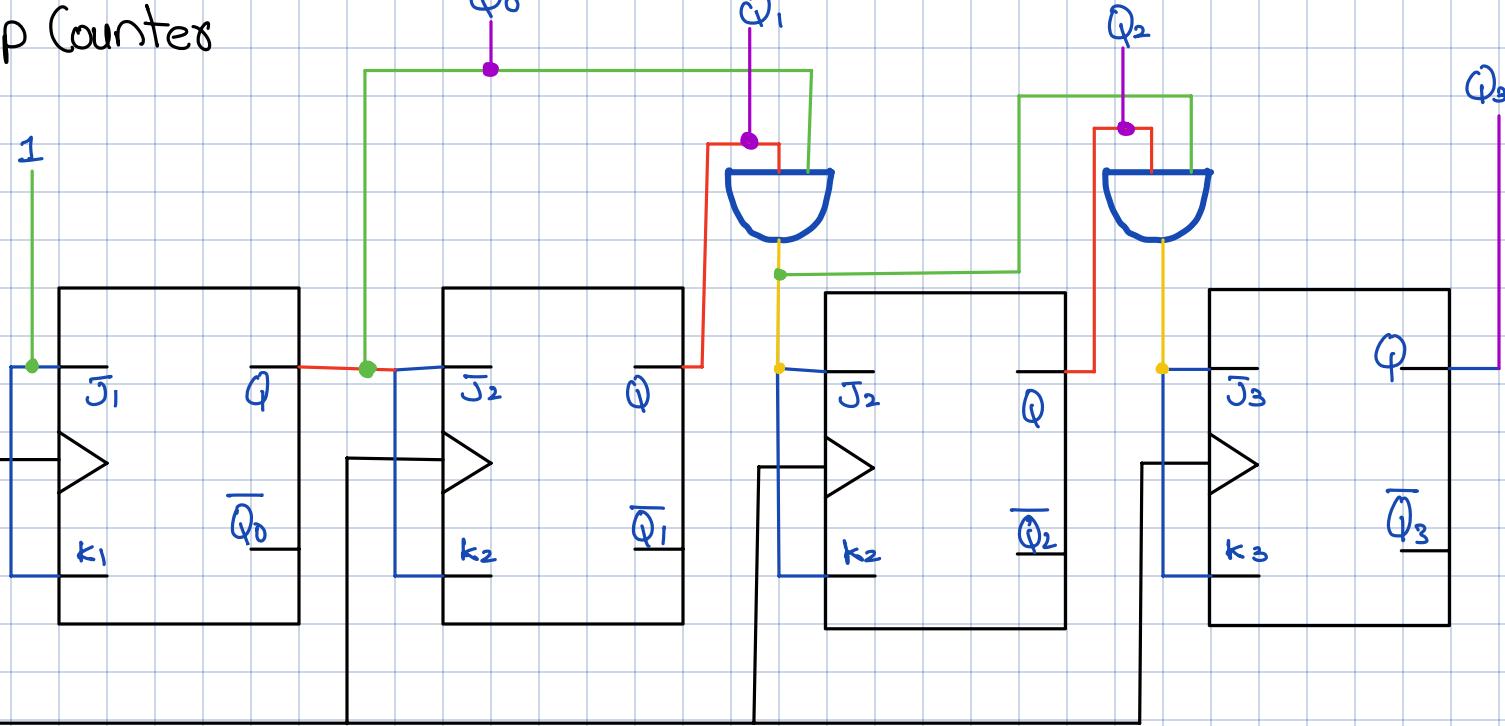
↳ Must count in a fixed sequence

↳ Types:

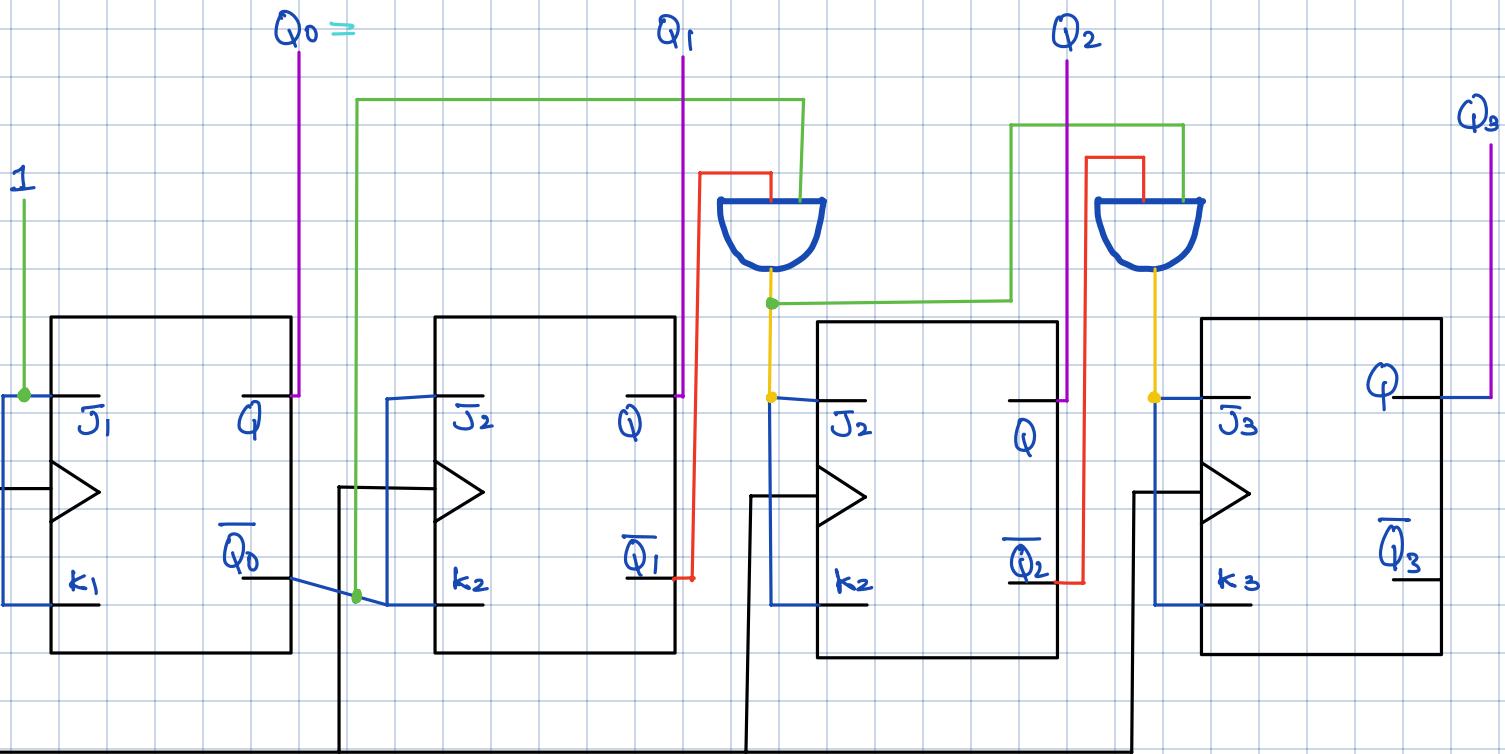
↳ Asynchronous Counters

↳ Synchronous Counter

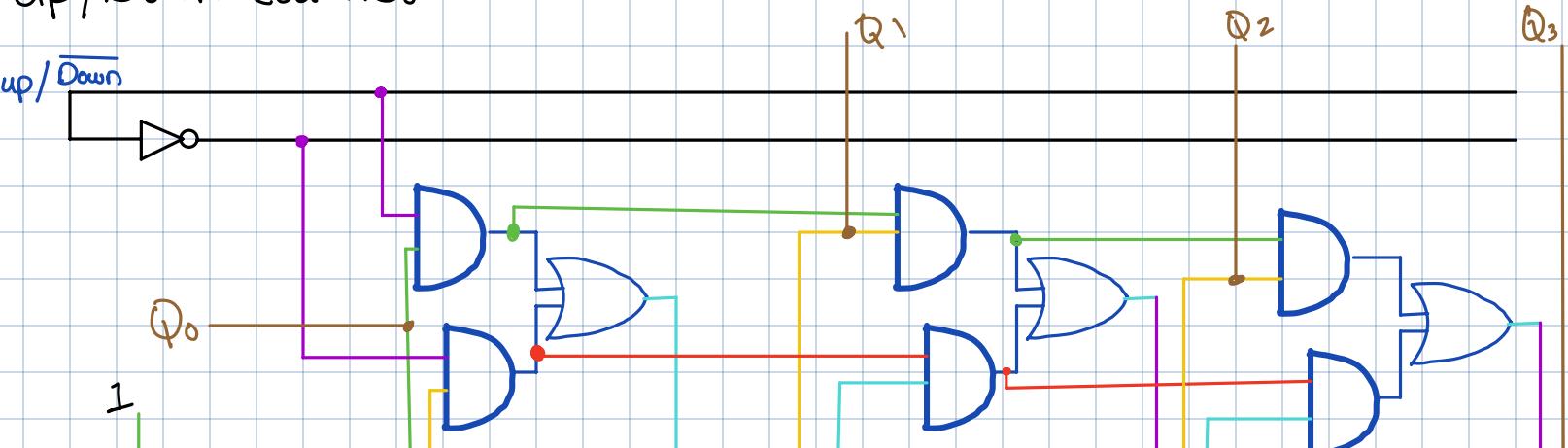
1. Up Counter

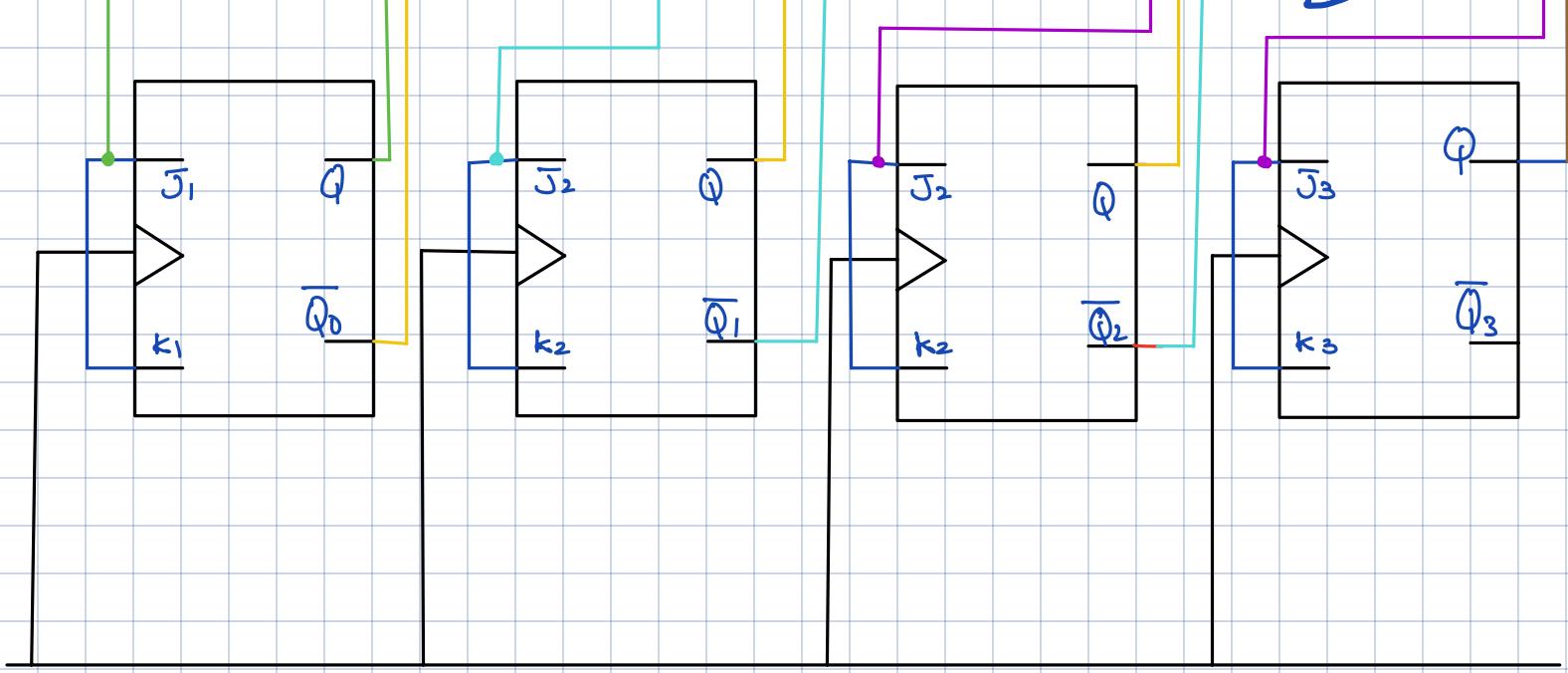


2. Down Counter

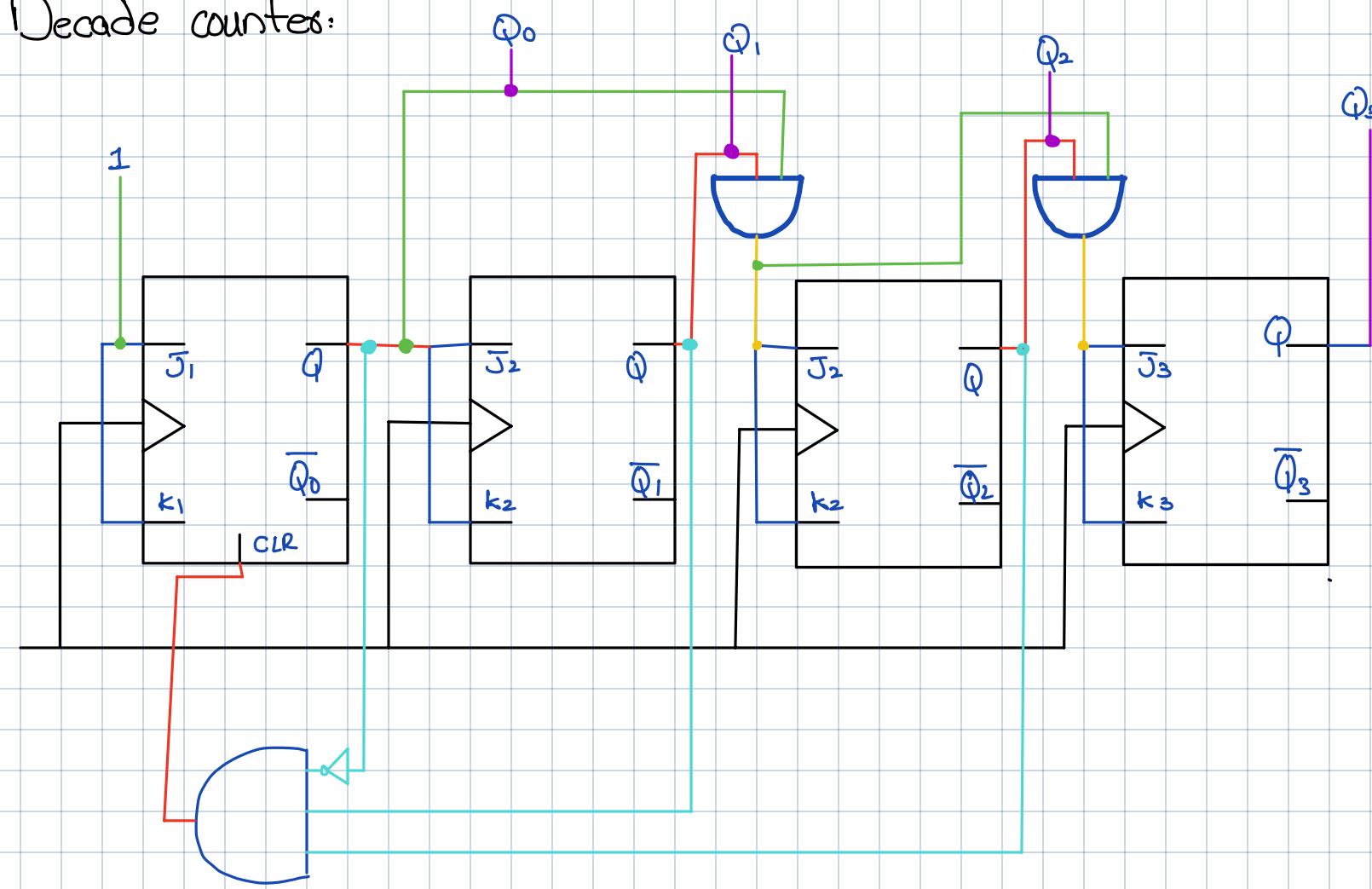


