ECEn/CS 224
Chapter 14 Homework Solutions

14.1 Design a 2-bit gray code counter with a CLR input and a INC input. In the case CLR = INC = '1', have the counter also increment.

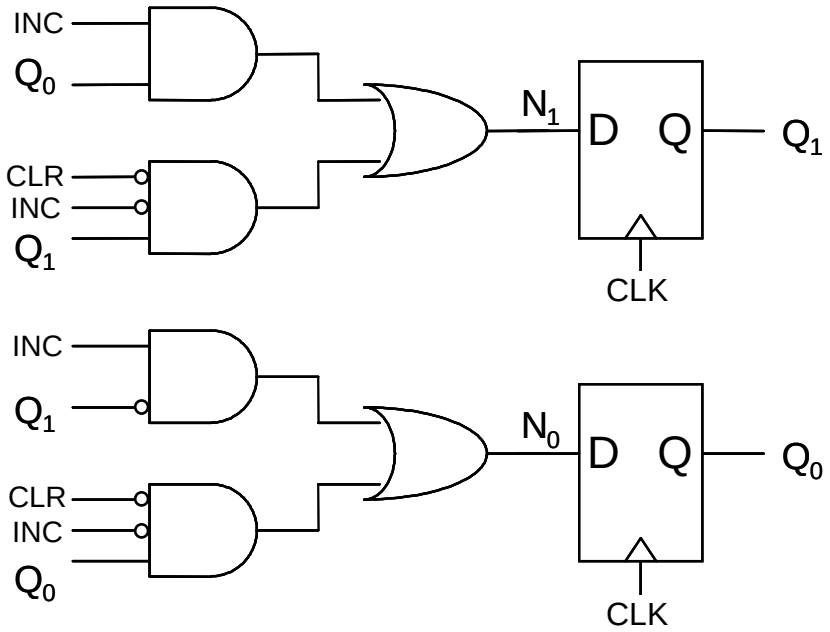
CLR	INC	Q_1	Q_0	N_1	N_0
0	0	0	0	0	0
0	0	0	1	0	1
0	0	1	0	1	0
0	0	1	1	1	1
0	1	0	0	0	1
0	1	0	1	1	1
0	1	1	0	0	0
0	1	1	1	1	0
1	0	0	0	0	0
1	0	0	1	0	0
1	0	1	0	0	0
1	0	1	1	0	0
1	1	0	0	0	1
1	1	0	1	1	1
1	1	1	0	0	0
1	1	1	1	1	0

N_1	CLR INC: 00	01	11	10
Q_1Q_0 = 00				
01		1	1	
11	1	1	1	
10	1			

N_0	CLR INC: 00	01	11	10
Q_1Q_0 = 00		1	1	
01	1	1	1	
11	1			
10				

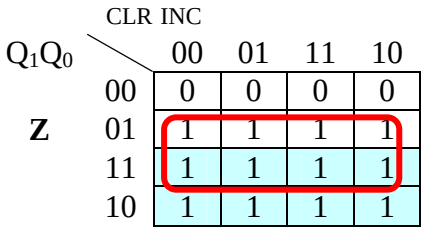
$N_1 = INC \cdot Q_0 + CLR' \cdot INC' \cdot Q_1$

$N_0 = INC \cdot Q_1' + CLR' \cdot INC' \cdot Q_0$



14.2 Modify the transition table for the counter in the previous problem to contain a static output. This output (call it *Z*) should be asserted any time the current counter value is not equal to '00'. Finally, write the equation for *Z*.

CLR	INC	Q_1	Q_0	N_1	N_0	Z
0	0	0	0	0	0	0
0	0	0	1	0	1	1
0	0	1	0	1	0	1
0	0	1	1	1	1	1
0	1	0	0	0	1	0
0	1	0	1	1	1	1
0	1	1	0	0	0	1
0	1	1	1	1	0	1
1	0	0	0	0	0	0
1	0	0	1	0	0	1
1	0	1	0	0	0	1
1	0	1	1	0	0	1
1	1	0	0	0	1	0
1	1	0	1	1	1	1
1	1	1	0	0	0	1
1	1	1	1	1	0	1



$$Z = Q_0 + Q_1$$

14.4 Design a 2-bit up/down counter. When CLR = '1' it should clear. Otherwise, the UP/DOWN# signal is as follows: '0' = decrement, '1' = increment.

