

Binary System:-

Decimal Number- 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

Base or radix is ten (10)

(1)

Least positional weight out of all digits depends

MSD (most significant digit) $\rightarrow$ MSB (most significant bit)

(Left most bit)

(Right most bit - lowest positional weight depends LSS)

Least significant digit $\rightarrow$ Least significant bit $\rightarrow$ Right most.

Binary Number System has Base 2

1 2 3
↑ ↑
MSB LSB

Nines' complement method.

9's complement number is obtained by subtracting each digit of that decimal number by 9

10's complement number is obtained by adding 1 to 9's complement.

If there is a carry it indicates that the answer is +ve.

Add this carry to the LSB

Find 9's complement.

Decimal digit.

0 $\rightarrow$ 9

1 $\rightarrow$ 8

2 $\rightarrow$ 7

3 $\rightarrow$ 6

4 $\rightarrow$ 5

5 $\rightarrow$ 4

6 $\rightarrow$ 3

7 $\rightarrow$ 2

8 $\rightarrow$ 1

9 $\rightarrow$ 0

(1) 3456

$$\begin{array}{r} 9999 \\ - 3456 \\ \hline 6543 \end{array}$$

(2) 782.54

$$\begin{array}{r} 999.99 \\ - 782.54 \\ \hline 217.45 \end{array}$$

(3) 4526.075

$$\begin{array}{r} 9999.999 \\ - 4526.075 \\ \hline 5473.924 \end{array}$$

$$\begin{array}{r} 12 \\ - 7 \\ \hline 5 \end{array}$$

$$\begin{array}{r} 12 \\ - 1 \\ \hline 11 \end{array}$$

$$\begin{array}{r} 12 \\ + 18 \\ \hline 30 \end{array}$$

find 10's complement.

(1) 4069

$$\begin{array}{r} 9999 \\ - 4069 \\ \hline 5930 \end{array} \leftarrow 9\text{'s complement}$$

$$\begin{array}{r} 5930 \\ + 1 \\ \hline 5931 \end{array} \leftarrow 10\text{'s complement}$$

(2) 1056.74

$$\begin{array}{r} 9999.99 \\ - 1056.74 \\ \hline 8943.25 \end{array} \leftarrow 9\text{'s complement}$$

$$\begin{array}{r} 8943.25 \\ + 1 \\ \hline 8943.26 \end{array} \leftarrow 10\text{'s complement}$$

subtract the following numbers using 9's complement method

(a) 745.81 - 436.62

$$\begin{array}{r} 999.99 \\ 745.81 \\ - 436.62 \\ \hline 563.37 \end{array}$$

$$\begin{array}{r} 745.81 \\ + 563.37 \\ \hline 1309.18 \end{array}$$

① 309.18

$$\begin{array}{r} 309.18 \\ + 1 \\ \hline 309.19 \end{array} \leftarrow \text{answer}$$

Ans

Find the 9's complement of 2nd digit number and then add to it

If carry is there then answer is +ve

(b) 436.62 - 745.81

$$\begin{array}{r} 999.99 \\ 436.62 \\ - 745.81 \\ \hline 254.18 \end{array}$$

$$\begin{array}{r} 436.62 \\ + 254.18 \\ \hline 690.80 \end{array}$$

$$\begin{array}{r} 999.99 \\ - 690.80 \\ \hline 309.19 \end{array}$$

-309.19 ← answer

→ But if there is carry, answer is +ve
→ So final answer 9's complement of 309.19
→ Add -ve sign

→ Arithmetic operation in digital system is easier

using 10's complement method.

$$\begin{array}{r} 2928.54 - 0416.73 \\ 9999.99 \\ \underline{0416.73} \\ 9583.26 \\ \underline{1} \\ 9583.27 \end{array} \leftarrow 10's \text{ comp.}$$

→ find 10's complement of second number, then add to first number

$$\begin{array}{r} 2928.54 \\ 9583.27 \\ \hline 2566.81 \end{array}$$

$$\begin{array}{r} 2928.54 \\ 9583.27 \\ \hline 2511.81 \end{array}$$

Ignore carry

The carry indicating that answer is five.

$$416.73 - 2928.54$$

$$\begin{array}{r} 9999.99 \\ - 2928.54 \\ \hline 7071.45 \\ \underline{1} \\ 7071.46 \end{array} \leftarrow 10's \text{ comp}$$

$$\begin{array}{r} 0416.73 \\ 7071.46 \\ \hline 7488.19 \end{array} \leftarrow \text{No carry}$$

$$\begin{array}{r} 9999.99 \\ 7488.19 \\ \hline 2511.80 \end{array}$$

$$\boxed{-2511.81} \leftarrow \text{Answer.}$$

* Binary Number System:-

→ Base of it is 2 (Two).

