Binary Arithmetic

We will be familiar with different arithmetic operations such as addition and subtraction in a digital system.

Binary Addition

The rules of binary addition are

X	Y	*Sum*	*Carry*
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Addition is carried out from the LSB and it proceeds to higher significant bits.

Ex) Add the binary numbers:

(a) 1010 and 1101 *(b) 0110 and 1111*

Solution.

(*a*)		1	0	1	0
	(+)	1	1	0	1
	1	0	1	1	1
	↑ Carry				

(b)

Binary Subtraction

It is possible to use the circuits designed for binary addition to perform binary subtraction. Only we have to change the problem of subtraction into an equivalent addition problem. This can be done by using of 1's and 2's complements.

Complements

Complements are used in for simplifying the subtraction operation and representing signed numbers. There are two types of complements: The r's complement and the (r – 1)'s complement. When we deal with a binary system, the complements are 2's and 1's complements.

(r-1) 's Complement

In binary system, the 1st complements can be obtained by replacing ones with zeros and zeros with ones.

The 1's complement of $(10110)_2$ is 01001

Or we can use the general formula to find the (r-1) 's Complement:

$(r^n - r^{-m})_{10} - N,\ Where$

r: Radix

n: Number of digits in the integer part

m: Number of digits in the fractional part

N: Number

Ex) Find the 9's complement of $(23450)_{10}$

$(r^n - r^{-m})_{10} - N$

$(10^5 - 10^0)_{10} - 23450 = 76549$

Ex) Find The 7's complement of $(2350)_8$

$(r^n - r^{-m})_{10} - N$

$= (8^4 - 8^0)_{10} - (2350)_8$

$= (4095)_{10} - (2350)_8$

$= (4095)_{10} - (1256)_{10} = (2839)_{10} = (5427)_8$

Ex) Find The 15's complement of $(A3E4)_{16}$

$(r^n - r^{-m})_{10} - N$

$= (16^4 - 16^0)_{10} - (A3E4)_{16}$

$= (65535)_{10} - (A3E4)_{16}$

$= (65535)_{10} - (41956)_{10} = (23579)_{10} = (5C1B)_{16}$

Ex) Find The 1's complement of $(0.1011)_2$

r's Complement

In binary system, the 2nd complements can be obtained by replacing ones with zeros and zeros with ones and then adding one to the final number.

Ex) Find the 2's complement of $(10110)_2$

$(10110)_2$ — 2's → 01001

$$\begin{array}{r} 01001 \\ +\quad\quad 1 \\ \hline 01010 \end{array}$$

Or the *r*'s complement of ***N number*** is given as

$(r^n)_{10} - N,\ Where$

r: Radix

n: Number of digits in the integer part

N: Number

Ex) Find the 10's complement of $(23450)_{10}$

$(r^n)_{10} - N$

$(10^5)_{10} - (23450)_{10} = (76550)_{10}$

Ex) Find the 10's complement of $(23.324)_{10}$

$(r^n)_{10} - N$

$(10^2)_{10} - (23.324)_{10} = (76.676)_{10}$

Ex) Find The 8's complement of $(376)_8$

$(r^n)_{10} - N$

$= (8^3)_{10} - (376)_8$

$= (512)_{10} - (376)_8$

$= (512)_{10} - (254)_{10} = (258)_{10} = (402)_8$

Ex) Find The 16's complement of $(4A30)_{16}$

$(r^n)_{10} - N$

$= (16^4)_{10} - (4A30)_{16}$

$= (65536)_{10} - (4A30)_{16}$

$= (65536)_{10} - (18992)_{10} = (46544)_{10} = (B5D0)_{16}$

Ex) Find The 2's complement of $(0.1011)_2$