ECE 212 Fundamentals of Logic Design
Spring Semester 2021
Homework 1

Due January 25, 2021 23:55PM

This homework assignment reviews basic concepts related to number systems, number conversions and some of the fundamental Boolean Algebra concepts. You should refer to lecture notes and/or the text book for additional background. Use extra paper as needed but please combine all sheets together in a single file before uploading your submission.This homework assignment reviews basic concepts related to number systems, number conversions and some of the fundamental Boolean Algebra concepts. You should refer to lecture notes and/or the text book for additional background. Use extra paper as needed but please combine all sheets together in a single file before uploading your submission.

Name (Print): Jason N Mansfield

NCSU Honor Pledge: "I have neither given nor received unauthorized aid on this test or assignment."

Student's signature: *Jason N Mansfield*

I understand that there will be point deductions for the following issues:

- Sloppy circuit diagrams, diagrams in general, tables, etc. You are urged to obtain a drawing template for logic circuit symbols and for straight lines (every ECE student should have one). Alternatively, you may use drawing software such as Visio.

Student's signature: *Jason N Mansfield*

1 [30 points total] Binary, Octal and Hexadecimal Representation of Numbers

a) [6 pts each] Convert the following hexadecimal numbers into binary and octal numbers: [Show your work for full credit]

i) Hexadecimal = 0xC6E1

(A) Binary =
$C = (1^8 + 1^4 + 0^2 + 0^1) = 1100$
$6 = (0^8 + 1^4 + 1^2 + 0^1) = 0110$
$E = (1^8 + 1^4 + 1^2 + 0^1) = 1110$
$1 = (0^8 + 0^4 + 0^2 + 1^1) = 0001$
$= 1100011011100001_2$

(B) Octal =
$1100011011100001_2 =$
$001 = (0^4 + 0^2 + 1^1) = 1$
$100 = (1^4 + 0^2 + 0^1) = 4$
$011 = (0^4 + 1^2 + 1^1) = 3$
$011 = (0^4 + 1^2 + 1^1) = 3$
$100 = (1^4 + 0^2 + 0^1) = 4$
$001 = (0^4 + 0^2 + 1^1) = 1$
$= 143341_8$

ii) Hexadecimal = 0xA08E

(A) Binary =
$C = (1^8 + 0^4 + 1^2 + 0^1) = 1010$
$6 = (0^8 + 0^4 + 0^2 + 0^1) = 0000$
$E = (1^8 + 0^4 + 0^2 + 0^1) = 1000$
$1 = (1^8 + 1^4 + 1^2 + 0^1) = 1110$
$= 1010000010001110_2$

(B) Octal =
$1010000010001110_2 =$
$001 = (0^4 + 0^2 + 1^1) = 1$
$010 = (0^4 + 1^2 + 0^1) = 2$

$$000 = (0^4 + 0^2 + 0^1) = 0$$
$$010 = (0^4 + 1^2 + 0^1) = 2$$
$$001 = (0^4 + 0^2 + 1^1) = 1$$
$$011 = (1^4 + 1^2 + 1^1) = 6$$
$$= 120216_8$$

b) [6 pts each] Perform the following number-system conversions: [Show your work for full credit]

i)

Decimal $= 227_{10} =$

$\frac{227}{2} = 113.5 = 1$

$\frac{113}{2} = 56.5 = 1$

$\frac{56}{2} = 28 = 0$

$\frac{28}{2} = 14 = 0$

$\frac{14}{2} = 7 = 0$

$\frac{7}{2} = 3.5 = 1$

$\frac{3}{2} = 1.5 = 1$

$\frac{1}{2} = .5 = 1$

Binary $= 11100011_2$

ii)

Decimal $= 591_{10} =$

$\frac{591}{8} = 73\frac{7}{8} = 7$

$\frac{73}{8} = 9\frac{1}{8} = 1$

$\frac{9}{8} = 1\frac{1}{8} = 1$

$\frac{1}{8} = \frac{1}{8} = 1$

Octal = 1117_8

iii)

Decimal = 1713 =

$\frac{1713}{16} = 107\frac{1}{16} = 1$

$\frac{107}{16} = 6\frac{11}{16} = 11$

6 mod 16 = 6

Hexadecimal = $6b1_{16}$

2 20 points total, 10 points each] Signed Magnitude, Two's Complement and One's Complement Representation of Numbers

Determine the signed magnitude, two's complement, and one's complement representations for each of the decimal numbers below using the appropriate number of bits:[Show your work for full credit].

a) -119

Convert Non-negative decimal first

$\frac{119}{2} = 59\frac{1}{2} = 1$

$\frac{59}{2} = 29\frac{1}{2} = 1$

$\frac{29}{2} = 14\frac{1}{2} = 1$

$\frac{14}{2} = 7 = 0$

$\frac{7}{2} = 3\frac{1}{2} = 1$

$\frac{3}{2} = 1\frac{1}{2} = 1$

$\frac{1}{2} = .5 = 1$

$01110111_2 = 119_{10}$

i) Signed Magnitude of 119

8 bit word length with signed MSbit:

11110111_2

ii) Two's Complement of 119

$01110111_2 = 119_{10}$

One's compliment 8-bit creates signed MSbit

01110111_2 to 10001000_2

Add a unity for a Two's compliment

Adding one to low order bit.

