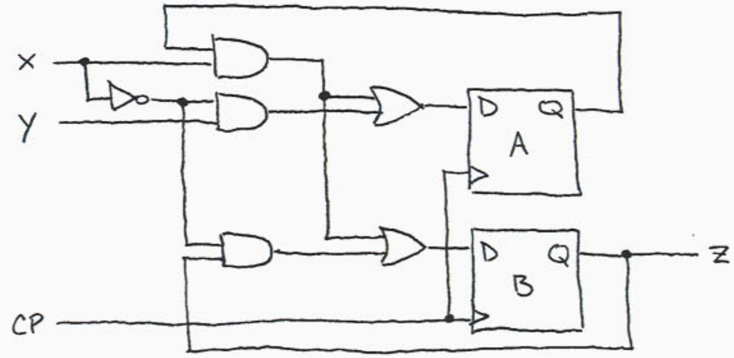
ENGINEERING SCIENCES 50
INTRODUCTION TO ELECTRICAL ENGINEERING

Solution Set 4
Mano exercises 6.6, 6.9, 6.11, 6.13, 6.18, 6.20, 6.25; additional simulation problem

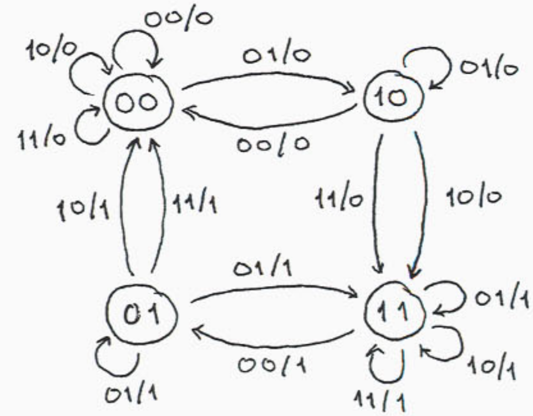
6.6. a)



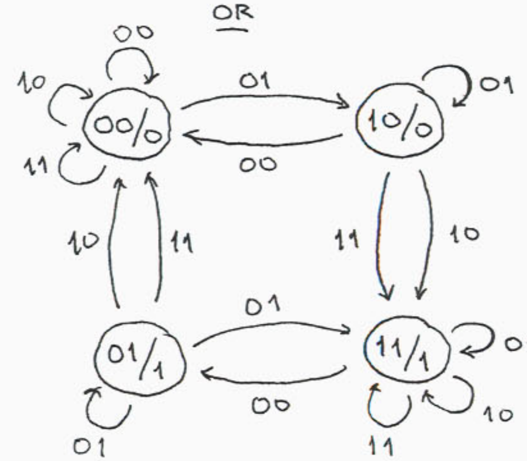
b)

present state A	B	inputs x	y	next state A	B	output z
0	0	0	0	0	0	0
0	0	0	1	1	0	0
0	0	1	0	0	0	0
0	0	1	1	0	0	0
0	1	0	0	0	1	1
0	1	0	1	1	1	1
0	1	1	0	0	0	1
0	1	1	1	0	0	1
1	0	0	0	0	0	0
1	0	0	1	1	0	0
1	0	1	0	1	1	0
1	0	1	1	1	1	0
1	1	0	0	0	1	1
1	1	0	1	1	1	1
1	1	1	0	1	1	1
1	1	1	1	1	1	1

c)

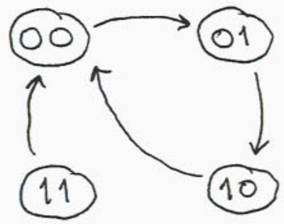


OR



6.9. $T_A = A + B \quad T_B = A + B$

current state A	current state B	flip-flop inputs T_A	flip-flop inputs T_B	next state A	next state B
0	0	0	1	0	1
0	1	1	1	1	0
1	0	1	0	0	0
1	1	1	1	0	0

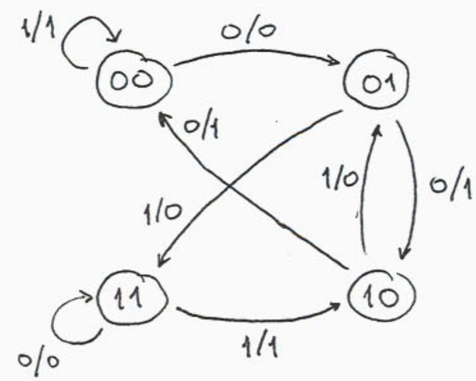


a self-correcting counter with repeating sequence 00, 01, 10

6.11. $J_A = B \quad K_A = \bar{B} \quad J_B = K_B = A \odot x$

$Y = A \oplus B \oplus x$

current state A	current state B	input x	flip-flop inputs J_A	K_A	J_B	K_B	next state A	next state B	output Y
0	0	0	0	1	1	1	0	1	0
0	0	1	0	1	0	0	0	0	1
0	1	0	1	0	1	1	1	0	1
0	1	1	1	0	0	0	1	1	0
1	0	0	0	1	0	0	0	0	1
1	0	1	0	1	1	1	0	1	0
1	1	0	1	0	0	0	1	1	0
1	1	1	1	0	1	1	1	0	1



6.13.

