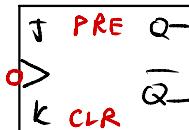


CLK ↗



CLK ↘

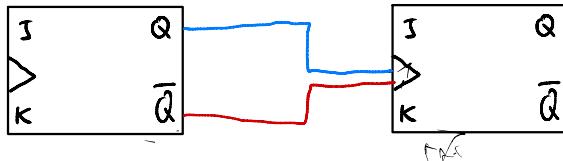
Usually have

→ Invert the CLK

$$M = 4 \rightarrow 2^n = 4 \Rightarrow n = 2$$

$$\text{Count from } 2^n - 1 \rightarrow 0 - 3$$

Count up / down



Count up / down khi có clock invert



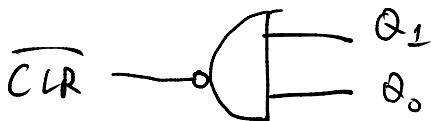
$$M = 5 \quad ?$$

Q_1	Q_0
0	0
0	1
1	0
1	1

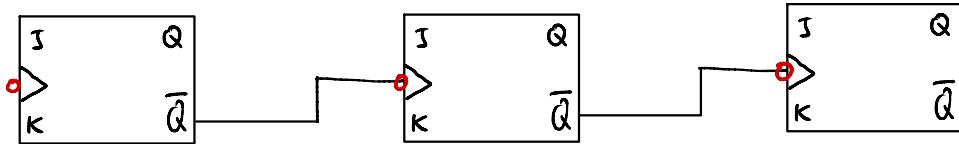
\overline{CLR} — o  Q_1 Q_0 become 0 to active CLR

$$M = 6$$

Q_2	Q_1	Q_0	
0	0	0	0
0	0	1	1
0	1	0	2
0	1	1	3
1	0	0	4
1	0	1	5



Design both up/down



$$M = 8, 2^M \Rightarrow m = 3, 0 - 7$$

$H = 0$, \bar{Q} is connect to CLK
 $H = 1$, \bar{Q} is connect to CLK

H	Q	\bar{Q}
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

Y

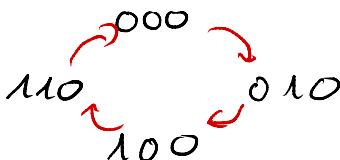
H	Q	\bar{Q}	0	1
	0	0	0	0
	0	1	1	1
	1	0	0	1
	1	1	1	0

$Y = H\bar{Q} + \bar{H}Q$
 $= H \oplus Q$

Synchronous Counter

Step 1: State Diagram

$$0 \rightarrow 2 \rightarrow 4 \rightarrow 6 \rightarrow 0$$



Trans Table

	J	K
0 → 0	0	X
0 → 1	1	X
1 → 0	X	1
1 → 1	X	0

Step 2: Next-state table

Present state | Next state (next)

