Number System

Signed Binary Number Representations

- Both signed and unsigned binary numbers consists of a string of bits when represented in computer.
- User determines whether a number is signed or not.
- Representation Types:
  - Signed-magnitude representation
  - Signed- Complement representation
    - 1’s Complement
    - 2’s Complement

Sign-Magnitude Representation

- The number consists of two parts:
  - Sign bit (leftmost bit)
  - Magnitude bits (other than leftmost bit)
- If the leftmost bit is
  - 0 – positive number
  - 1 – negative number
- The negative number has the same magnitude bits as the corresponding positive number but the sign bit is 1 rather than 0.
- Eg: 8-bit representation of ‘fifteen’
  - +15 – 0 0001111
  - -15 – 1 0001111

➢ It is used in ordinary arithmetic but usually not in computer arithmetic, since sign and magnitude bits must be handled separately.

1’s Complement Representation

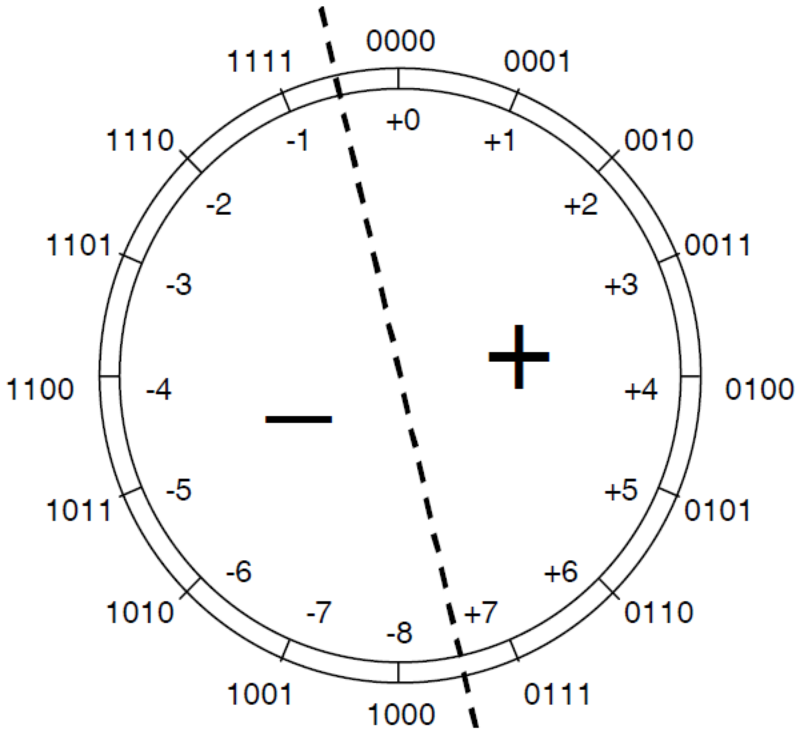
- The negative number is the 1’s complement of the corresponding positive number.
- Has some difficulties while used for arithmetic operations.
- It is used in logical operations.
- There are two different representations for zero.(i.e) 0000 and 1111 (4 bit +0 and -0).
- Eg: 8-bit representation of ‘fifteen’
  - +15 – 00001111
  - -15 – 11110000

2's Complement Representation

- The negative number is the 2's complement of the corresponding positive number.
- This is the most common representation used in computer arithmetic
- Eg: 8-bit representation of 'fifteen'
  - +15 – 0 0001111
  - -15 – 11110001

2’s Complement Representation

Note: leftmost bit of the representation acts a the sign bit (0 for positive values, 1 for negative ones)



Schematic representation of 4-bit 2’s-complement code for integers in [–8, +7].

Conversion of decimal numbers to signed binary numbers

- Express decimal number -39 as 8-bit number in (a)sign-magnitude (b)1's complement and (c)2's complement representations.
  - 8-bit representation for +39

    00100111

  - (a)8-bit Sign magnitude representation for -39:

    10100111

  - (b) 8-bit 1's complement representation for -39:

    11011000

  - (c) 8-bit 2's complement representation for -39:

    11011001

First represent the corresponding positive number in the given number of bits. Else the minimum number of bits required to represent that particular number should be taken.

Then use that number represented in the required number of bits to find the negative representation

Conversion of a signed binary number to decimal number

Determine the decimal value of signed binary number expressed in sign-magnitude representation.

- 10010101
  - Computing the weights of rightmost 7 bits:

    $0x2^6+0x2^5+1x2^4+0x2^3+1x2^2+0x2^1+1x2^0 = 16+4+1=21$
  - Sign bit(leftmost bit) is 1.Hence it's a negative number
  - Therefore, the decimal number is -21

Conversion of a signed binary number to decimal number

Determine the decimal value of signed binary number expressed in 1's complement representation.

- 00010111
  - Computing the weights of the bits with the weight of the leftmost bit as negative:

    $-0x2^7+0x2^6+0x2^5+1x2^4+0x2^3+1x2^2+1x2^1+1x2^0 = 16+4+2+1= +23$

  - Therefore, the decimal number is +23
- 11101000 *(complement of the previous question)*
  - Computing the weights of the bits with the weight of the leftmost bit as negative:

    $-1x2^7+1x2^6+1x2^5+0x2^4+1x2^3+0x2^2+0x2^1+0x2^0 = -128+64+32+8=-24$

  - Adding 1 to the result (i.e)-24+1=-23
  - Therefore, the decimal number is -23

Negative numbers alone add 1 if 1's complement representation

Conversion of a signed binary number to decimal number

Determine the decimal value of signed binary number expressed in 2's complement representation.

- 01010110
  - Computing the weights of the bits with the weight of the leftmost bit as negative:

    $-0 \times 2^7 + 1 \times 2^6 + 0 \times 2^5 + 1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0 = 64+16+4+2 = +86$
  - Therefore, the decimal number is +86
- 10101010 *(complement of the previous question)*
  - Computing the weights of the bits with the weight of the leftmost bit as negative:

    $-1 \times 2^7 + 0 \times 2^6 + 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0 = -128+32+8+2 = -86$
  - Therefore, the decimal number is -86

Need not add 1 like 1's complement representation

3-bit representation of signed numbers

No	Possible 3-bit represent ations	If only positive numbers represented	If negative numbers also should be represented (sign-magnitude)	If negative numbers also should be represented (1's complement)	If negative numbers also should be represented (2's complement)
1	000	0	+0	+0	0
2	001	1	+1	+1	+1
3	010	2	+2	+2	+2
4	011	3	+3	+3	+3
5	100	4	-0	-3	-4
6	101	5	-1	-2	-3
7	110	6	-2	-1	-2
8	111	7	-3	-0	-1

With the available combinations of binary numbers for a given number of bits, positive and negative numbers must be represented(FOR SIGNED NUMBERS)!