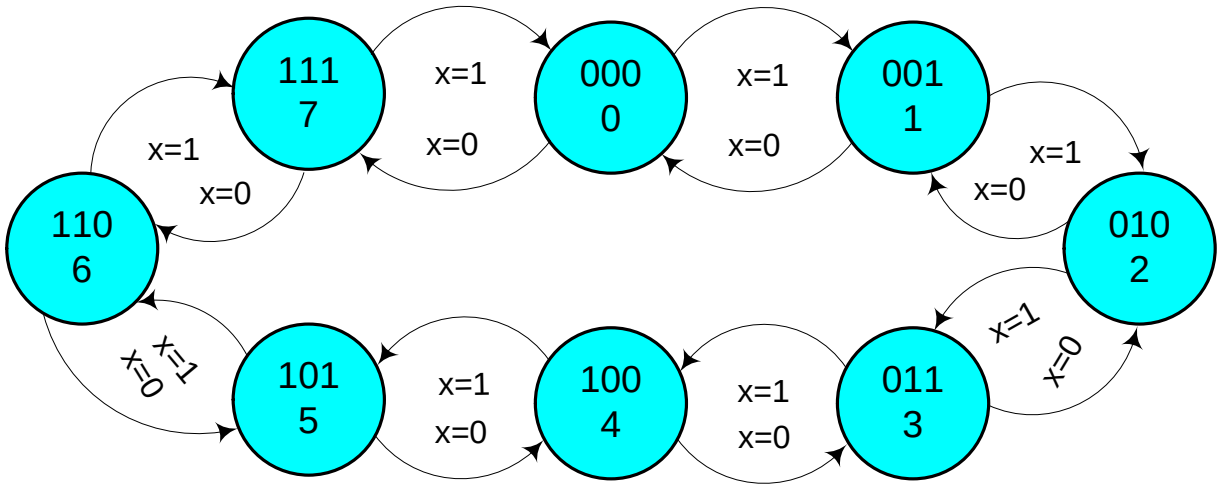
Example #2

Design a 3-bit Up-Down Counter. The counter counts up when input x=1 and counts down when input x=0. Design your circuit with D-Flip Flops and then use T Flip Flops. Compare your results.

Starting with the state diagram

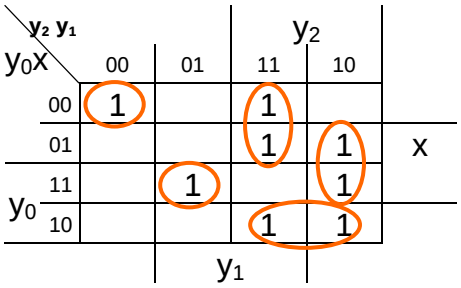


From the state diagram we deduce the state table directly without state assignment

Present State			Next State					
			x=1			x=0		
y_2	y_1	y_0	y_2^+	y_1^+	y_0^+	y_2^+	y_1^+	y_0^+
0	0	0	0	0	1	1	1	1
0	0	1	0	1	0	0	0	0
0	1	0	0	1	1	0	0	1
0	1	1	1	0	0	0	1	0
1	0	0	1	0	1	0	1	1
1	0	1	1	1	0	1	0	0
1	1	0	1	1	1	1	0	1
1	1	1	0	0	0	1	1	0

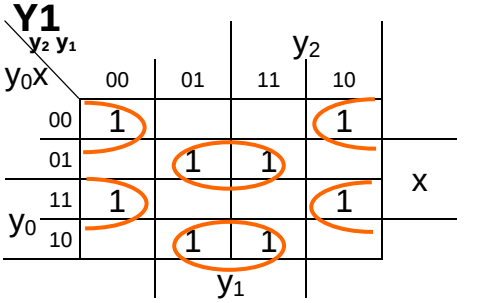
Next we determine the Next state table and since Y+ = D input then the excitation tables can be easily written from the transition table.

Y2



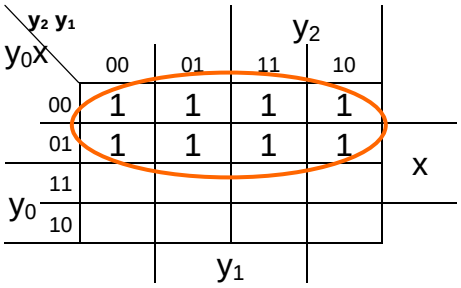
$$y_2^+ = \bar{y}_2 y_1 y_0 x + y_2 y_1 \bar{y}_0 + y_2 \bar{y}_1 x + \bar{y}_2 y_1 y_0 x + y_2 y_0 \bar{x}$$

Y1



$$y_1^+ = \bar{y}_1 y_0 x + y_1 \bar{y}_0 x + \bar{y}_1 y_0 x + y_1 y_0 \bar{x}$$

