E&CE 223
Assignment 7 - Solutions

1. A sequential circuit has two inputs x_1 and x_2 and one output z. Whenever an $x_1=1$ is observed, the output becomes 1 provided $x_2=1$ has been observed exactly twice since the last time $x_1=1$ was observed. The output remains 1 until $x_2=1$ is observed. Draw the state diagram as (a) a Mealy machine, and (b) as a Moore machine.

(b) Moore machine - five states are required:

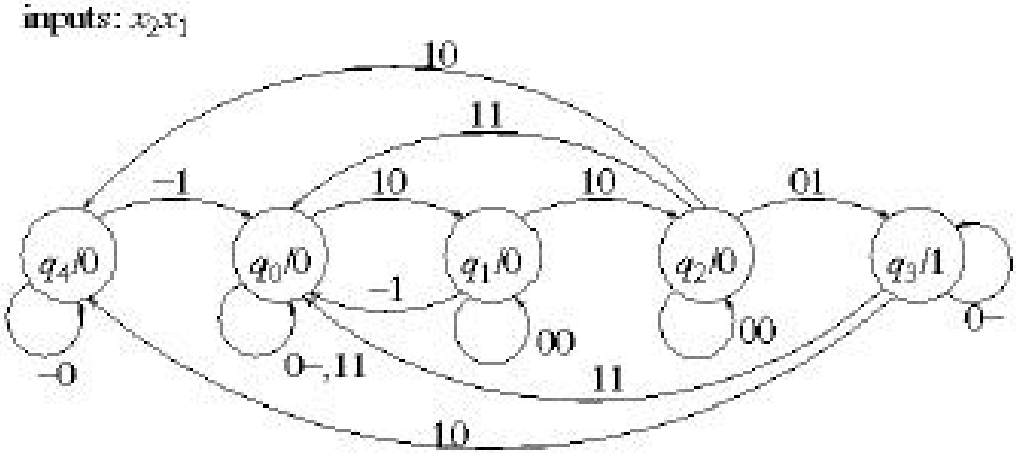
q_0 - have seen x_1=1, waiting for x_2=1; z=0

q_1 - have seen x_2=1 once since last time x_1=1; z=0

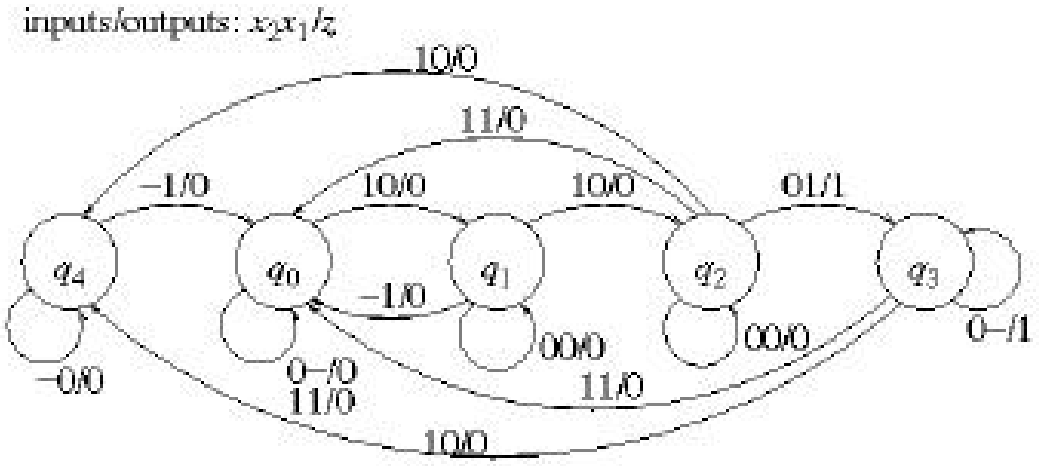
q_2 - have seen x_2=1 twice since last time x_1=1; z=0

q_3 - remain in this state until x_2=1; z=1

q_4 - wait for x_1=1; z=0



(a) Mealy machine - same five states. However the output is associated with the transitions between states at the clock pulse. Output z is zero except for transitions to state q_3.

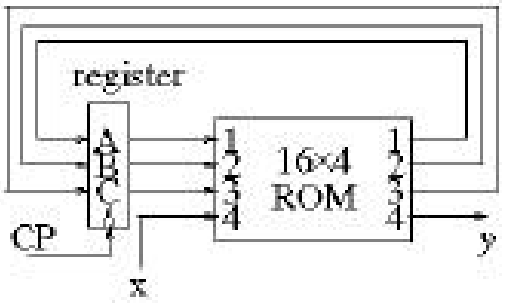


2. Mano 7.4

ROM table

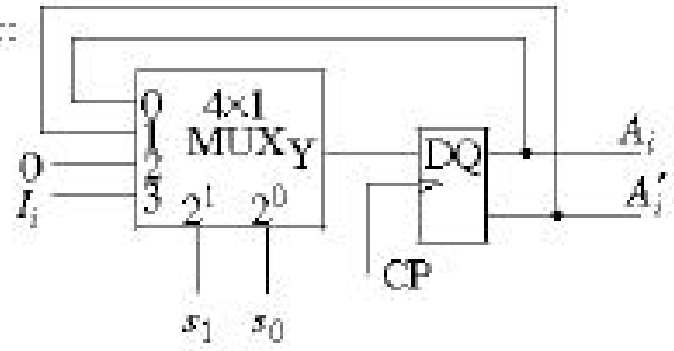
inputs				outputs			
1	2	3	4	1	2	3	4
A	B	C	x	A	B	C	y
0	0	0	0	0	0	1	0
0	0	0	1	0	1	0	0
0	0	1	0	0	0	1	0
0	0	1	1	0	1	0	0
0	1	0	0	0	1	1	0
0	1	0	1	1	0	0	0
0	1	1	0	0	0	1	0
0	1	1	1	1	0	0	0
1	0	0	0	1	0	1	0
1	0	0	1	1	0	0	1
1	0	1	0	0	0	1	0
1	0	1	1	1	0	0	1
1	1	0	0	1	1	1	0
1	1	0	1	1	0	0	1
1	1	1	0	0	0	1	0
1	1	1	1	1	0	0	1

The state diagram in Mano, page 247 was developed from the state table given in Mano, page 243. Hence the ROM program for states 001-101 follows directly from that table. The state 000, 110, and 111 are error states, and as discussed in Mano, page 246, are self-correcting.



3. Mano 7.9

One stage of register:



4. Mano 7.17

(a) 1 0 0 1 1 0 0 1 1 1

↓

1 0 0 1 1 0 1 0 0 0

x x x x - 4 flip-flops complemented

(b) 0 0 1 1 1 1 1 1 1 1

↓

0 1 0 0 0 0 0 0 0 0

x x x x x x x x x - 9 flip-flops complemented

5. Mano 7.23

State Transition method

present state				next state				transition			
A_8	A_4	A_2	A_1	A_8	A_4	A_2	A_1	A_8	A_4	A_2	A_1
0	0	0	0	0	0	0	1	ϕ	ϕ	ϕ	α
0	0	0	1	0	0	1	0	ϕ	ϕ	α	β
0	0	1	0	0	0	1	1	ϕ	ϕ	I	α
0	0	1	1	0	1	0	0	ϕ	α	β	β
0	1	0	0	0	1	0	1	ϕ	I	ϕ	α
0	1	0	1	0	1	1	0	ϕ	I	α	β
0	1	1	0	0	1	1	1	ϕ	I	I	α
0	1	1	1	1	0	0	0	α	β	β	β
1	0	0	0	1	0	0	1	I	ϕ	ϕ	α
1	0	0	1	0	0	0	0	β	ϕ	ϕ	β

States 1010 through 1111 are not used.

A_8A_4 \ A_2A_1	00	01	11	10
00	ϕ	ϕ	ϕ	ϕ
01	ϕ	ϕ	α	ϕ
11	X	X	X	X
10	I	β	X	X

A_8 transitions

A_8A_4 \ A_2A_1	00	01	11	10
00	ϕ	ϕ	α	ϕ
01	I	I	β	I
11	X	X	X	X
10	ϕ	ϕ	X	X

A_4 transitions

$$J_8 = A_4A_2A_1 \qquad J_4 = K_4 = A_2A_1$$

$$K_8 = A_1$$

A_8A_4 \ A_2A_1	00	01	11	10
00	ϕ	α	β	I
01	ϕ	α	β	I
11	X	X	X	X
10	ϕ	ϕ	X	X

A_2 transitions

A_8A_4 \ A_2A_1	00	01	11	10
00	α	β	β	α
01	α	β	β	α
11	X	X	X	X
10	α	β	X	X

A_1 transitions

$$J_2 = K_2 = A_8'A_1 \qquad J_1 = K_1 = 1$$

$$\text{or} \quad K_2 = A_1$$

All the error states 1010-1111 are self-correcting.

6. Mano 7.27

The key is to connect the ‘carry out’ of one counter to the ‘count’ input of the next. This makes the second counter increment each time the first counter hits 16. To stop at 64, the ‘A_7’ output needs to be fed back to the first counter to stop the counting process. Also, both counters should be cleared at the start so that the counting begins at 0.