SOLUTIONS MANUAL

DIGITAL DESIGN

WITH AN INTRODUCTION TO THE VERILOG HDL

Fifth Edition

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CHAPTER 1

1.1

Base 10	: 10 11 12 13 14 15 16 17 18 19 20 21 22
Octal	: 12 13 14 15 16 17 20 21 22 23 24 25 26
Hex	: A B C D E F 10 11 12 13 14 15 16
Base 12	: A B 10 11 12 13 14 15 16 17 18 19 1A

Base 10	: 23 24 25 26 27 28 29 30 31 32
Octal	: 27 30 31 32 33 34 35 36 37 40
Hex	: 17 18 19 1A 1B 1C 1D 1E 1F 20
Base 12	: 1B 20 21 22 23 24 25 26 27 28

1.2 **(a)** 16,384

(b) 33,554,432

(c) 3,435,973,837

1.3 **(a)** $(432)_5 = 4 \times 5^2 + 3 \times 5^1 + 2 \times 5^0$

$= 100 + 15 + 2$

$= (117)_{10}$

(b) $(A98)_{12} = 10 \times 12^2 + 9 \times 12^1 + 8 \times 12^0$

$= 1440 + 108 + 8$

$= (1556)_{10}$

(c) $(475)_8 = 4 \times 8^2 + 7 \times 8^1 + 5 \times 8^0$

$= 256 + 56 + 5$

$= (317)_{10}$

(d) $(2345)_6 = 2 \times 6^3 + 3 \times 6^2 + 4 \times 6^1 + 5 \times 6^0$

$= 432 + 108 + 24 + 5$

$= (569)_{10}$

1.4

12-bit binary	:	1111 1111 1111
Decimal	:	$2^{12} - 1 = (4095)_{10}$
Hexadecimal	:	$(FFF)_{16}$

1.5 Let b = base

(a) $12 \times 4 = 52 \quad \rightarrow \quad (b + 2)\,4 = 5b + 2$

$4b + 8 = 5b + 2$

$b = 6$

(b) $75/3 = 26 \quad \rightarrow (7b + 5) = 3(2b + 6)$

$7b + 5 = 6b + 18$

$b = 13$

(c) $(2 \times b + 4) + (b + 7) = 4b$, so $b = 11$

1.6 $x^2 - 13x + 32 = 0$

$(x - 5)(x - 4) = 0$

$x^2 - (5 + 4)x + 5 \times 4 = x^2 - 13x + 32$

So, $5 + 4 = b + 3$ OR $5 \times 4 = 3b + 2$

$b = 6$ $b = 6$

1.7 $(ABCD)_{16} = (1010\ 1011\ 1100\ 1101)_2$

$= \underbrace{1}_{1}\ \underbrace{010}_{2}\ \underbrace{101}_{5}\ \underbrace{111}_{7}\ \underbrace{001}_{1}\ \underbrace{101}_{5}$

$= (125715)_8$

1.8 **(a)** Converting $(512)_{10}$ to binary is by repeated division by 2.

2 | 512
2 | 256 – 0
2 | 128 – 0 $\Rightarrow (1000000000)_2$
2 | 64 – 0
2 | 32 – 0
2 | 16 – 0
2 | 8 – 0
2 | 4 – 0
2 | 2 – 0
1 – 0

(b) $(512)_{10}$ to hexadecimal is repeated division by 16.

16 | 512
16 | 32 – 0 $\Rightarrow (200)_{16}$
2 – 0 $\Downarrow$ replace each digit by binary

To binary

$(200)_{16} = (10\ 0000\ 0000)_2$

2nd method is faster.

1.9 **(a)** $(11010.0101)_2 = 16 + 8 + 2 + 0.25 + 0.0625$

$= (26.3125)_{10}$

(b) $(A6.5)_{16} = 10 \times 16 + 6 + 5 \times 0.0625$

$= (166.3125)_{10}$

(c) $(276.24)_8 = 2 \times 8^2 + 7 \times 8 + 6 + \dfrac{2}{8} + \dfrac{4}{64}$

$= 128 + 56 + 6 + 0.25 + 0.0625$

$= (190.3125)_{10}$

(d) $(BABA.B)_{16} = 11 \times 16^3 + 10 \times 16^2 + 11 \times 16^1 + 10 + \frac{11}{16}$

$= 45056 + 2560 + 176 + 10 + 0.6875$

$= (47802.6875)_{10}$

(e) $10110.1101 = 16 + 4 + 2 + 0.5 + 0.25 + 0.0625 = (22.8125)_{10}$

1.10 **(a)** $1.10010_2 = 0001.1001_2 = 1.9_{16} = 1 + \frac{9}{16} = 1.563_{10}$

(b) $(1100.010)_2 = (C.4)_{16}$

$= 12 + \frac{4}{16} = (12.25)_{10}$

Shifted to left by 3 places.

