ITI1100B&C

Professor: Qi Hao

Assignment # 6

Submission Deadline April 5th, 2017 midnight (11h59 PM), BlackBoard Learn

From the textbook Chapter five pages from pages 291 to 295, solve the following problems:

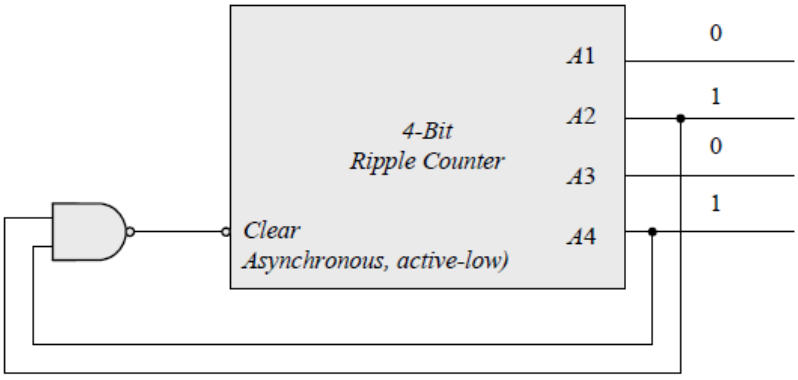
6.11, 6.13, 6.19, 6.27

6.11 Total 4 points

(a) A count down counter. 2 points

(b) A count up counter. 2 points

6.13 Total 4 points



6.19 **(a)**

Total 20 points

Present state	*Next state*	*Flip-flop inputs*			
$A_8\,A_4\,A_2\,A_1$	$A_8\,A_4\,A_2\,A_1$	$J_{A8}\,K_{A8}$	$J_{A4}\,K_{A4}$	$J_{A2}\,K_{A2}$	$J_{A1}\,K_{A1}$
0 0 0 0	0 0 0 1	0 x	0 x	0 x	1 x
0 0 0 1	0 0 1 0	0 x	0 x	1 x	x 1
0 0 1 0	0 0 1 1	0 x	0 x	x 0	1 x
0 0 1 1	0 1 0 0	0 x	1 x	x 1	x 1
0 1 0 0	0 1 0 1	0 x	x 0	0 x	1 x
0 1 0 1	0 1 1 0	0 x	x 0	1 x	x 1
0 1 1 0	0 1 1 1	0 x	x 0	x 0	1 x
0 1 1 1	1 0 0 0	1 x	x 1	x 1	x 1
1 0 0 0	1 0 0 1	x 0	0 x	0 x	1 x
1 0 0 1	0 0 0 0	x 1	0 x	0 x	x 1

3 points

$d(A_8, A_4, A_2, A_1) = \Sigma\,(10, 11, 12, 13, 14, 15)$

Flip Flop A_8

$J_{A8} = A_4A_2A_1$ 2 points $K_{A8} = A_1$

A_8A_4 \ A_2A_1	00	01	11	10
00	m_0	m_1	m_3	m_2
01	m_4	m_5	m_7 1	m_6
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8 x	m_9 x	m_{11} x	m_{10} x

A_8A_4 \ A_2A_1	00	01	11	10
00	m_0 x	m_1 x	m_3 x	m_2 x
01	m_4 x	m_5 x	m_7 x	m_6 x
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8	m_9 1	m_{11} x	m_{10} x

Flip Flop A_4

$J_{A4} = A_2A_1$ 2 points $K_{A4} = A_2A_1$

A_8A_4 \ A_2A_1	00	01	11	10
00	m_0	m_1	m_3 1	m_2
01	m_4 x	m_5 x	m_7 x	m_6 x
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8	m_9	m_{11} x	m_{10} x

Q_3Q_2 \ Q_1Q_0	00	01	11	10
00	m_0 x	m_1 x	m_3 x	m_2 x
01	m_4	m_5	m_7 1	m_6
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8 x	m_9 x	m_{11} x	m_{10} x

Flip Flop A_2

$J_{A2} = A_8'A_1$ 2 points $K_{A2} = A_1$

A_8A_4 \ A_2A_1	00	01	11	10
00	m_0	m_1 1	m_3 x	m_2 x
01	m_4	m_5 1	m_7 x	m_6 x
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8	m_9	m_{11} x	m_{10} x

