CSE1003
Digital Logic and Design

Module 1 Introduction
Lecture 2

Dr. S. Hemamalini
Professor
School of Electrical Engineering
VIT Chennai

Module 1 Introduction 3 hours

- Number System
- Base Conversion
- Binary Codes
- Complements (Binary and Decimal)

SIGNED BINARY NUMBERS

- Sign-magnitude representation
- 1's complement representation
- 2's complement representation

Decimal

+9 −9

+1001 −1001

1 for minus sign

0 for plus sign

Sign-magnitude Representation

+105

−105

- An additional bit is used as the *sign bit*.
- This sign bit is usually placed as the MSB.
- A 0 is reserved for a positive number and a 1 is reserved for a negative number.
- 8-bit signed binary number
  - $(01101001)_2$ $+(105)_{10}$

    MSB ↑ sign, +ve sign; magnitude 7 bits

  - 11101001 → $-(105)_{10}$.

    MSB 1 −ve no.

$(+44)_{10}$ ⇓ $110110 0_2$

Eg. 0101100 (MSB: +ve) find the decimal equivalent

$(+44)_{10}$

$1\times2^5+0\times2^4+1\times2^3+1\times2^2+0\times2^1+0\times2^0 = 44_{10}$

Find the decimal equivalent of the following binary numbers assuming the binary numbers have been represented in sign-magnitude form.

(a) 0101100 (b) 101000 (c) 1111 (d) 011011

Solution.

(*a*) Sign bit is 0, which indicates the number is positive.

Magnitude $101100 = (44)_{10}$

Therefore $(0101100)_2 = (+44)_{10}$.

(*b*) Sign bit is 1, which indicates the number is negative.

Magnitude $01000 = (8)_{10}$

Therefore $(101000)_2 = (-8)_{10}$.

(*c*) Sign bit is 1, which indicates the number is negative.

Magnitude $111 = (7)_{10}$

Therefore $(1111)_2 = (-7)_{10}$.

(*d*) Sign bit is 0, which indicates the number is positive.

Magnitude $11011 = (27)_{10}$

Therefore $(011011)_2 = (+27)_{10}$.

1’s Complement Representation

- In 1’s complement representation, both numbers are a complement of each other.
- If one of the numbers is positive, then the other will be negative with the same magnitude and vice versa.

Binary Decimal

0111_2 $(+7)_{10}$

$1000_2 \rightarrow$ 1's complement representation

$\rightarrow (-7)_{10}$

Represent +5 & −5 in 1's complement form

$(+5)_{10} \rightarrow (0101)_2$ $(-5) \rightarrow (1010)_2$

2's Complement Representation

- If 1 is added to 1's complement of a binary number, the resulting number is 2's complement of that binary number.

$0110_2 \quad (+6)_{10} \Rightarrow$

0110 Given No.

1001 1's complement

$+\ 1$

1010 2's complement

$\rightarrow (-6)_{10}$.

Binary group — 1's comple 2's comple

0000 +0 +0.

1111 −0 +1

1010 $(+5)_{10} \rightarrow (0101)_2$

$1010 \Rightarrow (-5)_{10}$

$1011 \rightarrow (-5)$

Represent (–19) in

(a) Sign-magnitude,

(b) one’s complement, and

(c) two’s complement representation.

Binary form

$19/2 \quad 9 \quad 1$

$9/2 \quad 4 \quad 1$

$4/2 \quad 2 \quad 0$

$2/2 \quad 1 \quad 0$

$(-19) \rightarrow (\underline{\underline{11011}})_2$

(a) $\underline{1}\,\underline{\underline{10011}}$ sign magnitude representation

sign magnitude

(b) 101100 1's complement representation

(c) 101101 2's complement representation

COMPLEMENTS

- Complements are used in digital computers for simplifying the subtraction operation and for logical manipulations.
- There are two types of complements for each number system of base-*r*: the *r*'s complement and the $(r – 1)$'s complement.
- For a binary system, the value of *r* is 2 and hence the complements are 2's and 1's complements.
- For a decimal system the value of *r* is 10 and the complements are 10's and 9's complements.
- With the same logic if the number system is octal the complements are 8's and 7's complement, while it is 16's and 15's complements for hexadecimal system.

The *r*'s Complement

- If a positive number N is given in base r with an integer part of n digits, the r's complement of N is given as $r^n - N$ for $N \neq 0$ and 0 for $N = 0$.

(r–1)'s Complement

- If a positive number N is given in base r with an integer part of n digits and a fraction part of m digits, then the (r – 1)'s complement of N is given as $(r^n - r^{-m} - N)$ for $N \neq 0$ and 0 for $N = 0$.

1’S AND 2’S COMPLEMENT ARITHMETIC

Subtraction Using 1’s Complement

- Binary subtraction can be performed by adding the 1’s complement of the subtrahend to the minuend.
- If a carry is generated, remove the carry, add it to the result. This carry is called the end-around carry.
- If the subtrahend is larger than the minuend, then no carry is generated.
- The answer obtained is 1’s complement of the true result and opposite in sign.

Subtract binary 10 from binary 101 using 1's complement.

$(10)_2 \rightarrow 2_{10}$ $(101)_2 \rightarrow 5_{10}$

$$\begin{array}{r} 5 \\ -2 \\ \hline +3 \\ \hline \end{array}$$

Minuend 101

Subtrahend −010

?

$$\begin{array}{r} 101 \\ 101 \\ \hline 1010 \\ +1 \\ \hline 011 \end{array}$$

101 Minuend

101 1's complement of 010

End of carry (EAC) → 1

+1 EAC added

011

+3

Subtract binary 110 from binary 101 using 1's complement.

$(110)_2 \to 6_{10}$ $\quad$ $101 \to 5_{10}$

Decimal		Binary		
5	Minuend	101	101	Minuend
-6	Subtrahend	-110	$+\ 001$	1's complement of 110
-1		?	110	SUM NO End of Carry

1's complement form of -1

Subtraction Using 2’s Complement

- Binary subtraction can be performed by adding the 2’s complement of the subtrahend to the minuend.
- If a carry is generated, discard the carry.
- Now if the subtrahend is larger than the minuend, then no carry is generated.
- The answer obtained is in 2’s complement and is negative.
- To get a true answer take the 2’s complement of the number and change the sign.
- The advantage of the 2’s complement method is that the end-around carry operation present in the 1’s complement method is not present here.

Subtract binary 10 from binary 101 using 2's complement.

5	Minuend	101	101	Minuend
− 2	Subtrahend	−010	+110	2's complement of 010
+3	Difference	?	1011	SUM

Extra carry ignored → 1

011

↑

+3

Subtract binary 011 from 001 using 2's complement.

$$\begin{array}{r} 1 \\ -3 \\ \hline -2 \\ \hline \end{array} \qquad \begin{array}{r} 001 \\ -011 \\ \hline ? \end{array} \qquad \begin{array}{rl} 001 & \text{Minuend} \\ +101 & \text{2's complement} \\ \hline 110 & \text{sum} \end{array}$$

NO carry

2's complement form of 110

-2