Up/Down Counter:

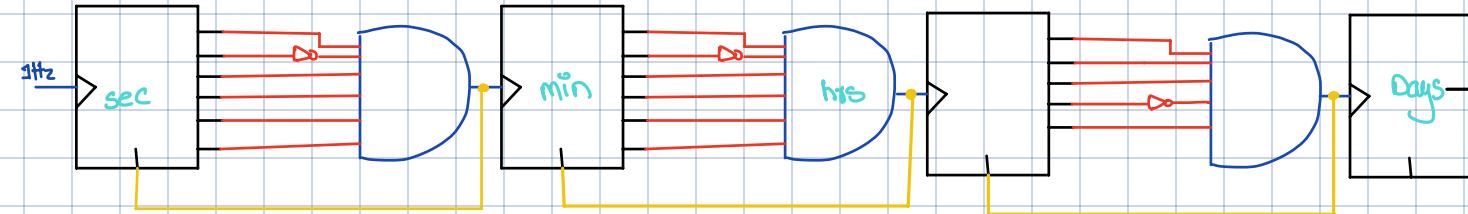




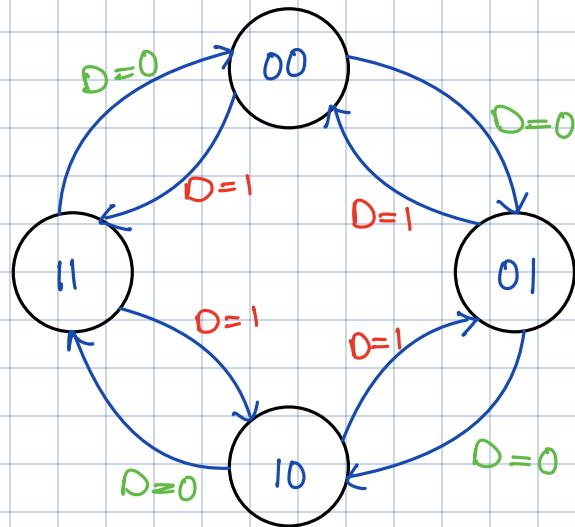
Decade counters:



Clock:



1. State Diagram



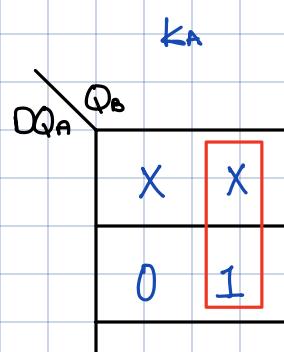
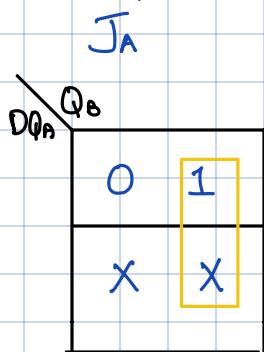
2. Next state table

