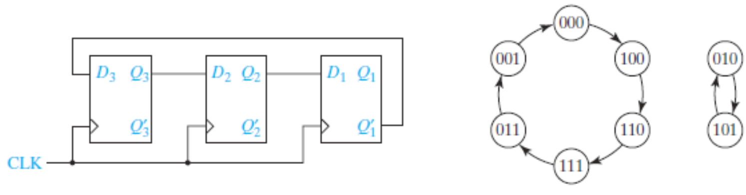
Name________ Student ID__________ Colleges & Schools_________ Department__________

Homework Unit 12 Solutions

1. Construct a 4-bit Johnson counter using J-K flip-flops. What sequence of states does the counter go through if it is started in state 0000? State 0110?

   (Hint: refer a 3-bit Johnson counter shown below)

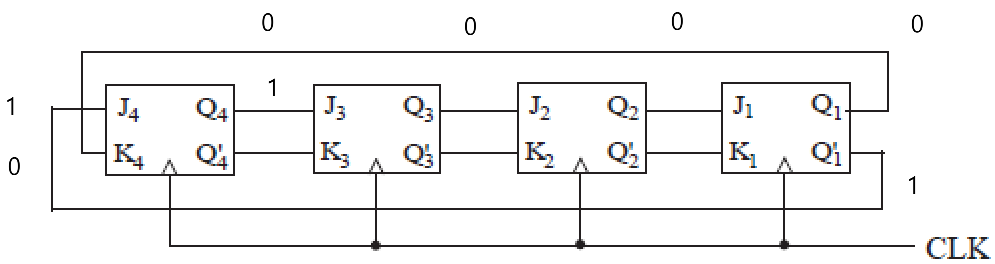
FIGURE 12-12
Shift Register with Inverted Feedback



(a) Flip-flop connections (b) Transition graph

Sol.)

4-bit Johnson counter using J-K flip-flops:



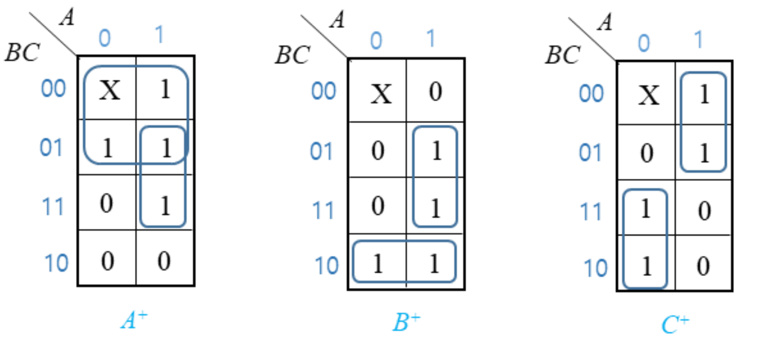
Starting in 0000: 0000, 1000, 1100, 1110, 1111, 0111, 0011, 0001, (repeat) 0000, ...

Starting in 0110: 0110, 1011, 0101, 0010, 1001, 0100, 1010, 1101, (repeat) 0110, ...

2. Design a 3-bit counter using D flip-flops which counts in the sequence: 001, 100, 101, 111, 110, 010, 011, (repeat) 001, ... What will happen if the counter of is started in state 000?

Sol.) A transition table for this binary counter can be represented as

$A\,B\,C$	$A^+B^+C^+$
0 0 0	X X X
0 0 1	1 0 0
0 1 0	0 1 1
0 1 1	0 0 1
1 0 0	1 0 1
1 0 1	1 1 1
1 1 0	0 1 0
1 1 1	1 1 0



$D_A = B'+AC$; $D_B = AC+BC'$; $D_C = A'B+AB'$

→ State 000 goes to 100, because $D_AD_BD_C = 100$

3. A sequential circuit contains a register of four flip-flops. Initially a binary number N (0000 ≤ N ≤ 1100) is stored in the flip-flops. After a single clock pulse is applied to the circuit, the register should contain N + 0011. In other words, the function of the sequential circuit is to add 3 to the contents of a 4-bit register. Design the circuit using J-K flip-flops.