1.11

```
       1010.1
110 | 111111
       110
       ----
        111          ⇒ (1010.1)2
        110
        ----
          110
          110
          ---
           0
```

1.12 **(a)**

```
  (1100)2            1100 × 110
 +(110)2                  0000
 -------                 1100+
 (10010)2               1100+
                    -----------
                     (1001000)2
```

(b)

```
  (AB)16             AB × 1C
 +(1C)16                 804
 -------               AB+
  (C7)16              ------
                     (12B4)16
```

1.13 **(a)** $(35.125)_{10} = (100011.001)_2$

```
2 | 35                       0.125 × 2 = 0.25
2 | 17 – 1 ↑                  0.25 × 2 = 0.5
2 | 8  – 1                     0.5 × 2 = 1.0
2 | 4  – 0
2 | 2  – 0
  |  1 – 0
```

(b) $\frac{1}{3} = 0.33333333$

$= (0.01010101)_2 \Rightarrow (0.33203125)_{10}$

(c) $(0.01010101)_2 = (0.55)_{16}$

$= \frac{5}{16} + \frac{5}{256}$

$= (0.33203125)_{10}$

Answer is same.

1.14

(a)	1111 0000	**(b)** 0000 0000	**(c)** 1101 1000
1's comp:	0000 1111	1111 1111	0010 0111
2's comp:	0001 0000	0000 0000	0010 1000

(d)	0101 0101	**(e)** 1000 0000	**(f)** 1111 1111
1's comp:	1010 1010	0111 1111	0000 0000
2's comp:	1010 1011	1000 0000	0000 0001

1.15

(a)	25,918,036	**(b)**	99,999,999
9's comp :	74,081,963	9's comp :	00,000,000
10's comp :	74,081,964	10's comp :	00,000,001

(c)	25,000,000	**(d)**	00000000
9's comp :	74,999,999	9's comp :	99999999
10's comp :	75,000,000	10's comp :	100000000

1.16 **(a)** $(CAD9)_{16}$

16's comp: $(3527)_{16}$

(b) $(CAD9)_{16} = (1100\ 1010\ 1101\ 1001)_2$

(c) 1100 1010 1101 1001

1's comp: 0011 0101 0010 0110

2's comp: 0011 0101 0010 0111

(d) 0011 0101 0010 0111

$= (3527)_{16}$

(a) and (d) both are same.

1.17 **(a)** 2579

9's comp : 7420

10's comp : 7421

$$\begin{array}{r} 3699 \\ \underline{+7421} \\ 1\ 1120 \end{array}$$

drop

Ans: 1120

(b) 1800

9's comp : 8199

$$\begin{array}{r} 974 \\ \underline{+8200} \end{array}$$

10's comp : 8200 9174 ⇒ –826

(c) 4361 2943
9's comp : 5638 <u>+5639</u>

10's comp : 5639 8582 ⇒ − 1418

(d) 0745 7631
9's comp : 9254 <u>+9255</u>
10's comp : 9255 1 6886 Ans: 6886
drop

1.18

(a) 10010 10101
1's comp : 01101 <u>+01110</u>
2's comp : 01110 1 00011 Ans: 00011
drop

(b) 100110 010010
1's comp : 011001 <u>+011010</u>

2's comp : 011010 101100 ⇒ −010100

(c) 110101 010011
1's comp : 001010 <u>+001011</u>

2's comp : 001011 011110 ⇒ −100010

(d) 101101 101000
1's comp : 010010 <u>+010011</u>

2's comp : 010011 111011 ⇒ −000101

1.19 +9081 → 009081 +954 → 000954
–9081 → 990918 (9's comp) –954 → 999045 (9's comp)
–9081 → 990919 (10's comp) –954 → 999046 (10's comp)

(a) (+9081) + (954) = 009081 + 000954
= 010035
(b) (+9081) + (–954) = 009081 + 999046

= 008127

1

drop

(c) (–9081) + (+954) = 990919 + 000954

= 991873 ⇒ –8127

(d) (–9081) + (–954) = 990919 + 999046

= 989965 ⇒ –10035

1

drop

1.20 +56 → 0 111000 +35 → 0 100011

–56 → 1 001000 −35 → 1 011101

(a) (+56) + (+35) ⇒ 0 111000

+0 100011

1 011011 (overflow)

1011011 → 91

(b) (+56) + (–35) ⇒ 0 111000

+1 011101

0010101 ⇒ +21

1

drop

(c) (–56) + (+35) ⇒ 1 001000

+0 100011

1 101011 ⇒ –21

1 101011 is the 2's complement of –21.

