

Answers to Problems

For Fundamentals of Logic Design
second edition (corrected version)

Answers to Chapter 2 Problems

1. (a) 151.875 (b) 238.125 (c) 53.5
(d) 1574.75 (e) 142.453125 (f) 4274.25
2. (a) $1000_{10} = 1331_9$ (b) $202_{10} = CA_{16}$
(c) $278_{10} = 2103_5$ (d) $3467_{10} = 13052_7$
3. (a) $.36_8$ (b) $.78_{16}$ (c) $.31_5$ (d) $.0011_2$
4. (a) $1000_{16} = 4096_{10} = 30544_6$ (b) $200_3 = 18_{10} = 30_6$
(c) $214_5 = 59_{10} = 135_6$ (d) $3467_8 = 1847_{10} = 12315_6$
5. $R = 8$
6. (a) $100_{10} = 64_{16} = (0110\ 0100)_2 = 144_8$
(b) $217_{10} = D9_{16} = (1101\ 1001)_2 = 331_8$
(c) $472.625_{10} = 1D8.A_{16} = (0001\ 1101\ 1000\ .\ 1010)_2 = 730.5_8$
(d) $256.03125_{10} = 100.08_{16} = (1\ 0000\ 0000.\ 0000\ 1000)_2 = 400.02_8$
7. (a) $2047_{10} = (2^{11} - 1)_{10} = (100\ 000\ 000\ 000 - 1)_2 = 11\ 111\ 111\ 111_2$
(b) $1\ 0000\ 0000\ 0000\ 0000_2$
(c) $111\ 111\ 111\ 111_2$
(d) $111\ 111_{10} = (1\ 1011\ 0010\ 0000\ 0111)_2$
8. (a) 215 (b) 150 (c) 706 (d) 947
9. (a) 11000011111 (b) 110110100001
(c) 10000000001100 (d) 10011100001111
10. (a) $21\ 32\ .\ 12_4 = 9\ E\ .\ 6_{16}$
(b) $212\ .\ 32_4 = (10\ 01\ 10\ .\ 11\ 10)_2$
(c) $132.02_4 = 30.125_{10}$
(d) $123_4 = 36_7$
11. (a) $(10\ 11\ 01)_2 = 2\ 3\ 1_4$
(b) $(101101)_{16} = (1\ 00\ 01\ 01\ 00\ 01)_4$
(c) $(101\ 101)_8 = (10\ 00\ 00\ 10\ 01\ 00\ 00\ 01)_2 = (2\ 0\ 0\ 2\ 1\ 0\ 0\ 1)_4$
(d) $745\ .\ 125_{10} = 23221.02_4$
12. (a) $(2508)_{10} = (0010\ 0101\ 0000\ 1000)_{BCD}$
(b) $(11111)_2 = (31)_{10} = (0011\ 0001)_{BCD}$
(c) $(1001\ 0011\ 0101\ 0111)_{BCD} = (9357)_{10}$
(d) $(0001\ 0001\ 0001)_{BCD} = (111)_{10} = (1101111)_2$

13. (a) $(1078)_{10} = (0100\ 0011\ 1010\ 1011)_{\text{Excess-3}}$
 (b) $(0101\ 1001\ 1011)_{\text{Excess-3}} = (268)_{10} = (0010\ 0110\ 1000)_{\text{BCD}}$
 (c) $(10000000)_2 = (128)_{10} = (0100\ 0101\ 1011)_{\text{Excess-3}}$
 (d) $(12CF)_{16} = (4815)_{10} = (0100\ 1000\ 0001\ 0101)_{\text{BCD}}$
14. (a) (0000, 0010, 0111, 0100, 0110, 1001, 1011, 1000, 1101, 1111) or
 (0000, 0101, 0111, 0100, 0110, 1001, 1011, 1000, 1010, 1111)
- (b) (00000, 00101, 01111, 01001, 01100, 10010, 10111, 10001, 11011, 11110) or
 (00000, 01010, 01111, 01001, 01100, 10010, 10111, 10001, 10100, 11110)
15. (a) Because it is impossible to encode decimal digit “1”.
 (b) Yes. For example : (6, 4, 3, -2) weighted code.
 How about (6, 4, -3, 2), (6, -4, 3, 2), and (-6, 4, 3, 2)?

Answers to Chapter 3 Problems

1.

ABCD	f(A, B, C, D)		
	(a)	(b)	(c)
0 0 0 0	0	1	0
0 0 0 1	0	0	0
0 0 1 0	1	1	1
0 0 1 1	0	1	0
0 1 0 0	0	0	0
0 1 0 1	1	1	0
0 1 1 0	1	1	1
0 1 1 1	1	1	0
1 0 0 0	1	1	1
1 0 0 1	1	1	0
1 0 1 0	1	0	0
1 0 1 1	0	0	0
1 1 0 0	1	1	1
1 1 0 1	1	1	1
1 1 1 0	1	1	1
1 1 1 1	1	1	1

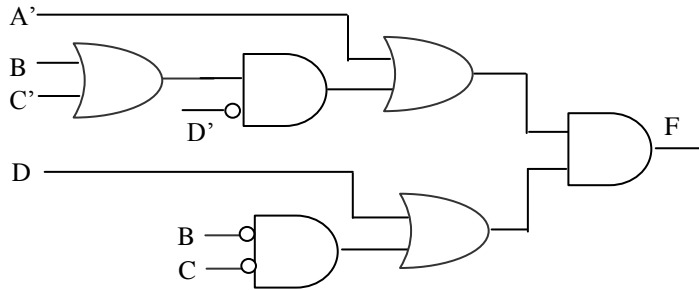
2. (a) C (b) B' (c) 1 (d) A
3. (a) $AB + C$ (b) $AB + CD$ (c) $A + B + C$ (d) $B' + C'D'$
4. (a) $x + y'$ (b) $x' + y'$ (c) 1 (d) $x' + y$
5. (a) $a'(b' + c + d)$ (b) $a'b(c' + d)$
(c) $b'd'$ (d) $a'b' + ab$
6. (a) $y' + w'xz$ (b) $b(a + c)$ (c) $ad' + c(b + d)$
7. (a) $ab + ad + cd$ (b) $ab' + b'd' + c'd' + ad'$
(c) $a'bd + bcd'$ (d) $ac + a'b' + a'c'd$
8. (c) $LHS = A'B + AC + B'C' = A'B + AC + B'C' + BC + A'C' + AB'$
 $= BC + A'C' + AB' = RHS$
9. (a) $ac' + abd' + a'bc$ (b) $ac'd + abd$ (c) $a'd + bd$
10. (a) $(a + c)(a + b)(a + d')$
(b) $d(a + c')(b + c')(a + b)$
(c) $a(b + c + d')$

11. (a) $(a + b + c)[(e + d'c') a']$
 (b) $(a + b + d)[c' + (a' + b') \bullet 1 \bullet d']$
 (c) $[(w' + x) \bullet 0 + (y + z) u] (u' + w' + xy)$
12. (a) $(a + b + c') (b + c + d) (a' + c' + d')$
 (b) $(a + b'd) (a' + c' + be)$
 (c) $(d' + a'c + b'c') (a + d)$
13. (a) $c + a'bd' + ab'd'$
 (b) $ab' + ad' + b'c'$
 (c) $y' + u'x'wz + w'xz$
14. (a) $(a' + b')(a' + d)(a + c')$
 (b) $(b' + d')(a' + b + d)(b + c' + d)$
 (c) $(a' + b' + d)(b' + c' + d)(a + b + c)(b + c' + d')$

Answers to Chapter 4 Problems

1. (a) $xy'z' + xy'z + x'y'z' + x'y'z + x'yz' + x'yz$
 (b) $w'x'y'z' + w'x'y'z + wx'y'z' + wx'y'z + wxy'z' + wxy'z + w'x'yz' + w'xyz'$
 (c) $ABCD' + ABCD + A'B'CD + AB'CD + A'B'C'D' + A'BC'D' + AB'C'D' + ABC'D'$
 (d) $A'BC'D' + A'BC'D + A'BCD' + A'BCD + A'B'CD + AB'CD + A'B'C'D' + A'B'CD' + AB'C'D' + AB'CD' + ABC'D' + ABCD'$
2. (a) $(x + y' + z')(x + y' + z)(x' + y' + z')(x' + y + z')$
 (b) $(w' + x + y' + z')(w + x + y' + z')(w + x' + y' + z)(w + x' + y + z)(w + x + y' + z)(w + x + y + z)$
3. (a) $\Sigma m(3,5,7,11,12,13,14,15) = \pi M(0,1,2,4,6,8,9,10)$
 (b) $\Sigma m(0,1,4,5,6,13,15) = \pi M(2,3,7,8,9,10,11,12,14)$
 (c) $\pi M(0,1,2,3,4,6,10,12,14) = \Sigma m(5,7,8,9,11,13,15)$
 (d) $\pi M(1,2,3,5,6,7,9,11,13,14,15) = \Sigma m(0,4,8,10,12)$
 (e) $\pi M(5,7,8,13,15,16-24,29,31) = \Sigma m(0-4,6,9-12,14,25-28,30)$
 (f) $\Sigma m(8,9,11,12,13,16,17,20,21,24,25,27,28,29) = \pi M(0-7,10,14,15,18,19,22,23,26,30,31)$
4. (a) $\Sigma m(0,1,2,4,6,8,9,10) = \pi M(3,5,7,11,12,13,14,15)$
 (b) $\Sigma m(2,3,7,8,9,10,11,12,14) = \pi M(0,1,4,5,6,13,15)$
 (c) $\Sigma m(0,1,2,3,4,6,10,12,14) = \pi M(5,7,8,9,11,13,15)$
 (d) $\Sigma m(1,2,3,5,6,7,9,11,13,14,15) = \pi M(0,4,8,10,12)$
 (e) $\Sigma m(5,7,8,13,15,16-24,29,31) = \pi M(0-4,6,9-12,14,25-28,30)$
 (f) $\pi M(8,9,11,12,13,16,17,20,21,24,25,27,28,29) = \Sigma m(0-7,10,14,15,18,19,22,23,26,30,31)$
5. (a) $w'x'y'z' + w'x'y'z + w'x'yz' + w'xy'z' + w'xyz' + wx'y'z' + wx'yz' + wxy'z' + wxyz'$
 (b) $(w + x + y' + z')(w + x' + y + z')(w + x' + y' + z')(w' + x + y + z')(w' + x + y' + z')(w' + x' + y + z')$
 (c) $w'x'y' + z'$
 (d) $(w' + z')(x' + z')(y' + z')$
6. $F(A,D,B,C) = \Sigma m(0,4,5,6,7,9,11,12,14)$
7. $\Sigma m(0,1,2,4,5,6,7,9,11) + d(12,13,14,15) = \pi M(3,8,10) \cdot D(12,13,14,15)$
8. (a) $f' = \Sigma m(0,3,6,8,9,10,13,14)$
 (b) $g' = \Sigma m(3,4,5,6,10,11,13)$
 (c) $f \cdot g = \Sigma m(1,2,7,12,15)$
 (d) $f + g = \Sigma m(0,1,2,4,5,7,8,9,11,12,14,15)$
 (e) $f' \cdot g = \Sigma m(0,8,9,14)$
 (f) $f \cdot g' = \Sigma m(4,5,11)$

- (g) $f'' + g' = (f \cdot g)' = \sum m(0,3,4,5,6,8,9,10,11,13,14)$
 (h) $f \oplus g = f'' \cdot g + f \cdot g' = \sum m(0,8,9,14) + \sum m(4,5,11) = \sum m(0,4,5,8,9,11,14)$
9. (a) $a'b'c' + a'b'c + a'b'c + abc$
 (b) $a'c' + a'b'c$
 (c) $a + b + de$
10. (a) $\sum m(2,3,4,5,7,10,11,14)$
 (b) $\sum m(1,3,5,6,8,13,14,15)$
 (c) $\sum m(0,1,2,3,4,5,6,8,9,11,12,13)$
11. $F_{AD=00} = B'C$, $F_{AD=01} = B + C'$, $F_{AD=10} = B$, $F_{AD=11} = B + C'$
12. $F = B'D'(A' + E') + B'D(AE') + BD'(0) + BDA(C + E') = A'B'D' + B'D'E' + ADE' + ABCD$
13. $F_{AC=00} = B'E + BD$
14. The correct given sub-functions are as follows: (corrections in red)
- $$\begin{aligned} F_{AB=00} &= DE + C'D' \\ F_{AB=01} &= (C + D')E \\ F_{AB=10} &= C + D'E \\ F_{ABD=110} &= C \\ F_{ABD=111} &= C + E \end{aligned}$$
- $F = A'B'DE + A'B'C'D' + A'BCE + A'BD'E + AB'C + AB'D'E + ABCD' + ABCD + ABDE$
 $= A'B'DE + A'B'C'D' + A'BCE + A'BD'E + AB'C + AB'D'E + ABC + ABDE$
 $= A'B'DE + A'B'C'D' + A'BCE + A'BD'E + AC + AB'D'E + ABC + ABDE$
 $= A'E(B'D + BC + BD') + A'B'C'D' + AC + AB'D'E + ABC + ABDE$
 $= A'E(B'D + BC + CD + BD') + A'B'C'D' + AC + AB'D'E + ABC + ABDE$ (Consensus Th.)
 $= A'E(B'D + CD + BD') + A'B'C'D' + AC + AB'D'E + ABC + ABDE$ (Consensus Th.)
 $= A'B'DE + A'CDE + A'BD'E + A'B'C'D' + AC + AB'D'E + ABC + ABDE$
 $= A'B'DE + CDE + A'BD'E + A'B'C'D' + AC + AB'D'E + ABC + ABDE$
15. $f = \pi M(0,3,4,6) = (A + B' + C')(B + C)(A' + C)$
16. Circuit (a) $x = a'b' + ab$ $y = a'bc'$ $z = b'c + bc'$
 Circuit (b) $x = a'b$ $y = a'b + c'$ $z = 1$
 Circuit (c) $x = ab$ $y = ab + c' + d'$ $z = c' + d'$
17. $F = (A' + B + C')(A' + D)(B' + D)(C' + D)$
 $= A'D + BD + C'D + A'B'C'$
18. $F = A'D + BD + C'D + A'B'C'$



19. Let the inputs of the (6,3,1,1) weighted code be A,B,C,D.
 Simplest SOP $F = C'D + ABC$
 Simplest POS $F = (A + C')(B + C')(C + D)$
20. $V(a,b,c,d) = \sum m(0,1,2,3,6,8,9,10,11,14) = \pi M(4,5,7,12,13,15)$
21. $W(a,b,c,d) = \sum m(8,9,10,11,12) + d(0,1,2,13,14,15) = \pi M(3,4,5,6,7) \cdot D(0,1,2,13,14,15)$
 $X(a,b,c,d) = \sum m(7,8) + d(0,1,2,13,14,15) = \pi M(3,4,5,6,9,10,11,12) \cdot D(0,1,2,13,14,15)$
 $Y(a,b,c,d) = \sum m(5,6,7,8,9,10) + d(0,1,2,13,14,15) = \pi M(3,4,11,12) \cdot D(0,1,2,13,14,15)$
 $Z(a,b,c,d) = \sum m(4,5,10,11) + d(0,1,2,13,14,15) = \pi M(3,6,7,8,9,12) \cdot D(0,1,2,13,14,15)$

Answers to Chapter 5 Problems

1. (a) $\Sigma m(0,1,4,5,6)$
 (b) $\Sigma m(2-7,10,12,13,14)$
 (c) $\Sigma m(0-5,7-11)$
 (d) $\Sigma m(1,2,3,6,7,12,14,16-20,22,24,26,28,30)$
2. (a) $\pi M(0,4,5,7,8,10-13,15)$
 (b) $\pi M(2,3,6-15,17,19,21,23,24,25,27,28,29)$
3. (a) Distinguished 1-cell: 3,5,8,14
 Prime implicant: $A'CD$ (3,7), $AC'D'$ (8,12), BD (5,7,13,15), AB (12,13,14,15)
 (b) Distinguished 1-cell: 4,6,11,13
 Prime implicant: (1,3,5,7), (4,5,6,7), (1,5,9,13), (1,3,9,11)
 (c) Distinguished 1-cell: 2,9,10,15
 Prime implicant: (0,2,8,10), (0,1,8,9), (1,5), (5,7), (7,15)
 (d) Distinguished 1-cell: 5,8,9,14
 Prime implicant: (5,7), (2,6,10,14), (8,9,10,11), (2,3,6,7), (2,3,10,11)
4. (a) Distinguished 0-cell: 4,6
 Prime implicate: (0,2,4,6), (0,1), (1,9), (9,11), (10,11), (2,10)
 (b) Distinguished 0-cell: 0,2,12,15
 Prime implicate: (0,2,8,10), (8,10,12,14), (14,15)
 (c) Distinguished 0-cell: 3,4,6,11,13,14
 Prime implicate: (3,11), (4,6,12,14), (12,13)
 (d) Distinguished 0-cell: 1,15
 Prime implicate: (0,1), (13,15), (0,4), (4,12), (12,13)
5. (a) $A'CD + AC'D' + BD + AB$
 (b) $A'B + C'D + B'D$
 (c) $B'D' + B'C' + BCD + A'BD$ or $B'D' + B'C' + BCD + A'C'D$
 (d) $A'BD + CD' + AB' + B'C$ or $A'BD + CD' + AB' + A'C$
6. (a) $(A+D)(B+C+D')(A'+B+C')$
 (b) $(B+D)(A'+D)(A'+B'+C')$
 (c) $(B+C'+D')(B'+D)(A'+B'+C)$
 (d) $(A+B+C)(A'+B'+D')(B'+C+D)$
7. (a) Distinguished 1-cell: 3,5,8,14,21,23,26
 Prime implicant: (1,3,5,7,17,19,21,23), (6,7), (6,14), (8,9,24,25), (1,9,17,25), (17,19,25,27), (24,25,26,27)
 (b) Distinguished 1-cell: 2,4,10,17
 Prime implicant: (1,5,9,13), (4,5), (5,7,13,15), (18,22,26,30), (22,23,30,31), (25,27), (26,27,30,31), (1,9,17,25), (2,10,18,26), (7,15,23,31)

8. (a) $B'E + BC'D' + A'CDE' + ABC'$
 (b) $A'B'CD' + C'DE' + C'D'E + A'CE + ACD + ABD$
9. (a) $(B+C+E)(C'+D+E)(B'+C'+E')(A'+C'+E)(A+B'+C+D')$
 (b) $(A+C+D'+E')(A+C'+D'+E)(B+C+D'+E')(C+D+E)(A'+C'+D)(B'+D+E)$
10. $f_1 = A'C + ABD + AB'C'$
 $f_2 = A'CD + A'BC + ABD + AB'C'$
 $f_3 = A'D' + A'C + ABD + AB'C'$
11. (a) $B'CD' + BD + ACD'$ or $B'CD' + BD + ABC$
 (b) $BC' + A'C$
 (c) $B'C + A'D'E + BD'E + ABDE'$
12. (a) $f(A,B,C,D) = \sum m(1,2,3,6,7,10,14)$
 (b) $f(A,B,C,D) = \sum m(0,1,3,4,5,7,11,13)$
13. (a) $f_1 = f_2 \oplus BCD = \sum m(9,11,13,15) \oplus \sum m(7,15) = \sum m(7,9,11,13)$
 (b) $f_1 = f_2 \oplus A'BD = \sum m(2,3,6,7) \oplus \sum m(5,7) = \sum m(2,3,5,6)$
 (c) $f_1 = f_2 \oplus BCD = \sum m(8,9,10,11,12,13,14,15) \oplus \sum m(7,15) = \sum m(7,8,9,10,11,12,13,14)$
 (d) $f_1 = f_2 \oplus BD = \sum m(0,1,4,5,8,9,12,13) \oplus \sum m(5,7,13,15) = \sum m(0,1,4,7,8,9,12,15)$
14. (a) $A'BC + A'BD + ABC'D' = A'B \oplus BC'D'$
 (b) $A'BC' + A'BD' + A'B'CD = A'B \oplus A'CD$
 (c) $AB' + AC' + AD' + A'BCD = A \oplus BCD$
 (d) $AB' + AD' + A'BD = A \oplus BD$

15.

	$F_{BD=00}$	$F_{BD=01}$	$F_{BD=10}$	$F_{BD=11}$
AC				
00	0 0	1 1	0 4	1 5
01	1 2	1 3	1 6	0 7
11	0 10	0 11	1 14	0 15
10	1 8	1 9	1 12	0 13

16. (a) $F_{BC=00} = A$, $F_{BC=0a} = A' + D'$, $F_{BC=10} = A$, $F_{BC=11} = AD'$
 (b) $F_{BC=00} = A$, $F_{BC=0a} = 1$, $F_{BC=10} = A$, $F_{BC=11} = AD'$

17. (a) $F_{ADE=000} = BC$, $F_{ADE=001} = B' + C$, $F_{ADE=010} = B'C$, $F_{ADE=011} = B'$,
 $F_{ADE=100} = BC$, $F_{ADE=101} = 1$, $F_{ADE=110} = B'C$, $F_{ADE=111} = 1$
- (b) $F_{ADE=000} = BC$, $F_{ADE=001} = B'$, $F_{ADE=010} = B'C$, $F_{ADE=011} = B'$,
 $F_{ADE=100} = BC$, $F_{ADE=101} = 1$, $F_{ADE=110} = B'C$, $F_{ADE=111} = 1$

Answers to Chapter 6 Problems

1. (a), (b) $f = A'B'C + BC' + AC'D = [(A'B'C)' (BC')' (AC'D)']'$
 (c) $f = (A + B + C) (B' + C') (A' + C') (B + C + D)$
 or $(A + B + C) (B' + C') (A' + C') (A' + B + D)$
 (d) $f = [(A + B + C)' + (B' + C')' + (A' + C')' + (B + C + D)]'$
 or $[(A + B + C)' + (B' + C')' + (A' + C')' + (A' + B + D)]'$
 (e) $f = (A'B'C' + BC + AC + B'C'D')'$
 or $(A'B'C' + BC + AC + AB'D')'$

2. (a), (b) $f = BC' + A'B'D + ACE + CD'E = [(BC')' (A'B'D)' (ACE)' (CD'E)']'$
 (c) $f = (A' + B + C) (B + C + D) (A + B' + C' + D') (A' + C' + E) (C' + D + E)$
 (d) $f = [(A' + B + C)' + (B + C + D)' + (A + B' + C' + D')' + (A' + C' + E)' + (C' + D + E)']'$
 (e) $f = (AB'C' + B'C'D' + A'BCD + ACE' + CD'E')'$

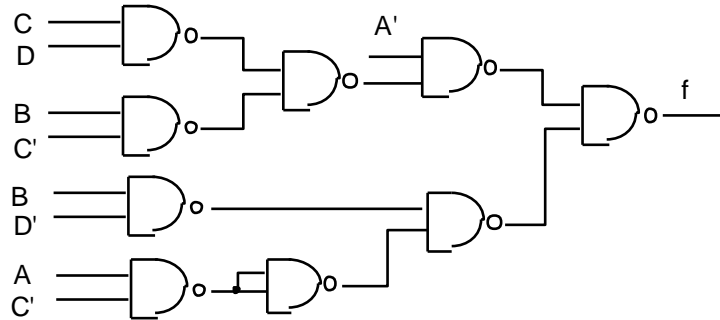
3. (b) $F = \Sigma m(7, 11, 13, 14, 15)$
 (c) $F = \pi M(0-6, 8, 9, 10, 12)$
 (d) $F = A'BCD + AB'CD + ABC'D + ABCD' + ABCD$
 $= BCD + ACD + ABD + ABC + ABCD = BCD + ACD + ABD + ABC$
 (e) $F = (A + B) (A + C) (A + D) (B + C) (B + D) (C + D)$
 (f) $F' = [(A + B) (A + C) (A + D) (B + C) (B + D) (C + D)]'$
 $= (A + B)' + (A + C)' + (A + D)' + (B + C)' + (B + D)' + (C + D)'$
 $= A'B' + A'C' + A'D' + B'C' + B'D' + C'D'$
 (g) $F' = [BCD + ACD + ABD + ABC]'$
 $= (BCD)' (ACD)' (ABD)' (ABC)'$
 $= (A' + B' + C') (A' + B' + D') (A' + C' + D') (B' + C' + D')$
 (h) From (d), $F = [(ABC)' (ABD)' (ACD)' (BCD)']'$
 (i) From (e), $F = [(A + B)' + (A + C)' + (A + D)' + (B + C)' + (B + D)' + (C + D)']'$
 (j) From (f), $F' = [(A'B)' (A'C)' (A'D)' (B'C)' (B'D)' (C'D)']'$
 (k) From (g), $F' = [(A' + B' + C')' + (A' + B' + D')' + (A' + C' + D')' + (B' + C' + D')']'$
 (l) From (f), $F = (A'B' + A'C' + A'D' + B'C' + B'D' + C'D')'$
 (m) From (d), $F' = (ABC + ABD + ACD + BCD)'$

4. (a) $f = (A'BD' + B'C' + C'D' + AB'D)'$
 (b) $f = (A'BD')' (B'C')' (C'D')' (AB'D)'$
 (c) $f' = (B' + D') (A + B + C') (A' + C' + D)$
 $f = [(B' + D') (A + B + C') (A' + C' + D)]'$
 (d) $f = (B' + D')' + (A + B + C')' + (A' + C' + D)'$

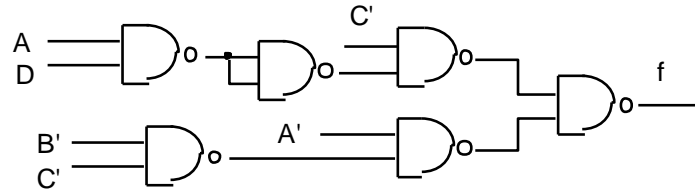
5. (a) $f = B' + A'CD' + CDE + ADE'$
 (b) $f = [B (A'CD')' (CDE)' (ADE')']'$
 (c) $f = (A + B' + D' + E) (A' + B' + D) (B' + C + E') (A + B' + C)$
 (d) $f = [(A + B' + D' + E)' + (A' + B' + D)' + (B' + C + E')' + (A + B' + C)']'$
 (e) $f = (A'BDE' + ABD' + BC'E + A'BC')'$

- (f) $f = (A'BDE')' (ABD')' (BC'E)' (A'BC')'$
 (g) $f = [B(A+C'+D)(C'+D'+E')(A'+D'+E)]'$
 (h) $f = B' + (A+C'+D)' + (C'+D'+E')' + (A'+D'+E)'$

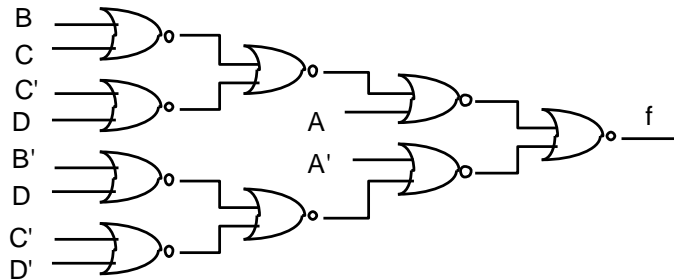
6. (a) $f(A,B,C,D) = A'(CD + BC') + AC'(B' + D)$



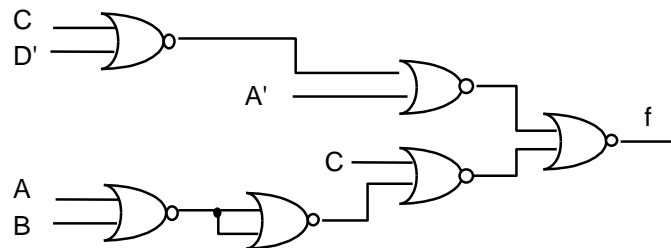
- (b) $f(A,B,C,D) = A'C + A'B + AC'D = A'(B + C) + AC'D$



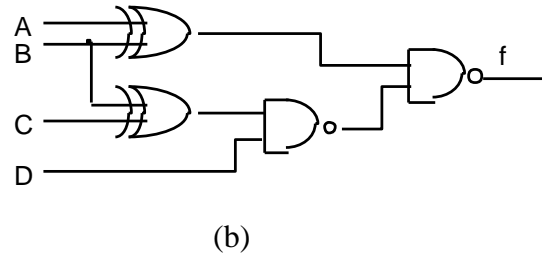
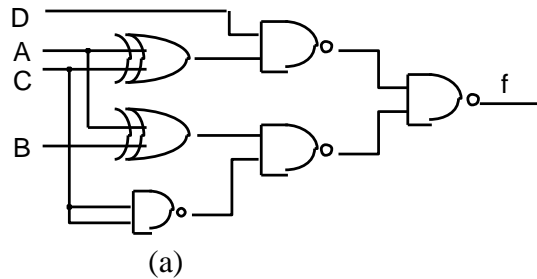
7. (a) $f(A,B,C,D) = (A+B+C)(A+C'+D)(A'+B'+D)(A'+C'+D')$
 $= [A + (B + C)(C' + D)] [A' + (B' + D)(C' + D')]$



- (b) $f(A,B,C,D,E) = (A+B+C)(A'+D)(A'+C') = (A+B+C)(A'+C'D)$



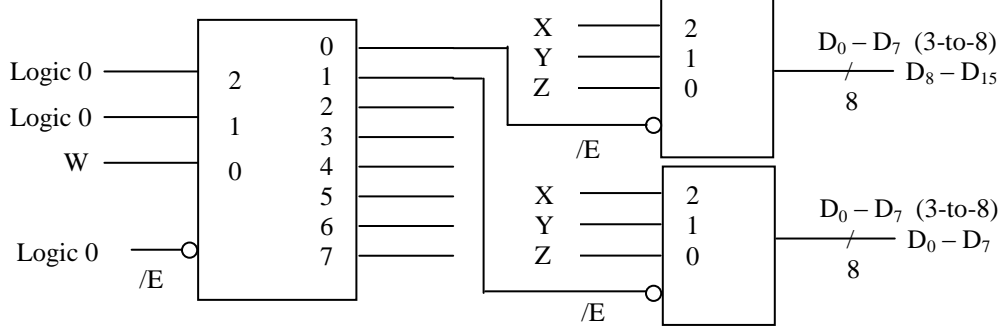
8. (a) $f(A,B,C,D) = A'CD + A'BC' + AB'C' + AC'D$
 $= D(A'C + AC') + C'(A'B + AB') = D(A \oplus C) + C'(A \oplus B)$
 (b) $f(A,B,C,D) = A'B' + AB + BC'D + B'CD = (A \oplus B)' + D(B \oplus C)$



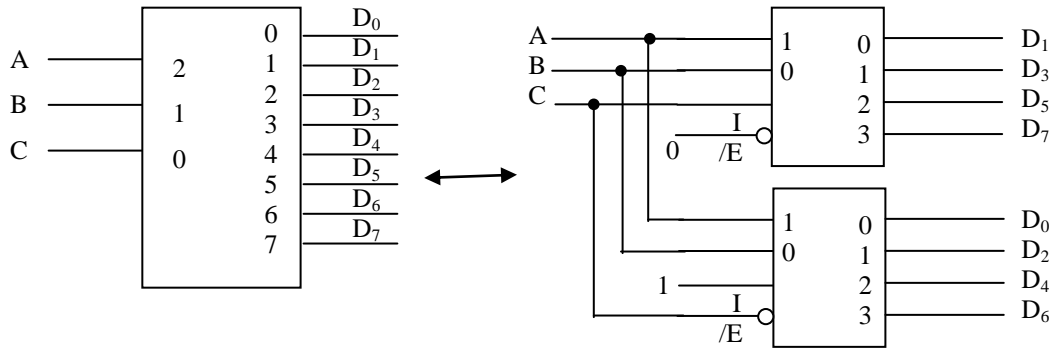
9. $EQ = (a_1 \odot b_1) (a_0 \odot b_0)$
 $GT = a_1 b_1' + (a_1 \odot b_1)' a_0 b_0'$
 $LT = a_1' b_1 + (a_1 \odot b_1) a_0' b_0$
10. $EQ = (a_2 \odot b_2) (a_1 \odot b_1) (a_0 \odot b_0)$
 $GT = a_2 b_2' + (a_2 \odot b_2) a_1 b_1' + (a_2 \odot b_2) (a_1 \odot b_1)' a_0 b_0'$
 $LT = a_2' b_2 + (a_2 \odot b_2) a_1' b_1 + (a_2 \odot b_2) (a_1 \odot b_1) a_0' b_0$

Answers to Chapter 7 Problems

1. $D_0 - D_7$: Output of 3-to-8 decoder $D_0 - D_{15}$: Output of 4-to-16 decoder



2.

