## 15.2

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| b | c-e | | | | | | | |
| c | X | X | | | | | | |
| d | ~~e-h<br>e-a~~ | ~~c-h<br>e-a~~ | X | | | | | |
| e | X | X | h-f | X | | | | |
| f | X | X | ~~i-e<br>h-g~~ | X | ~~i-e<br>f-g~~ | | | |
| g | ~~e-h<br>e-b~~ | ~~c-h<br>e-b~~ | X | a-b | X | X | | |
| h | X | X | ~~c-i<br>d-h~~ | X | ~~c-i<br>f-d~~ | c-e<br>g-d | X | |
| i | ~~e-f<br>e-b~~ | ~~c-f<br>b-e~~ | X | h-f<br>a-b | X | X | h-f | X |
| | a | b | c | d | e | f | g | h |

$a \equiv b$
$c \equiv e$
$h \equiv f$
$d \equiv g \equiv i$

*See FLD p. 766 for reduced state table.*

## 15.3

| | | | |
|---|---|---|---|
| $S_0$ | $S_5 - a$<br>$S_1 - b$ | ~~$S_5 - a$<br>$S_1 - c$~~ | X |
| $S_1$ | ~~$S_5 - a$<br>$S_6 - b$~~ | $S_5 - a$<br>$S_6 - c$ | X |
| $S_2$ | ~~$S_2 - a$<br>$S_6 - b$~~ | ~~$S_2 - a$<br>$S_6 - c$~~ | X |
| $S_3$ | X | X | $S_0 - a$<br>$S_1 - b$ |
| $S_4$ | ~~$S_4 - a$<br>$S_3 - b$~~ | ~~$S_4 - a$<br>$S_3 - c$~~ | X |
| $S_5$ | $S_0 - a$<br>$S_1 - b$ | ~~$S_0 - a$<br>$S_1 - c$~~ | X |
| $S_6$ | X | X | $S_5 - a$<br>$S_1 - b$ |
| | a | b | c |

$S_0 \equiv a$
$S_1 \equiv b$
$S_3 \equiv c$
$S_5 \equiv a$
$S_6 \equiv c$
$S_2$ and $S_4$ have no equivalent states.

(a)

$a \equiv S_0, S_5$
$b \equiv S_1$
$c \equiv S_3, S_6$

Since $S_2$ and $S_4$ do not have corresponding states, the circuits are *not* equivalent.

(b)

Starting from $S_0$, it is not possible to reach $S_2$ or $S_4$. So then the circuits would perform the same.

## 15.6

(a)

Group $(S_1, S_4, S_6, S_7)$ and $(S_2, S_3, S_5, S_8)$.

| BC \ A | 0 | 1 |
|---|---|---|
| 00 | $S_1$ | $S_2$ |
| 01 | $S_4$ | $S_3$ |
| 11 | $S_6$ | $S_5$ |
| 10 | $S_7$ | $S_8$ |

One possible assignment:

$S_1 = 000$ $\quad S_5 = 111$
$S_2 = 100$ $\quad S_6 = 011$
$S_3 = 101$ $\quad S_7 = 010$
$S_4 = 001$ $\quad S_8 = 110$

| BC \ A | 0 | 1 |
|---|---|---|
| 00 | | 1 |
| 01 | | 1 |
| 11 | | 1 |
| 10 | | 1 |

$Z = A$

(b)

I: $(S_3, S_4)$✓ $(S_1, S_8)$✓ $(S_3, S_7)$✓ $(S_5, S_8)$✓
II: $(S_4, S_5)$✓ $(S_1, S_6)$ $(S_7, S_8)$ $(S_1, S_7)$✓ $(S_2, S_3)$✓
$(S_2, S_4)$ $(S_6, S_8)$✓ $(S_3, S_5)$
Adjacencies that are satisfied are checked (✓)

One possible assignment:

$S_1 = 000$ $\quad S_5 = 101$
$S_2 = 010$ $\quad S_6 = 110$
$S_3 = 011$ $\quad S_7 = 001$
$S_4 = 111$ $\quad S_8 = 100$

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

$D_A = A'B' + X'AC' + XA'$

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

$D_B = X'B'C + ABC' + XC' + XAB'$

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

$D_C = B'C' + X'BC + XAB' + X'AC'$

| State | $ABC$ | $A^+B^+C^+$ $X=0$ | $X=1$ |
|---|---|---|---|
| $S_1$ | 000 | 101 | 111 |
| $S_7$ | 001 | 110 | 100 |
| $S_2$ | 010 | 000 | 110 |
| $S_3$ | 011 | 001 | 100 |
| $S_8$ | 100 | 101 | 011 |
| $S_5$ | 101 | 010 | 011 |
| $S_6$ | 110 | 111 | 010 |
| $S_4$ | 111 | 001 | 000 |

## 15.9

*See FLD p. 767 for solution using* $Q_1$, $Q_2$, *and* $Q_3$.

Alternate solution using $Q_0$, $Q_1$ and $Q_2$:

$D_0 = X'Q_0 + XY'Q_2$

$D_1 = XQ_0 + YQ_2 + X'Q_1$

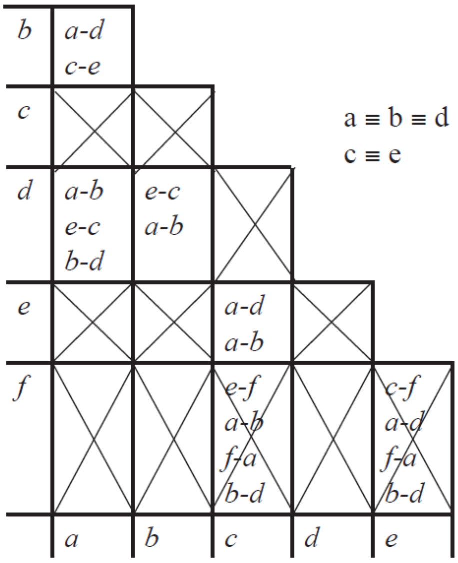
$D_2 = YQ_1 + X'Y'Q_2$

$P = XQ_0 + Y'Q_2 + XQ_1$

$S = X'Q_0 + XY'Q_2$

## 15.15

(a)

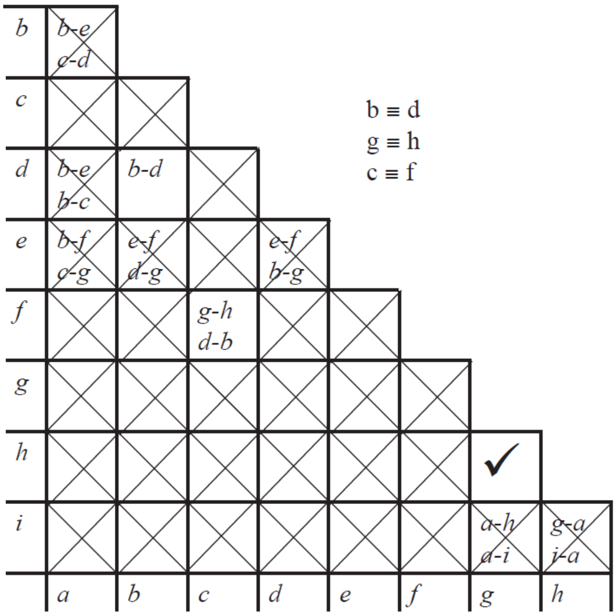



a ≡ b ≡ d

c ≡ e

| Present State | Next State 00 | 01 | 11 | 10 | $Z$ |
|---|---|---|---|---|---|
| $a$ | $a$ | $c$ | $c$ | $a$ | 0 |
| $c$ | $c$ | $a$ | $f$ | $a$ | 1 |
| $f$ | $f$ | $a$ | $a$ | $a$ | 1 |