Y0



$$y_0^+ = \bar{y}_0$$

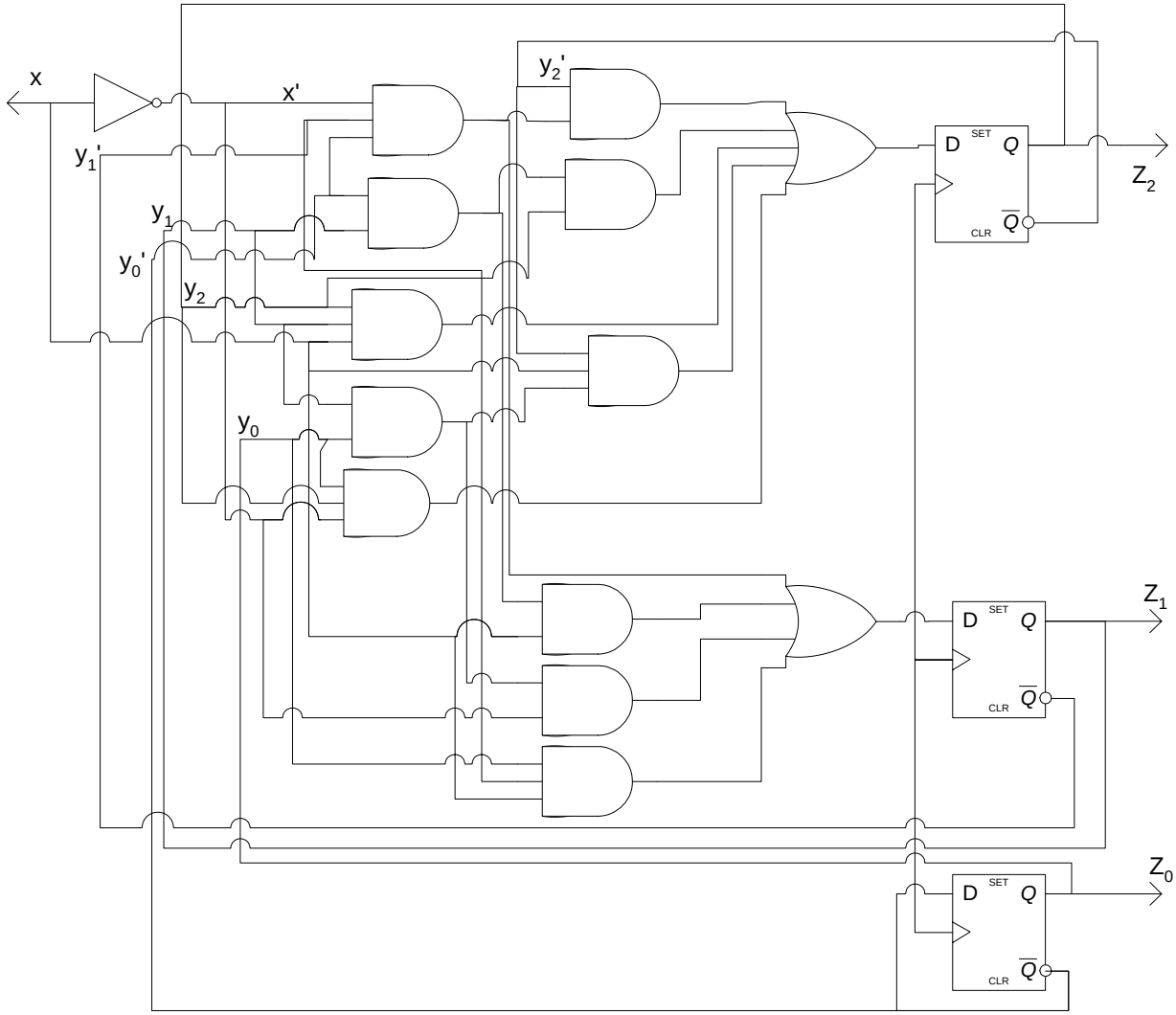
using D-FFs then the excitation vectors are:

$$D_2 = y_2^+ = \bar{y}_2 \bar{y}_1 \bar{y}_0 \bar{x} + y_2 y_1 \bar{y}_0 + y_2 \bar{y}_1 x + \bar{y}_2 y_1 y_0 x + y_2 y_0 \bar{x}$$

$$D_1 = y_1^+ = \bar{y}_1 \bar{y}_0 \bar{x} + y_1 \bar{y}_0 x + \bar{y}_1 y_0 x + y_1 y_0 \bar{x}$$

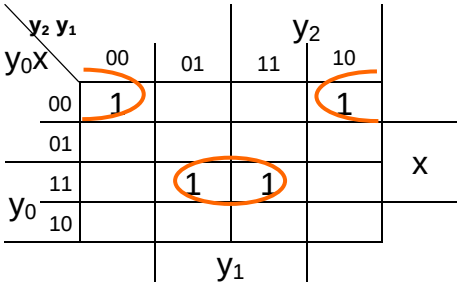
$$D_0 = y_0^+ = \bar{y}_0$$

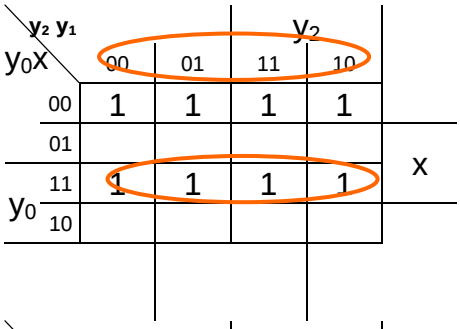
Circuit Diagram with D-Flip Flop

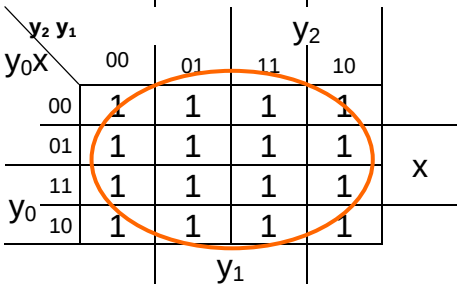


For the T-Flip Flop we do the next state K-Map

Y2 Transitions







T2 = y1 y0 x + y0' y1 'x'
T1 = x' y0' + x y0
T0= 1

Then draw the map accordingly. Assuming that the D-Flip Flop and T-Flip Flop being of equal price and quality, then the T-Flip Flop implementation is more economical