* Signed Binary Numbers:

* Sign-Magnitude Representation:

- In the decimal number system a plus (+) sign is used to denote a positive number and a minus (−) sign for denoting a negative number.
- This representation of numbers is known as signed number.
- Digital circuits can understand only two symbols, 0 & 1. Therefore, the same symbols are to be used to indicate the sign of the number also.
- Normally, an additional bit is used as the sign bit and it is placed as the MSB.
- '0' used to represent a '+ve' number and
- '1' used to represent a '−ve' number.

Eg: 8-bit signed number: 01000100

$(01000100)_2$ → +ve number & its value (magnitude) is $(1000100) = (68)_{10}$.

$(11000100)_2 \rightarrow (-68)_{10}$

- This kind of representation for signed numbers is known as sign-magnitude representation.

Prob: Find the decimal equivalent of the following binary numbers assuming sign-magnitude representation of the binary numbers

a) 10110D

Sol: Sign bit is 1, Which means the number is -ve

Magnitude = 0110D = $(12)_{10}$

$\therefore (101100)_2 = (-12)_{10}$

b) $(0111)_2 = (+7)_2$

c) $(1111)_2 = (-7)_2$

* **1's Complement Representation**

- In a binary number, if each 1 is replaced by 0 and each 0 by 1, the resulting number is known as the One's complement of the number.
- In fact, both the numbers are complement of each other.
- (If one of these numbers is +ve, then the other number will be -ve with the same magnitude and vice-versa).

Eg: $(0101)_2 \xrightarrow{\text{represents}} (+5)_{10}$

$(1010)_2 \xrightarrow{\text{represents}} (-5)_{10}$ in this representation

- This method is used for representing Signed numbers.

Prob: Find the 1's complement of the following binary numbers:

a) 0100111001 b) 110111010

Sol: a) 1011000110 b) 00100101

Prob: Represent the following numbers in 1's complement form.

a) +7 & -7 b) +8 & -8 c) +15 & -15

Sol: In 1's complement representation

a) $+7 = (0111)_2$ & $-7 = (1000)_2$

b) $+8 = (01000)_2$ & $-8 = (10111)_2$

c) $+15 = (01111)_2$ & $-15 = (10000)_2$

Note: For an n-bit number, the maximum +ve & -ve numbers that can be represented in 1's complement representation is $+/-(2^{n-1}-1)$

* Two's complement Representation:

- If '1' is added to 1's complement of a binary number, the resulting number is known as the "two's complement of the binary number.

Eg: $0101 \xrightarrow{2\text{'s comp}} 1011$

$0101 \rightarrow (+5)_{10}$ $\quad$ $1011 \rightarrow (-5)_{10}$ in 2's complement representation.

- In this representation also, if the MSB is 0 the number is +ve, whereas if the MSB is 1, the number is -ve.

- Note: For an n-bit number, the maximum +ve number which can be represented in 2's complement form is $(2^{n-1}-1)$ and the maximum -ve number is -2^{n-1}

Prob: find the 2's complement of the numbers:

i) 01001110 $\quad$ (ii) 00110101

Sol: i) Number 01001110 $(+78)_{10}$

1's comp 10110001

Add 1 $\quad$ 1

10110010 $(-78)_{10}$

ii) Number 00110101 $(+53)_{10}$

1's comp 11001010

Add 1 $\quad$ 1

11001011 $(-53)_{10}$

b: Represent $(-17)_{10}$ in

(i) Sign- magnitude

(ii) One's complement

(iii) Two's complement representation.

: The minimum number of bits required to represent $(+17)_{10}$ in signed number format is six.

$$(+17)_{10} = (010001)_2$$

$\therefore$ $(-17)_{10}$ is represented by:

(i) Sign- magnitude form : $(110001)_2$

(ii) One's complement form : $(101110)_2$

(iii) Two's complement form : $(101111)_2$

Table: Sign- magnitude, 1's and 2's complement Representation using 4-bits

Decimal Number	Binary Number		
	Sign- magnitude	One's Complement	Two's complement
0	0000	0000	0000
1	0001	0001	0001
2	0010	0010	0010
3	0011	0011	0011
4	0100	0100	0100
5	0101	0101	0101
6	0110	0110	0110
7	0111	0111	0111
-8	—	—	1000
-7	1111	1000	1001
-6	1110	1001	1010
-5	1101	1010	1011
-4	1100	1011	1100
-3	1011	1100	1101
-2	1010	1101	1110
-1	1001	1110	1111
-0	1000	1111	—