D	Q_A	Q_B	Q_{A+1}	Q_{B+1}	J_A	K_A	J_B	K_B
0	0	0	0	1	0	X	1	X
0	0	1	1	0	1	X	X	1
0	1	0	1	1	X	0	1	X
0	1	1	0	0	X	1	X	1
1	0	0	1	1	1	X	1	X
1	0	1	0	0	0	X	X	1
1	1	0	0	1	X	1	1	X
1	1	1	1	0	X	0	X	1

3. Excitation table:

Q_N	Q_{N+1}	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

4. K-Maps:



X	X
1	0

1	0
X	X

$$J_A = D\bar{Q}_B + \bar{D}Q_B = k_A$$

J_B

1	X
1	X
1	X
1	X

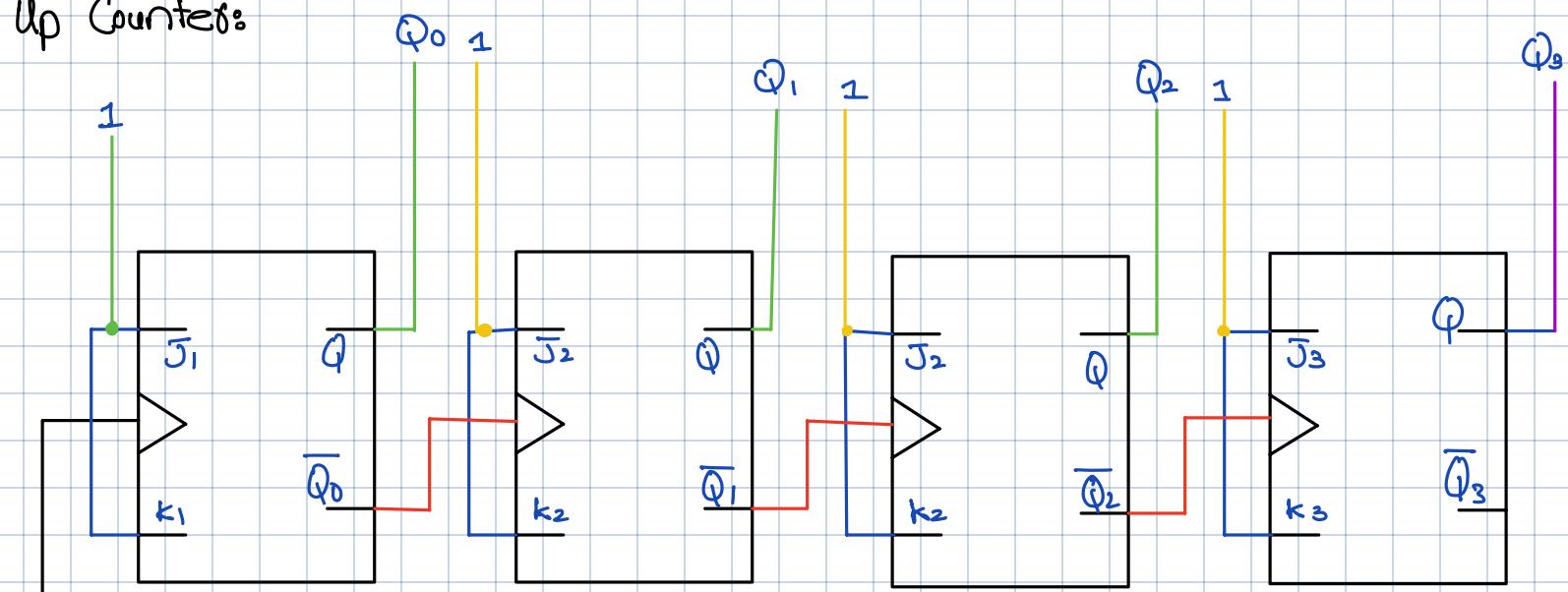
k_B

X	1
X	1
X	1
X	1

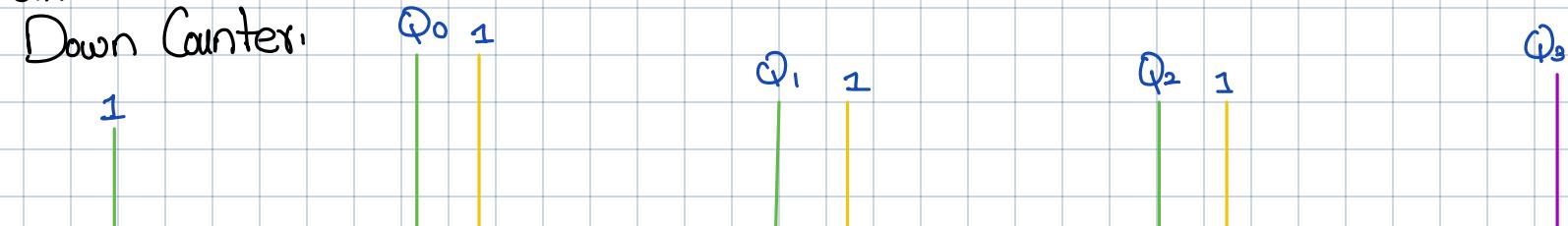
$$J_B = 1 = k_B$$

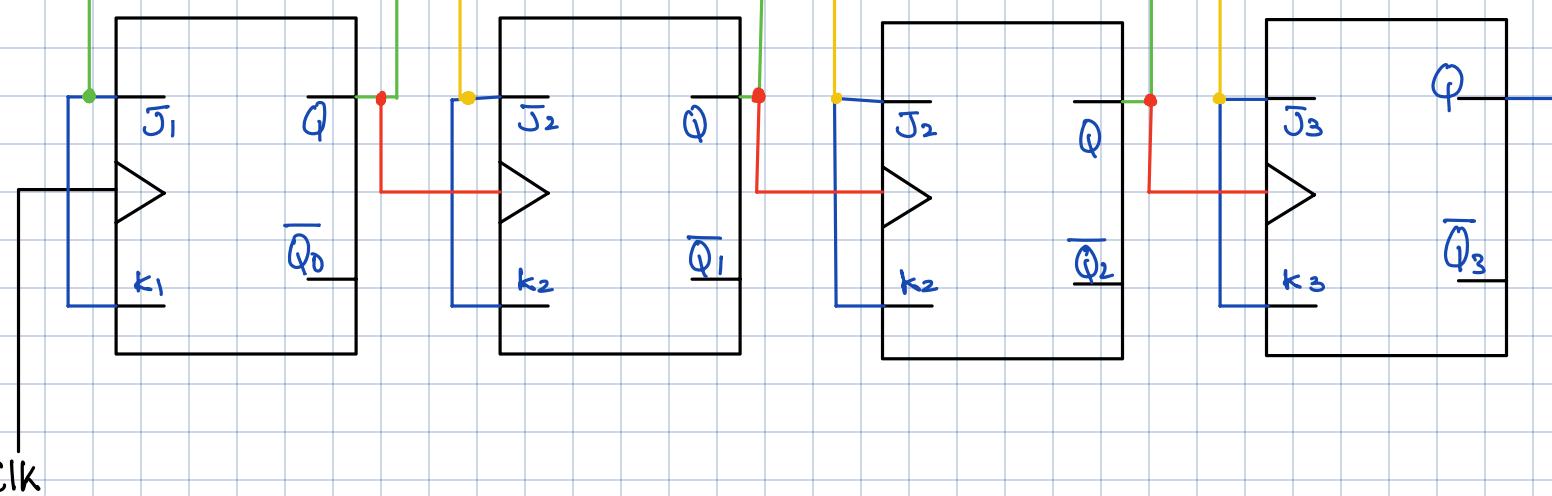
Asynchronous Counters:

Up Counter:



Down Counter:

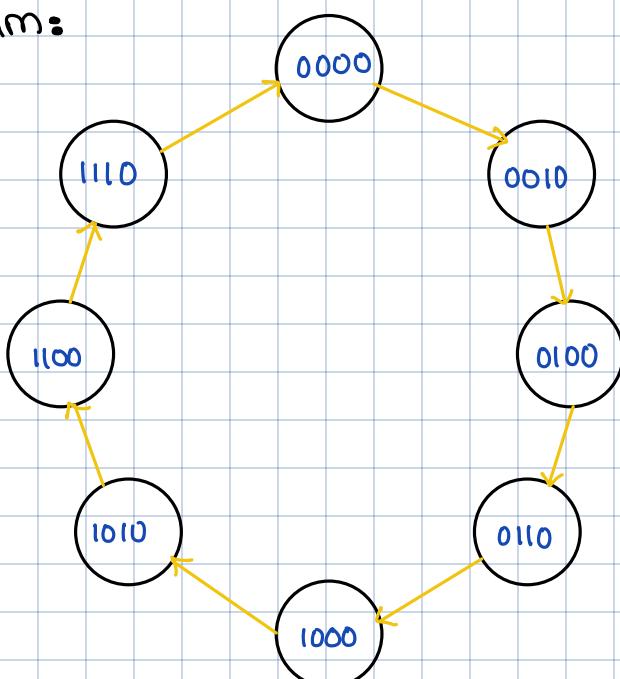




Design Problems:
Counters:

↪ Count in sequence: $0 \rightarrow 2 \rightarrow 4 \rightarrow 6 \rightarrow 8 \rightarrow 10 \rightarrow 12 \rightarrow 14$

1. State diagram:



2. Next state table:

	Q_3	Q_2	Q_1	Q_0	$Q_{3(n)}$	$Q_{2(n)}$	$Q_{1(n)}$	$Q_{0(n)}$	$D_{3(n)}$	$D_{2(n)}$	$D_{1(n)}$	$D_{0(n)}$
0	0	0	0	0	0	0	1	0	0	0	1	0
2	0	0	0	1	X	X	X	X	X	X	X	X
4	0	0	1	0	0	1	0	0	0	1	0	0
6	0	0	1	1	X	X	X	X	X	X	X	X
8	0	1	0	0	0	1	1	0	0	1	1	0
10	0	1	0	1	X	X	X	X	X	X	X	X
12	0	1	1	0	1	0	0	0	1	0	0	0
14	0	1	1	1	X	X	X	X	X	X	X	X
1	1	0	0	0	1	0	1	0	1	0	1	0

10	0	0	1	X	X	X	X	X	X	X	X
12	0	1	0	1	1	0	0	1	1	0	0
14	0	1	1	X	X	X	X	X	X	X	X
1	1	0	0	1	1	0	1	1	1	0	1
1	1	0	1	X	X	X	X	X	X	X	X
1	1	1	0	0	0	0	0	0	0	0	0
1	1	1	1	X	X	X	X	X	X	X	X

3. Excitation table:

$Q \rightarrow Q_n$	D
0 → 0	0
0 → 1	1
1 → 0	0
1 → 1	1

4. K-Maps:

$Q_3 Q_2 \backslash Q_1 Q_0$	00	01	11	10	D_0
00	0	X	X	0	
01	0	X	X	0	
11	0	X	X	0	
10	0	X	X	0	

$$D_0 = 0$$

$Q_3 Q_2 \backslash Q_1 Q_0$	00	01	11	10	D_1
00	1	X	X	0	
01	1	X	X	0	
11	1	X	X	0	
10	1	X	X	0	

$$D_1 = \bar{Q}_1$$

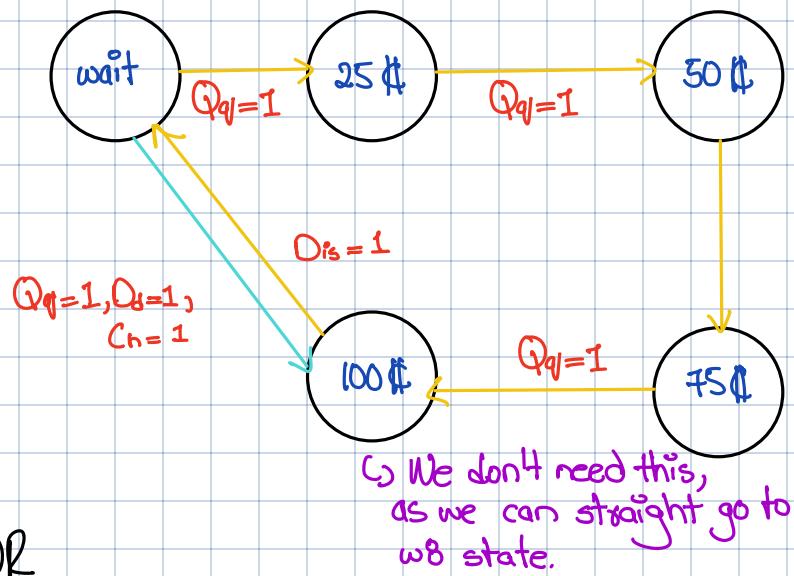
$Q_3 Q_2 \backslash Q_1 Q_0$	00	01	11	10	D_2
00	0	X	X	1	
01	1	X	X	0	
11	1	X	X	0	
10	0	X	X	1	

$Q_3 Q_2 \backslash Q_1 Q_0$	00	01	11	10	D_3
00	0	X	X	0	
01	0	X	X	1	
11	1	X	X	0	
10	1	X	X	1	

