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ITI1100Z

## Assignment # 1 Solution

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**Text Book:** Digital Design, 6<sup>th</sup> edition.

Professor: M.Alja' Afreh  
UNIVERSITY OF OTTAWA

## Theory Part:

Concisely and briefly explain:

Why Digital systems replaced analog systems?

*Digital systems are more accurate, and reusable most digital devices are programmable. By changing the program in a programmable device, the same underlying hardware can be used for many different applications, thereby allowing its cost of development to be spread across sales to a wider customer base. Dramatic cost reductions in digital devices have come about because of advances in digital integrated circuit technology.*

Why it is important to use and understand binary?

*The first and foremost reason is that electronic components, as a natural coincidence, operate in a binary mode. A switch is either open/off (called 0 state) or closed/on (called 1 state); a transistor is either not conducting (0 state) or is conducting (1 state).*

*This two-state nature of the electronic components can be easily expressed with the help of binary numbers.*

*The second reason is that computer circuits have to handle only two bits instead of 10 digits of the decimal system. This simplifies the design of the machine, reduces the cost and improves the reliability.*

*Lastly, binary number system is used because all the operations that can be done in the decimal system can also be done with a binary number of radix 2.*

Why it is important to use complement in general?

*Complements are used in digital computers to simplify the subtraction operation and for logical manipulation. Simplifying operations leads to simpler, less expensive circuits to implement the operations.*

## Exercises' Part:

1) Convert the following numbers with the indicated bases to decimal:

- (a)  $(4310)_5$
- (b)  $(198)_{12}$
- (c)  $(445)_8$
- (d)  $(345)_6$

$$(4310)_5 = 4 * 5^3 + 3 * 5^2 + 1 * 5^1 = 580_{10}$$

$$(198)_{12} = 1 * 12^2 + 9 * 12^1 + 8 * 12^0 = 260_{10}$$

$$(445)_8 = 4 * 8^2 + 4 * 8^1 + 5 * 8^0 = 293_{10}$$

$$(345)_6 = 3 * 6^2 + 4 * 6^1 + 5 * 6^0 = 137_{10}$$

2) Convert the hexadecimal number 64CD to binary, and then convert it from binary to octal.

$$64CD_{16} = 0110\_0100\_1100\_1101_2 = 110\_010\_011\_001\_101 = (62315)_8$$

3) Express the following numbers in decimal:

- (a)  $(26.24)_8$
- (b)  $(DABA.B)_{16}$
- (c)  $(1011.1001)_2$

$$\rightarrow 26.24_8 = 2 * 8 + 6 + 2/8 + 4/64 = 22.3125$$

$$\rightarrow DABA.B_{16} = 13*16^3 + 10*16^2 + 11*16 + 10 + 11/16 = 55,994.6875$$

$$\rightarrow 1011.1001_2 = 8 + 2 + 1 + .5 + .0625 = 11.5625$$

4) Do the following conversion problems:

- (a) Convert decimal 27.315 to binary.
- (b) Calculate the binary equivalent of  $2/3$  out to eight places. Then convert from binary to decimal. How close is the result to  $2/3$ ?
- (c) Convert the binary result in (b) into hexadecimal. Then convert the result to decimal. Is the answer the same?

(a) Convert 27.315 to binary:

	Integer Quotient		Remainder	Coefficient
27/2 =	13	+	½	a <sub>0</sub> = 1
13/2	6	+	½	a <sub>1</sub> = 1
6/2	3	+	0	a <sub>2</sub> = 0
3/2	1	+	½	a <sub>3</sub> = 1
½	0	+	½	a <sub>4</sub> = 1

$$27_{10} = 11011_2$$

	Integer		Fraction	Coefficient
.315 x 2 =	0	+	.630	a <sub>1</sub> = 0
.630 x 2 =	1	+	.26	a <sub>2</sub> = 1
.26 x 2 =	0	+	.52	a <sub>3</sub> = 0
.52 x 2 =	1	+	.04	a <sub>4</sub> = 1

$$.315_{10} \approx .0101_2 = .25 + .0625 = .3125$$

$$27.315 \approx 11011.0101_2$$

(b)  $2/3 \approx .6666666667$

	Integer		Fraction	Coefficient
.6666_6666_67 x 2 =	1	+	.3333_3333_34	a <sub>1</sub> = 1
.3333333334 x 2 =	0	+	.6666666668	a <sub>2</sub> = 0
.6666666668 x 2 =	1	+	.3333333336	a <sub>3</sub> = 1
.3333333336 x 2 =	0	+	.6666666672	a <sub>4</sub> = 0
.6666666672 x 2 =	1	+	.3333333344	a <sub>5</sub> = 1
.3333333344 x 2 =	0	+	.6666666688	a <sub>6</sub> = 0
.6666666688 x 2 =	1	+	.3333333376	a <sub>7</sub> = 1
.3333333376 x 2 =	0	+	.6666666752	a <sub>8</sub> = 0

$$.6666666667_{10} \approx .10101010_2 = .5 + .125 + .0313 + .0078 = .6641_{10}$$

$$.10101010_2 = .1010_2 = .AA_{16} = 10/16 + 10/256 = .6641_{10} \text{ (Same as (b)).}$$

5) Obtain the 1's and 2's complements of the following binary numbers:

- (a) 00000000
- (b) 11011010
- (c) 10100101
- (d) 11111111.

