HW #3 Introduction to Digital Circuits 20191286 김나현

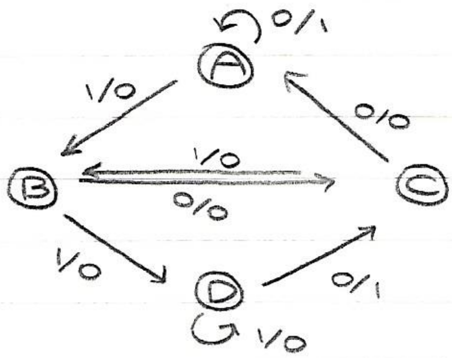
CH5

#1-(d). For each of the following state tables, show a state diagram and complete the timing trace as far as possible. (even after the input is no longer known.)

d.

q	q* x=0	q* x=1	z x=0	z x=1
A	A	B	1	0
B	C	D	0	0
C	A	B	0	0
D	C	D	1	0

① State diagram



② timing trace

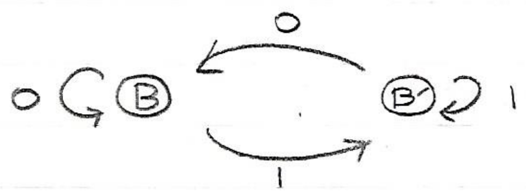
x 0 1 0 0 0 1 1 1 1 0 1

q A A B C A A B D D D C B

z 1 0 0 0 1 0 0 0 0 1 0 0

#6. We have a new type of flip flop, with inputs A and B. If A=0, then $Q^* = B$; if A=1, $Q^* = B'$.

a. Show a state diagram for this flip flop.



Q	Q* A=0	Q* A=1
B	B	B'
B'	B	B'

b. Write an equation for Q^* in terms of A, B and Q.

A	B	Q	Q*
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	0

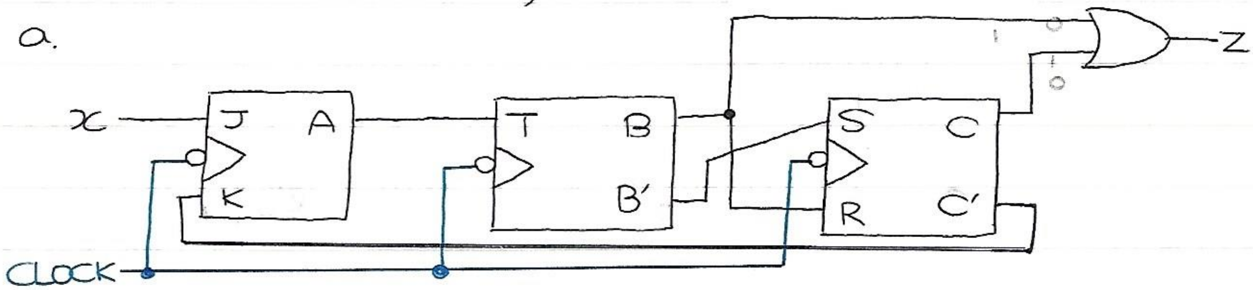
Q \ AB	00	01	11	10
0		1		1
1		1		1

Q*

$Q^* = A'B + AB'$

#9-(a). For the following circuits, complete the timing trace as far as possible. The state of some flip flops and the output can be determined for as many as three clocks after the input is no longer known. Assume that all flip flops are initially 0.

a.



(1) equations for inputs and output Z

X	0 1 1 0 1 0 1
A	
B	
C	
Z	

① $J = x$

② $K = C'$

③ $T = A$

④ $S = B'$

⑤ $R = B$

⑥ $Z = B + C$

(2) draw the state table

① ABC=000 ─ x=0 : Z=B+C=0, $A^*=0$, $B^*=0$, $C^*=1$ ($A^*B^*C^*=001$)
　└ x=1 : Z=B+C=0, $A^*=1$, $B^*=0$, $C^*=1$ ($A^*B^*C^*=101$)

② ABC=001 ─ x=0 : Z=B+C=1, $A^*=0$, $B^*=0$, $C^*=1$ ($A^*B^*C^*=001$)
　└ x=1 : Z=B+C=1, $A^*=1$, $B^*=0$, $C^*=1$ ($A^*B^*C^*=101$)

③ ABC=010 ─ x=0 : Z=B+C=1, $A^*=0$, $B^*=1$, $C^*=0$ ($A^*B^*C^*=010$)
　└ x=1 : Z=B+C=1, $A^*=1$, $B^*=1$, $C^*=0$ ($A^*B^*C^*=110$)

