Unit 13 Problem Solutions

13.2 Notice that this is a shift register. At each falling clock edge, Q_3 takes on the value Q_2 had right before the clock edge, Q_2 takes on the value Q_1 had right before the clock edge, and Q_1 takes on the value X had right before the clock edge. For example, if the initial state is 000 and the input sequence is $X = 1100$, the state sequence is = 100, 110, 011, 001, and the output sequence is $Z = (0)0011$. Z is always Q_3, which does not depend on the present value of X. So it's a Moore machine. *See FLD p. 758 for the state graph.*

13.3 (a) $A^+ = AK_A' + A'J_A = A(B' + X) + A'(BX' + B'X)$
$B^+ = B'J_B + BK_B' = AB'X + B(A' + X')$
$Z = AB$

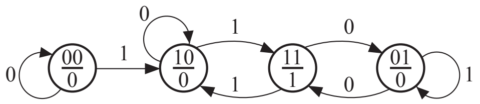
A^+

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

B^+

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

Present State AB	Next State A^+B^+ $X = 0$	$X = 1$	Z
00	00	10	0
01	11	01	0
11	01	10	1
10	10	11	0



13.3 (b)

$X =$		0	1	1	0	0
$AB =$	00	00	10	11	01	11
$Z =$	(0)	0	0	1	0	1

13.3 (c) *See FLD p. 758 for solution.*

13.4 (a)

$Q_1^+ = D_1$

Q_2Q_3 \ XQ_1	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	0	0	0	0
10	1	1	1	1

$Q_2^+ = D_2$

Q_2Q_3 \ XQ_1	00	01	11	10
00	0	0	0	0
01	1	1	1	1
11	1	1	1	1
10	0	0	0	0

$Q_3^+ = D_3$

Q_2Q_3 \ XQ_1	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	0	0	1	1
10	0	0	1	1

Z

Q_2Q_3 \ XQ_1	00	01	11	10
00	0	0	1	1
01	0	0	1	1
11	1	1	0	0
10	1	1	0	0

Z depends on the input X, so this is a Mealy machine. Because there are more than 2 state variables, we cannot put the state table in Karnaugh Map order (i.e. 00, 01, 11, 10), but we can still read the next state and output from the Karnaugh map. For example, when the input is X = 1 and the state is $Q_1Q_2Q_3 = 110$, we can read the next state and output from the $XQ_1Q_2Q_3 = 1110$ position in the Karnaugh maps for Q_1^+, Q_2^+, Q_2^+, and Z. So in this case, the next state is $Q_1^+Q_2^+Q_3^+ = 101$ and the output is $Z = 0$. The entire table can be derived from the Karnaugh maps in this manner. *Note*: We can also fill in the state table directly from the equations, without using Karnaugh maps. See FLD p. 758 for the state table and state graph.

13.4 (b - d) *See FLD p. 759 for solutions.*

Unit 13 Solutions

13.5 (a) Mealy machine, because the output, Z, depends on the input X as well as the present state.

13.5 (c - d) *See FLD p. 759 for solutions.*

13.5 (b)

Z

B C \ X A	00	01	11	10
00	1	1	0	0
01	1	1	0	0
11	0	0	1	1
10	0	0	1	1

Note: Not all Karnaugh map entries are needed. See FLD p. 759 for the state table.

13.6 (a) After a rising clock edge, it takes 4 ns for the flip-flop outputs to change. Then the ROM will take 8 ns to respond to the new flip-flop outputs. The ROM outputs must be correct at the flip-flop inputs for at least the setup time of 2 ns before the next rising clock edge. So the minimum clock period is (4 + 8 + 2) ns = 14 ns.

13.6 (b) The correct output sequence is 0101. See FLD p. 760 for the timing diagram.

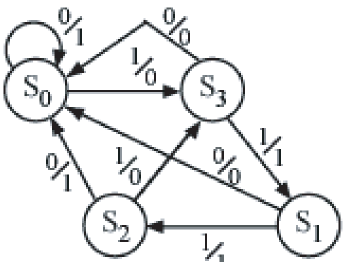
13.6 (c) Read the state transition table from ROM truth table. See FLD p. 760 for the state graph and table.

Present State	Next State $Q_1^+Q_2^+$		Z	
Q_1Q_2	$X = 0$	$X = 1$	$X = 0$	$X = 1$
00	10	10	0	0
01	00	11	0	0
10	11	01	0	1
11	01	11	1	1

Alternate solution: Using Karnaugh map order, swap states S_2 and S_3 in the graph and table.

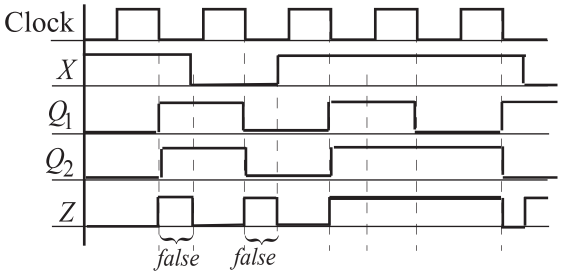
13.7 (a)
$$Q_1^+ = J_1Q_1' + K_1'Q_1 = XQ_1' + XQ_2'Q_1$$
$$Q_2^+ = J_2Q_2' + K_2'Q_2 = XQ_2' + XQ_1Q_2$$
$$Z = X'Q_2' + XQ_2$$

Present State	Next State $Q_1^+Q_2^+$		Z	
Q_1Q_2	$X = 0$	$X = 1$	$X = 0$	$X = 1$
00	00	11	1	0
01	00	10	0	1
11	00	01	0	1
10	00	11	1	0



13.7 (c) Z = 00011

13.7 (b)