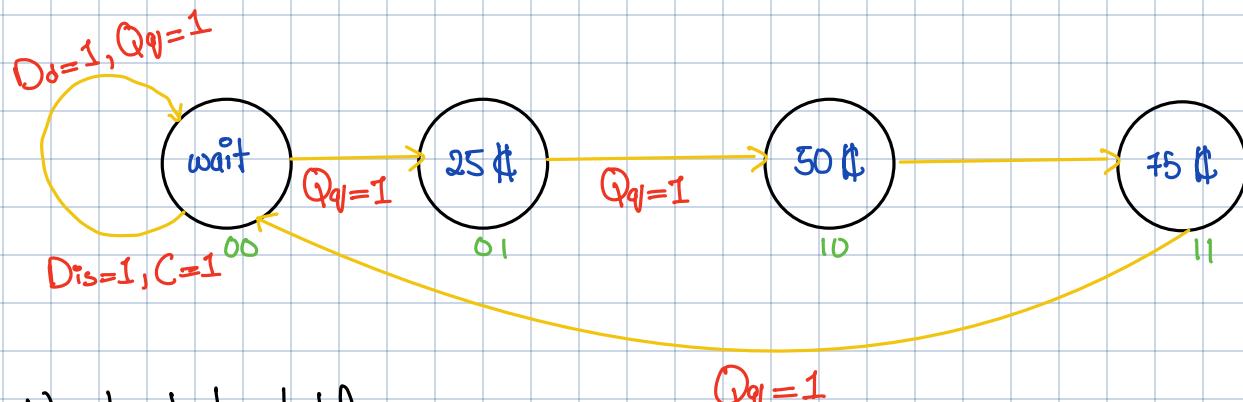
$$D_3 = \bar{Q}_3 \bar{Q}_2 + Q_3 \bar{Q}_1 + \bar{Q}_3 Q_2 Q_1$$

$$D_2 = Q_2 \bar{Q}_1 + \bar{Q}_2 Q_1$$

Vending Machine:



OR



2. Next state table:

Q_1	Q_0	D_d	Q_{qj}	$Q_{1(n)}$	$Q_{0(m)}$	Dispense	Change	$D_{1(n)}$	$D_{0(m)}$
0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	1	0	0	0	1
0	0	1	0	0	0	1	0	0	0
0	0	1	1	0	0	1	1	0	0
0	1	0	0	0	1	0	0	0	1
0	1	0	1	1	0	0	0	1	0
0	1	1	0	0	1	0	0	0	1
0	1	1	1	0	1	0	0	0	1
1	0	0	0	1	0	0	0	1	0
1	0	0	1	1	1	0	0	1	1
1	0	1	0	1	0	0	0	1	0
1	0	1	1	1	0	0	0	1	0
1	1	0	0	1	1	0	0	1	1
1	1	0	1	1	0	1	0	1	0
1	1	1	0	0	0	1	0	0	1
1	1	1	1	1	1	0	0	1	1

4. K-Maps:

$Q_1 Q_0 \backslash Q_d Q_q$	00	01	11	10
00	0	1	0	0
01	1	0	1	1
11	1	0	1	1
10	0	1	0	0

$$D_0 = Q_0 D_d + Q_0 \bar{Q}_q + \bar{Q}_0 \bar{D}_d Q_q$$

$Q_1 Q_0 \backslash Q_d Q_q$	00	01	11	10
00	0	0	0	0
01	0	1	0	0
11	1	0	1	1
10	1	1	1	1

$$D_1 = Q_1 D_d + Q_1 \bar{Q}_q + Q_1 \bar{Q}_0 + \bar{Q}_1 Q_0 \bar{D}_d Q_q$$

$Q_1 Q_0 \backslash Q_d Q_q$	00	01	11	10
00			1	1
01				
11	1			
10				

$$D_{\text{Dispense}} = Q_1 Q_0 \bar{D}_d Q_q + \bar{Q}_1 \bar{Q}_0 D_d$$

$Q_1 Q_0 \backslash Q_d Q_q$	00	01	11	10
00	0	0	1	0
01	0	0	0	0
11	0	0	0	0
10	0	0	0	0

$$\text{Change} = \bar{Q}_1 \bar{Q}_0 D_d Q_q$$

Sequence Detection:

↪ Detect 1001

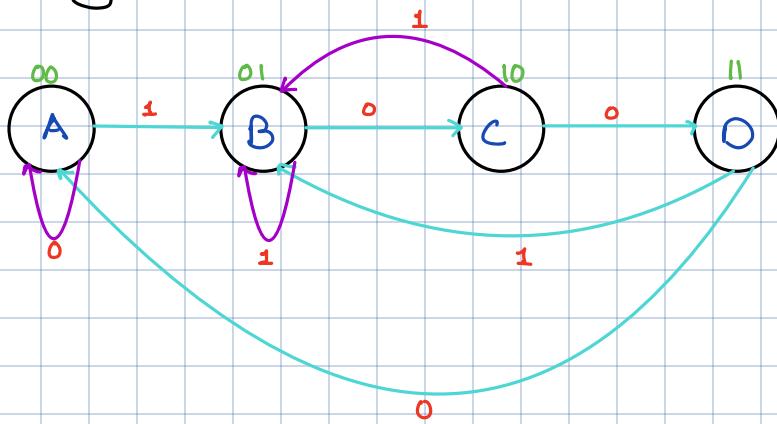
1. With overlapping:

$$X = \underline{1} \underline{0} \underline{0} \underline{1} \underline{0} \underline{0} \underline{1} \underline{0} \underline{0} \underline{1} \underline{0} \underline{0} \underline{1}$$

$$Y = \underline{0} \underline{0} \underline{0} \underline{1} \underline{0} \underline{0} \underline{1} \underline{0} \underline{0} \underline{1} \underline{0} \underline{0} \underline{1}$$

↓ ↓ ↓ ↓
Detected Sequence

a. State Diagram:

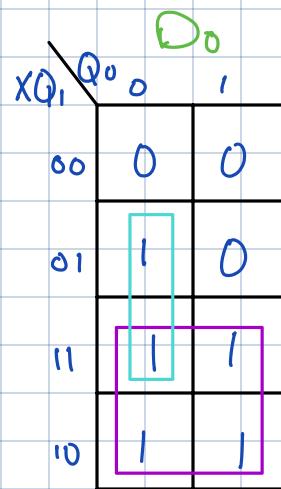


b. State table

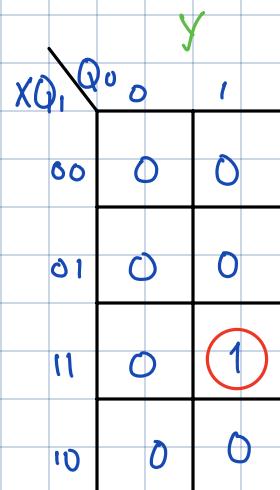
X	Q_1	Q_0	Q_1^t	Q_0^t	Y	D_1	D_0
0	0	0	0	0	0	0	0
0	0	1	1	0	0	1	0
0	1	0	1	1	0	1	1
0	1	1	0	0	0	0	0
1	0	0	0	1	0	0	1
1	0	1	0	1	0	0	1
1	1	0	0	1	0	0	1
1	1	1	0	1	1	0	1

c. K-Maps:

$X\bar{Q}_1$	\bar{Q}_0	1
00	0	1
01	1	0
11	0	0
10	0	0



$$D_0 = X + \bar{Q}_1 \bar{Q}_0$$



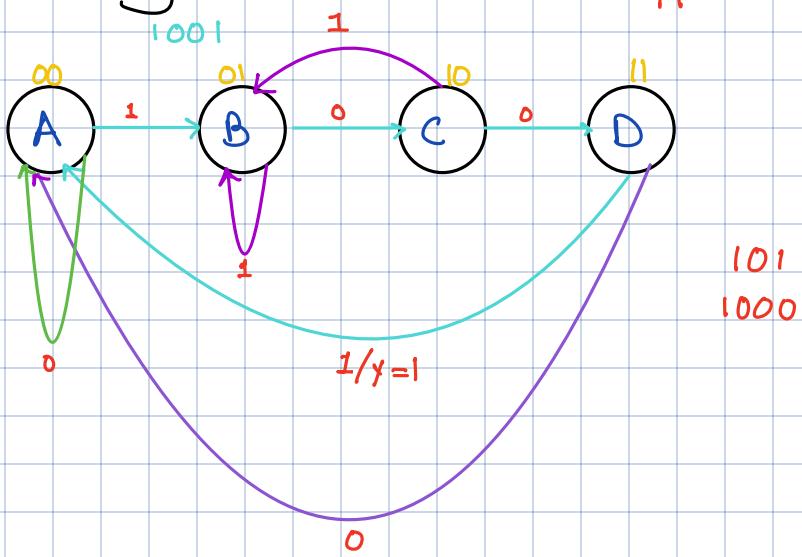
$$Y = X\bar{Q}_1 \bar{Q}_0$$

2. Without Sequence:

$$X = 1 \underline{001} 001 \underline{001} 001$$

$$Y = 0001\underline{000000}1000$$

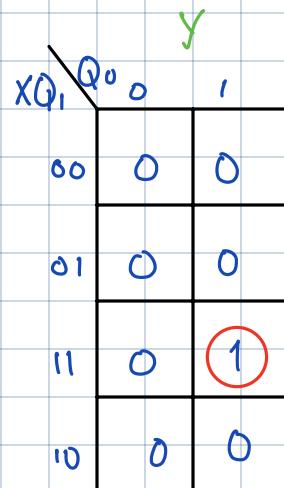
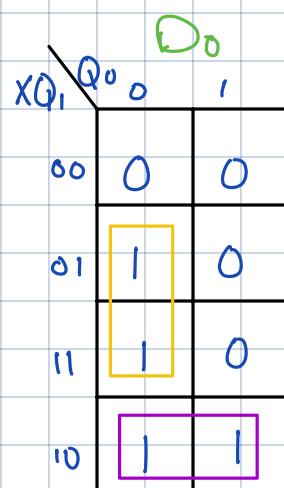
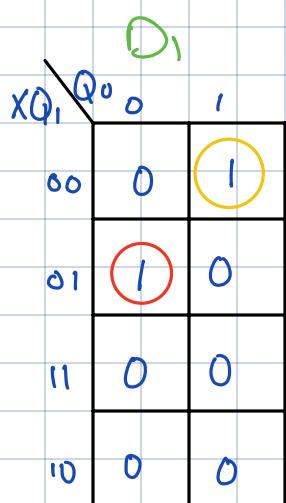
a. State Diagram



b. State table

X	Q_1	Q_0	Q_1^*	Q_0^*	Y	D_1	D_0
0	0	0	0	0	0	0	0
0	0	1	1	0	0	1	0
0	1	0	1	1	0	1	1
0	1	1	0	0	0	0	0
1	0	0	0	1	0	0	1
1	0	1	0	1	0	0	1
1	1	0	0	1	0	0	1
1	1	1	0	0	1	0	0

c. K-Maps:



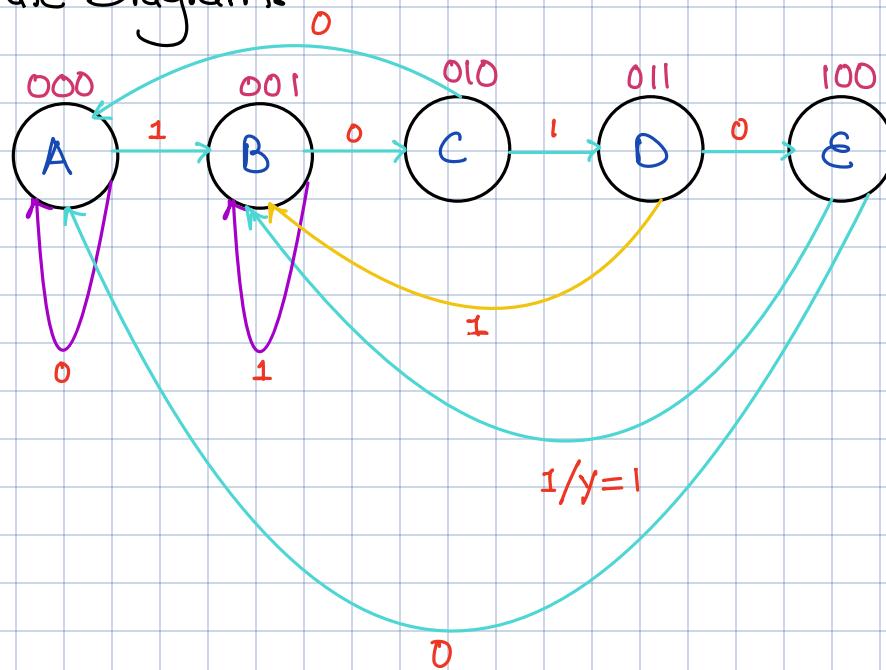
$$D_0 = Q_1 \bar{Q}_0 + X \bar{Q}_1$$

$$Y = X Q_1 Q_0$$

$$D_1 = \bar{X} Q_1 Q_0 + \bar{X} \bar{Q}_1 Q_0$$

2. Detect 10101

a. State Diagram:



b. State table

X	Q_2	Q_1	Q_0	Q_2^+	Q_1^+	Q_0^+	Y
0	0	0	0	0	0	0	0
0	0	0	1	0	1	0	0
0	0	1	0	0	0	0	0
0	0	1	1	1	0	0	0
0	1	0	0	0	0	0	0
0	1	0	1	X	X	X	0
0	1	1	0	X	X	X	0
0	1	1	1	X	X	X	0
1	0	0	0	0	0	1	0
1	0	0	1	0	0	1	0
1	0	1	0	0	1	1	0
1	0	1	1	0	0	1	0
1	1	0	0	0	0	1	1
1	1	0	1	X	X	X	0
1	1	1	0	X	X	X	0
1	1	1	1	X	X	X	0

c. K-Map

D_2

$XQ_2 \backslash Q_1 Q_0$	00	01	11	10
00	0	0	1	0
01	0	X	X	X
11	0	X	X	X
10	0	0	0	0

$$D_2 = \overline{X}Q_1Q_0$$

 D_1

$XQ_2 \backslash Q_1 Q_0$	00	01	11	10
00	0	1	0	0
01	0	X	X	X
11	0	X	X	X
10	0	0	0	1

$$D_1 = \overline{X}\overline{Q}_1Q_0 + XQ_1\overline{Q}_0$$

 D_0

$XQ_2 \backslash Q_1 Q_0$	00	01	11	10
00	0	0	0	0
01	0	X	X	X
11	1	X	X	X
10	1	1	1	1

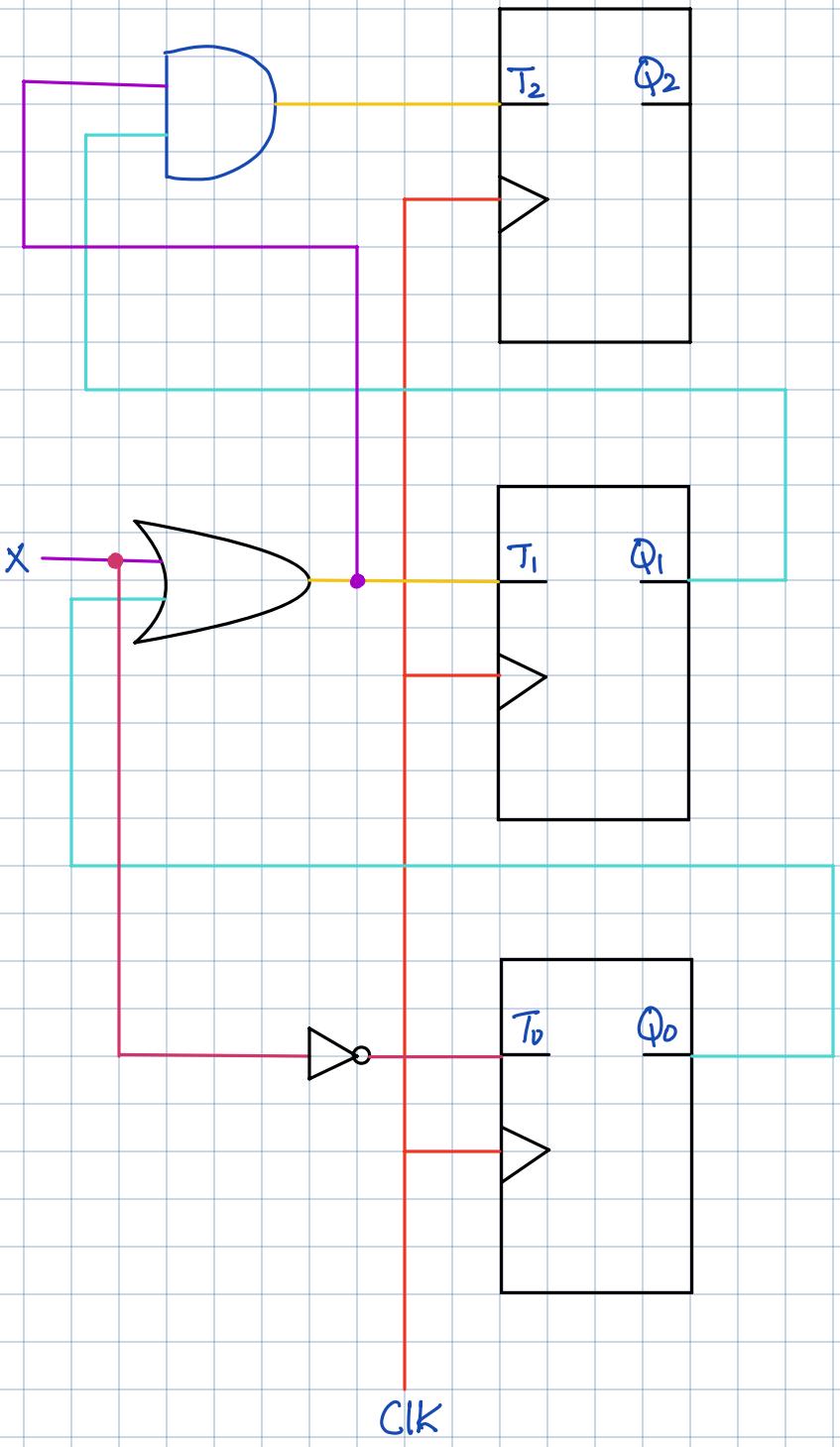
$$D_0 = X$$

 y

$XQ_2 \backslash Q_1 Q_0$	00	01	11	10
00	0	0	0	0
01	0	X	X	X
11	1	X	X	X
10	0	0	0	0

$$Y = XQ_2$$

From Circuit write state table and diagram



Equations:

$$T_2 = Q_1(X + Q_0)$$

$$T_1 = X + Q_0$$

$$T_0 = X$$

State table:

X	Q_2	Q_1	Q_0	Q_2^t	Q_1^t	Q_0^t
0	0	0	0	0	0	1
0	0	0	1	0	1	0
0	0	1	0	0	1	1
0	0	1	1	1	0	0
0	1	0	0	1	0	1
0	1	0	1	1	1	0
0	1	1	0	1	1	1
0	1	1	1	0	0	0
1	0	0	0	0	1	0
1	0	0	1	0	1	1
1	0	1	0	1	0	0
1	0	1	1	1	0	1
1	1	0	0	1	1	0
1	1	0	1	1	1	1
1	1	1	0	0	0	0
1	1	1	1	0	0	1

State diagram:

