Assignment 1 CS2253 Fall 2021

SOLUTIONS

Total: 35 marks

Due Date: September 23, 2021 - 8:30 am

Purpose: practice working with representations and operations on binary and hexadecimal numbers (textbook, Chapter 2).

Problem 1. **(2 marks, 1 each)**

a) Assume that 453 scientists have been invited to attend a conference. If every scientist is to be assigned a unique bit pattern, what is the minimum number of bits required to do this?

453 < 512. So 9 bits.

b) How many more scientists can be invited to the conference, without requiring additional bits for each person's unique id?

512-453 = 59

Problem 2. **(6 marks)**

a) What is the largest positive number one can represent in an 10-bit 2's complement code? Write your result in binary and decimal.

(1 mark) 511 in decimal, 0111111111 in binary.

b) What is the greatest magnitude negative number one can represent in an 10-bit 2's complement code? Write your result in binary and decimal.

(1 mark) -512 in decimal, 1000000000 in binary.

c) What is the largest positive number one can represent in n-bit 2's complement code?

(2 marks) $(2^{n-1}) - 1$.

d) What is the greatest magnitude negative number one can represent in n-bit 2's complement code?

(2 marks) $-(2^{n-1})$.

Problem 3. **(4 marks, 1 each)** Convert the following 2's complement binary numbers to decimal.

a) 11010 **-6**
b) 01100110011 **819**
c) 11111111010 **-6**
d) 01110000010000 **7184**

Problem 4. **(4 marks, 2 each)** Perform the specified arithmetic operation for the following 2's complement binary numbers (Don't forget to sign-extend when required!). Show the results in 8-bit numbers. Verify your result by performing the operations with decimal numbers.

a) $11011 - 111 = \mathbf{11111011 - 11111111 = 11111011 + 00000001 = 11111100}$. $\mathbf{-5 - (-1) = -4}$
b) $111 - 11011 = \mathbf{11111111 - 11111011 = 11111111 + 00000101 = 00000100}$. $\mathbf{-1 - (-5) = 4}$

Problem 5. **(4 marks, 1 each)** The following binary numbers are 5-bit 2's complement binary numbers. Which of the following operations generate overflow? Justify your answers by translating the operands and results into decimal.

a) $00111 + 00110$

$= 01101 = 13$, $7 + 6 = 13$, no overflow

b) $10111 - 11110$

$= 11001 = -7$, $(-9) - (-2) = -7$, no overflow

c) $11000 - 00011$

$= 10101 = -11$, $(-8) - 3 = -11$, no overflow

d) $10110 + 10011$

$= 01001 = 9$, $(-10) + (-13) = -23$, overflow

Problem 6. **(2+1 marks)** Perform the following operation in 2's complement arithmetic, where both 8-bit operands are in hexadecimal: `F6 + 49`. First convert the numbers to binary, then add them. Does this operation cause overflow? Why or why not?

Sum is 0011 1111 Does not cause overflow since the operands are of opposite sign.

Problem 7. **(4 marks, 1 each)** Perform the following logical operations. Express your answer in hexadecimal notation.

a) `x5478 AND xFDEA = x5468`
b) `xABCD OR x1234 = xBBFD`
c) `NOT((NOT(xDEFA)) AND (NOT(xFFFF))) = xFFFF`
d) `x00FF XOR x3232 = x32CD`

Problem 8. **(4 marks, 2 each)** Write the decimal equivalents for the following IEEE floating point numbers.

a) `1 01111110 01000000000000000000000`

$(-1)^1 \times 2^{126-127} \times (1.01)_2 = -0.625$

b) `0 10000001 10100000000000000000000`

$(-1)^0 \times 2^{129-127} \times (1.101)_2 = 6.5$

Problem 9. (2 marks) Write the IEEE floating point representation of the decimal number 10.75.

$(10.75)_{10} = (1010.11)_2 = (1.01011)_2 \times 2^3 = (-1)^0 \times 2^{130-127} \times (1.01011)_2$

01000001001011000000000000000000

Problem 10. **(2 marks)** Define a mathematical expression to convert the base ten digits 0-9 from their binary value to their ASCII value.

We can add 0011 0000 to the binary representation for any digit to get the ASCII representation for that digit.

To pass in the assignment: Create a single pdf document and submit it via D2L. Name your document `LastName_FirstName A1.pdf` (LastName and FirstName are of course substituted with *your* last and first name).