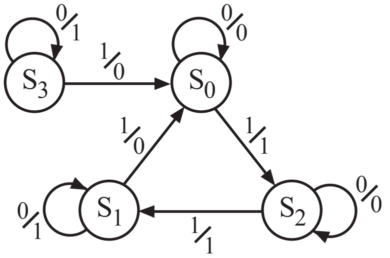


Unit 13 Solutions

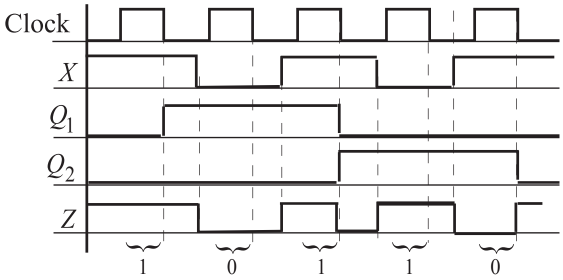
13.8 (a)

$$Q_1^+ = J_1Q_1' + K_1'Q_1 = XQ_2'Q_1' + X'Q_1$$
$$Q_2^+ = J_2Q_2' + K_2'Q_2 = X\,Q_1Q_2' + X'Q_2$$
$$Z = XQ_2' + X'Q_2$$

Present State Q_1Q_2	Next State $Q_1^+Q_2^+$ $X=0$	$X=1$	Z $X=0$	$X=1$
00	00	10	0	1
01	01	00	1	0
11	11	00	1	0
10	10	01	0	1



13.8 (b)

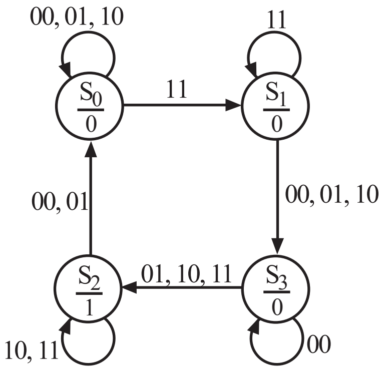


13.8 (c) Z = 10110

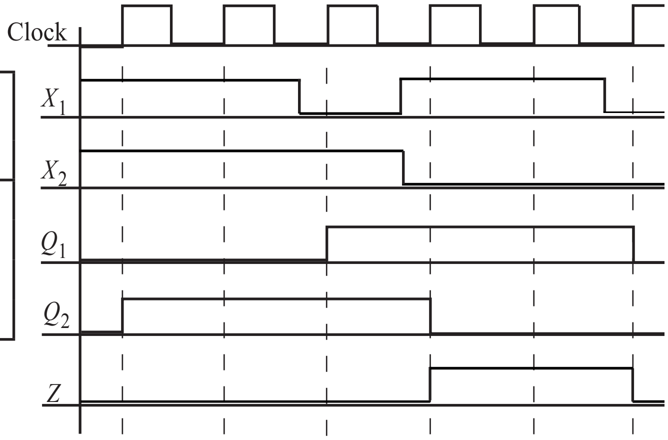
13.9 (a)

$$Q_1^+ = D_1 = (X_1' + X_2' + Q_1)(Q_1 + Q_2)(X_1' + Q_2)$$
$$Q_2^+ = D_2 = (X_1'X_2' + Q_1')(X_1X_2 + Q_2)$$
$$Z = Q_1Q_2'$$

State	Present State Q_1Q_2	Next State X_1X_2 00	01	11	10	Z
S_0	00	00	01	01	00	0
S_1	01	11	11	01	11	0
S_3	11	11	10	10	10	0
S_2	10	10	10	00	00	1



13.9 (b)

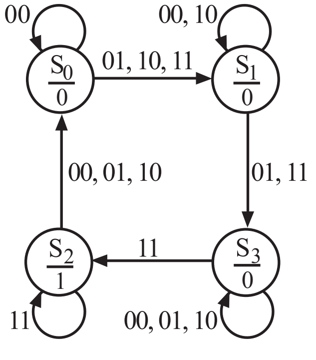


13.9 (c) Z = (0)000110

13.10(a)

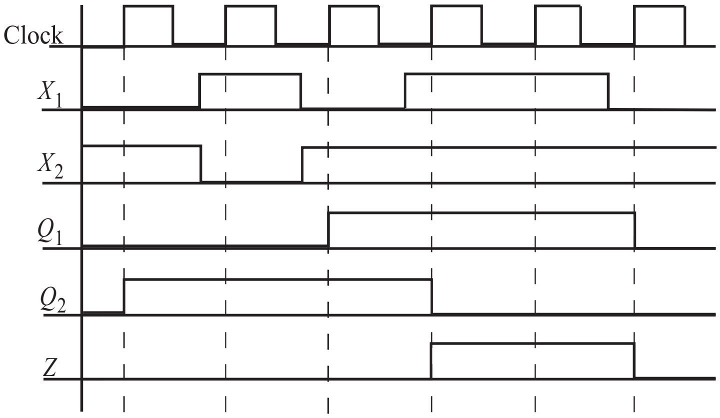
$$Q_1^+ = D_1 = X_1X_2Q_1 + Q_1Q_2 + X_2Q_2$$
$$Q_2^+ = D_2 = (X_1' + X_2')Q_2 + (X_1 + X_2)Q_1'$$
$$Z = Q_1Q_2'$$

State	Present State Q_1Q_2	Next State $X_1X_2 =$ 00	01	11	10	Z
S_0	00	00	01	01	01	0
S_1	01	01	11	11	01	0
S_3	11	11	11	10	11	0
S_2	10	00	00	10	00	1



Unit 13 Solutions

13.10(b)



13.10(c)

Z = (0)000110

13.11 (a) Notice that Z depends on the input X, so this is a Mealy machine.

