

COMPUTER ORGANIZATION AND ARCHITECTURE**UNIT –III****TOPIC- DATA REPRESENTATION-COMPLEMENTS****Complements**

In binary arithmetic, "complements" refer to a method of representing negative numbers by manipulating the bits of their positive binary equivalent, primarily using "1's complement" (flipping all bits) and "2's complement" (flipping all bits and then adding 1), which allows for subtraction to be performed using addition operations within a computer system.

1's Complement

- The 1's complement of a binary number is obtained by change each 0 to 1 and each 1 to 0 or subtract each bit from Binary "1".

Example for 7-digit binary numbers:

- 1's complement is $(r^n - 1) - N = (2^7 - 1) - N = 1111111 - N$.

Example1:

Find the 1's complement of $(1011000)_2$

$$\begin{array}{r} 1111111 \\ - 1011000 \\ \hline 0100111 \end{array}$$

1's complement of 1011000 is 0100111

2's Complement

- Obtain 1's complement of given number and then add 1 to the least significant bit (L.S.B)
- Toggle all bits and add '1' from the right

Example1:

The 2's complement of 10110000 is 01010000

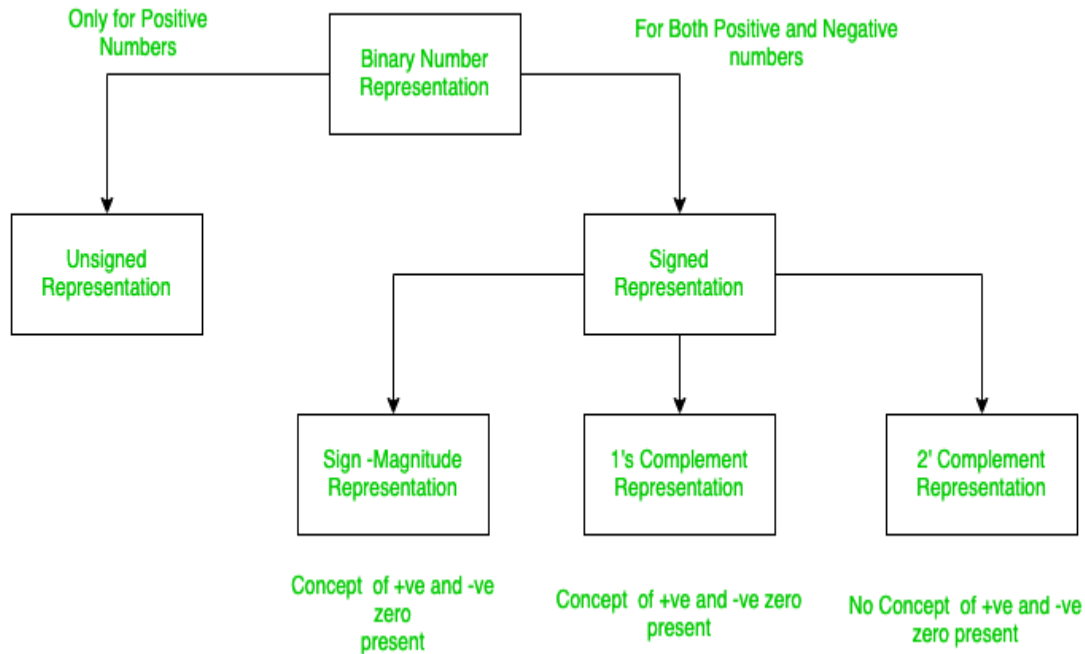
Number: 1 0 1 1 0 0 0 0

1's Complement: 01001111

2's Complement: 01010000

$$\begin{array}{r} 1\ 0\ 1\ 1\ 0\ 0\ 0\ 0 \\ 0\ 1\ 0\ 0\ 1\ 1\ 1\ 1 \\ \hline + \qquad \qquad \qquad 1 \\ \hline 0\ 1\ 0\ 1\ 0\ 0\ 0\ 0 \end{array}$$

Fixed-Point Representation



In Binary Number Representation, Positive integers and zero can be represented by unsigned representation. Negative numbers must be represented by signed representation since + and – signs are not available, only 1's and 0's are used.

- Signed numbers have MSB as 0 for positive and 1 for negative – MSB is the sign bit
- Two ways to designate binary point position in a register:

1. Fixed point representation
2. Floating-point representation

- When an integer is positive, the MSB, or sign bit, is 0 and the remaining bits represent the magnitude.

- When an integer is negative, the MSB, or sign bit, is 1, but the rest of the number can be represented in one of three ways:

1. Signed-magnitude representation
2. Signed-1's complement representation
3. Signed-2's complement representation

- Consider an 8-bit register and the number +14 which is represented as 00001110

- Consider an 8-bit register and the number –14 which can be represented as:

- o Signed magnitude: 1 0001110

- o Signed 1's complement: 1 1110001

- o Signed 2's complement: 1 1110010

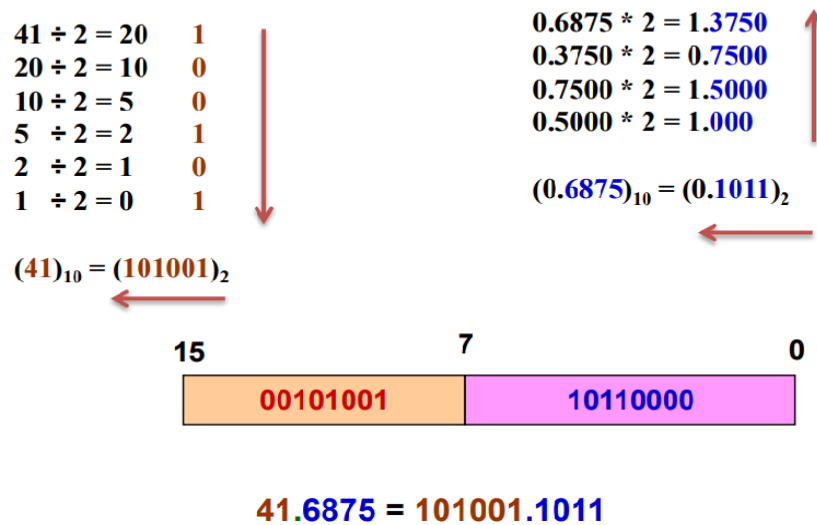
Example 1

Representation of -9 in Sign-Magnitude, One's Complement and Two's Complement form.

| | |
|---------------------------------------|----------|
| Signed-magnitude representation: | 10001001 |
| Signed-1's-complement representation: | 11110110 |
| Signed-2's-complement representation: | 11110111 |

Example 2:

represent the real number 41.6875 by using fixed point method.



Signed Fixed Point Representation

Ex: Represent $(-7.5)_{10}$ using 8-bit binary representation with 4 digits integer & 4 fraction bits

Sol: $(7.5)_{10} = (111.1)_2 \Rightarrow$ Binary form.

$= (0111.1000)_2 \Rightarrow$ 4 int & 4 fraction digits

$(-7.5)_{10} = 2's \text{ Compl} = 1's \text{ complement} + 1$

$1's \text{ complement} = 1000.0111$
 $\phantom{1's \text{ complement} = } $

$2's \text{ complement} = \underline{1000.1000}$

In fixed point representation, the position of binary point is fixed.