# Signed Binary Addition and Subtraction

Tom Kelliher, CS 220

Oct. 13, 2003

## 1 Administrivia

### Announcements

### Assignment

Read 3.13

### From Last Time

Exam.

### Outline

1. Complements.
2. Subtraction using 2's complement.
3. Signed numbers.
4. Combined 2's complement adder/subtractor.

**Coming Up**

VHDL.

# 2 Complements

Used for *signed* representations.

1. Diminished radix complement: 1's complement.

   (a) The 1's complement of an $n$ bit binary number $A$ is $2^n - 1 - A$.

   (b) What's the bit representation of $2^n - 1$? The one's complement of $A$? $A$ plus its one's complement?

2. Radix complement: 2's complement.

   (a) The 2's complement of an $n$ bit binary number $A$ is $2^n - A$.

   (b) 1's complement plus one.

   Two's complement of $A$? $A$ plus its two's complement?

# 3 Subtraction Using 2's Complement

Subtract by *adding*!

Adding works the same.

1. Denote the 2's complement of $B$ as $B'$.

   Recall $B' = 2^n - B$.

2. $A - B = A + B' - 2^n$.

   Note we should get a carry out of the msb when we perform $A + B'$.

3. Work the two examples again.

# 4 Signed Numbers

Skip sign-magnitude representation.

1. The Complement (1's, 2's) of a number is its additive identity.

   Well, almost. What's the 1's complement of 0? In 1's complement, what does a number and its complement add to?

2. Msb is sign bit. Weight of sign bit. 2's complement: $-2^{n-1}$. 1's complement: $-2^{n-1}-1$.

   Bit patterns for: most positive number, most negative number, 1, -1.

3. Range:

   (a) 2's complement

   (b) 1's complement

## 4.1 Practice

For six bit numbers, what is the range of:

1. Unsigned integers.

2. 1's complement integers.

3. 2's complement integers.

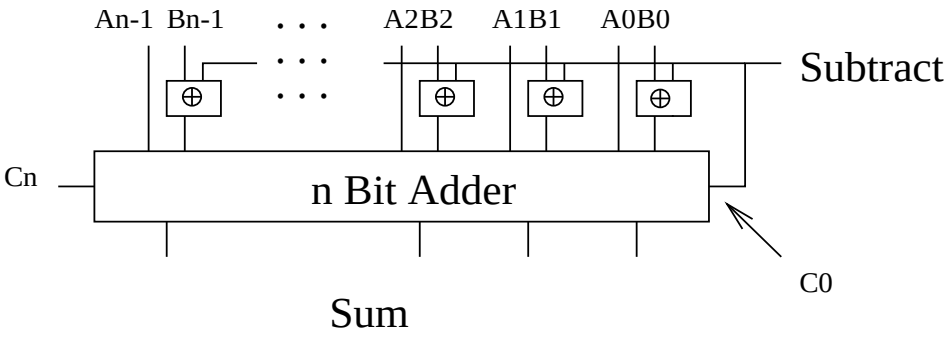
In 1's and 2's complements, what are the representations of 15, -18, 27, -4, 33, -32, -35, 10?

# 5 A 2's Complement Combined Adder/Subtractor

1. 2's complement: invert bits, add one.

2. EXOR gate can be used as a conditional inverter.

3. We're not using $C_0$ for anything.




Computes A + B or A - B.