$Q_1^+ = J_1Q_1' + K_1'Q_1 = XQ_1'Q_2 + X'Q_1$

$Q_2^+ = J_2Q_2' + K_2'Q_2 = XQ_1'Q_2' + X'Q_2$

$Z = Q_2 \oplus X = XQ_2' + X'Q_2$

Q_1Q_2 \ X	0	1
00	0	0
01	0	1
11	1	0
10	1	0

Q_1^+

Q_1Q_2 \ X	0	1
00	0	1
01	1	0
11	1	0
10	0	0

Q_2^+

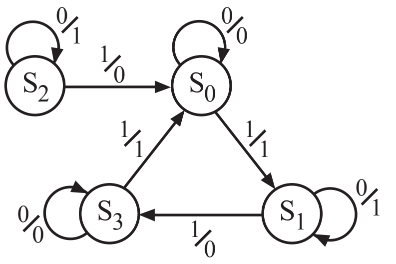
Q_1Q_2 \ X	0	1
00	0	1
01	1	0
11	1	0
10	0	1

Z

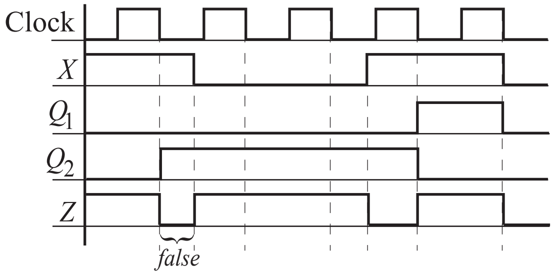
State	Present State	Next State $Q_1^+Q_2^+$		Z	
	Q_1Q_2	$X=0$	$X=1$	$X=0$	$X=1$
S_0	00	00	01	0	1
S_1	01	01	10	1	0
S_2	11	11	00	1	0
S_3	10	10	00	0	1

Alternate solution: Swap states S_2 and S_3.

13.11 (a) (cont.)



13.11 (b)



Correct output: $Z = 11101$

13.12(a) Notice that Z does not depend on either input, so this is a Moore machine.

$Q_1^+ = X_1X_2Q_1 + Q_1Q_2 + X_1Q_2$

$Q_2^+ = Q_1'(X_1 + X_2) + Q_2(X_1' + X_2')$

$= X_1Q_1' + X_2Q_1' + X_1'Q_2 + X_2'Q_2$

$Z = Q_1Q_2'$

Q_2 \ Q_1	0	1
0	0	1
1	0	0

Z

Q_1Q_2 \ X_1X_2	00	01	11	10
00	0	0	0	0
01	0	0	1	1
11	1	1	1	1
10	0	0	1	0

Q_1^+

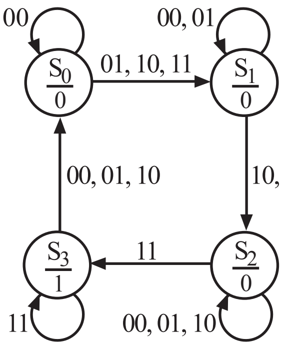
Q_1Q_2 \ X_1X_2	00	01	11	10
00	0	1	1	1
01	1	1	1	1
11	1	1	0	1
10	0	0	0	0

Q_2^+

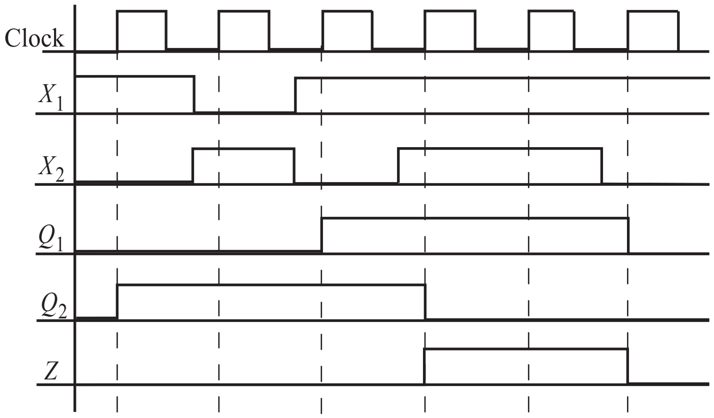
Unit 13 Solutions

13.12(a) (cont.)

State	Present State	Next State				Z
		$X_1X_2 =$				
	Q_1Q_2	00	01	11	10	
S_0	00	00	01	01	01	0
S_1	01	01	01	11	11	0
S_2	11	11	11	10	11	0
S_3	10	00	00	10	00	1

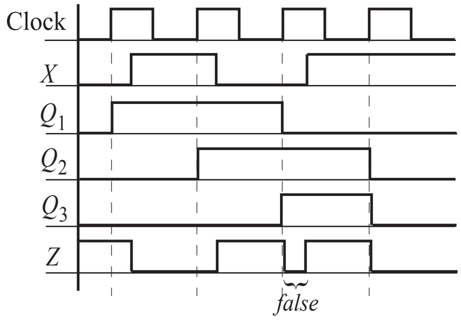


13.12(b)



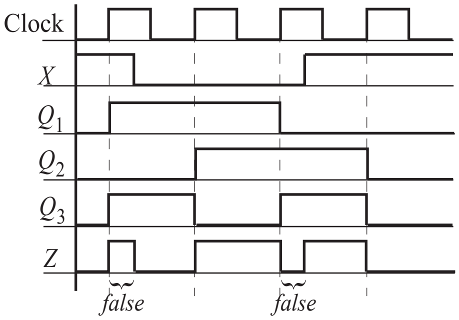
Correct output: $Z = (0)00110$

13.13



Correct output: $Z = 1011$

13.14



Correct output: $Z = 0011$

13.15 (a)

Q_2Q_3 \ XQ_1	00	01	11	10
00	0	0	0	1
01	0	0	0	1
11	0	0	0	1
10	1	1	1	1

$D_1 = Q_1^+$

Q_2Q_3 \ XQ_1	00	01	11	10
00	0	0	0	0
01	1	1	1	1
11	1	1	1	1
10	1	1	0	0

$D_2 = Q_2^+$

Q_2Q_3 \ XQ_1	00	01	11	10
00	1	1	1	1
01	1	1	1	1
11	0	0	1	1
10	0	0	1	1

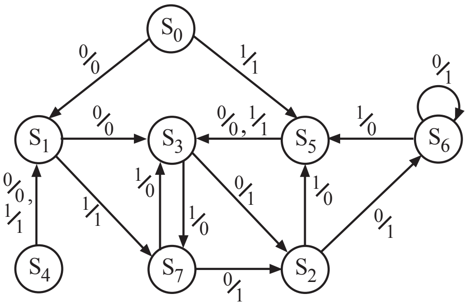
$D_3 = Q_3^+$

Q_2Q_3 \ XQ_1	00	01	11	10
00	0	0	1	1
01	0	0	1	1
11	1	1	0	0
10	1	1	0	0

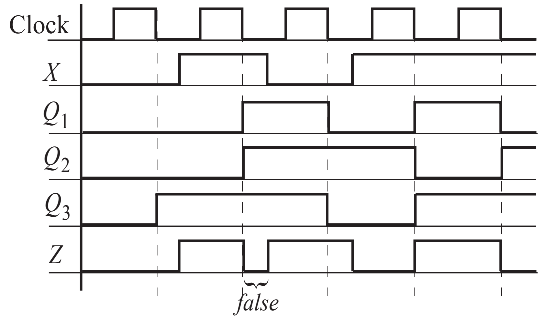
Z

13.15 (a) (cont.)

State	Present State $Q_1Q_2Q_3$	Next State $Q_1^+Q_2^+Q_3^+$ $X=0$	$X=1$	Z $X=0$	$X=1$
S_0	000	001	101	0	1
S_1	001	011	111	0	1
S_2	010	110	101	1	0
S_3	011	010	111	1	0
S_4	100	001	001	0	1
S_5	101	011	011	0	1
S_6	110	110	101	1	0
S_7	111	010	011	1	0



13.15 (b)



13.15 (c) From diagram: 0, 1, (0), 1, 0, 1
From graph: 0, 1, 1, 0, 1
(they are the same, except for the false output)

13.15 (d) Change the input on the falling edge of the clock (assuming negligible circuit delays).

13.16 (a)

Q_2Q_3 \ XQ_1	00	01	11	10
00	1	1	0	0
01	0	0	0	0
11	0	0	0	0
10	1	1	0	0

$D_1 = Q_1^+$

Q_2Q_3 \ XQ_1	00	01	11	10
00	0	1	1	1
01	0	0	1	1
11	0	0	0	0
10	0	1	1	0

$D_2 = Q_2^+$

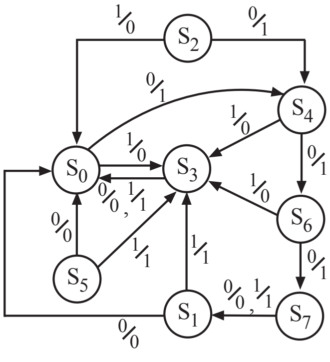
Q_2Q_3 \ XQ_1	00	01	11	10
00	0	0	1	1
01	0	0	1	1
11	0	1	1	0
10	0	1	1	0

$D_3 = Q_3^+$

Q_2Q_3 \ XQ_1	00	01	11	10
00	1	1	0	0
01	0	0	1	1
11	0	0	1	1
10	1	1	0	0

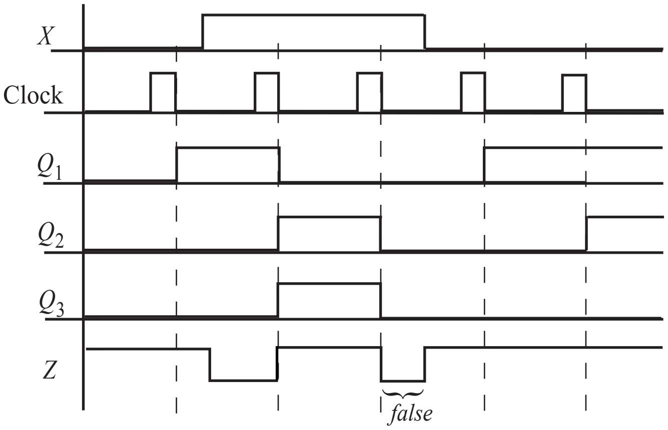
Z

State	Present State $Q_1Q_2Q_3$	Next State $Q_1^+Q_2^+Q_3^+$ $X=0$	$X=1$	Z $X=0$	$X=1$
S_0	000	100	011	1	0
S_1	001	000	011	0	1
S_2	010	100	000	1	0
S_3	011	000	000	0	1
S_4	100	110	011	1	0
S_5	101	000	011	0	1
S_6	110	111	011	1	0
S_7	111	001	001	0	1



Unit 13 Solutions

13.16 (b)



13.16 (c)

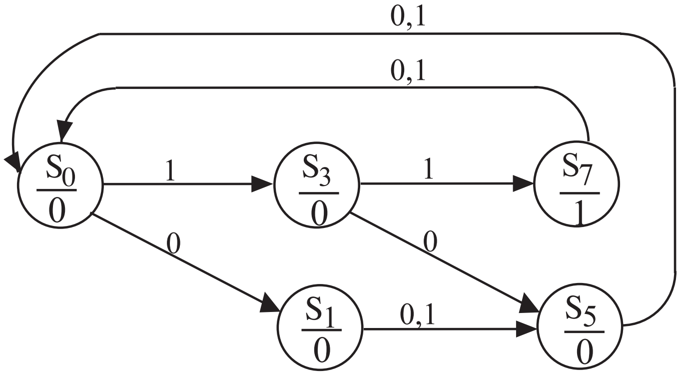
From diagram: 1 0 1 (0) 1 1
From graph: 1 0 1 1 1
(they are the same, except for the false output)

13.16 (d)

Change the input on the falling edge of the clock (assuming negligible circuit delays).

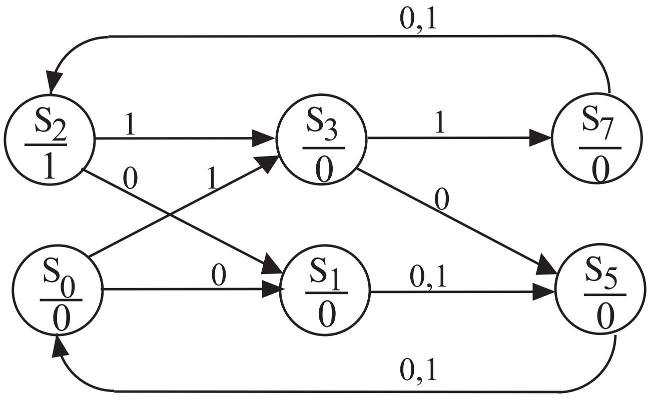
13.17 (a) Circuit 1

$Q_2Q_1Q_0$	Present State	Next State $X = 0$	$X = 1$	Output Z
000	S_0	001	011	0
001	S_1	101	101	0
010	S_2	001	011	0
011	S_3	101	111	0
100	S_4	000	000	0
101	S_5	000	000	0
110	S_6	000	000	1
111	S_7	000	000	1



Circuit 2

$Q_2Q_1Q_0$	Present State	Next State $X = 0$	$X = 1$	Output Z
000	S_0	001	011	0
001	S_1	101	101	0
010	S_2	001	011	1
011	S_3	101	111	0
100	S_4	000	010	0
101	S_5	000	000	0
110	S_6	010	010	1
111	S_7	010	010	0



13.17 (b) Both circuits examine 3 consecutive inputs and produce an output of 1 if the three consecutive inputs represent a binary number larger than 5.

13.17 (c) The output of both circuits does not depend upon the input so they are Moore circuits.

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13.17 (d) Circuit 1 produces the 1 output when the 3rd bit is present on the input, i.e., prior to the active clock edge when the 3rd bit is present. Circuit 2 produces the 1 output when the circuit enters the next state after receiving the 3rd bit. Circuit 1 has the functional dependence of a Moore circuit but the timing of a Mealy circuit. Circuit 2 is a Moore circuit both from the functional dependence and from the timing viewpoint.

.

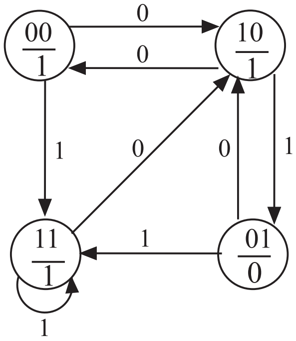
Unit 13 Solutions

13.18 (a) $D_1 = Q_1' + Q_2, D_2 = x, z = Q_1 + Q_2'$

13.18 (b)

Present Q_1Q_2	Next State $x = 0$	$x = 1$	Output z
00	10	11	1
01	10	11	0
10	00	01	1
11	10	11	1

13.18 (c)



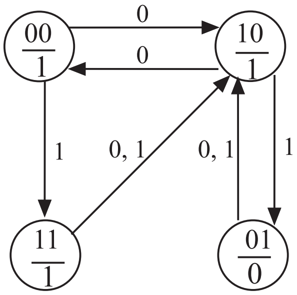
13.18 (d) Any input sequence ending with an odd number of 0's (1, 3, 5, etc.) followed by a single 1.

13.19 (a) $D_1 = Q_1' + Q_2, D_2 = xQ_2', z = Q_1 + Q_2'$

13.19 (b)

Present Q_1Q_2	Next State $x = 0$	$x = 1$	Output z
00	10	11	1
01	10	10	0
10	00	01	1
11	10	10	1

13.19 (c)

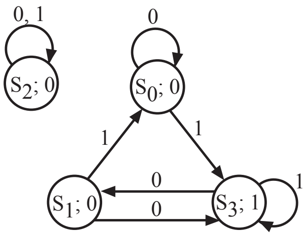


13.19 (d) Any sequence ending with an odd number of 0's (1, 3, 5, etc.) followed by an odd number of 1's.

13.20 (a)

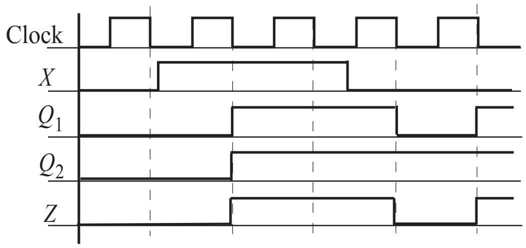
$$
\begin{aligned}
Q_1+ &= J_1Q_1' + K_1'Q_1 \\
&= (XQ_2' + XQ'_2)Q_1' + (X + Q_2')Q_1 \\
&= XQ_1'Q_2' + X'Q_1'Q_2 + XQ_1 + Q_1Q_2' \\
&= X\,Q_2' + X'Q_1'Q_2 + XQ_1 + Q_1Q_2' \\
Q_2+ &= J_2Q_2' + K_2'Q_2 \\
&= XQ_1'Q_2' + (X' + Q_1)Q_2 \\
&= XQ_1'Q_2' + X'Q_2 + Q_1Q_2 \\
Z &= Q_1Q_2
\end{aligned}
$$

Present State Q_1Q_2	Next State $Q_1^+Q_2^+$ $X = 0$	$X = 1$	Z
00	00	11	0
01	11	00	0
10	10	10	0
11	01	11	1



The circuit is a Moore circuit. State 2 is unused.

13.20 (b)



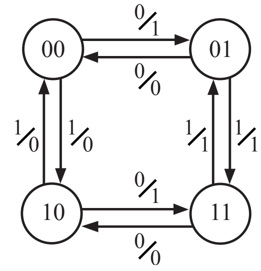
13.20 (c) Z = (0)01101

Unit 13 Solutions

13.21

Clock Cycle	Information Gathered
1	$Q_1Q_2 = 00, X = 0 \Rightarrow Z = 1, Q_1^+Q_2^+ = 01$
2	$Q_1Q_2 = 01, X = 0 \Rightarrow Z = 0; X = 1 \Rightarrow Z = 1, Q_1^+Q_2^+ = 11$
3	$Q_1Q_2 = 11, X = 1 \Rightarrow Z = 1; X = 0 \Rightarrow Z = 0, Q_1^+Q_2^+ = 10$
4	$Q_1Q_2 = 10, X = 0 \Rightarrow Z = 1; X = 1 \Rightarrow Z = 0, Q_1^+Q_2^+ = 00$
5	$Q_1Q_2 = 00, X = 1 \Rightarrow Z = 0, Q_1^+Q_2^+ = 10$
6	$Q_1Q_2 = 10, X = 1 \Rightarrow (Z = 0); X = 0 \Rightarrow (Z = 1), Q_1^+Q_2^+ = 11$
7	$Q_1Q_2 = 11, X = 0 \Rightarrow (Z = 0); X = 1 \Rightarrow (Z = 1), Q_1^+Q_2^+ = 01$
8	$Q_1Q_2 = 01, X = 1 \Rightarrow (Z = 1); X = 0 \Rightarrow (Z = 0), Q_1^+Q_2^+ = 00$
9	$Q_1Q_2 = 00, X = 0 \Rightarrow (Z = 1)$
Note: Information inside parentheses was already obtained in a previous clock cycle.	

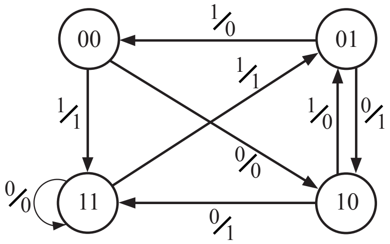
Present State	Next State $Q_1^+Q_2^+$		Z	
Q_1Q_2	$X = 0$	$X = 1$	$X = 0$	$X = 1$
00	01	10	1	0
01	00	11	0	1
10	11	00	1	0
11	10	01	0	1



13.22

Clock Cycle	Information Gathered
1	$Q_1Q_2 = 00, X = 0 \Rightarrow Z = 0, Q_1^+Q_2^+ = 10$
2	$Q_1Q_2 = 10, X = 0 \Rightarrow Z = 1; X = 1 \Rightarrow Z = 0, Q_1^+Q_2^+ = 01$
3	$Q_1Q_2 = 01, X = 1 \Rightarrow Z = 0; X = 0 \Rightarrow Z = 1, Q_1^+Q_2^+ = 10$
4	$Q_1Q_2 = 10, X = 0 \Rightarrow (Z = 1), Q_1^+Q_2^+ = 11$
5	$Q_1Q_2 = 11, X = 0 \Rightarrow Z = 0, Q_1^+Q_2^+ = 11$
6	$Q_1Q_2 = 11, X = 0 \Rightarrow (Z = 0); X = 1 \Rightarrow Z = 1, Q_1^+Q_2^+ = 01$
7	$Q_1Q_2 = 01, X = 1 \Rightarrow (Z = 0), Q_1^+Q_2^+ = 00$
8	$Q_1Q_2 = 00, X = 1 \Rightarrow Z = 1, Q_1^+Q_2^+ = 11$
9	$Q_1Q_2 = 11, X = 1 \Rightarrow (Z = 1)$
Note: Information inside parentheses was already obtained in a previous clock cycle.	

Present State	Next State $Q_1^+Q_2^+$		Z	
Q_1Q_2	$X = 0$	$X = 1$	X = 0	X = 1
00	10	11	0	1
01	10	00	1	0
10	11	01	1	0
11	11	01	0	1



13.23

Clock Cycle	Information Gathered
1	$Q_1Q_2 = 00, X_1X_2 = 01 \Rightarrow Z_1Z_2 = 10, Q_1^+Q_2^+ = 01$
2	$Q_1Q_2 = 01, X_1X_2 = 01 \Rightarrow Z_1Z_2 = 01; X_1X_2 = 10 \Rightarrow Z_1Z_2 = 10, Q_1^+Q_2^+ = 10$
3	$Q_1Q_2 = 10, X_1X_2 = 10 \Rightarrow Z_1Z_2 = 00; X_1X_2 = 11 \Rightarrow Z_1Z_2 = 00, Q_1^+Q_2^+ = 01$
4	$Q_1Q_2 = 01, X_1X_2 = 11 \Rightarrow Z_1Z_2 = 11; X_1X_2 = 01 \Rightarrow (Z_1Z_2 = 01), Q_1^+Q_2^+ = 11$
5	$Q_1Q_2 = 11, X_1X_2 = 01 \Rightarrow Z_1Z_2 = 01$

Note: When $Q_1Q_2 = 01$, the outputs Z_1Z_2 vary depending on the inputs X_1X_2, so this is a Mealy machine.

Present State	$Q_1^+Q_2^+$ $X_1X_2=$				Z_1Z_2 $X_1X_2=$			
Q_1Q_2	00	01	11	10	00	01	11	10
00	?	01	?	?	?	10	?	?
01	?	11	?	10	?	01	11	10
11	?	?	?	?	?	01	?	?
10	?	?	01	?	?	?	00	00

Unit 13 Solutions

13.24

Present State Q_1Q_2	$Q_1^+Q_2^+$ $X_1X_2=$ 00	01	11	10	Z_1Z_2 $X_1X_2=$ 00	01	11	10
00	?	01	?	?	?	10	?	?
01	?	11	?	10	?	01	11	10
11	?	?	?	?	?	01	?	?
10	?	?	01	?	?	?	00	00

? indicates next state or output values that cannot be determined from the timing chart

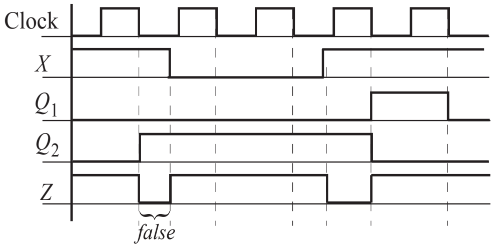
13.25(a) $Q_1^+ = D_1 = X'Q_1 + XQ_1'Q_2$

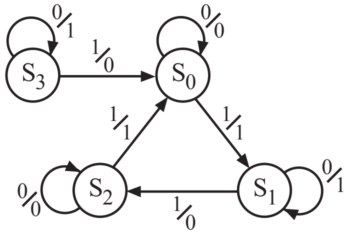
$Q_2^+ = D_2 = X'Q_2 + XQ_1'Q_2'$

$Z = X'Q_2 + XQ_1'Q_2' + XQ_1Q_2'$

Present State Q_1Q_2	Next State $Q_1^+Q_2^+$ $X=0$	$X=1$	Z $X=0$	$X=1$
S_0=00	00	01	0	1
S_1=01	01	10	1	0
S_3=11	11	00	1	0
S_2=10	10	00	0	1

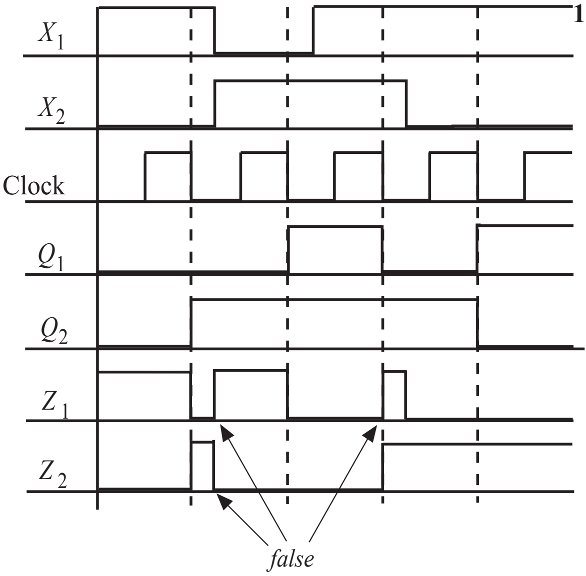
13.25(b)





13.25(c) $Z = 11101$

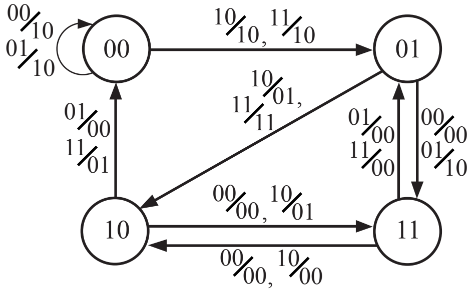
13.26 (a)



Correct output: Z_1Z_2 = 10, 10, 00, 01

13.26 (b)

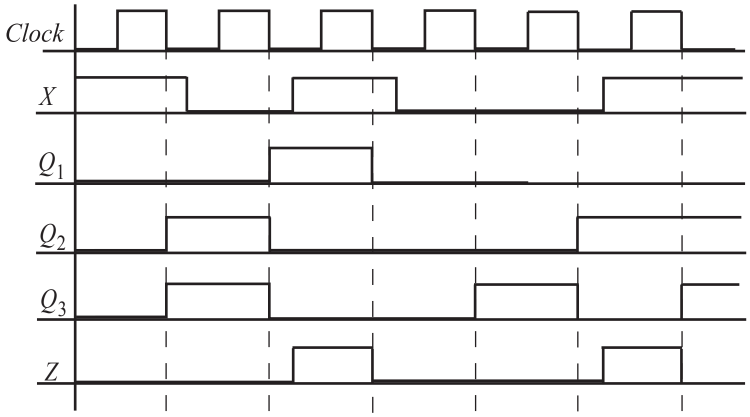
Present State Q_1Q_2	$Q_1^+Q_2^+$ $X_1X_2=$ 00	01	10	11	Z_1Z_2 $X_1X_2=$ 00	01	10	11
00	00	00	01	01	10	10	10	10
01	11	11	10	10	00	10	01	11
10	11	00	11	00	00	00	01	01
11	10	01	10	01	00	00	00	00