For simplicity, we will refer to UP/DOWN# as simply U in this solution.

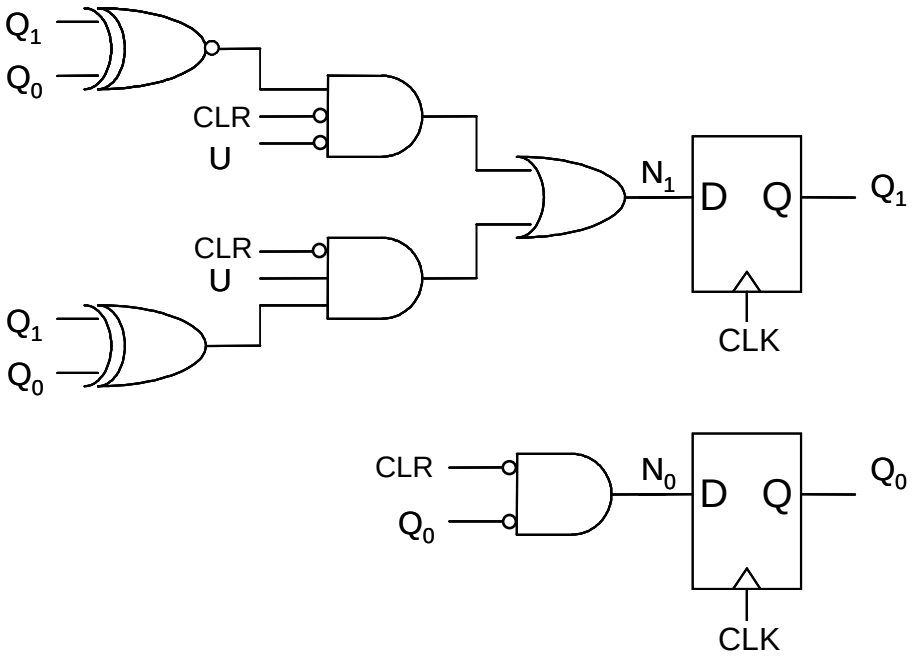
CLR	U	Q_1	Q_0	N_1	N_0
0	0	0	0	1	1
0	0	0	1	0	0
0	0	1	0	0	1
0	0	1	1	1	0
0	1	0	0	0	1
0	1	0	1	1	0
0	1	1	0	1	1
0	1	1	1	0	0
1	-	-	-	0	0

N_1	CLR U: 00	01	11	10
Q_1Q_0 = 00	1			
01		1		
11	1			
10		1		

N_0	CLR U: 00	01	11	10
Q_1Q_0 = 00	1	1		
01				
11				
10	1	1		

$N_1 = CLR' \bullet U' \bullet (Q_1' \bullet Q_0' + Q_1 \bullet Q_0) + Clr' \bullet U \bullet (Q_1' \bullet Q_0 + Q_1 \bullet Q_0')$

