Chapter 1

§1-2

1. (a) 30.75
   (b) 161.5

2. (a) 7
   (b) 6

3. (a) i. 10001 ii. 10010
   (b) i. 10110011 ii. 101011111

§1-3 & 1-4

4. (a) $(19.5)_{10} = (10011.1)_2 = (23.4)_8 = (13.8)_{16}$
   $(63.75)_8 = (51.953125)_{10} = (110011.111101)_2 = (33.F4)_{16}$
   (b) $(237.875)_{10} = (11101101.111)_2 = (355.7)_8 = (ED.E)_{16}$
   $(156.375)_8 = (110.494140625)_{10} = (1101110.011111101)_2 = (6E.7E8)_{16}$

§1-5

5. (a) i. 10111001, 10111010 ii. 00100101, 00100110
   (b) i. 10101100, 10101101 ii. 01100111, 01101000

6. (a) i. 01100, -01111 ii. 01100, -01111
   (b) i. 01101000, -01101000 ii. 01101000, -01101000

§1-6

7. (a) i. 110001 ii. Overflow
   (b) i. overflow ii. 00000010

§1-7

8. (a) 000100010010_{BCD}
   (b) 0001001000011001_{BCD}

Chapter 2

§2-5

11. (a) XZ+YZ′ , 4 literals
    (b) Y + X′Z′ , 3 literals
    (c) A′B + AC + B′C′D , 7 literals

12. (a) (X′+Y′)(X′+Z′)(X+Y′+Z)
    (b) (X′+Y′+Z)(XZ′ + Y′Z)

§2-6

13. (a) X'YZ' + XY'Z + XYZ' + XYZ , (X+Y+Z)(X+Y+Z')(X+Y'+Z')(X'+Y+Z)
    (b) X′Y′Z′+X'YZ'+X'YZ+XYZ'+ XYZ , (X+Y+Z') (X'+Y+Z) (X'+Y+Z')

Technology Parameters

14. (a) 0.312ns
    (b) 0.312ns

15. (a) 2 buffers
    (b) 3 buffers

Chapter 3

§3-2

16. (a) i. $X + Z$, $GIC_{after} = 2$

ii. $XZ + YZ'$, $GIC_{before} = 12$, $GIC_{after} = 7$

(b) $Y + X'Z'$, $GIC_{before} = 13$, $GIC_{after} = 6$

§3-3

17. (a) PIs: BD, AB, BC, ACD, A′C′D ; EPIs: AB, BC, ACD, A′C′D

F=AB + BC + ACD + A′C′D

(b) PIs: A′B, AC, BC, A′C′D, AB′D, B′C′D ; EPIs: A′B, AC

F = A′B + AC + B′C′D

§3-4

18. (a) F = AB+BC+ACD+A′C′D , GIC = 16;

F= (B+D)(A′+B+C)(A+B+C′)(A+C +D), GIC = 17

(b) F = F=A′B + AC + B′C′D , GIC = 13

F=(A′+B′+C) (A+B+C′) (B+C+D) , GIC = 15

§3-5

19. (a) i. $F = WYZ + XZ + \begin{Bmatrix} WX \\ XY \end{Bmatrix}$ $= \Sigma m(5, 7, 11, 12, 13, 14, 15)$, GIC = 10

$= \Sigma m(5, 6, 7, 11, 13, 14, 15)$, GIC = 10

ii. $F = (X+Z)\,(W+X)\begin{Bmatrix} (Y+Z) \\ (W+Z) \end{Bmatrix}\begin{Bmatrix} (W'+Y) \\ (X+Y) \end{Bmatrix}$ * 4 possible solutions

(b) i. $F = X'Z' + XZ + \begin{Bmatrix} WXY \\ WYZ' \end{Bmatrix}$ $= \Sigma m(0, 2, 5, 7, 8, 10, 13, 14, 15)$, GIC = 12

$= \Sigma m(0, 2, 5, 7, 8, 10, 13, 14, 15)$, GIC = 12

ii. $F = (X+ Z')\begin{Bmatrix} (W'+X'+Y) \\ (X'+Y+Z) \end{Bmatrix}\begin{Bmatrix} (W+X'+Z) \\ (W+X'+Y') \end{Bmatrix}$ * 4 possible solutions