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

J_2	K_2	J_1	K_1	J_0	K_0
0	X	1	X	0	0
1	X	1	X	0	0
X	0	1	X	0	0
X	1	X	1	1	0

J_0

Q_2	Q_1	Q_0	J_0	Q_2	Q_1	Q_0
0	0	0	0	0	0	X
0	1	0	0	0	1	X
1	1	0	0	1	1	X
1	0	0	0	0	0	X

J_1

Q_2	Q_1	Q_0	J_1	Q_2	Q_1	Q_0
0	0	0	1	1	X	X
0	0	1	0	0	1	X
0	1	0	1	1	X	X
1	1	0	1	0	0	X

$J_2 = Q_1$

Q_2	Q_1	Q_0	$J_2 = Q_1$	Q_2	Q_1	Q_0
0	0	0	0	0	0	0
0	0	1	0	0	1	0
0	1	0	1	1	X	X
1	1	0	1	0	0	X

K_0

Q_2	Q_1	Q_0	K_0	Q_2	Q_1	Q_0
0	0	0	X	0	0	X
0	1	0	X	0	1	X
1	1	0	X	1	1	X
1	0	0	X	0	0	X

K_1

Q_2	Q_1	Q_0	K_1	Q_2	Q_1	Q_0
0	0	0	X	0	0	X
0	0	1	X	0	1	X
0	1	0	X	1	1	X
1	1	0	X	0	0	X

$K_2 = Q_1$

Q_2	Q_1	Q_0	$K_2 = Q_1$	Q_2	Q_1	Q_0
0	0	0	X	0	0	X
0	0	1	X	0	1	X
0	1	0	X	1	1	X
1	1	0	X	0	0	X

1 1 0 - 3 - 5 - 7 - 0

2 1 0 - 1 - 2 - 4 - 5 - 3 - 6 - 7 - 0

3 1 0 - 1 - 3 - 2 - 6 - 7 - 5 - 4 - 0

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Trans Table	
0	0
0	1
1	0
1	1

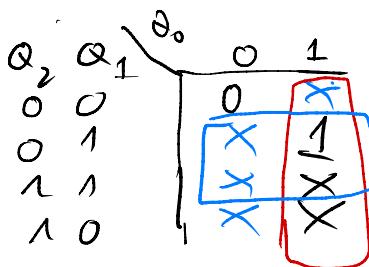
Present state N ext C state

Q_2	Q_1	Q_0	N_{ext}	C_{state}
0	0	0	0 1 1	
0	1	1	1 0 1	
1	0	1	1 1 1	
1	1	1	0 0 0	

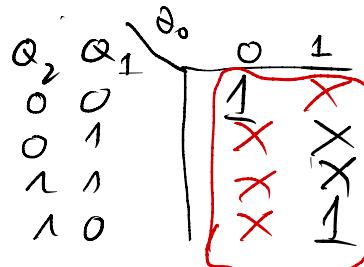
J_2	K_2	J_1	K_1
0	X	1	X
0	X	1	X
1	X	1	X
0	X	1	X

J_0	K_0
1	X
X	0
0	X

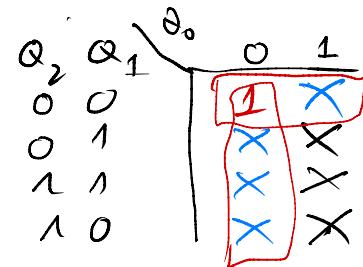
$$J_2 = Q_1$$



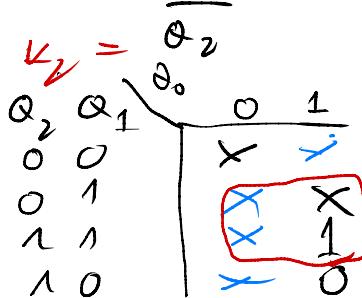
$$J_1 = 0$$



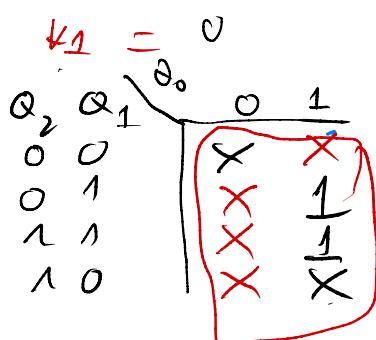
$$J_0 = \bar{Q}_0$$



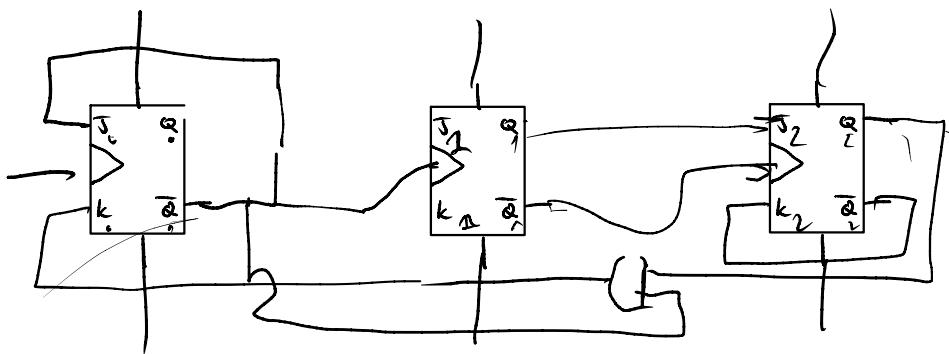
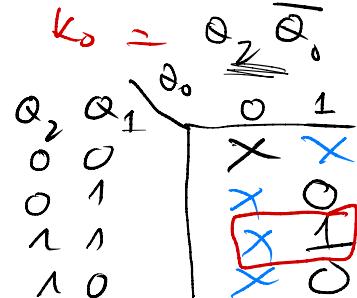
$$K_2 = \bar{Q}_2$$



