Week 5

Complements of Binary Numbers

6- Complements of Binary Numbers

- 1's complements
- 2's complements

- They are important because they permit the representation of negative numbers in computers

6-1 1st Complement

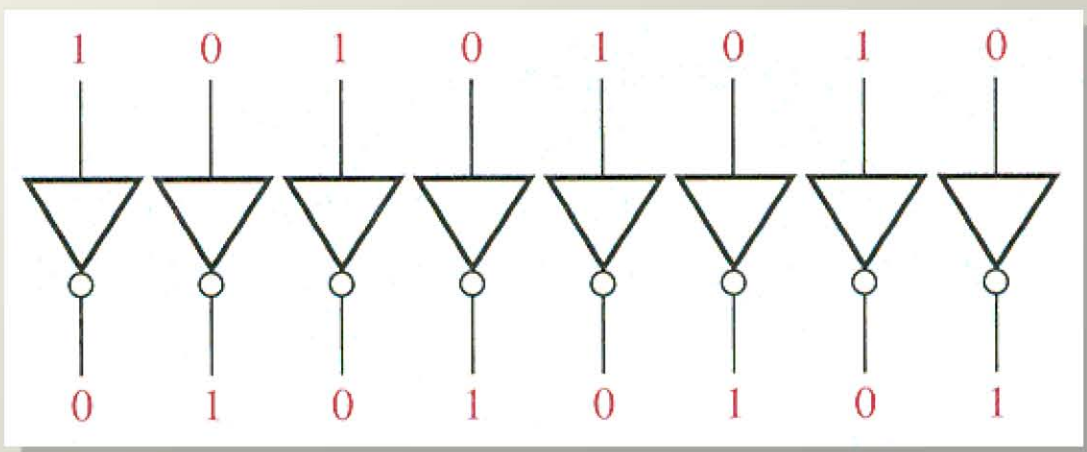
Method : Invert each bit to get the 1st complement

Example -1-

1 0 1 1 0 0 1 0	Binary number
↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓	
0 1 0 0 1 1 0 1	1's complement