Quine-McCluskey Method

20. (a) $F = Y'Z + \begin{Bmatrix} YZ' \\ XY \end{Bmatrix}$

(b) i. $F = WYZ + XZ + \begin{Bmatrix} XY \\ WX \end{Bmatrix}$

ii. $F = X'Z' + XZ + \begin{Bmatrix} WXY \\ WYZ' \end{Bmatrix}$

Multiple-Level Circuit Optimization

21. (a) $F = (B + D)(AC' + A'C)$, $GIC_{before} = 18$, $GIC_{after} = 12$

    (b) $F = (A + B)(C + D)(C + A' + B')$, $GIC_{before} = 16$, $GIC_{after} = 12$

§3-6

22. (a) i. $F = A'C + AC' + \begin{Bmatrix} AB' \\ B'C \end{Bmatrix}$

$= ((A'C)' (AC')' \begin{Bmatrix} (AB')' \\ (B'C)' \end{Bmatrix})'$

ii. $F = (A+C)(A'+B'+C')$

$= ((A+C)' + (A'+B'+C')')'$

(b) i. $F = AB + BC + ACD + A'C'D$

$= ((AB)'(BC)'(ACD)'(A'C'D)')'$

ii. $F = (B+D)(A'+B+C)(A+B+C')(A+C+D)$

$= ((B+D)'+(A'+B+C)'+(A+B+C')'+(A+C+D)')'$

§3-7

23. (a) AND-NOR, NAND-AND: AOI

$F'=A'C'+ABC$

$F =(A'C')' (ABC)'$

OR-NAND, NOR-OR: OAI

$F'= (A'+C)(A+C') \begin{Bmatrix} (A'+B) \\ (B+C') \end{Bmatrix}$

$F = (A'+C)' + (A+C')' + \begin{Bmatrix} (A'+B)' \\ (B+C')' \end{Bmatrix}$

(b) AND-NOR, NAND-AND: AOI

$F' = B'D' + AB'C' + A'B'C + A'C'D'$

$F = (B'D')' (AB'C')' (A'B'C)' (A'C'D')'$

OR-NAND, NOR-OR: OAI

$F' = (A'+B') (B'+C') (A'+C'+D') (A+C+D')$

$F = (A'+B')' + (B'+C')' + (A'+C'+D')' + (A+C+D')'$

§3-8

24. $P = (x \oplus y \oplus z)'$, $C = (x \oplus y \oplus z \oplus P)'$

Chapter 4

§4-3

25. (a) F = A′D + BC′ + B′D

(b) F = 0

§4-4

26. (a) ii. SOP: F = w′x′y′ + w′x′z′ + wxz + wxy , GIC = 20

POS: F = (w + x′) (w′ + x) (w′ + y + z) (w + y′ + z′) , GIC = 18

iii. SOP: F = w′x′ (y′ + z′) + wx (z + y), GIC = 16

POS: No multiple-level optimization.

(b) ii. SOP: P3 = A1A0B1B0

P2 = A1A0′B1 + A1B1B0′

P1 = A1′A0B1 + A0B1B0′ + A1B1′B0 + A1A0′B0

P0 = A0B0

GIC = 34

POS: P3 = A1A0B1B0

P2 = A1B1 (A0′ + B0′)

P1 = (B1 + B0) (A1 + A0) (A0 + B0) (A1 + B1) (A1′ + A0′ + B1′ + B0′)

P0 = A0B0

GIC = 32

iii. SOP: w = A0B0 , x = A1B1 , y = A0B1 , z = A1B0

P3 = wx , P2 = xw′ , P1 = yz′ + zy′ , P0 = w

GIC = 21

POS: w = A0B0 , x = A1B1

P3 = wx, P2 = xw′ , P1 = (B1 + B0) (A1 + A0) w x (w′ + x′) , P0 = w

GIC = 21

§4-5

27. (a) ii. Di = Xi′Yi + XiYi′ , Bi+1 = Xi′Yi

iii. Di = Xi⊕Yi, Bi+1 = Xi′Yi

(b) ii. Di = Xi′Yi′Bi + Xi′YiBi′ + XiYi′Bi′ + XiYiBi , Bi+1 = Xi′Bi + Xi′Yi + YiBi

iii. Di = = Xi ⊕Yi ⊕Bi , Bi+1 = Bi (Xi⊕Yi)′+Xi′Yi = Yi (Xi⊕Bi)′ + Xi′Bi

(c) ii. 20*n +20 (ns)