A_8A_4 \ A_2A_1	00	01	11	10
00	m_0 x	m_1 x	m_3 1	m_2
01	m_4 x	m_5 x	m_7 1	m_6
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8 x	m_9 x	m_{11} x	m_{10} x

Flip Flop A_1

2 points
Not necessary to show K-maps

$J_{A1} = 1$

A_8A_4 \ A_2A_1	00	01	11	10
00	m_0 1	m_1 x	m_3 x	m_2 1
01	m_4 1	m_5 x	m_7 x	m_6 1
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8 1	m_9 x	m_{11} x	m_{10} x

$K_{A1} = 1$

Q_3Q_2 \ Q_1Q_0	00	01	11	10
00	m_0 x	m_1 1	m_3 1	m_2 x
01	m_4 x	m_5 1	m_7 1	m_6 x
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8 1	m_9 x	m_{11} x	m_{10} x

(b)

State Table: Don't care states are $d = \sum(10,11,12,13,14,15)$ (not shown in the state table)

State Table								D FF Inputs			
Current State				Next State							
Q_3	Q_2	Q_1	Q_0	Q_3	Q_2	Q_1	Q_0	D_3	D_2	D_1	D_0
0	0	0	0	0	0	0	1	0	0	0	1
0	0	0	1	0	0	1	0	0	0	1	0
0	0	1	0	0	0	1	1	0	0	1	1
0	0	1	1	0	1	0	0	0	1	0	0
0	1	0	0	0	1	0	1	0	1	0	1
0	1	0	1	0	1	1	0	0	1	1	0
0	1	1	0	0	1	1	1	0	1	1	1
0	1	1	1	1	0	0	0	1	0	0	0
1	0	0	0	1	0	0	1	1	0	0	1
1	0	0	1	0	0	0	0	0	0	0	0

3 points

Flip Flop $D_3 = Q_3Q_0'+Q_2Q_1Q_0$

Flip Flop $D_2 = Q_2Q_1'+Q_2Q_0'+Q_2'Q_1Q_0$

2 points

Q_3Q_2 \ Q_1Q_0	00	01	11	10
00	m_0	m_1	m_3	m_2
01	m_4	m_5	m_7 1	m_6
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8 1	m_9	m_{11} x	m_{10} x

Q_3Q_2 \ Q_1Q_0	00	01	11	10
00	m_0	m_1	m_3 1	m_2
01	m_4 1	m_5 1	m_7	m_6 1
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8	m_9	m_{11} x	m_{10} x

Flip Flop D_1 $= Q_3'Q_1'Q_0+Q_3'Q_1Q_0'$

Flip Flop D0 $= Q_0'$

2 points

Q_3Q_2 \ Q_1Q_0	00	01	11	10
00	m_0	m_1 1	m_3	m_2 1
01	m_4	m_5 1	m_7	m_6 1
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8	m_9	m_{11} x	m_{10} x

Q_3Q_2 \ Q_1Q_0	00	01	11	10
00	m_0 1	m_1	m_3	m_2 1
01	m_4 1	m_5	m_7	m_6 1
11	m_{12} x	m_{13} x	m_{15} x	m_{14} x
10	m_8 1	m_9	m_{11} x	m_{10} x

The set of FF input equations that represent the design of each solution is:

T FF (from book)

$$T_{Q1} = 1$$
$$T_{Q2} = Q'_8 Q_1$$
$$T_{Q4} = Q_2 Q_1$$
$$T_{Q8} = Q_8 Q_1 + Q_4 Q_2 Q_1$$
$$y = Q_8 Q_1$$

JK FF

$$J_{A8} = A_4 A_2 A_1$$
$$K_{A8} = A_1$$
$$J_{A4} = A_2 A_1$$
$$K_{A4} = A_2 A_1$$
$$J_{A1} = 1$$
$$K_{A1} = 1$$

D FF

$D_3 = Q_3Q_0' + Q_2Q_1Q_0$
$D_2 = Q_2Q_1' + Q_2Q_0' + Q_2'Q_1Q_0$
$D_1 = Q_3'Q_1'Q_0 + Q_3'Q_1Q_0'$
$D0 = Q_0'$

Define efficiency as the number of gates used in the combinational circuits.

