

Problem Set 9 Solutions

Problem 9.1a (7.11 from McCluskey)

| | x2x1 | | | |
|---|------|-----|-----|-----|
| | 00 | 01 | 11 | 10 |
| A | (A) | B | - | (A) |
| B | (B) | (B) | C | A |
| C | - | - | (C) | D |
| D | B | - | - | (D) |

There is 1 essential hazard.

Start at state = d and $x_2x_1 = 10$

change $x_2x_1 \rightarrow 00 \Rightarrow d \rightarrow b$

change $x_2x_1 \rightarrow 10 \Rightarrow b \rightarrow a$

$x_2x_1 \rightarrow 00 \Rightarrow a \rightarrow a$

$b \neq a \Rightarrow$ hazard

Problem 9.1b

| | x2x1 | | | |
|---|------|-----|-----|-----|
| | 00 | 01 | 11 | 10 |
| A | (A) | - | B | (A) |
| B | - | C | (B) | D |
| C | D | (C) | B | - |
| D | (D) | - | F | (D) |
| E | - | (E) | F | (E) |
| F | - | C | (F) | E |

There are 3 essential hazards.

i) Start at state = a and $x_2x_1 = 10$

change $x_2x_1 \rightarrow 11 \Rightarrow a \rightarrow b$

change $x_2x_1 \rightarrow 10 \Rightarrow b \rightarrow d$

$x_2x_1 \rightarrow 11 \Rightarrow d \rightarrow f$

$b \neq f \Rightarrow$ hazard

ii) Start at state = b and $x_2x_1 = 11$

change $x_2x_1 \rightarrow 10 \Rightarrow b \rightarrow d$

change $x_2x_1 \rightarrow 11 \Rightarrow d \rightarrow f$

$x_2x_1 \rightarrow 10 \Rightarrow f \rightarrow e$

$d \neq e \Rightarrow$ hazard

iii) Start at state = e and $x_2x_1 = 01$

change $x_2x_1 \rightarrow 11 \Rightarrow e \rightarrow f$

change $x_2x_1 \rightarrow 01 \Rightarrow f \rightarrow c$

$x_2x_1 \rightarrow 11 \Rightarrow c \rightarrow b$

$f \neq b \Rightarrow$ hazard

Problem 9.2 (7.2 from McCluskey)

a.

| | | y | |
|----|----|---|---|
| | | 0 | 1 |
| SR | 00 | 0 | 1 |
| | 01 | 0 | 0 |
| | 11 | 1 | 1 |
| | 10 | 1 | 1 |

$$Y = S + yR'$$

b.

| | | y | |
|----|----|---|---|
| | | 0 | 1 |
| SR | 00 | 0 | 1 |
| | 01 | 0 | 0 |
| | 11 | 0 | 0 |
| | 10 | 1 | 1 |

$$Y = SR' + R'y$$

or

$$Y = R'(S+y)$$

c.

| | | CR | | | |
|------|----|----|----|----|----|
| | | 00 | 01 | 11 | 10 |
| SaSb | 00 | y | y | 0 | y |
| | 01 | y | y | d | 1 |
| | 11 | 1 | 1 | d | 1 |
| | 10 | 1 | 1 | d | 1 |

$$Y = Sa + SbC + C'y + R'y (+ Sby)$$

d.

| | | y | |
|----|----|---|---|
| | | 0 | 1 |
| DC | 00 | 0 | 1 |
| | 01 | 0 | 0 |
| | 11 | 1 | 1 |
| | 10 | 0 | 1 |

$$Y = DC + C'y (+Dy)$$

Problem 9.3 (7.5 abcd from McCluskey)

a. Add amplifiers directly after the outputs of the two NOR gates (before the feedback loops) leading to the outputs Q and P. The Input/Output of the amplifier leading to Q will be labeled E1/y1, and the I/O of the amplifier leading to P will be labeled E2/y2.