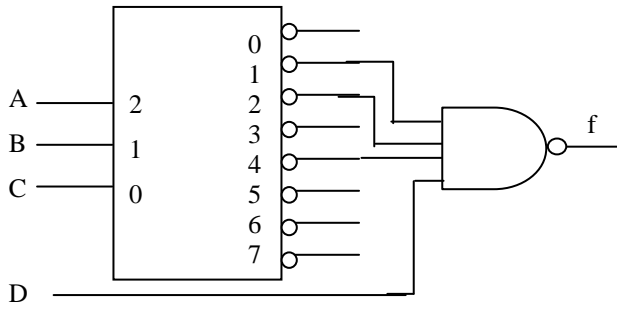


3. $/d_0(b_3, b_2, b_1, b_0) = M_0 \bullet D(10-15) = b_3 + b_2 + b_1 + b_0$
 $/d_1(b_3, b_2, b_1, b_0) = M_1 \bullet D(10-15) = b_3 + b_2 + b_1 + b_0'$
 $/d_2(b_3, b_2, b_1, b_0) = M_2 \bullet D(10-15) = b_2 + b_1' + b_0$
 $/d_3(b_3, b_2, b_1, b_0) = M_3 \bullet D(10-15) = b_2 + b_1' + b_0'$
 $/d_4(b_3, b_2, b_1, b_0) = M_4 \bullet D(10-15) = b_2' + b_1 + b_0$
 $/d_5(b_3, b_2, b_1, b_0) = M_5 \bullet D(10-15) = b_2' + b_1 + b_0'$
 $/d_6(b_3, b_2, b_1, b_0) = M_6 \bullet D(10-15) = b_2' + b_1' + b_0$
 $/d_7(b_3, b_2, b_1, b_0) = M_7 \bullet D(10-15) = b_2' + b_1' + b_0'$
 $/d_8(b_3, b_2, b_1, b_0) = M_8 \bullet D(10-15) = b_3' + b_0$
 $/d_9(b_3, b_2, b_1, b_0) = M_9 \bullet D(10-15) = b_3' + b_0'$

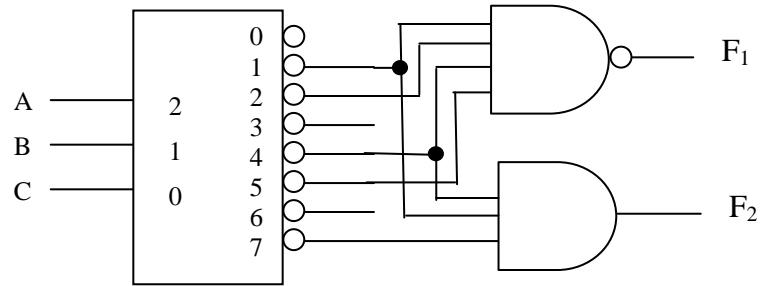
4. $F(A, B, C) = (A + B)(A' + B)C = BC = \sum m(3, 7)$

5. (a) $F(A, B, C) = \sum m(3, 4, 6, 7) = (D_0 + D_1 + D_2 + D_5)'$
 (b) $F(A, B, C) = \sum m(1, 2, 5, 7) = (D_0 + D_3 + D_4 + D_6)'$

6. (a) $f(A, B, C, D) = \sum m(0, 2, 3, 4, 5, 6, 8, 9, 10, 12, 14) = D' + A'B'C + A'BC' + AB'C'$



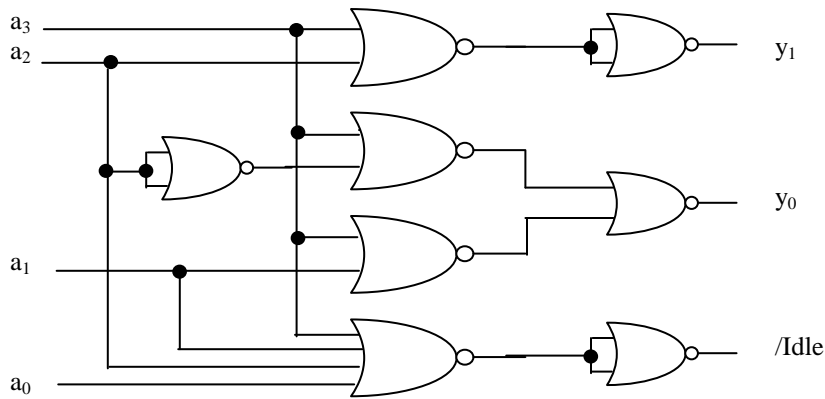
7.



8. $y_1 = a_3 + a_2$

$y_1 = (a_3 + a_2')(a_3 + a_1)$

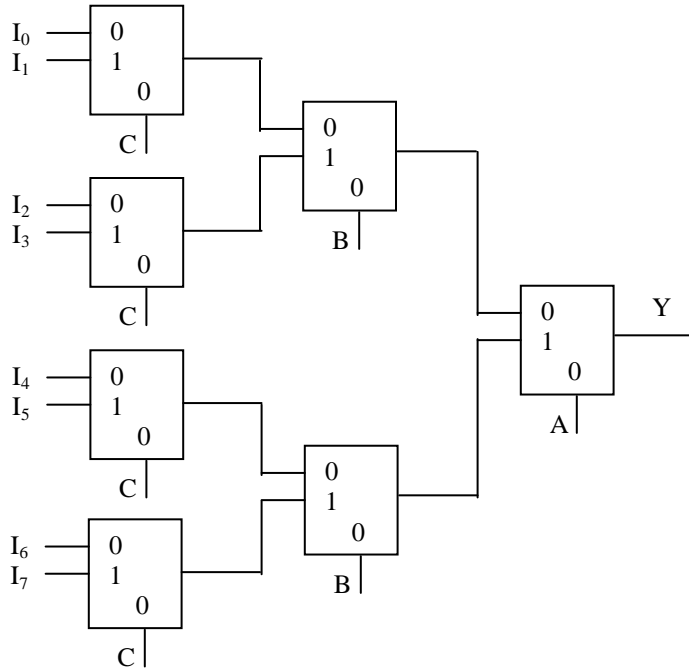
$/Idle = a_3 + a_2 + a_1 + a_0$



9. $F = W'X' + W'Y' + WXZ + VW' + VZ$

10. $A = w'x$ $B = (wx)' = w' + x'$ $C = (y+z)(y'+z) = z$ $D = y' + z'$
 $F = u'w'x + u'vw' + u'vx' + uv'z + uvy' + uvz'$

11.



$$\begin{aligned}
 12. \quad f &= A'D'(I_0) + A'D(I_1) + AD'(I_2) + AD(I_3) \\
 &= A'D'(C + B'E) + A'D(C) + AD'(B'C + C'E) + AD(BC + C'E) \\
 &= \underline{A'CD'} + A'B'D'E + \underline{A'CD} + AB'CD' + \underline{AC'D'E} + ABCD + \underline{AC'DE} \\
 &= \underline{A'C} + A'B'D'E + AB'CD' + ABCD + \underline{AC'E} \\
 &= A'C + A'B'D'E + B'CD' + BCD + AC'E \\
 &= A'C + A'B'D'E + \underline{B'CD'} + BCD + \underline{AC'E} + \underline{AB'D'E} \\
 &= A'C + B'D'E + B'CD' + BCD + AC'E
 \end{aligned}$$

$$\begin{aligned}
 \text{or } f &= A'CD' + A'B'D'E + A'CD + AB'CD' + AC'D'E + ABCD + AC'DE \\
 &= \Sigma m(1, 4-7, 12-15, 17, 19, 20, 21, 25, 27, 30, 31) \\
 &= A'C + B'D'E + B'CD' + BCD + AC'E
 \end{aligned}$$

$$13. \quad I_0 = A + C, \quad I_1 = A'(C + E), \quad I_2 = 0, \quad I_3 = AC + A'E$$

$$14. \quad I_0 = A', \quad I_1 = (A + C)(A' + B), \quad I_2 = A + C, \quad I_3 = B' \quad (\text{Three 2-input gates.})$$