- **Thus the T-FF design requires 6 gates (5 AND gates and 1 OR gate),**
- **The JK-FF design requires 4 AND gates, and**
- **The D-FF design requires 10 gates (7 AND gates and 3 OR gates).**

2 points for comparison of designs

Base on the above criteria, the JK FF design is the most efficient. Note also that the JK-FF design is a single level implementation (no ORing of signals) while the other two designs required 2 levels of gates. This also supports that JK-FF solution as the more efficient solution.

6.27 (a)

Total 12 points

Present State	Next State	JK FF Inputs					
ABC	ABC	J_A	K_A	J_B	K_B	J_C	K_C
0 0 0	0 0 1	0	x	0	x	1	x
0 0 1	0 1 0	0	x	1	x	x	1
0 1 0	0 1 1	0	x	x	0	1	x
0 1 1	1 0 0	1	x	x	1	x	1
1 0 0	1 0 1	x	0	0	x	1	x
1 0 1	1 1 0	x	0	1	x	x	1
1 1 0	0 0 0	x	1	x	1	0	x
1 1 1	x x x	x	x	x	x	x	x

2 points

FF A

$J_A = BC$ 2 points $K_A = B$

A \ BC	00	01	11	10
0	m_0	m_1	m_3 1	m_2
1	m_4 x	m_5 x	m_7 x	m_6 x

A \ BC	00	01	11	10
0	m_0 x	m_1 x	m_3 x	m_2 x
1	m_4	m_5	m_7 x	m_6 1

FF B

$J_B = C$ 2 points $K_B = A + C$

A \ BC	00	01	11	10
0	m_0	m_1 1	m_3 x	m_2 x
1	m_4	m_5 1	m_7 x	m_6 x

A \ BC	00	01	11	10
0	m_0 x	m_1 x	m_3 1	m_2
1	m_4 x	m_5 x	m_7 x	m_6 1

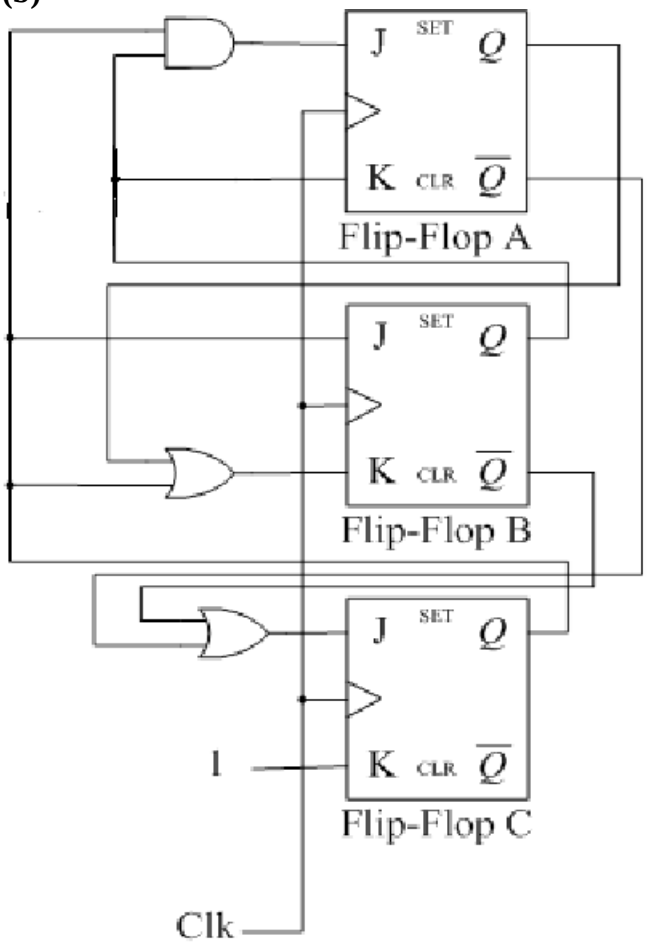
FF C

$J_C = A' + B'$ 2 points $K_C = 1$

A \ BC	00	01	11	10
0	m_0 1	m_1 x	m_3 x	m_2 1
1	m_4 1	m_5 x	m_7 x	m_6

A \ BC	00	01	11	10
0	m_0 x	m_1 1	m_3 1	m_2 x
1	m_4 x	m_5 1	m_7 x	m_6 x

(b)


J
SET
Q
K
CLR
Q
Flip-Flop A
J
SET
Q
K
CLR
Q
Flip-Flop B
J
SET
Q
K
CLR
Q
Flip-Flop C
1
Clk

4 points