④ ABC=011 ─ x=0 : Z=B+C=1, $A^*=0$, $B^*=1$, $C^*=0$ ($A^*B^*C^*=010$)
　└ x=1 : Z=B+C=1, $A^*=1$, $B^*=1$, $C^*=0$ ($A^*B^*C^*=110$)

⑤ ABC=100 ─ x=0 : Z=B+C=0, $A^*=0$, $B^*=1$, $C^*=1$ ($A^*B^*C^*=011$)
　└ x=1 : Z=B+C=0, $A^*=0$, $B^*=1$, $C^*=1$ ($A^*B^*C^*=011$)

⑥ $ABC = 101$ — $x=0$: $Z = B+C = 1$, $A^* = 1$, $B^* = 1$, $C^* = 1$ $(A^*B^*C^* = 111)$
$x=1$: $Z = B+C = 1$, $A^* = 1$, $B^* = 1$, $C^* = 1$ $(A^*B^*C^* = 111)$

⑦ $ABC = 110$ — $x=0$: $Z = B+C = 1$, $A^* = 0$, $B^* = 0$, $C^* = 0$ $(A^*B^*C^* = 000)$
$x=1$: $Z = B+C = 1$, $A^* = 0$, $B^* = 0$, $C^* = 0$ $(A^*B^*C^* = 000)$

⑧ $ABC = 111$ — $x=0$: $Z = B+C = 1$, $A^* = 1$, $B^* = 0$, $C^* = 0$ $(A^*B^*C^* = 100)$
$x=1$: $Z = B+C = 1$, $A^* = 1$, $B^* = 0$, $C^* = 0$ $(A^*B^*C^* = 100)$

(3) Construct the state table

	$A^*B^*C^*$		Z	
ABC	$x=0$	$x=1$	$x=0$	$x=1$
000	001	101	0	0
001	001	101	1	1
010	010	110	1	1
011	010	110	1	1
100	011	011	0	0
101	111	111	1	1
110	000	000	1	1
111	100	100	1	1

(4) Complete the given timing trace

X 0 1 1 0 1 0 1
A 0 0 1 1 1 0 0 1 0
B 0 0 0 1 0 1 1 1 0 0
C 0 1 1 1 0 1 0 0 0 1 1
Z 0 1 1 1 0 1 1 1 0 1 1

CH6

#3-(e). For each of the following state tables and state assignments, find the flip flop input equations and the system output equation for an implementation using

i. D flip flops

ii. JK flip flops

e.

q	q^* $x=0$	q^* $x=1$	z $x=0$	z $x=1$
A	B	D	0	0
B	D	C	1	0
C	A	B	0	0
D	C	A	1	0

q	q_1q_2
A	0 0
B	0 1
C	1 1
D	1 0

(i)

x	q_1	q_2	q_1^*	q_2^*	D_1	D_2	z
0	0	0	0	1	0	1	0
0	0	1	1	0	1	0	1
0	1	0	1	1	1	1	1
0	1	1	0	0	0	0	0
1	0	0	1	0	1	0	0
1	0	1	1	1	1	1	0
1	1	0	0	0	0	0	0
1	1	1	0	1	0	1	0

q_1q_2 \ x	0	1
00		1
01	1	1
11		
10	1	

D_1

q_1q_2 \ x	0	1
00	1	
01		1
11		1
10	1	

D_2

q_1q_2 \ x	0	1
00		
01	1	
11		
10	1	

z

$D_1 = q_1'q_2 + xq_1' + x'q_1q_2'$

$D_2 = x'q_2' + xq_2$

$z = x'q_1'q_2 + x'q_1q_2'$

(ii)

x	q_1	q_2	q_1^*	q_2^*	J_1	K_1	J_2	K_2
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	0	1	X	0	X
1	0	1	1	1	1	X	X	0
1	1	0	0	0	X	1	0	X
1	1	1	0	1	X	1	X	0

q_1q_2 \ x	0	1
00		1
01	1	1
11	X	X
10	X	X

J_1

q_1q_2 \ x	0	1
00	X	X
01	X	X
11	1	1
10		1

K_1

$J_1 = K_1 = q_2 + x$

q_1q_2 \ x	0	1
00	1	
01	X	X
11	X	X
10	1	

J_2

q_1q_2 \ x	0	1
00	X	X
01	1	
11	1	
10	X	X

K_2

$J_2 = K_2 = x'$

cf D FF design table

q	Q^*	D
0	0	0
0	1	1
1	0	0
1	1	1

cf JK FF design table

q	Q^*	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

#9. Design a counter with two JK flip-flops, A and B, and one input, x. If $x=0$, it counts 1, 3, 0 and repeat; if $x=1$, it counts 1, 2, 3 and repeat.

a. Assume that x changes only when it is in state 1 or 3 (in which case there are two combinations which never occur – state 2 and $x=0$, and state 0 and $x=1$.)

b. After building the design of part a (with the two don't cares), what happens if somehow x is 0 in state 2 and what happens if somehow x is 1 in state 0?

