Signed Binary Addition and Subtraction

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1 Administrivia

Announcements

Assignment

Read 3.13

From Last Time

Exam.

Outline

1. Complements.

2. Subtraction using 2’s complement.

3. Signed numbers.

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

\[ \begin{array}{ccccccc}
A_{n-1} & B_{n-1} & \cdots & A_2 & B_2 & A_1 & B_1 & A_0 & B_0 \\
\oplus & \oplus & \cdots & \oplus & \oplus & & & & \\
\text{Subtract} & & & & & & & \\
\text{Sum} & & & & & & & & \\
C_0 & & & & & & & \\
\end{array} \]

Computes $A + B$ or $A - B$. 