(b)




b ≡ d

g ≡ h

c ≡ f

| State | Next State $X=0$ | $X=1$ | $Z$ $X=0$ | $X=1$ |
|---|---|---|---|---|
| $a$ | $b$ | $c$ | 1 | 0 |
| $b$ | $e$ | $b$ | 1 | 0 |
| $c$ | $g$ | $b$ | 1 | 1 |
| $e$ | $c$ | $g$ | 1 | 0 |
| $g$ | $g$ | $i$ | 0 | 1 |
| $i$ | $a$ | $a$ | 0 | 1 |

## 15.17

(a)

$S_0 \equiv e \equiv f,\ S_1 \equiv c \equiv d,\ S_2 \equiv S_3 \equiv a \equiv b$

Since every state in $N$ has an equivalent state in $M$, and vice versa, $N$ and $M$ are equivalent.

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| $S_0$ | | | $\cancel{E-S_3}$ $\cancel{D-S_1}$ | $\cancel{E-S_3}$ $\cancel{C-S_1}$ | $B-S_3$ $D-S_1$ | $B-S_3$ $C-S_1$ |
| $S_1$ | | | $E-S_0$ $D-S_1$ | $E-S_0$ $C-S_1$ | $\cancel{B-S_0}$ $\cancel{D-S_1}$ | $\cancel{B-S_0}$ $\cancel{C-S_1}$ |
| $S_2$ | $E-S_0$ $A-S_2$ | $F-S_0$ $B-S_2$ | | | | |
| $S_3$ | $E-S_0$ $A-S_3$ | $F-S_0$ $B-S_3$ | | | | |

(b)

M

| | X = 0 | 1 | |
|---|---|---|---|
| $S_0$ | $S_2$ | $S_1$ | 0 |
| $S_1$ | $S_0$ | $S_1$ | 0 |
| $S_2$ | $S_0$ | $S_2$ | 1 |

$S_2 \equiv S_3$

N

| | X = 0 | 1 | |
|---|---|---|---|
| $A$ | $E$ | $A$ | 1 |
| $C$ | $E$ | $C$ | 0 |
| $E$ | $A$ | $C$ | 0 |

$E \equiv F$, $C \equiv D$, $A \equiv B$

*Note:* $S_2 \equiv A$, $S_1 \equiv C$, $S_0 \equiv E$

## 15.33

I. None

II. $(4, 7)$✓ $(6, 7)$✓ $(2, 4)$✓ $(2, 6)$✓

Assignment:

$S_0 = 000$, $S_2 = 100$, $S_4 = 111$, $S_6 = 110$, $S_7 = 101$

| BC \ A | 0 | 1 |
|---|---|---|
| 00 | $S_0$ | $S_2$ |
| 01 | | $S_7$ |
| 11 | | $S_4$ |
| 10 | | $S_6$ |

| Present State | Next State $W = 0$ | $1$ | Output 0 | 1 |
|---|---|---|---|---|
| $S_0$ | $S_0$ | $S_0$ | 0 | 0 |
| $S_2$ | $S_4$ | $S_7$ | 1 | 0 |
| $S_4$ | $S_7$ | $S_6$ | 0 | 0 |
| $S_6$ | $S_2$ | $S_4$ | 0 | 0 |
| $S_7$ | $S_6$ | $S_2$ | 0 | 0 |

| Present State | Next State $W = 0$ | $1$ | Output 0 | 1 |
|---|---|---|---|---|
| 000 | 000 | 000 | 0 | 0 |
| 100 | 111 | 101 | 1 | 0 |
| 111 | 101 | 110 | 0 | 0 |
| 110 | 100 | 111 | 0 | 0 |
| 101 | 110 | 100 | 0 | 0 |

T input equations derived from the transition table using Karnaugh maps:

$T_A = 0$; $T_B = W'A$; $T_C = WB + AB'$; $Z = W'AB'C'$