Answers to Chapter 8 Problems

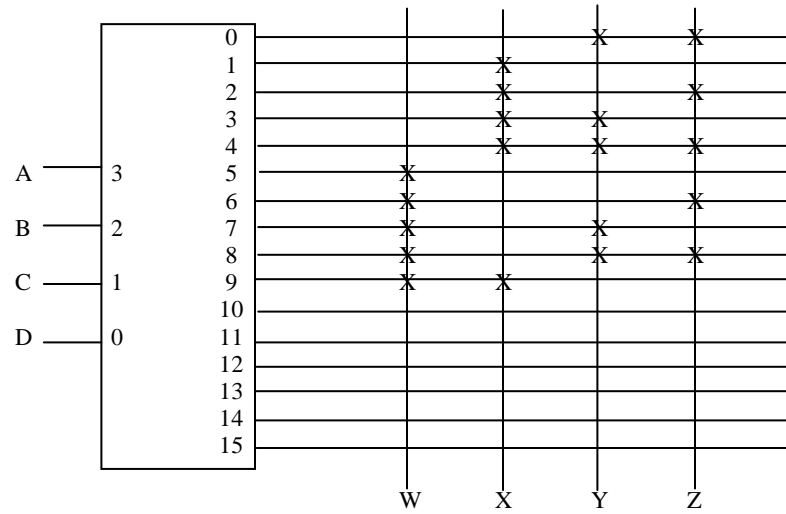
1. 4-bit BCD inputs: A, B, C, D 4-bit excess-3 outputs: W, X, Y, Z

$$W = \sum m(5,6,7,8,9) + d(10-15)$$

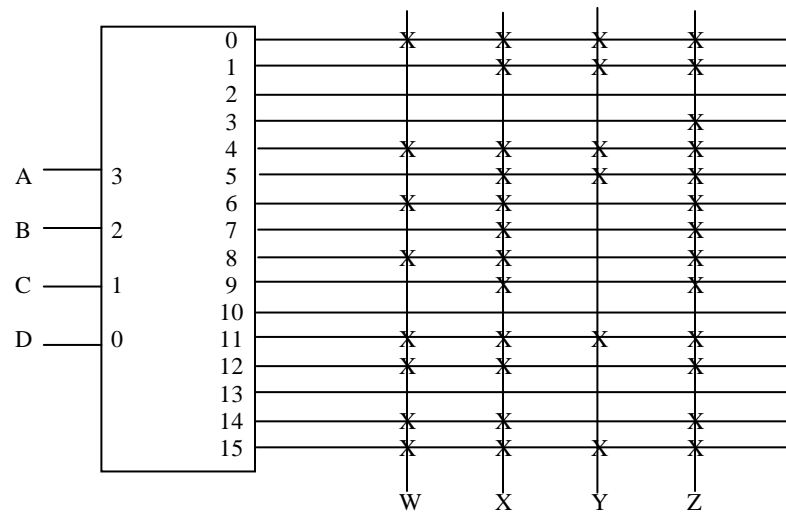
$$X = \sum m(1,2,3,4,9) + d(10-15)$$

$$Y = \sum m(0,3,4,7,8) + d(10-15)$$

$$Z = \sum m(0,2,4,6,8) + d(10-15)$$



2. $W = \sum m(0,4,6,8,11,12,14,15)$
 $X = \sum m(0,1,4,5,6,7,8,9,11,12,14,15)$
 $Y = \sum m(0,1,4,5,11,15)$
 $Z = \sum m(0,1,3,4,5,6,7,8,9,11,12,14,15)$



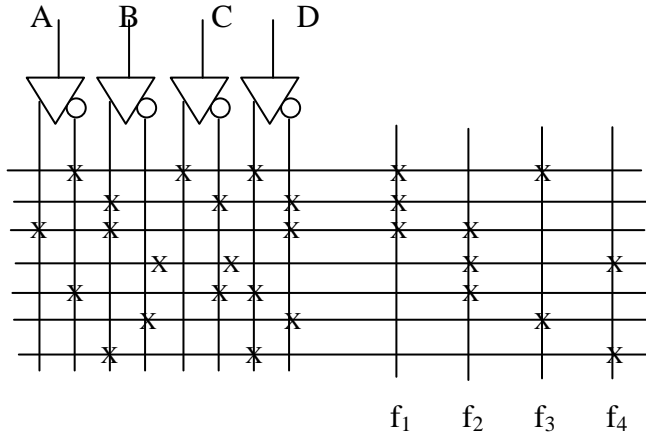
3.

$$f_1 = A'CD + BC'D + ABD'$$

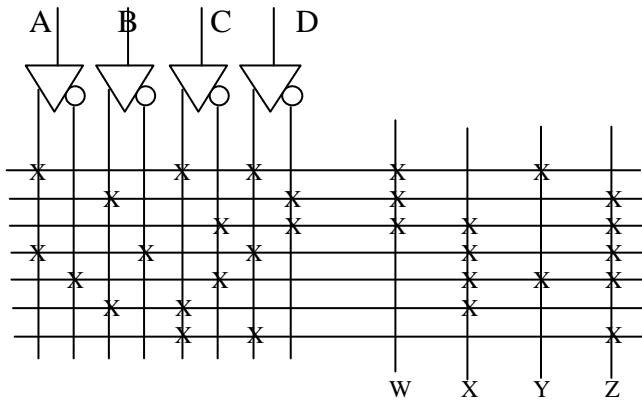
$$f_2 = A'B' + A'C'D + ABD'$$

$$f_3 = B'D' + A'CD$$

$$f_4 = A'B' + BD$$



4.



5.

$$f_1 = A'CD + BC'D + ABD'$$

$$f_2 = A'B' + A'C'D + ABD'$$

$$f_3 = B'D' + B'C$$

$$f_4 = A'B' + BD$$

6.

$$V = A' + B'C' + BC$$

(Use two 2-input OR)

$$W = C'D' + BD' + ACD$$

(Use one 4-input OR)

$$X = C'D' + A'C' + BC + AB'D$$

(Use one 4-input OR)

$$Y = A'C' + ACD$$

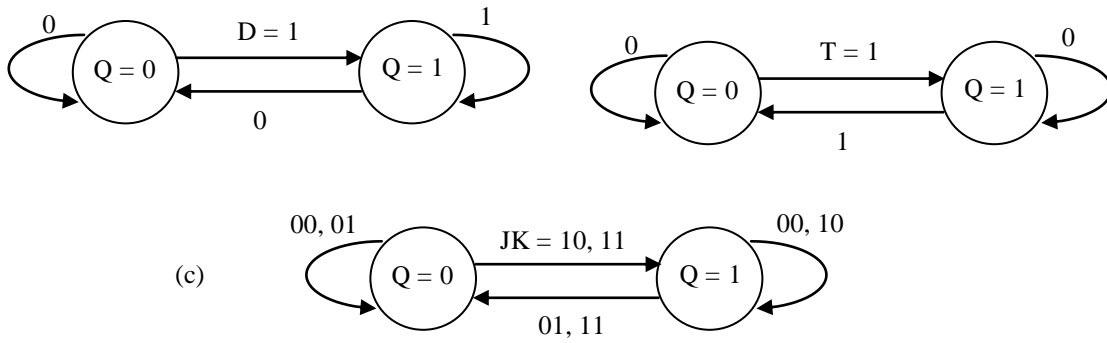
(Use one 2-input OR)

$$Z = X + A'D$$

(Use one 2-input OR)

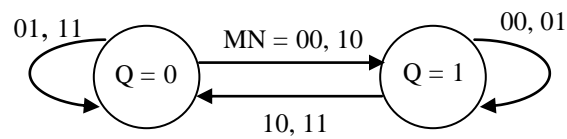
Answers to Chapter 9 Problems

1.



2.

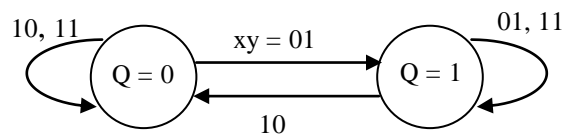
Characteristic equation $Q^+ = M'Q + N'Q'$



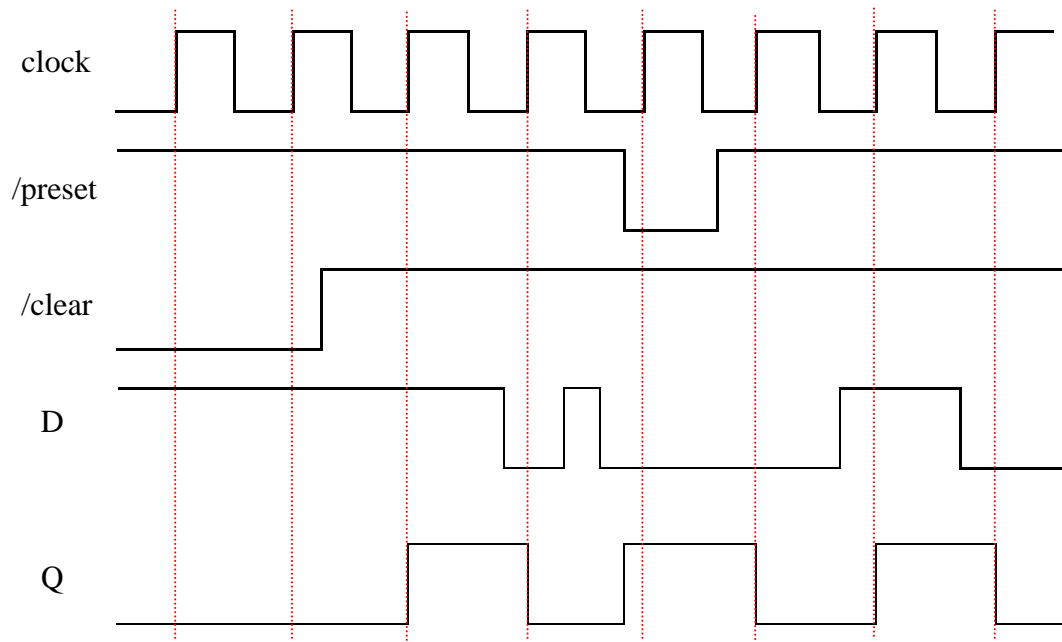
3. Characteristic table for xy latch.