$$K_1 = 0$$



$$K_0 = \bar{Q}_2 \bar{Q}_0$$



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Table	
	K
0 → 0	0
0 → 1	1
1 → 0	X
1 → 1	0

Present state			1 st ext	2 nd ext	etc
0	Q ₂	Q ₁	Q ₂ ⁺	Q ₁ ⁺	Q ₀ ⁺
1	0	0	0	0	1
2	0	0	1	0	0
3	0	1	0	0	0
4	1	0	0	1	0
5	1	0	1	0	1
6	0	1	1	1	1
7	1	1	0	1	1
			0	0	0

Transition Table		
0 → 0	0	X
0 → 1	1	X
1 → 0	X	0
1 → 1	X	0

0 1 2 4 5 3 6 7

J₂ =

		θ ₀
Q ₂	Q ₁	0
0	0	0
0	1	0
1	1	1
1	0	X

J₁ =

		θ ₀
Q ₂	Q ₁	0
0	0	0
0	1	0
1	1	1
1	0	X

J₀ =

		θ ₀
Q ₂	Q ₁	0
0	0	1
0	1	X
1	1	X
1	0	1

K₂ =

		θ ₀
Q ₂	Q ₁	0
0	0	0
0	1	X
1	1	X
1	0	1

K₁ =

		θ ₀
Q ₂	Q ₁	0
0	0	0
0	1	1
1	1	0
1	0	X

K₀ =

		θ ₀
Q ₂	Q ₁	0
0	0	X
0	1	1
1	1	X
1	0	X

Q₂ ⊕ Q₁

3/ 0 - 1 - 3 - 2 - 6 - 7 - 5 - 4 - 0

Present State	Next State
$Q_2 \ Q_1 \ Q_0$	$Q_2^+ \ Q_1^+ \ Q_0^+$
0 0 0	0 0 1
0 0 1	0 1 1
0 1 1	0 1 0
0 1 0	1 1 0
1 1 0	1 1 1
1 1 1	1 0 1
1 0 1	1 0 0
1 0 0	0 0 0

$J_2 \ K_2$	$J_1 \ K_1$	$J_0 \ K_0$
0 X	0 X	1 X
1 X	1 X	0 1
0 X	0 X	0 X
X 0	X 0	1 X
X X	X 1	0 X
X 0	X 1	1 X
X 0	X X	0 1
X 1	0 X	0 X

$$J_2 = Q_0 + Q_1$$

$Q_2 \ Q_1$	Q_0	J_2
0 0	0	0
0 1	1	1
1 1	X	X
1 0	X	X

$$J_1 = \overline{Q_0} \overline{Q_2}$$

$Q_2 \ Q_1$	Q_0	J_1
0 0	0	0
0 1	0	1
1 1	X	X
1 0	0	0

$$J_0 = \overline{Q_2} \overline{Q_1} + \overline{Q_2} Q_1$$

$Q_2 \ Q_1$	Q_0	J_0
0 0	0	1
0 1	1	X
1 1	X	X
1 0	0	X

$$K_2 = Q_0 + Q_2 \overline{Q_1}$$

$Q_2 \ Q_1$	Q_0	K_2
0 0	X	X
0 1	X	X
1 1	0	0
1 0	0	1

$$K_1 = Q_0 Q_2$$

$Q_2 \ Q_1$	Q_0	K_1
0 0	X	X
0 1	0	0
1 1	0	1
1 0	X	X

$$K_0 = \overline{Q_2} Q_1 + Q_2 \overline{Q_1}$$

$Q_2 \ Q_1$	Q_0	K_0
0 0	X	0
0 1	1	X
1 1	X	0
1 0	1	X

