Understanding 1's Complement, 2's Complement, Signed, and Unsigned Integers

1's Complement

The 1's complement of a binary number is obtained by inverting all the bits in the binary representation of the number.

This means that all 0s are turned into 1s and all 1s are turned into 0s.

Example:

Original binary number: 1010

1's complement: 0101

Original binary number: 1100

1's complement: 0011

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2's Complement

The 2's complement of a binary number is obtained by adding 1 to the 1's complement of the number.

This is widely used for representing signed integers in binary.

Example:

Original binary number: 1010

1's complement: 0101

Add 1: 0101 + 1 = 0110

2's complement: 0110

Original binary number: 1100

1's complement: 0011

Add 1: 0011 + 1 = 0100

2's complement: 0100

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Signed and Unsigned Integers

In binary representation, integers can be signed (able to represent both positive and negative numbers) or unsigned (only positive numbers).

Unsigned Integers:

- Use all bits to represent the value, allowing only non-negative numbers.
- For an 8-bit unsigned integer, the range is 0 to 255.

Example:

Binary: 00001010 (10 in decimal)

Binary: 11111111 (255 in decimal)

Signed Integers:

- Use the most significant bit (MSB) as the sign bit. 0 indicates positive and 1 indicates negative.
- For an 8-bit signed integer, the range is -128 to 127.
- Positive numbers are represented as usual.
- Negative numbers are represented using 2's complement.

Example:

Binary: 00001010 (10 in decimal)

Binary: 11110110 (-10 in decimal, which is 2's complement of 00001010)

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Examples

Example 1:

Original number: 5

Binary: 00000101

1's complement: 11111010

2's complement: 11111011

Example 2:

Original number: -5 (in an 8-bit signed integer)

Binary: 11111011 (2's complement representation)

Example 3:

Original number: 12

Binary: 00001100

1's complement: 11110011

2's complement: 11110100

Example 4:

Original number: -12 (in an 8-bit signed integer)

Binary: 11110100 (2's complement representation)