0000\_0000 → 1s comp: 1111\_1111, 2s comp: 0000\_0000  
 1101\_1010 → 1s comp: 0010\_0101 and 2s comp: 0010\_0110  
 1010\_0101 → 1s comp: 0101\_1010 and 2s comp: 0101\_1011  
 1111\_1111 → 1s comp: 0000\_0000 and 2s comp: 0000\_0001

- 6) (a) Find the 16's complement of C3AF.  
 (b) Convert C3AF to binary.  
 (c) Find the 2's complement of the result in (b).  
 (d) Convert the answer in (c) to hexadecimal and compare with the answer in (a).  
 (e) Encode each of the following numbers  $(39)_{10}$  and  $(10001)_2$  in BCD.

C3AFC3AF: 1100\_0011\_1010\_1111  
 15s comp: 3C50 1s comp: 0011\_1100\_0101\_0000  
 16s comp: 3C51 2s comp: 0011\_1100\_0101\_0001 = 3C51  
 e)  $39_{10} = 0011\ 1001_{BCD}$  and  $10001_2 = 17_{10} = 0001\ 0111_{BCD}$

- 7) Calculate  $10000 \times 1001$ , and  $10000 \div 1001$ .

$\begin{array}{r} 1\ 0\ 0\ 0\ 0 \\ \times 1\ 0\ 0\ 1 \\ \hline 1\ 0\ 0\ 0\ 0 \\ 0\ 0\ 0\ 0\ 0 \\ 0\ 0\ 0\ 0\ 0 \\ 1\ 0\ 0\ 0\ 0 \\ \hline 1\ 0\ 0\ 1\ 0\ 0\ 0\ 0 \end{array}$	$\begin{array}{r} 1\ 0\ 0\ 1 \overline{) 1\ 0\ 0\ 0\ 0\ 0\ .0\ 0} \\ \underline{- 1\ 0\ 0\ 1} \\ 0\ 1\ 1\ 1\ 0 \\ \underline{1\ 0\ 0\ 1} \\ 0\ 1\ 0\ 1\ 0 \\ \underline{1\ 0\ 0\ 1} \\ 0\ 0\ 0\ 1 \end{array}$
	<p style="text-align: center;">Remainder <span style="margin-left: 100px;">0 0 0 1</span></p>

- 9) Perform subtraction on the given unsigned numbers using the 10's complement of the subtrahend. Where the result should be negative, find its 10's complement and affix a minus sign. Verify your answers.

- (a)  $6,473 - 5,297$   
 (b)  $125 - 1,800$

**(a)**  $6,473 - 5,297 = 1,176$

$5297 \rightarrow 05297 \rightarrow 94702$  (9s comp)  $\rightarrow 94703$  (10s comp)

$6473 - 5297 = 6473 + 94703 = 101,176$  (positive)

Magnitude: 1,176

Result:  $6,473 - 5,297 = 1,176$

b) 9's of 1800 = 8199 → 10's(1800) = 8200  
 125 + 8200 = 8325 → negative number → to find the magnitude → 10's complement of 8325 = 1675  
 Result = -1675

10) Perform subtraction on the given unsigned binary numbers using the 2's complement of the subtrahend. Where the result should be negative, find its 2's complement and affix a minus sign.

- (a) 10011 - 10010  
 (b) 100010 - 100110

<p>(a)      0_10110(22)</p> <p>1s comp: 1_01001</p> <p>2s comp: 1_01010</p> <p>          0_10111(23)</p> <p>Diff:    0_00001 (Positive)</p> <p>result is negative</p> <p>          Result: +1</p> <p>Check:    23 - 22 = +1</p>	<p>(b)      0_100110</p> <p>1s comp: 1_011001 with sign extension</p> <p>2s comp: 1_011010</p> <p>          0_100010</p> <p>          1_111100 sign bit indicates that the</p> <p>          0_000011 1s complement</p> <p>          0_000100 2s complement</p> <p>          0_000100 magnitude</p> <p>          Result: -4</p> <p>          Check: 34 - 38 = -4</p>
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11) Convert decimal +49 and +29 to binary, using the signed-2's-complement representation and enough digits to accommodate the numbers. Then perform the binary equivalent of (+29) + (-49), (-29) + (+49), and (-29) + (-49). Convert the answers back to decimal and verify that they are correct.

+49 → 0\_110001 (Needs leading zero extension to indicate + value);

+29 → 0\_011101 (Leading 0 indicates + value)

-49 → 1\_001110 + 0\_000001 → 1\_001111

-29 → 1\_100011 (sign extension indicates negative value)

(a) (+29) + (-49) = 0\_011101 + 1\_001111 = 1\_101100 (1 indicates negative value.)

Magnitude = 0\_010011 + 0\_000001 = 0\_010100 = 20; Result (+29) + (-49) = -20

(b) (-29) + (+49) = 1\_100011 + 0\_110001 = 0\_010100 (0 indicates positive value)

(-29) + (+49) = +20

(c) Must increase word size by 1 (sign extension) to accommodate overflow of values:

(-29) + (-49) = 11\_100011 + 11\_001111 = 10\_110010 (1 indicates negative result)

Magnitude: 01\_001110 = 78<sub>10</sub>

Result: (-29) + (-49) = -78<sub>10</sub>

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