$10001000_2 + 1 = 10001001_2$

Convert base 2 back to base 10

$10001001_2 = -119_{10}$

iii) Signed Magnitude of -119

8 bit word length with unsigned MSbit:

10001001_2 to 01110110_2

Add a unity for a Two's compliment

Adding one to low order bit.

$01110110_2 + 1 = 01110111_2$

$01110111_2 = 119_{10}$

iv) Two's Complement of -119

One's compliment 8-bit creates unsigned MSbit

$10001001_2 =$

b) +71

$\frac{71}{2} = 35\frac{1}{2} = 1$

$\frac{35}{2} = 17\frac{1}{2} = 1$

$\frac{17}{2} = 8\frac{1}{2} = 1$

$\frac{8}{2} = 4 = 0$

$\frac{4}{2} = 2 = 0$

$\frac{2}{2} = 1 = 0$

$\frac{1}{2} = \frac{1}{2} = 1$

$01000111 = 71_2$

i) Signed Magnitude =

8 bit word length with signed MSbit:

11000111

ii) Two's Complement =

One's compliment 8-bit creates signed MSbit

01000111 to 10111000

Add a unity for a Two's compliment

Adding one to low order bit.

$10111000_2 + 1 = 10111001_2$

$10111001_2 = 71_{10}$

3 [26 points total, 6.5 points each] Two's Complement Addition

Perform the following addition operations using 8-bit two's complement representations.

 (i) Indicate if there was overflow

 (ii) Also, explain the criterion you used to determine whether of not there was overflow.

[Show your work for full credit].

- number carries are in orange

- overflow is in red

a)

Addends signs and result are all negative therefore no overflow.
$(C_{in} = C_{out})$

$$1\ 0111\ 0000$$
$$1001\ 1001$$
$$+\underline{1011\ 1000}$$
$$1\ 0101\ 0001$$

(1)

b)

Addends signs are not the same and therefore no overflow.
$(C_{in} = C_{out})$

$$1\ 1111\ 1110$$
$$1101\ 1101$$
$$+\underline{0111\ 1011}$$
$$1\ 0101\ 1000$$

(2)

c)

Addends are the same and the result is opposite and therefore overflow occured.
$(C_{in} \neg C_{out})$

$$1110\ 0000$$
$$0101\ 0001$$
$$+\underline{0111\ 1010}$$
$$1100\ 1011$$

(3)

d)

Addends signs and result are all negative therefore no overflow.
($C_{in} = C_{out}$)

$$\begin{array}{r} \text{\colorbox{orange}{1 1000 0000}} \\ 1101\ 0101 \\ +\underline{1100\ 1000} \\ 1\ 1001\ 1101 \end{array}$$

(4)

4 [24 points total, 8 points each] Binary Math Use two's complement binary math to perform the operations below as a binary addition. Show all work. Assume 8-bit binary values.

a)

$$(-15_{10} - 6_{10})$$

$$-(15 = (1^8 + 1^4 + 1^2 + 1^1) = 1111_2)$$
$$\underline{-(6 = (0^8 + 1^4 + 1^2 + 0^1) = 0110_2)}$$

$$-1111_2$$
$$\underline{-110_2}$$
$$-1\ 0101$$

$$-(1^{16} + 0 + 1^4 + 0 + 1^1)$$

$$-21$$

b)

$$(32_{10} - 12_{10})$$

$$(32 = (1^{32} + 0^{16} + 0^{8} + 0^{4} + 0^{2} + 0^{1}) = 100000)$$

$$\underline{-(12 = (1^{8} + 1^{4} + 0^{2} + 0^{1}) = 1100)}$$

$$\begin{array}{r} 100000 \\ \underline{-1100} \end{array}$$

$$-001100 = (110011 + 1) = 110100$$

$$\begin{array}{r} 100000 \\ \underline{110100} \\ 1010100 \end{array}$$

$$\cancel{1}010100$$

$$10100$$

$$(1^{16} + 0^{8} + 1^{4} + 0^{2} + 0^{1}) = 20$$

c)

$$(-103_{10} - 88_{10})$$

$$-(103 = (1^{64} + 1^{32} + 0^{16} + 0^8 + 1^4 + 1^2 + 1^1) = 1100111_2)$$
$$-(88 = (1^{64} + 0^{32} + 1^{16} + 1^8 + 0^4 + 0^2 + 0^1) = 1011000_2)$$

$$\begin{array}{r} 1100111_2 \\ \underline{1011000_2} \\ 10111111_2 \end{array}$$

$$-10111111_2 = -(1^{128} + 0^{64} + 1^{32} + 1^{16} + 1^8 + 1^4 + 1^2 + 1^1) = -191$$