Henry Post

Binary Integers

CS 350: Computer Organization & Assembler Language Programming

Lab 1, due Fri Sep 9 (2400 hrs) *

A. Why?

- A basic way to store information in a computer is to use binary integers.
- There are multiple ways to represent negative integers.

B. Outcomes

After this lab, you should be able to

- Represent binary integers in sign-magnitude, 1's complement, or 2's complement; to list the pros and cons of each of these three systems and to explain why hardware commonly uses 2's complement to represent negative integers.
- List the representations of the most positive and negative values in each system; know when overflow occurs and how to recognize it.

C. Problems [50 points total]

1. [1 pt] Read as an unsigned binary number, 110111 represents what decimal value?
2. [3 pts] Let *V* be the decimal value from Problem 1; what is the 7-bit representation of -*V* in (a) sign-magnitude, (b) 1's complement, and (c) 2's complement? (Add a sign bit and possibly modify the 6 bits inherited from problem 1.)
3. [3 pts] Reading 110111 as a signed 6-bit value, what are the bitstring and decimal representations of –(110111) in (a) sign-magnitude, (b) 1's complement, and (c) 2's complement?
4. [6 = 3*2 pts] What is the bitstring and decimal value for the most negative 6-bit number in (a) sign-magnitude, (b) 1's complement, and (c) 2's complement?

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* Have you read the syllabus to find out how to get an automatic one-day extension?

1) 32 16 8 4 2 1
1 1 0 1 1 1 as unsigned bin:

= 63 - 8 = 55

2) V = 110111 = 55

What is the 7-bit representation of -V in...

a) sign-mag?	b) 1's comp?	c) 2's comp?
1 1 1 0 1 1 1	1 0 0 1 0 0 0	1 0 0 1 0 0 1

3) Reading 110111 as a signed 6-bit value, what is it in decimal in...

a) sign-mag?	b) 1's comp?	c) 2's comp?
16 8 4 2 1 1 1 0 1 1 1 -(32 - 8) = -23	1 1 0 1 1 1 = -(0 0 1 0 0 0) = -8	1 1 0 1 1 1 = -(0 0 1 0 0 1) = -9

4) What is the bitstring and decimal value for the most negative 6-bit number in...

a) sign-mag?	b) 1's comp?	c) 2's comp?
16 8 4 2 1 1 1 1 1 1 1 = -31	1 0 0 0 0 0 = -(0 1 1 1 1 1) = -31	1 0 0 0 0 0 = -(0 1 1 1 1 1 + 1) = -(1 0 0 0 0 0) = -32

31 in 2's comp -31

= 0 1 1 1 1 1 -(0 1 1 1 1 1) = 1 0 0 0 0 0 = -31

5. [6 = 3*2 pts] What is the bitstring and decimal value for the most negative *n*-bit number in (a) sign-magnitude, (b) 1's complement, and (c) 2's complement?
6. [4 pts] Which of the three systems have two forms of zero ("positive" and "negative" zero), and how do you write them in each of those systems?
7. [2 pts] In which (if any) of the three systems does taking the negative of the most negative number cause overflow? What about the negative of the most positive number?
8. [2 pts] What is 111011 + 001110, using unsigned addition? Does overflow occur?
9. [2 pts] What is 111000 – 001101, using unsigned subtraction?

For Problems 10 – 12, rewrite the following additions and subtractions in 6-bit 2's complement. E.g., –3 – 5 = –000011 – 000101 = 111101 – 000101 = 111101 + 111011 = 111000 = –001000 = –8

10. [7 pts] 13 – 30 = –17
11. [7 pts] –25 – 7 = –32
12. [7 pts] 24 + 10 = ??? (Be sure to show the decimal result; you should get overflow.)

D. How to Submit Labs

See http://cs.iit.edu/~cs350 → Syllabus > Labs > Submitting Work for your options.

+55 = 011011 (± 32 16 8 4 2 1)

-55 in 1's comp

1001000 = -55

-55 in 2's comp

1001001

5) bitstring and decimal value for most negative n-bit number in...

a) sign-mag?

$1\underbrace{111\ldots1}_{(n-1)}$

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

b) 1's comp?

$1\underbrace{000\ldots0}_{(n-1)}$

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

c) 2's comp?

$1\underbrace{000\ldots0}_{(n-1)}$

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

6) sign-mag and 1's complement have two zeroes.

$1\underbrace{0\ldots0}_{(n-1)}$

$1\underbrace{1\ldots1}_{(n-1)}$

7) In 2's comp, -(most_neg) causes overflow.

In no system does -(most_pos) cause overflow.

8)
$$\begin{array}{r} 111011 \\ +001110 \\ \hline 1001001 \end{array}$$

(overflow does occur)

EXTRA

$= \boxed{1001001}$

9)
$$\begin{array}{r} 111000 \\ -001101 \end{array}$$

100000

-000101

101111

-000100

$= \boxed{101011}$

10 - 12: Rewrite subtractions in 6-bit 2's complement.

10) $13 - 30 = -17$

$001101 - (011110)$

$= 001101 + 100010$

$= 101111$

$= -(010001) = \boxed{-17}$

11) $-25 - 7 = -32$

$-(011001) - (000111)$

$= 100111 + 111001$

$= 100111$
$+ 111001$
$= \boxed{100000 = -32}$

12) $24 + 10 = ?$

011000
$+ 001010$
$\hline 100010$

$= -(011110) = \boxed{-29}$ because overflow!