Present inputs x y	Present state Q	Next state Q ⁺
0 0	0	d
0 0	1	d
0 1	0	1
0 1	1	1
1 0	0	0
1 0	1	0
1 1	0	0
1 1	1	1

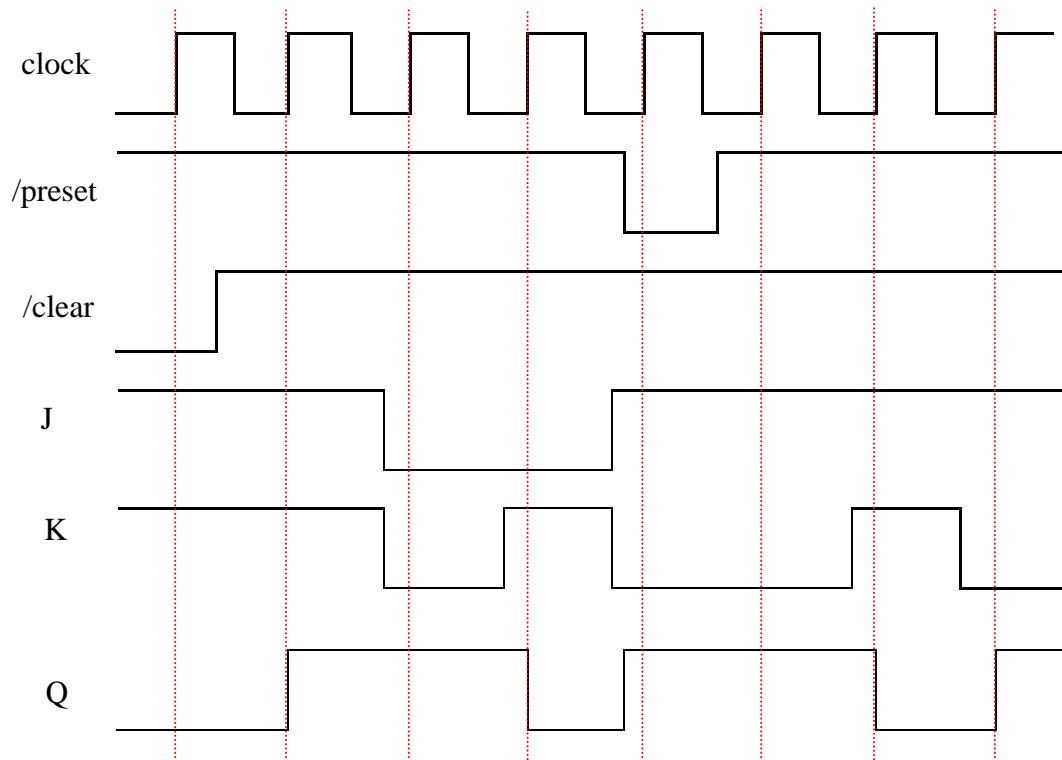
Characteristic equation $Q^+ = x' + yQ$
Necessary condition $x + y = 1$



4.



5.



Answers to Chapter 10 Problems

1.

Q ₁ Q ₀	Present State	Next state, z	
		x = 0	x = 1
0 0	A	A, 0	B, 0
0 1	B	A, 0	D, 0
1 1	C	A, 0	C, 1
1 0	D	A, 0	C, 0

2.

Q ₁ Q ₀	Present State	Next state, z	
		x = 0	x = 1
0 0	A	A, 0	D, 0
0 1	B	B, 0	C, 1
1 1	C	D, 0	A, 1
1 0	D	C, 0	B, 0

3.

Q ₁ Q ₀	Present state	Next state		Z
		x = 0	x = 1	
0 0	A	D	A	0
0 1	B	D	C	0
1 1	C	A	A	0
1 0	D	D	B	1

4. $D_0 = Q_3'$ $D_1 = Q_0$ $D_2 = Q_1$ $D_3 = Q_2$

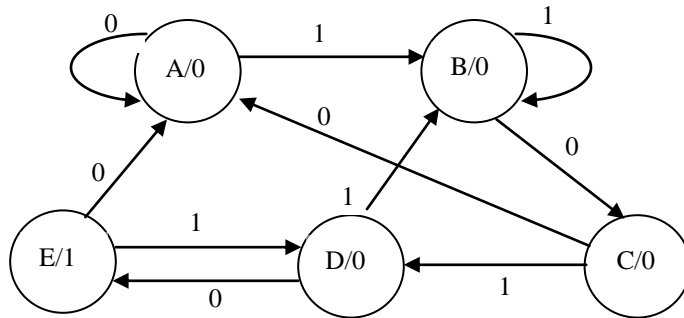
5. $D_3 = x Q_2' Q_1' Q_0' + x Q_1 Q_0$ $D_2 = x Q_1' Q_0 + x Q_1 Q_0' + x' Q_1 Q_0 + x' Q_2$
 $D_1 = x' Q_0'$ $z = Q_1' Q_0 + x Q_1 Q_0' + x' Q_2$

6. (a) $D_1 = x$ $D_2 = Q_1'$ $z = Q_1 \oplus Q_0$
(b) $J_1 = x$, $K_1 = x'$ $J_0 = y_1'$ $K_0 = y_1$ $z = y_1 \oplus y_0$

7. (a) $D_1 = x$ Q_0 $D_2 = (x + Q_1 + Q_0)(x + Q_1' + Q_0')(x' + Q_1' + Q_0)$ $z = x' Q_1 Q_0'$
(b) $T_1 = x' Q_1' Q_0 + x Q_1 + Q_1 Q_0'$ $T_0 = x' Q_1 + x Q_1' Q_0'$ $z = x' Q_1 Q_0'$
(c) $J_1 = x' Q_0$ $K_1 = x + Q_0'$ $J_0 = x \oplus Q_1$ $K_0 = x' Q_1$ $z = x' Q_1 Q_0'$

8. $J_2 = x'$ $K_2 = x'$ $J_1 = xQ_2'Q_0$ $K_1 = Q_2'$ $J_0 = x'Q_1' + Q_2'Q_1'$ $K_0 = x + Q_2$
 $z = Q_2'Q_0 + xQ_0 + x'Q_2Q_1'Q_0' + xQ_2Q_1$

9.



10.

	y_1y_0	Y_1Y_0		Z
		$x = 0$	$x = 1$	
A	0 0	0 0	0 1	0
B	0 1	0 0	1 1	0
C	1 1	1 0	1 1	0
D	1 0	0 0	0 1	1

$D_1 = xy_0 + y_1y_0$
 $D_0 = x$
 $Z = y_1y_0'$

11.

	y_1y_0	Y_1Y_0, Z	
		$x = 0$	$x = 1$
A	0 0	0 0, 0	0 1, 0
B	0 1	0 0, 0	1 1, 0
C	1 1	0 0, 1	1 1, 0
Unuse d	1 0	d d, d	d d, d

$D_1 = xy_0$
 $D_0 = x$
 $Z = x'y_1$

12.