(d) ii. 60 ns

§4-9

29. (a) i. $f1 = \Sigma m(1,4,5)$, $f2' = \Sigma m(1,5)$

ii. $f1' = \Pi M(1,4,5) = f2 \cdot M4$, $f2 = \Pi M\,(1,5)$

(b) i. $f1' = \Sigma m(1,4,6)$, $f2 = \Sigma m(1,2,6)$

ii. $f1 = \Pi M(1,4,6)$, $f2' = \Pi M\,(1,2,4)$

§4-10

30. (a) ii. $A1 = D0'D1'$, $A0 = D0'D1 + D0'D2'$, $V = D3 + D2 + D1 + D0$

(b) ii. $A2 = D6 + D5 + D4$

$A1 = D6 + D5'D4'D3 + D5'D4'D2$

$A0 = D6'D5 + D6'D4'D3 + D6'D4'D2'D1$

$V = D6 + D5 + D4 + D3 + D2 + D1 + D0$

§4-11

31. (a) i. 0, z, z′, 1, 1, 1, z, z′

ii. yz , y+z′ , 1, y′z+yz′ (or $y \oplus z$)

(b) i. 0, z′, z, z′, 1, 0, 1, z′

ii. yz′ , $y \oplus z$, y′ , y′+z′

Chapter 5

§5-3

32. (a) C: 1→1→0→0→… , D: 0→1→1→1→… ; 20 ns
    (b) i. C: 0→1→1→1→… , D: 1→1→0→0→… ; 20 ns
    ii. C: 0→1→1→… , D: 1→1→1→… ; 10 ns
    iii. C: 1→0→1→0→… , D: 1→0→1→0→… ; isolated

§5-5

34. (b) $A(t+1) = x'A + xy$, $B(t+1) = x'A + xB$
    (e) AB: 00 00 10 10 11 01 00 10 00
    Z: 0 0 1 1 0 0 0 1 0

35. (a) $J_A = Bx'$, $K_A = Bx$, $J_B = x$, $K_B = Ax + A'x'$, $Z = Bx'$
    (b) $A^+ = Bx' + AB'$, $B^+ = A'x + B'x + ABx'$

Sequential Circuit Timing

36. (a) 4 ns (b) 3.5 ns (c) 6 ns (d) 5.5 ns (e) 167 MHz

§5-7 & 5-8

37. (a) 7 states

40. $D_A = B$, $D_B = A + B'x$, $Z = Bx + Ax'$

41. $J_A = B$, $K_A = 1$, $J_B = A + x$, $K_B = 1$

State Reduction

38. (a) None.
    (b) (0, 3, 4); (1, 5)

State Assignment

39. (a) Highest: ACE, BCE ; Medium: AB, CD, AD×2, DE ; Lowest: ABCE, ABCD

Chapter 6

§6-2

42. $D_1 = S_1'S_0'A_1 + S_1'S_0I_1 + S_1S_0'A_0$, $D_0 = S_1'S_0'A_0 + S_1'S_0I_0 + S_1S_0'SI$

§6-3

43. FF_0 : C_0 : CLOCK, $D_0 = Q_0'$
FF_1 : $C_1 : Q_0 \uparrow \Rightarrow Q_0' \downarrow$, $D_1 = Q_1'$

§6-4

44. $D_1 = Q_1^+ = Q_1 \oplus Q_0'$, $D_0 = Q_0^+ = Q_0'$

Chapter 7

§7-3

46. (a) Decoder: one 13×2^{13} decoder ; #AND gates: 2^{13} ; #inputs/gate: 13

(b) Decoders: one 7-to-2^7 decoder and one 6-to-2^6 decoder;

2^7 7-input & 2^6 6-input AND gates

§7-5

48. (a) ii. 8 × 4 ROM iii. 8 × 3 ROM

(b) ii. 8 × 3 ROM iii. 8 × 2 ROM

§7-6

49. (a) i. $A = xy'z + x'y + x'z' + yz'$, $A' = xy'z' + x'y'z + xyz$

$B = xy' + xz + y'z$, $B' = x'y + yz' + x'z'$

ii. 3×4×2 PLA

(b) i. $A = wy' + wz' + w'x'y$, $A' = w'x + w'y' + wyz$

$B = x'y'z' + w'y' + w'z'$, $B' = wx + wy + wz + yz$

ii. 4×5×2 PLA

§7-7

50. (a) i. $A = xy'z + x'y + x'z' + yz' = C + x'z' + yz'$ * One of the possible solutions!

$B = xy' + xz + y'z$

(b) i. $A = wy' + wz' + w'x'y$, $B = x'y'z' + w'y' + w'z'$