b. Excitation Equations

$$\begin{aligned} E1 &= (x1 + x2 + (x1 + y1 + y2 + x3)' + y2)' \\ &= x1'x2'(x1 + y1 + y2 + x3)y2' \\ &= x1'x2'y1y2' + x1'x2'x3y2' \end{aligned}$$

$$\begin{aligned} E2 &= ((x1 + y1 + y2 + x3)' + x2 + y1 + x3)' \\ &= x1x2'x3'y1' + x2'x3'y1'y2 \end{aligned}$$

$$Q = y1$$

$$P = y2$$

c. Transition and Output Tables

| | | x1x2 | | | |
|------|----|-------|----|----|----|
| | | 00 | 01 | 11 | 10 |
| y1y2 | 00 | x30 | 00 | dd | 01 |
| | 01 | x3x3' | 00 | dd | 01 |
| | 11 | 00 | 00 | dd | 00 |
| | 10 | 10 | 00 | dd | 00 |

E1E2

| | | x1x2 | | | |
|------|----|------|----|----|----|
| | | 00 | 01 | 11 | 10 |
| y1y2 | 00 | 00 | 00 | dd | 00 |
| | 01 | 01 | 01 | dd | 01 |
| | 11 | 11 | 11 | dd | 11 |
| | 10 | 10 | 10 | dd | 10 |

QP

d. Flow Table

| | | x1x2 (x3=0) | | | |
|---|-----|-------------|----|-----|----|
| | | 00 | 01 | 11 | 10 |
| A | (A) | (A) | - | B | |
| B | (B) | A | - | (B) | |
| C | A | A | - | B | |
| D | (D) | A | - | B | |

S

| | | x1x2 (x3=1) | | | |
|---|-----|-------------|----|-----|----|
| | | 00 | 01 | 11 | 10 |
| A | D | (A) | - | B | |
| B | D | A | - | (B) | |
| C | D | A | - | B | |
| D | (D) | A | - | B | |

S

Problem 9.4 (8.1 from McCluskey)

a.

Excitation Equations

$$J1 = xQ2$$

$$K1 = x'Q2'$$

$$J2 = x'Q1$$

$$K2 = xQ1'$$

$$z = xQ1'$$

Let $Q1 = y1$ and $Q2 = y2$

Transition Table

| | | x | |
|------|----|----|----|
| | | 0 | 1 |
| y1y2 | 00 | 00 | 00 |
| | 01 | 01 | 10 |
| | 11 | 11 | 11 |
| | 10 | 01 | 10 |

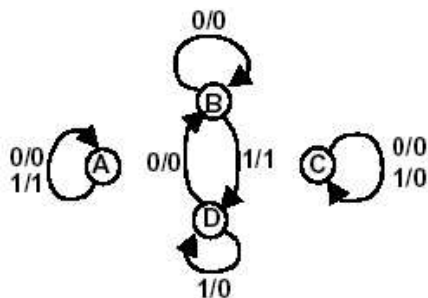
Y1Y2

State/Output Table

| | x | |
|---|-----|-----|
| | 0 | 1 |
| A | A,0 | A,1 |
| B | B,0 | D,1 |
| C | C,0 | C,0 |
| D | B,0 | D,0 |

S,Z

State/Output Diagram



b.

Excitation Equations

$$D1 = y2 \oplus y3$$

$$D2 = y1$$

$$D3 = (y1 \oplus y2)'$$

| | y1 | y2 | y3 | Y1 | Y2 | Y3 |
|---|----|----|----|----|----|----|
| A | 0 | 0 | 0 | 0 | 0 | 1 |
| B | 0 | 0 | 1 | 1 | 0 | 1 |
| C | 0 | 1 | 0 | 1 | 0 | 0 |
| D | 0 | 1 | 1 | 0 | 0 | 0 |
| E | 1 | 0 | 0 | 0 | 1 | 0 |
| F | 1 | 0 | 1 | 1 | 1 | 0 |
| G | 1 | 1 | 0 | 1 | 1 | 1 |
| H | 1 | 1 | 1 | 0 | 1 | 1 |

State/Output Diagram