$y_2y_1y_0$	Present state	Next state		Z
		$x = 0$	$x = 1$	
0 0 0	A	A	B	0
0 0 1	B	A	C	0
0 1 1	C	D	C	0
0 1 0	D	E	B	0
1 1 0	E	E	F	1
1 0 0	F	E	A	1

$T_2 = x'y_2'y_1y_0' + xy_2y_1'$
 $T_1 = x(y_1 \oplus y_0) + x'y_2y_1'$
 $T_0 = y_2' (x \oplus y_0)$

Answers to Chapter 11 Problems

1. (a) 1 1 0 1 1 0 1 1 (b) 0 0 1 0 0 0 0 0 (c) 0 0 0 0 0 0 0 1
(d) 1 1 1 0 1 1 1 0 (e) 0 1 1 1 1 1 0 1 (f) 1 0 0 0 0 0 0 1
2. (a) -23 (b) +96 (c) -2 (d) -106 (e) -128 (f) +127
3. (a) 0111 1110 1001 (b) 0011 0101 0010 (c) 1001 0010 0111
(d) 1000 0000 0001 (e) 1101 0000 1111 (f) 1110 1110 1010

4. (a) $A = 01010101_2 = +85_{10}$ $B = 00001010_2 = +10_{10}$
 $-A = 10101011_2 = -85_{10}$ $-B = 11110110_2 = -10_{10}$
 $A + B = 01010101 + 00001010 = 01011111$ $85 + 10 = +95$
 $A - B = 01010101 + 11110110 = (1) 01001011$ $85 - 10 = +75$
 (Bit in parentheses discarded)
 $-A + B = 10101011 + 00001010 = 10110101$ $-85 + 10 = -75$
 $-A - B = 10101011 + 11110110 = (1) 10100001$ $-85 - 10 = -95$

- (b) $A = 01101011_2 = +107_{10}$ $B = 00101010_2 = +42_{10}$
 $-A = 10010101_2 = -107_{10}$ $-B = 11010110_2 = -42_{10}$

$$A + B = 01101011 + 00101010 = 10010101 \quad 107 + 42 = +149$$

The greatest positive number for 8-bit signed number is +127. The result of A+B in 2's complement arithmetic is a negative number, which is an overflow.

$$A - B = 01101011 + 11010110 = (1) 01000001 \quad 107 - 42 = +65$$

$$-A + B = 10010101 + 00101010 = 10111111 \quad -107 + 42 = -65$$

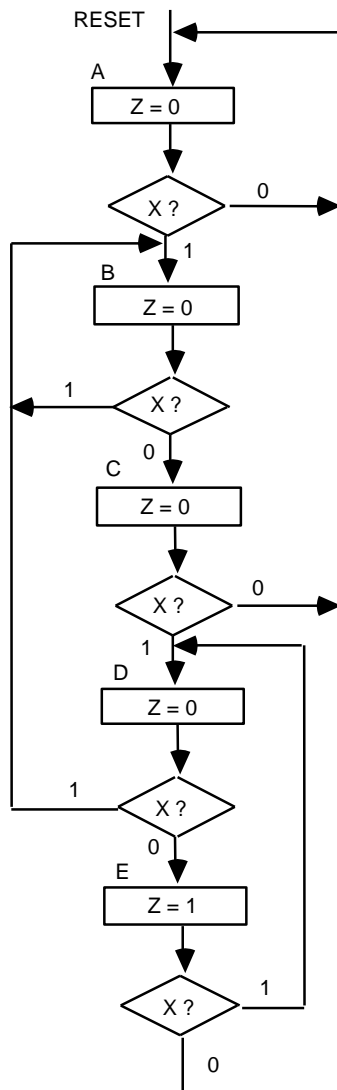
$$-A - B = 10010101 + 11010110 = (1) 01101011 \quad -107 - 42 = -149$$

The smallest negative number for 8-bit signed number is -128. The result of -A-B in 2's complement arithmetic is a positive number, which is an overflow.

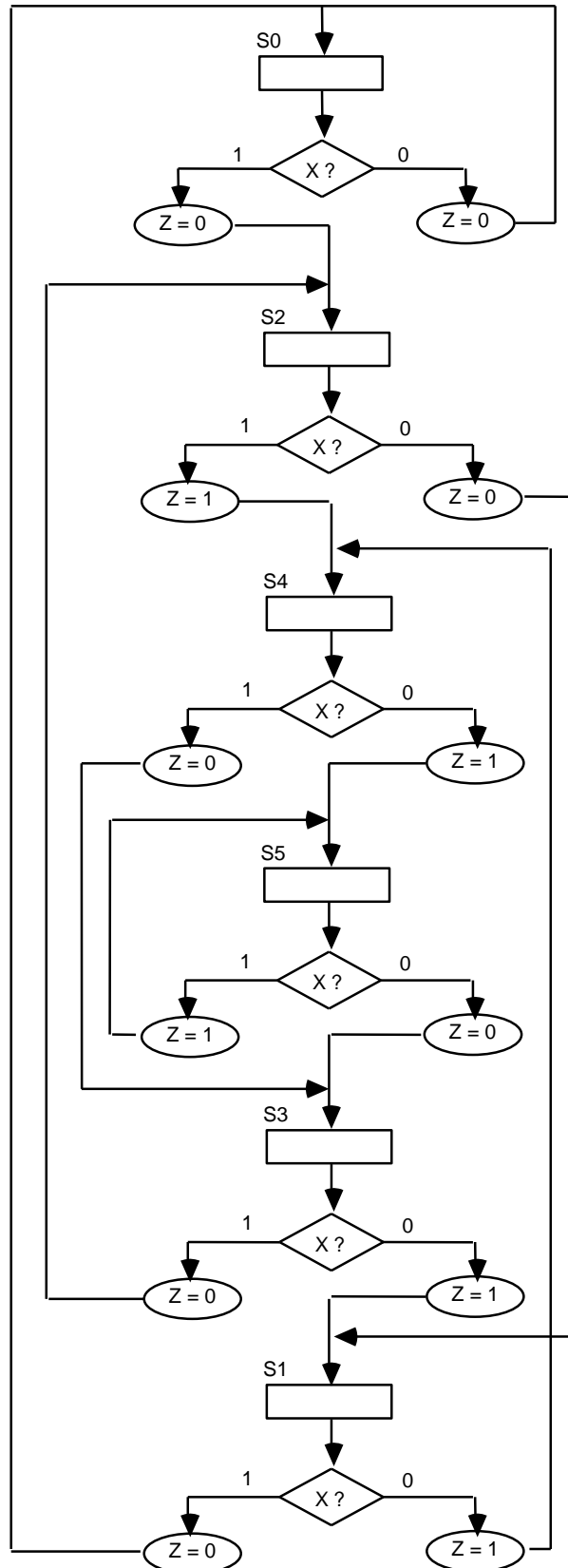
- (c) $A = 11101010_2 = -22_{10}$ $B = 00101111_2 = +47_{10}$
 $-A = 00010110_2 = +22_{10}$ $-B = 11010001_2 = -47_{10}$
 $A + B = 11101010 + 00101111 = (1) 00011001$ $-22 + 47 = +25$
 $A - B = 11101010 + 11010001 = (1) 10111011$ $-22 - 47 = -69$
 $-A + B = 00010110 + 00101111 = 01000101$ $22 + 47 = +69$
 $-A - B = 00010110 + 11010001 = 11100111$ $22 - 47 = -25$

- (d) $A = 10000000_2 = -128_{10}$ $B = 01111111_2 = +127_{10}$
 $-A = 10000000_2 = (?)_{10}$ $-B = 10000001_2 = -127_{10}$
 $A + B = 10000000 + 01111111 = 11111111$ $-128 + 127 = -1$
 $A - B = 10000000 + 10000001 = (1) 00000001$ $-128 - 127 = -255$
 (can't do $-A + B$ & $-A - B$ because $-A = +128_{10}$ can't be represented by 8 bits.)

5.



6.



7. $y_3 = T_0 + T_1 + T_2 = T_3'$
 $y_2 = X' T_0 + X' T_1 + X' T_3 = X' (T_0 + T_1 + T_3) = X' T_2'$
 $y_1 = X' T_2 + T_3$
 $y_0 = X T_0 + X T_1 + X T_2 + T_3 = X (T_0 + T_1 + T_2) + T_3 = X T_3' + T_3 = X + T_3$
8. $D_0 = Q_0^+ = x' (Q_0 + Q_5)$ $D_1 = Q_1^+ = x Q_0$ $D_2 = Q_2^+ = Q_1$
 $D_3 = Q_3^+ = x' (Q_2 + Q_4)$ $D_4 = Q_4^+ = Q_3$ $D_5 = Q_5^+ = x (Q_2 + Q_4 + Q_5)$
 (Refer to Figure 11.12 for RESET.)
9. $B - 1, \quad B, \quad A - B - 1, \quad A - B, \quad -A + B - 1, \quad B - A, \quad A, \quad A + 1$
10. (a) 01000 (b) 11011 (c) 01010 (d) 11100
 (e) 10011 (f) 01111 (g) 01011 (h) 11001