Unit 13 Solutions

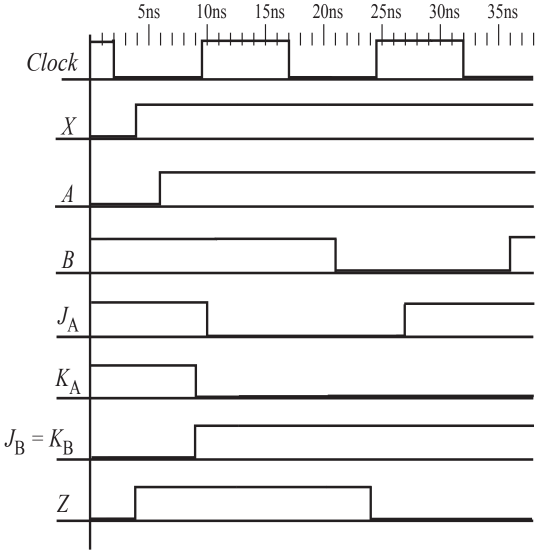
13.27 Transition table using a straight binary state assignment:

State	Present State	Next State $Q_1^+Q_2^+Q_3^+$		Z	
	$Q_1Q_2Q_3$	$X = 0$	$X = 1$	$X = 0$	$X = 1$
S_0	000	001	011	0	0
S_1	001	010	011	0	0
S_2	010	001	011	0	1
S_3	011	100	000	0	0
S_4	100	011	000	0	1



Correct output: $Z = 0, 0, 1, 0, 0, 1$

13.28 (a)



All flip-flop inputs are stable for more than the setup time before each falling clock edge. So the circuit is operating properly.

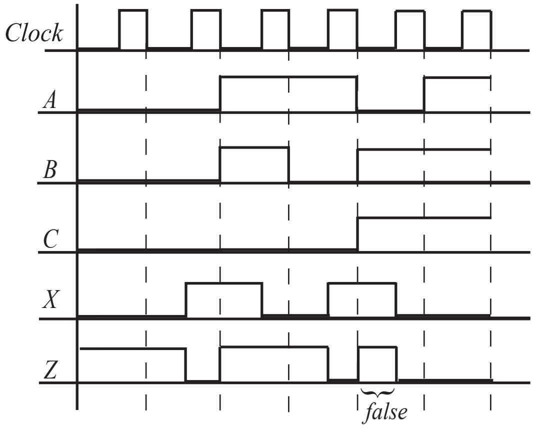
13.25(b) If X is changed early enough:

Minimum clock period = Flip-flop propagation delay + Two NAND-gate delays + Setup time

$= 4 + (3 + 3) + 2 = 12$ ns

X can change as late as 8 ns (two NAND-gate delays plus the setup time) before the next falling edge without causing improper operation.

13.29



Correct output: $Z = 1\ 0\ 1\ 0\ 1$

Deriving the State Table:

JK flip-flop equation:

$$Q^+ = JQ' + K'Q$$

$$\therefore\ A^+ = (X'C + XC')\,A' + X'A$$

$$[\text{As, } J_A = X'C + XC',\ K_A = X,\ Q = A]$$

$$= A'X'C + A'XC' + X'A$$

Similarly, $B^+ = XC' + XA + X'A'C$

$$C^+ = 0' \cdot C + (XB'A) \cdot C' = C + XB'A$$

$$Z = XB + X'C' + X'B'A$$

13.29
(cont.)

A^+

BC \ XA	00	01	11	10
00	0	1	0	1
01	1	1	0	0
11	1	1	0	0
10	0	1	0	1

B^+

BC \ XA	00	01	11	10
00	0	0	1	1
01	1	0	1	0
11	1	0	1	0
10	0	0	1	1

C^+

BC \ XA	00	01	11	10
00	0	0	1	0
01	1	1	1	1
11	1	1	1	1
10	0	0	0	0

Z

BC \ XA	00	01	11	10
00	1	1	0	0
01	0	1	0	0
11	0	0	1	1
10	1	1	1	1

From the Karnaugh maps, we can get the state table that follows:

State	Present State	Next State $A^+B^+C^+$		Z	
	ABC	$X = 0$	$X = 1$	$X = 0$	$X = 1$
S_0	000	000	110	1	0
S_1	001	111	001	0	0
S_2	010	000	110	1	1
S_3	011	111	001	0	1
S_4	100	100	011	1	0
S_5	101	101	011	1	0
S_6	110	100	010	1	1
S_7	111	101	011	0	1

13.30

$$R = X_2\,(X_1' + B)$$
$$S = X_2'\,(X_1' + B')$$
$$\begin{aligned} A^+ &= A[(X_2)\,(X_1' + B)]' + X_2'\,(X_1' + B') \\ &= A\,(X_2' + X_1B') + X_2'X_1' + X_2'B' \end{aligned}$$
$$A^+ = AX_2' + AX_1B' + X_2'X_1' + X_2'B'$$

$$T = X_1'BA + X_1'B'A'$$
$$\begin{aligned} B^+ &= BT' + B'T \\ &= B(X_1'BA + X_1'B'A')'\,B'\,(X_1'BA + X_1'B'A')' \\ &= B\,[(X_1'BA)'\,(X_1'B'A')'] + X_1'B'A' \\ &= B\,[(X_1 + B' + A')\,(X_1 + B + A)] + X_1'B'A' \\ &= (BX_1 + BA')\,(X_1 + B + A) + X_1'B'A' \\ &= BX_1 + BX_1 + BX_1A + BA'X_1 + BA' + X_1'B'A' \\ &= X_1B(1 + 1 + A + A') + A'\,(B + X_1'B) \\ &= X_1B + A'B + X_1'A' \end{aligned}$$

13.30
(cont.)

State	Present State	A^+B^+ $X_1X_2 =$				Z_1Z_2 $X_1X_2 =$			
	AB	00	01	10	11	00	01	10	11
S_0	00	11	01	10	00	10	10	00	00
S_1	01	11	01	01	01	11	00	11	00
S_2	10	10	00	10	10	01	00	01	00
S_3	11	10	00	11	01	00	00	00	00