(a)

q	q^*	J	K
0	0	0	X
0	1	1	X
1	0	X	1
1	1	X	0

$x=0$: 1, 3, 0, 1, 3, 0, ...

$x=1$: 1, 2, 3, 1, 2, 3, ...

x	B	A	B^*	A^*	J_B	K_B	J_A	K_A
0	0	0	0	1	0	X	1	X
0	0	1	1	1	1	X	X	0
0	1	0	X	X	X	X	X	X
0	1	1	0	0	X	1	X	1
1	0	0	X	X	X	X	X	X
1	0	1	1	0	1	X	X	1
1	1	0	1	1	X	0	1	X
1	1	1	0	1	X	1	X	0

① J_B, K_B

J_B

BA \ x	0	1
00		X
01	1	1
11	X	X
10	X	X

K_B

BA \ x	0	1
00	X	X
01	X	X
11	1	1
10	X	

$J_B = K_B = A$

② J_A, K_A

J_A

BA \ x	0	1
00	1	X
01	X	X
11	X	X
10	X	1

K_A

BA \ x	0	1
00	X	X
01		1
11	1	
10	X	X

$J_A = 1$

$J_B = xB' + x'B$

(b) By (a), $\begin{cases} J_B = A \\ K_B = A \\ J_A = 1 \\ K_A = x'B + xB' \end{cases}$

J	K	q^*
0	0	q
0	1	0
1	0	1
1	1	q^*

Write the truth table for the desired constraints using the flip flop input equations.

x	B	A	J_B	K_B	J_A	K_A	B^*	A^*
0	0	0	0	0	1	0	0	1
1	1	0	0	0	1	1	1	1

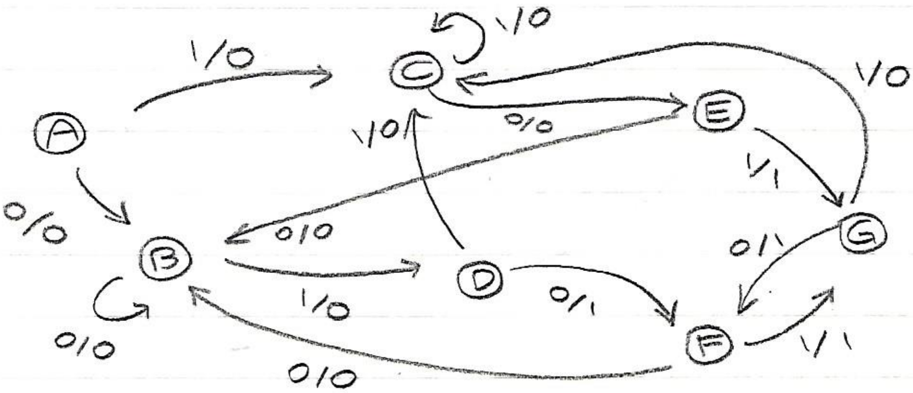
⇒ From the table, we know that the counter counts from 0 to 1 if $x=0$ and the counter counts from 2 to 3 if $x=1$

#15. For each of the following problems show a state table or a state diagram. (A sample input/output trace and the minimum number of states required is shown for each.)

d. A Mealy system that produces a 1 output iff the input has been either 0 1 0 or 1 0 1. Overlapping is allowed. When first turned on, it is in an initial state A. (There are four additional states.)

x 0 0 1 0 0 1 0 1 0 0 1 1 0 1 1 0 1 0 0

Z 0 0 0 1 0 0 1 1 1 0 0 0 0 1 0 0 1 1 0 0



g. A Mealy system, the output of which is 1 iff there have been exactly two consecutive 1's followed by at least two consecutive 0's (five states).

x 0 1 1 0 0 0 1 1 0 0 1 1 0 0 1 0 0 0 0 1 1 0 0

Z ? 0 0 0 1 1 0 0 0 1 0 0 0 1 0 0 0 0 0 0 0 0 1