$00 \xrightarrow{0/0} 00 \xrightarrow{1/0} 01 \xrightarrow{0/1} 00 \xrightarrow{1/0} 01 \xrightarrow{1/0} 11 \xrightarrow{0/1} 00 \xrightarrow{1/0} 01 \xrightarrow{1/0} 11 \xrightarrow{1/0} 10 \xrightarrow{0/1} 00 \xrightarrow{1/0} 01 \xrightarrow{1/0} 11 \xrightarrow{1/0} 10 \xrightarrow{1/0} 10 \xrightarrow{0/1} 00$

output sequence: 001001000100001

6.18. $D = Q \oplus T$

present state Q	input T	flip-flop input D	next state Q
0	0	0	0
0	1	1	1
1	0	1	1
1	1	0	0

T flip-flop:

present state Q	input T	next state Q
0	0	0
0	1	1
1	0	1
1	1	0

6.20.

present state A	B	input x	next state A	B	flip-flop inputs D_A	D_B
0	0	0	0	0	0	0
0	0	1	0	1	0	1
0	1	0	0	1	0	1
0	1	1	1	1	1	1
1	0	0	1	0	1	0
1	0	1	0	0	0	0
1	1	0	1	1	1	1
1	1	1	1	0	1	0

A \ Bx	00	01	11	10
0	0	0	1	0
1	1	0	1	1

$D_A = A\bar{x} + Bx$

A \ Bx	00	01	11	10
0	0	1	1	1
1	0	0	0	1

$D_B = \bar{A}x + B\bar{x}$

6.25. a) $J_A = BC$ $\quad J_B = C$ $\quad J_C = \bar{A} + \bar{B}$
$K_A = B$ $\quad K_B = A + C$ $\quad K_C = 1$

b) $D_A = A \oplus B$ $\quad D_B = A\bar{B} + C$ $\quad D_C = \bar{A}\bar{B}\bar{C}$

c) $T_A = B$ $\quad T_B = C$ $\quad T_C = AB + \bar{C}$

d) $T_A = A \oplus B$ $\quad T_B = B \oplus C$ $\quad T_C = AC + \bar{A}\bar{C}$ (not self-correcting)
$T_C = AC + \bar{A}B\bar{C}$ (self-correcting)

Since these problems are similar, I will only show part (d) being worked out:

present state A	B	C	next state A	B	C	flip-flop inputs T_A	T_B	T_C
0	0	0	0	0	1	0	0	1
0	0	1	0	1	1	0	1	0
0	1	1	1	1	1	1	0	0
1	1	1	1	1	0	0	0	1
1	1	0	1	0	0	0	1	0
1	0	0	0	0	0	1	0	0

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

$T_A = A \oplus B$

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

$T_B = B \oplus C$

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

$T_C = AC + \bar{A}\bar{C}$

Check unused states:

present state A	B	C	flip-flop inputs T_A	T_B	T_C	next state A	B	C
0	1	0	1	1	1	1	0	1
1	0	1	1	1	1	0	1	0

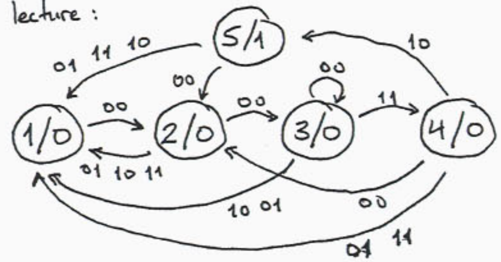
Go back to the Karnaugh maps and change the groupings so that the circuit is self-correcting by leaving out a "d" that previously was included: $T_C = AC + \bar{A}B\bar{C}$ (leaves out d at 010)
(other solutions possible)

Now, 010 → 100

Simulation problem:

Moore machine: output depends only on current state

from lecture:



State transition table:

present state	next state for x_1x_2 = 00	01	10	11	output z
1	2	1	1	1	0
2	3	1	1	1	0
3	3	1	4	1	0
4	2	1	1	5	0
5	2	1	1	1	1

State assignment: (many solutions possible)

1 → 000 2 → 001 3 → 011 4 → 111 5 → 110

State table:

present state A	B	C	inputs x_1	x_2	next state A	B	C
0	0	0	0	0	0	0	1
0	0	0	0	1	0	0	0
0	0	0	1	0	0	0	0
0	0	0	1	1	0	0	0
0	0	1	0	0	0	1	1
0	0	1	0	1	0	0	0
0	0	1	1	0	0	0	0
0	0	1	1	1	0	0	0
0	1	1	0	0	0	1	1
0	1	1	0	1	0	0	0
0	1	1	1	0	1	1	1
0	1	1	1	1	0	0	0
1	1	1	0	0	0	0	1
1	1	1	0	1	0	0	0
1	1	1	1	0	0	0	0
1	1	1	1	1	1	1	0
1	1	0	0	0	0	0	1
1	1	0	0	1	0	0	0
1	1	0	1	0	0	0	0
1	1	0	1	1	0	0	0

A = 0

BC \ x_1x_2	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	0	0	0	1
10	d	d	d	d

A = 1

BC \ x_1x_2	00	01	11	10
00	d	d	d	d
01	d	d	d	d
11	0	0	1	0
10	0	0	0	0

$D_A = BCx_1(A \odot x_2)$

or

$D_A = \bar{A}Bx_1\bar{x}_2 + ACx_1x_2$

A = 0

BC \ x_1x_2	00	01	11	10
00	0	0	0	0
01	1	0	0	0
11	1	0	0	1
10	d	d	d	d

A = 1

BC \ x_1x_2	00	01	11	10
00	d	d	d	d
01	d	d	d	d
11	0	0	1	0
10	0	0	0	0

$D_B = D_A + \bar{A}C\bar{x}_1\bar{x}_2$

A = 0

BC \ x_1x_2	00	01	11	10
00	1	0	0	0
01	1	0	0	0
11	1	0	0	1
10	d	d	d	d

A = 1

BC \ x_1x_2	00	01	11	10
00	d	d	d	d
01	d	d	d	d
11	1	0	0	0
10	1	0	0	0

$D_C = \bar{x}_1\bar{x}_2 + \bar{A}B\bar{x}_2$

From these expressions, build the circuit and test it.