Example -2- : Determine the first complement of the following binary

00011010 - 11110111 - 10001101



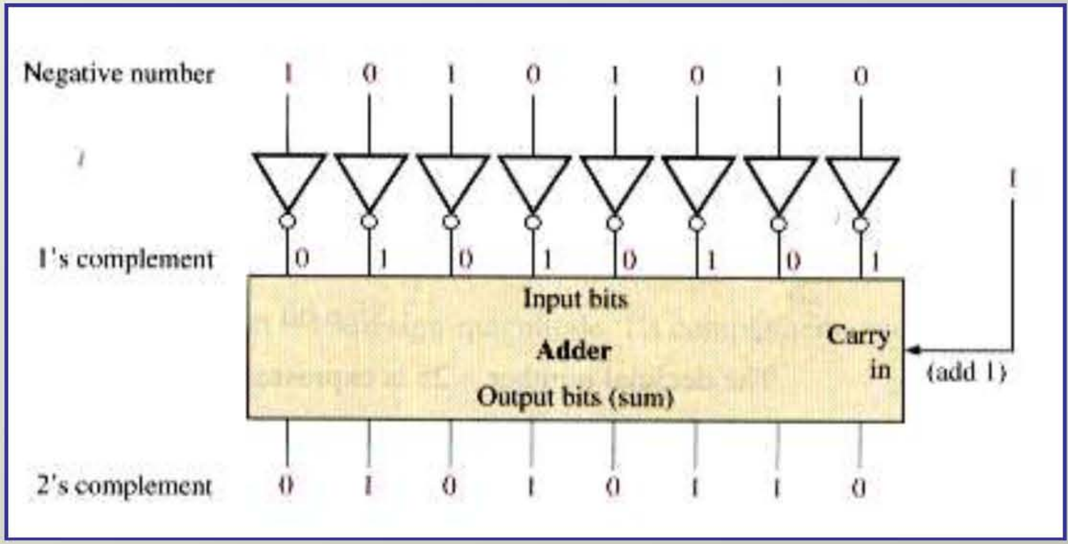
6-1 2nd Complement

Method -1- : 2nd complement = 1st complement + 1

Example -1-

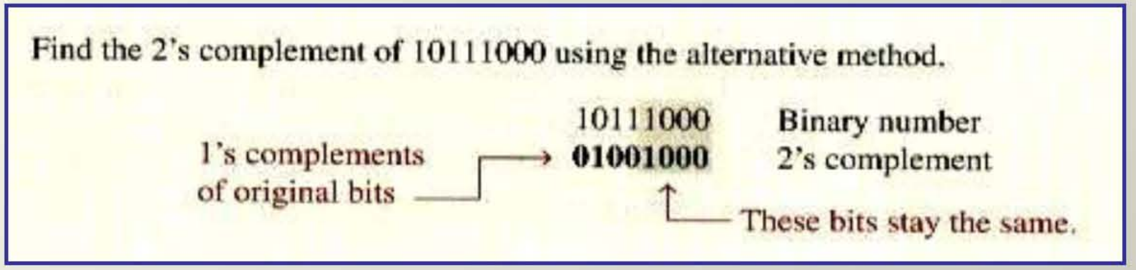
10110010	Binary number
01001101	1's complement
+ 1	Add 1
01001110	2's complement

Application Example



2^{nd} complement (cont.) :

Method -2- : Change all the bits to the left of the least significant 1 to gets the 2^{nd} complement



Example -1- : Determine the 2^{nd} complement of the following binary

00010110 - 11111100 - 10010001

7- Signed Numbers

Digital Systems , such as computer , must be able to handle both positive and negative numbers .

A signed binary number consists of both sign (positive or negative) and magnitude (value) information .

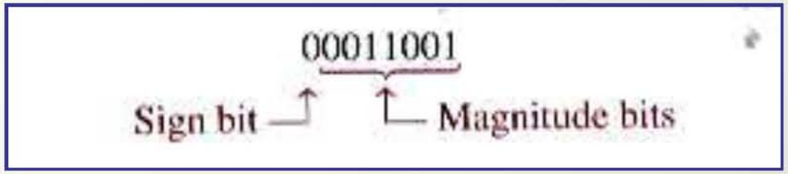
The Sign Bit

The left most bit is the sign bit .

" 0 " indicates positive - "1" indicates Negative

- Three methods for sign number representation
  1. Signed-magnitude form (rarely used)
  2. 1's complement form
  3. 2's complement form (most commonly used)

1- Sign –magnitude form:



+25 = 00011001

-25 = 10011001

- A 0 sign bit indicates a positive magnitude
- A 1 sign bit indicates a negative magnitude

2- 1st complement form:

A negative number is the 1st complement of the corresponding positive number

+25 = 00011001

-25 = 11100110

3- 2nd complement form:

A negative number is the 2nd complement of the corresponding positive number

+25 = 00011001

-25 = 11100111

Example :

Express the decimal number −39 as an 8-bit number in the sign-magnitude, 1's complement, and 2's complement forms.

Solution First, write the 8-bit number for +39.

00100111

In the *sign-magnitude form*, −39 is produced by changing the sign bit to a 1 and leaving the magnitude bits as they are. The number is

10100111

In the *1's complement form*, −39 is produced by taking the 1's complement of +39 (00100111).

11011000

In the *2's complement form*, −39 is produced by taking the 2's complement of +39 (00100111) as follows:

11011000	1's complement
+ 1	
11011001	2's complement

Example : express +19 , -19 in sign magnitude , 1st complement , 2nd complement

8- Decimal value of signed numbers

1- Sign –magnitude method :

1. **Convert the magnitude to decimal**
2. **Check the sign bit**

Example : Determine the decimal value of the following sign numbers expressed in signed magnitude :

01110111 , 10010110 , 10010101

2- 1st complement method :

1. **Summing the weights in all bits positions where there are "1" and ignoring those positions where there are "0".**

   $-2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$

1. **Add "1" in case of negative results**

Example : Determine the decimal value of the following sign numbers expressed in 1^{st} complement

00010111 , 11101000

3- 2^{nd} complement method :

1. **Summing the weights in all bits positions where there are "1" and ignoring those positions where there are "0"**

   $-2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$

Example : Determine the decimal value of the following sign numbers expressed in 2^{nd} complement

01010110 , 10101010

Negative Numbers are saved as 2^{nd} complement in computer

- Range of Values

  2's complement form:

$$-(2^{n-1}) \text{ to } +(2^{n-1}-1)$$