1's Complement and 2's Complement Arithmetic

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1's Complement Arithmetic

The Formula

$$\overline{N} = (2^n - 1) - N$$

where: n is the number of bits per word
N is a positive integer
$\overline{N}$ is -N in 1's complement notation

For example with an 8-bit word and N = 6, we have:

$\overline{N} = (2^8 - 1) - 6 = 255 - 6 = 249 = 11111001_2$

In Binary

An alternate way to find the 1's complement is to simply take the bit by bit complement of the binary number.

For example: $N = +6 = 00000110_2$

$\overline{N} = -6 = 11111001_2$

Conversely, given the 1's complement we can find the magnitude of the number by taking it's 1's complement.

The largest number that can be represented in 8-bit 1's complement is 01111111_2 = 127 = $7F. The smallest is 10000000_2 = -127. Note that the values 00000000_2 and 11111111_2 both represent zero.

Addition

End-around Carry. When the addition of two values results in a carry, the carry bit is added to the sum in the rightmost position. There is no **overflow** as long as the magnitude of the result is not greater than 2^n-1.

2's Complement Arithmetic

The Formula

$$N^* = 2^n - N$$

where: n is the number of bits per word
N is a positive integer
N^* is -N in 2's complement notation

For example with an 8-bit word and N = 6, we have:

$N^* = 2^8 - 6 = 256 - 6 = 250 = 11111010_2$

In Binary

An alternate way to find the 2's complement is to start at the right and complement each bit to the left of the first "1".

For example: $N = +6 = 00000110_2$

$N^* = -6 = 11111010_2$

Conversely, given the 2's complement we can find the magnitude of the number by taking it's 2's complement.

The largest number that can be represented in 8-bit 2s complement is 01111111_2 = 127. The smallest is 10000000_2 = -128.

Addition

When the addition of two values results in a carry, the carry bit is ignored. There is no **overflow** as long as the is not greater than 2^n-1 nor less than -2^n.

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