1.21 $+9542 \rightarrow 009542$ $+641 \rightarrow 000641$
$-9542 \rightarrow 990458$ $-641 \rightarrow 999359$

(a) $(+9542) + (+641) \Rightarrow 009542$

$$\begin{array}{r} \underline{+\ 000641} \\ 010183 \end{array}$$

(b) $(+9542) + (-641) \Rightarrow 009542$

$$\begin{array}{r} \underline{+999359} \\ 1\ \ 008901 \end{array}$$

drop

(c) $(-9542) + (+641) \Rightarrow 990458$

$$\begin{array}{r} \underline{+000641} \\ 991099 \end{array} \Rightarrow -8901$$

(d) $(-9542) + (-641) = 990458$

$$\begin{array}{r} \underline{+\ 999359} \\ 989817 \end{array} \Rightarrow -10183$$

1

drop

1.22 $(7654)_{10}$
BCD: 0111 0110 0101 0100
ASCII: 0 $\underbrace{0110111}_{7}$ $\underbrace{0110110}_{6}$ $\underbrace{0110101}_{5}$ $\underbrace{0110100}_{4}$

1.23

$$\begin{array}{rcr} 694 & & 0110\ 1001\ 0100 \\ \underline{+538} & \Rightarrow & +\ \underline{0101\ 0011\ \ 1000} \end{array}$$

1232 1011 1100 1100

$\underline{0110\ 0110\ 0110}$

$\underbrace{0001}_{1}\ \underbrace{0010}_{2}\ \underbrace{0011}_{3}\ \underbrace{0010}_{2}$

1.24

Octal Digit	**6311**	**6421**
0	0000	0000
1	0001/0010	0001
2	0011	0010
3	0100	0011
4	0110/0101	0100
5	0111	0101
6	1000	0110/1000
7	1001/1010	1001/0111

1.25 $(6514)_{10}$

(a) BCD : 0110 0101 0001 0100
(b) Excess 3 : 1001 1000 0100 0111
(c) 2421 : 1100 1011 0001 0100
(d) 6311 : 1000 0111 0001 0101

1.26 6514

9’s comp : 3485
2421 : 0011 0100 1110 1011 → ①

1’s comp of : 1100 1011 0001 0100 is
0011 0100 1110 1011 → ②

Hence ① and ② are some → self complementing.

1.27 For a deck with 52 cards, we need 6 bits ($2^5 = 32 < 52 < 64 = 2^6$). Let the msb's select the suit (e.g., diamonds, hearts, clubs, spades are encoded respectively as 00, 01, 10, and 11. The remaining four bits select the "number" of the card. Example: 0001 (ace) through 1011 (9), plus 101 through 1100 (jack, queen, king). This a jack of spades might be coded as 11 1010. (Note: only 52 out of 64 patterns are used.)

1.28 G e o r g e
(space) 1100 0111 1110 0101 1110 1111 1111 0010 0110 0111
1110 0101 0010 0000 B
1100 0010 1010 1110

1.29 Digital Systems

1.30 **(a)**

C9:	1 100 1001	I
EE:	1 110 1110	n
F3:	1 111 0011	s
74:	0 111 0100	t
69:	0 110 1001	i
74:	0 111 0100	t
F5:	1 111 0101	u
74:	0 111 0100	t
65:	0 110 0101	e

(b) Even parity.

1.31 62 + 32 = 94 printing characters

1.32 bit 6 from the right

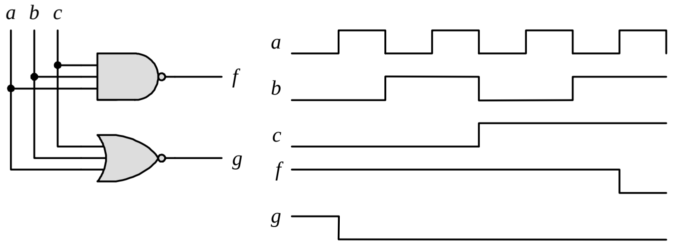
1.33

	0101	**0110**	**0100**
(a) BCD	5	6	4
(b) Excess-3	2	3	1
(c) 84-2-1	3	2	4
(d) Binary no.	$(1380)_{10}$		

1.34 ASCII for decimal digits with even parity:

0 → 1 011 0000
1 → 0 011 0001
2 → 0 011 0010
3 → 1 011 0011
4 → 0 011 0100
5 → 1 011 0101
6 → 1 011 0110
7 → 0 011 0111

1.35 **(a)**



1.36