Quaid-e-Awam University of Engineering, Science and Technology

بِسۡمِ اللّٰہِ الرَّحۡمٰنِ الرَّحِیۡمِ

In the name of Allah, the Most Merciful, the Most Kind

Date: 09-09-2021

BCS 103
Digital Logic & Computer Architecture

Lecture 3 and 4

Department of Computer Science

IN THE LAST LECTURE

- Analog vs Digital
- Digital Systems
- Overview of Number Systems

CONTENTS

- 1's Complement
- 2's Complement

- Binary Addition
- Binary Subtraction
- Binary Multiplication

- Conversion

One’s Complement

One’s Complement or 1’s Complement as it is also termed, is another method which we can use to represent negative binary numbers in a signed binary number system.

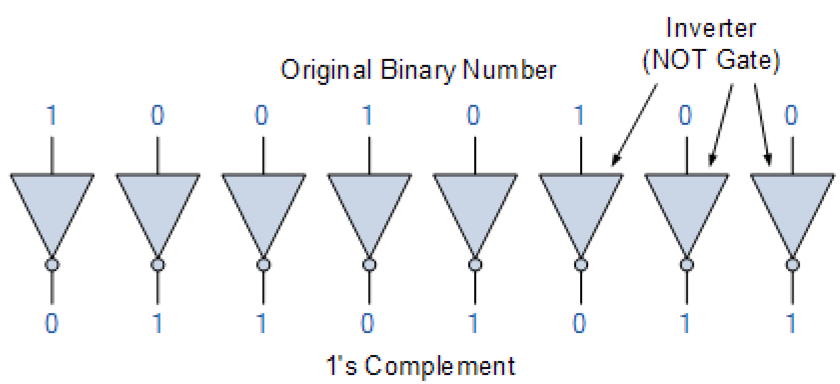
Negative numbers however, are represented by taking the one’s complement of the unsigned positive number. Since positive numbers always start with a “0”, the complement will always start with a “1” to indicate a negative number.

One’s Complement

The one’s complement of a negative binary number is the complement of its positive counterpart, so to take the one’s complement of a binary number, all we need to do is change each bit in turn. Thus the one’s complement of “1” is “0” and vice versa, then the one’s complement of 10010100 is simply 01101011 as all the 1’s are changed to 0’s and the 0’s to 1’s.

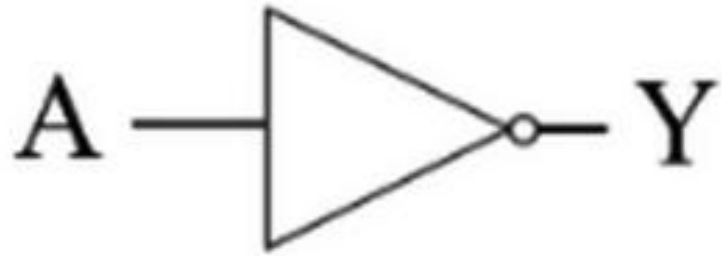
One's Complement

The easiest way to find the one's complement of a signed binary number when building digital arithmetic or logic decoder circuits is to use Inverters. The inverter is naturally a complement generator and can be used in parallel to find the 1's complement of any binary number as shown.



The 'NOT' Gate

- This is the most basic type of logic gate which only accepts one input.
- The function of this gate is to function as a logical inverter, and hence reverses the logic state of its input.



A	Y
0	1
1	0

$$\overline{A} = Y$$

(Read as 'A not equals Y')

Two’s Complement

A -> (invert of A) = 1’s complement of A

1’s complement of A + 1 = 2’s complement of A

Two's Complement

Let's look at the subtraction of our two 8-bit numbers 115 and 27 from above using two's complement, and we remember from above that the binary equivalents are:

115 in binary is: 01110011
27 in binary is: 00011011

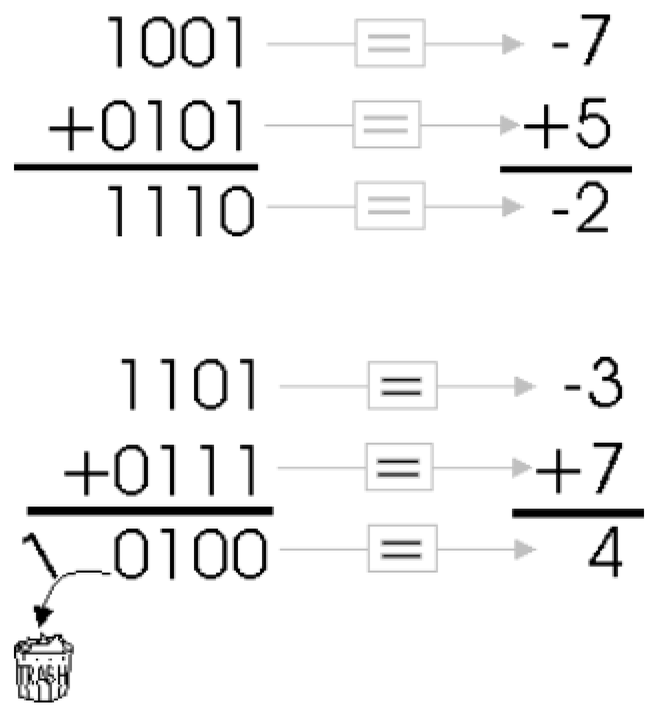
Therefore the sum is:
115 + (2's complement of 27)

01110011 + 11100101 = 1 01011000

PRACTICAL

4 bit data representation

Represent Negative Numbers



BINARY ADDITION

Example (8-bit numbers)

Add 7 and 4 (both positive)

7	00000111
+4	+00000100
11	00001011

BINARY ADDITION

Example (8-bit numbers)

- Add 15 and -6 (positive > negative)

		00001111	15
		+11111010	+ -6
Discard carry	1	00001001	9

BINARY ADDITION

Example (8-bit numbers)

- Add 16 and -24 (negative > positive)

00010000	16
+11101000	+ -24
11111000	-8

Sign bit is negative so negative number in 2's complement form

BINARY ADDITION

Example (8-bit numbers)

- Add -5 and -9 (both negative)

		11111011	-5
		+11110111	+ -9
Discard carry →	1	11110010	-14

BINARY ADDITION

Perform

15	+	-24	=
12	+	-14	=
-20	+	-42	=

Description

BINARY SUBTRACTION

Example (8-bit numbers)

- Find 8 minus 3.

		00001000	8	Minuend
		+11111101	- 3	Subtrahend
Discard carry →	1	00000101	5	Difference

Description

BINARY SUBTRACTION

Example (8-bit numbers)

- Find 12 minus -9.

00001100	12
+00001001	- -9
00010101	21

BINARY SUBTRACTION

Example (8-bit numbers)

- Find -25 minus 19.

		11100111	-25
		+11101101	- 19
Discard carry →	1	11010100	-44

Description

BINARY SUBTRACTION

Example (8-bit numbers)

- Find -120 minus -30.

10001000	-120
+00011110	- -30
10100110	-90

Description

BINARY SUBTRACTION

Perform

11 - 10 =

17 - -13 =

-9 - -22 =

Description

BINARY MULTIPLICATION

- Both numbers must be in uncomplemented form
- Multiply 3 by -5.

Opposite signs, so product will be negative.

$3_{10} = 00000011_2$

$-5_{10} = 11111011_2$

2's complement of -5

00000101

	00000011	Multiplicand
X	00000101	Multiplier
	00000011	First partial product
+	0000000	Second partial product
	00000011	Sum of 1st and 2nd
+	000011	Third partial product
	00001111	Sum and Final Product

Final result is negative, so take 2's complement.

11110001 is the result which in decimal is -15.

Description

BINARY MULTIPLICATION

Perform

5	x	-10	=
7	x	9	=
-5	x	-8	=

CONVERSION

Decimal to Binary
Decimal to Octal
Decimal to Hexadecimal

Binary to Decimal
Octal to Decimal
Hexadecimal to Decimal

CONVERSION

Without Decimal Number

How to convert Binary to Octal?

Binary → Decimal → Octal

Thanks