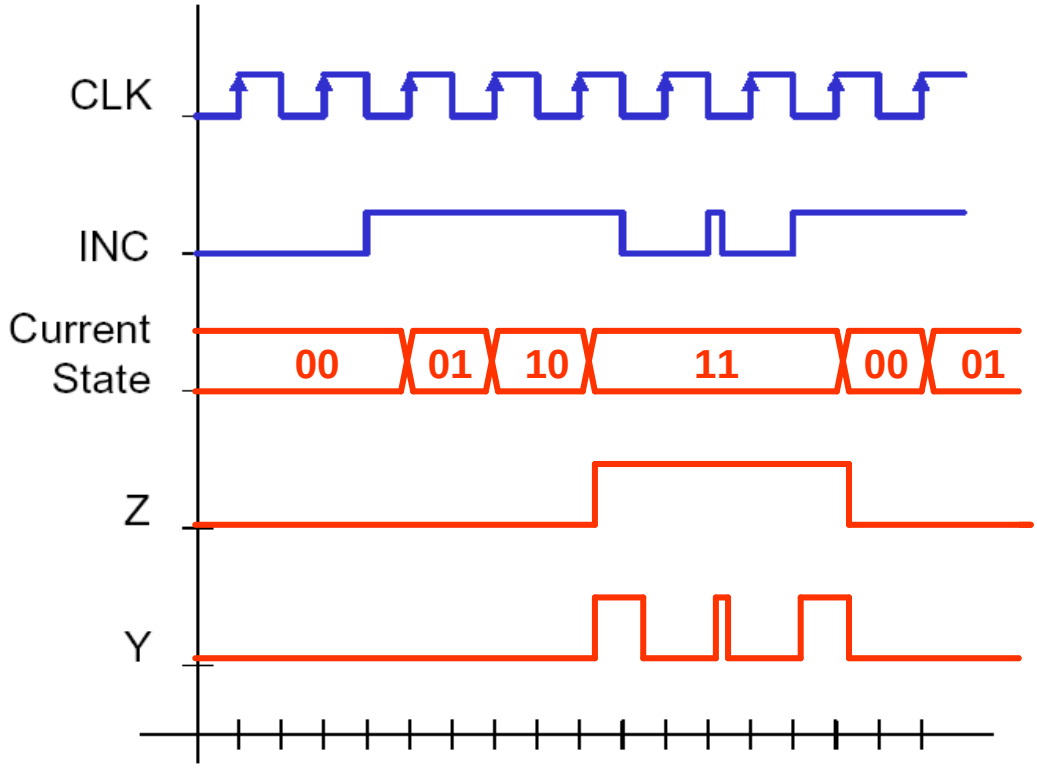
$N_0 = CLR' \bullet Q_0'$



14.5 Below is a timing diagram for the counter of Figure 14.6. Complete the waveforms for Z and Y assuming the counter value starts as '00'. Use approximate timing.

INC	Q1	Q0	N1	N0	Z	Y
0	0	0	0	0	0	0
0	0	1	0	1	0	0
0	1	0	1	0	0	0
0	1	1	1	1	1	0
1	0	0	0	1	0	0
1	0	1	1	0	0	0
1	1	0	1	1	0	0
1	1	1	0	0	1	1

Figure 14.6



14.6 Determine what happens when INC = CLR = '1' in the case of the transition table shown in Figure 14.5.

CLR	INC	Q1	Q0	N1	N0
0	0	0	0	0	0
0	0	0	1	0	1
0	0	1	0	1	0
0	0	1	1	1	1
0	1	0	0	0	1
0	1	0	1	1	0
0	1	1	0	1	1
0	1	1	1	0	0
1	0	0	0	0	0
1	0	0	1	0	0
1	0	1	0	0	0
1	0	1	1	0	0
1	1	0	0	X	X
1	1	0	1	X	X
1	1	1	0	X	X
1	1	1	1	X	X

Figure 14.5

N_1	CLR INC 00	01	11	10
Q_1Q_0 00			x	
01		1	x	
11	1		x	
10	1	1	x	

N_0	CLR INC 00	01	11	10
Q_1Q_0 00		1	x	
01	1		x	
11	1		x	
10		1	x	

$N_1 = INC \bullet Q_1' \bullet Q_0 + CLR' \bullet INC' \bullet Q_1 + CLR' \bullet Q_1 \bullet Q_0'$
$N_0 = CLR' \bullet INC' \bullet Q_0 + INC \bullet Q_0'$

For INC = CLR = '1', these equations become:

$N_1 = Q_1' \bullet Q_0$
$N_0 = Q_0'$

Thus we have the transition table rows shown below. Notice that the first two and the last row have the behavior of incrementing, whereas the third row has the behavior or decrementing.

CLR	INC	Q1	Q0	N1	N0
1	1	0	0	0	1
1	1	0	1	1	0
1	1	1	0	0	1
1	1	1	1	0	0