Sol.) A transition table for a given sequential circuit can be expressed as

$ABCD$	$A^+B^+C^+D^+$	$J_A\ K_A\ J_B\ K_B\ J_C\ K_C\ J_D\ K_D$
0 0 0 0	0 0 1 1	0 X 0 X 1 X 1 X
0 0 0 1	0 1 0 0	0 X 1 X 0 X X 1
0 0 1 0	0 1 0 1	0 X 1 X X 1 1 X
0 0 1 1	0 1 1 0	0 X 1 X X 0 X 1
0 1 0 0	0 1 1 1	0 X X 0 1 X 1 X
0 1 0 1	1 0 0 0	1 X X 1 0 X X 1
0 1 1 0	1 0 0 1	1 X X 1 X 1 1 X
0 1 1 1	1 0 1 0	1 X X 1 X 0 X 1
1 0 0 0	1 0 1 1	X 0 0 X 1 X 1 X
1 0 0 1	1 1 0 0	X 0 1 X 0 X X 1
1 0 1 0	1 1 0 1	X 0 1 X X 1 1 X
1 0 1 1	1 1 1 0	X 0 1 X X 0 X 1
1 1 0 0	1 1 1 1	X 0 X 0 1 X 1 X
1 1 0 1	X X X X	X X X X X X X X
1 1 1 0	X X X X	X X X X X X X X
1 1 1 1	X X X X	X X X X X X X X

CD \ AB	00	01	11	10
00	0	0	X	X
01	0	1	X	X
11	0	1	X	X
10	0	1	X	X

J_A

CD \ AB	00	01	11	10
00	X	X	0	0
01	X	X	X	0
11	X	X	X	0
10	X	X	X	0

K_A

CD \ AB	00	01	11	10
00	0	X	X	0
01	1	X	X	1
11	1	X	X	1
10	1	X	X	1

J_B

CD \ AB	00	01	11	10
00	X	0	0	X
01	X	1	X	X
11	X	1	X	X
10	X	1	X	X

K_B

CD \ AB	00	01	11	10
00	1	1	1	1
01	0	0	X	0
11	X	X	X	X
10	X	X	X	X

J_C

CD \ AB	00	01	11	10
00	X	X	X	X
01	X	X	X	X
11	0	0	X	0
10	1	1	X	1

K_C

CD \ AB	00	01	11	10
00	1	1	1	1
01	X	X	X	X
11	X	X	X	X
10	1	1	X	1

J_D

CD \ AB	00	01	11	10
00	X	X	X	X
01	1	1	1	X
11	1	1	1	X
10	X	X	X	X

K_D

Using Karnaugh maps:

J_A = A+BD+BC, K_A = 0 J_B = C+D, K_B = C+D

J_C = D', K_C = D' J_D = 1, K_D = 1

4. An L-M flip-flop works as follows:

If LM = 00, the next state of the flip-flop is 1.

If LM = 01, the next state of the flip-flop is the same as the present state.

If LM = 10, the next state of the flip-flop is the complement of the present state.

If LM = 11, the next state of the flip-flop is 0.

(a) Complete the following table (use don't-cares when possible).

Sol.)

$Q\ Q^+$	LM
0 0	$\left.\begin{matrix}0\ 1\\1\ 1\end{matrix}\right\}$X1
0 1	$\left.\begin{matrix}0\ 0\\1\ 0\end{matrix}\right\}$X0
1 0	$\left.\begin{matrix}1\ 0\\1\ 1\end{matrix}\right\}$1X
1 1	$\left.\begin{matrix}0\ 0\\0\ 1\end{matrix}\right\}$0X

(b) Using this table and Karnaugh maps, derive and minimize the input equations for a counter composed of three L-M flip-flops which counts in the following sequence: ABC = 000, 100, 101, 111, 011, 001, (repeat) 000, …

Sol.) $L_A = B$, $M_A = C$; $L_B = A'$, $M_B = A' + C'$; $L_C = A'B'$, $M_C = A'$;

$A\ B\ C$	$A^+B^+C^+$
0 0 0	1 0 0
0 0 1	0 0 0
0 1 0	X X X
0 1 1	0 0 1
1 0 0	1 0 1
1 0 1	1 1 1
1 1 0	X X X
1 1 1	0 1 1

A^+

BC \ A	0	1
00	1	1
01	0	1
11	0	0
10	X	X

B^+

BC \ A	0	1
00	0	0
01	0	1
11	0	1
10	X	X

C^+

BC \ A	0	1
00	0	1
01	0	1
11	1	1
10	X	X

BC \ A	0	1
00	X	0
01	X	0
11	X	1
10	X	X

$L_A = B$

BC \ A	0	1
00	0	X
01	1	X
11	1	X
10	X	X

$M_A = C$

BC \ A	0	1
00	X	X
01	X	X
11	1	0
10	X	X

$L_B = A'$

BC \ A	0	1
00	1	1
01	1	0
11	X	X
10	X	X

$M_B = A' + C'$

BC \ A	0	1
00	X	X
01	1	0
11	0	0
10	X	X

$L_C = A'B'$

BC \ A	0	1
00	1	0
01	X	X
11	X	X
10	X	X

$M_C = A'$