→ Binary number consists of sequence of bits, each bit is either 0 or 1

→ Convert 10101010 decimal.

$$\begin{array}{r} 168421 \\ 10101 \\ \hline 1641 \end{array}$$

$$\begin{array}{c} \text{MSB} \qquad \qquad \text{LSB} \\ 1 \ 0 \ 1 \ 0 \ 1 \\ 2^4 \ 2^3 \ 2^2 \ 2^1 \ 2^0 \end{array}$$

$$\begin{aligned} & (d_n \times 2^n) + (d_{n-1} \times 2^{n-1}) \\ & + (d_1 \times 2^1 + d_0 \times 2^0) \\ & + (d_{-1} \times 2^{-1} + d_{-2} \times 2^{-2}) \end{aligned}$$

$$\begin{aligned} & 2^4 \times 1 + 0 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 0 \times 2^0 \\ & = 16 + 0 + 4 + 0 + 0 \\ & = 16 + 4 + 0 \\ & = 20 \end{aligned}$$

Convert 11011.1012 to decimal

$$\begin{array}{cccccccc}
 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & 2^{-1} & 2^{-2} & 2^{-3} \\
 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1
 \end{array}$$

$$\begin{aligned}
 &= 2^4 \times 1 + 2^3 \times 1 + 2^2 \times 0 + 2^1 \times 1 + 2^0 \times 1 + 2^{-1} \times 1 + 2^{-2} \times 0 + 2^{-3} \times 1 \\
 &= 2^4 + 2^3 + 2^1 + 2^0 + 0.5 + 0 + 0.125 \\
 &= 16 + 8 + 2 + 1 + 0.5 + 0 + 0.125 \\
 &= (27.625)_{10}
 \end{aligned}$$

Convert 1001011 to decimal

$$\begin{array}{ccccccc}
 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 \\
 1 & 0 & 0 & 1 & 0 & 1 & 1
 \end{array}$$

$$\begin{aligned}
 &= 2^6 + 2^3 + 2^1 + 2^0 \\
 &= 64 + 8 + 2 + 1 \\
 &= (75)_{10}
 \end{aligned}$$

Decimal to Binary [Double double method]

Ex 168.8451

(1) (105.15)10

2	105	Reminder
2	52	1
2	26	0
2	13	0
2	6	1
2	3	0
2	1	1

(2) 52

2	52	Reminder
2	26	0
2	13	0
2	6	1
2	3	0
2	1	1
2	0	0

0.15/2=0.075
0.075/2=0.0375
0.0375/2=0.01875

(110100)

$$\begin{aligned} 0.1572 &= 0.30 \\ 0.3072 &= 0.60 \\ 0.6072 &= 1.20 \\ 0.2072 &= 0.40 \\ 0.4072 &= 0.80 \\ 0.8072 &= 1.60 \end{aligned}$$

$$\begin{aligned} 0.1572 &= 0.30 \\ 0.3072 &= 0.60 \\ 0.6072 &= 1.20 \\ 0.2072 &= 0.40 \\ 0.4072 &= 0.80 \\ 0.8072 &= 1.60 \end{aligned}$$

$$(001001)$$

121.001001) 2

$$0.75 \times 2 = 1.50$$

$$0.5742 \times 2 = 1.00$$

$$s = (0.11)_2$$

163-875

$$\begin{array}{r|l}
 2 & 163 \\
 \hline
 2 & 81 \rightarrow 1 \\
 \hline
 2 & 40 \rightarrow 1 \\
 \hline
 2 & 20 \rightarrow 0 \\
 \hline
 2 & 10 \rightarrow 0 \\
 \hline
 2 & 5 \rightarrow 0 \\
 \hline
 2 & 2 \rightarrow 1 \\
 \hline
 2 & 1 \rightarrow 0 \\
 \hline
 2 & \rightarrow 1
 \end{array}$$

Remainder

$$\begin{aligned} 0.675 \times 2 &= 1.350 \\ 0.350 \times 2 &= 0.700 \\ 0.700 \times 2 &= 1.400 \end{aligned}$$

$$(10100011.111)_2$$

Binary addition = $0+0=0$, $0+1=1$, $1+0=1$, $1+1=10$

(a)
$$\begin{array}{r} 1010 \\ 111 \\ \hline 0001 \end{array}$$
 Ans.

(b)
$$\begin{array}{r} 1101 \\ 111011 \\ \hline 0101000 \end{array}$$
 Ans.

$1+1+1=1$ carry 1 Ans.

Scanned by CamScanner

Binary Subtraction:-

$0-0=0$, $1-1=0$, $1-0=1$, $0-1=1$ with

(1) Subtract 102 from 10002

$$\begin{array}{r} 1000 \\ - 10 \\ \hline 0110 \end{array}$$

(2) Subtract 111.111_2 from 1010.011_2

$$\begin{array}{r} 1010.011 \\ - 111.111 \\ \hline 0010011 \end{array}$$

$$\begin{array}{r} 1010.011 \\ - 111.111 \\ \hline 0010011 \end{array}$$

$$\begin{array}{r} 1010.011 \\ - 111.111 \\ \hline 0010011 \text{ Ans.} \end{array}$$

3) Multiplication

$$\begin{array}{r} 1010.011 \\ \times 111.111 \\ \hline 0100011 \end{array}$$

$$\begin{array}{r} 1101 \\ \times 110 \\ \hline 0000 \\ 1101 \\ 1101 \\ \hline 100110 \end{array}$$

$$\begin{array}{r} 1010.011 \\ \times 111.111 \\ \hline 00110011 \end{array}$$

$$\begin{array}{r} 1010.011 \\ \times 111.111 \\ \hline 00110011 \end{array}$$

$$\begin{array}{r} 1000 \\ \times 10 \\ \hline 0100 \end{array}$$

$$\begin{array}{r} 1000 \\ \times 10 \\ \hline 0100 \end{array}$$

$$\begin{array}{r} 1000 \\ \times 10 \\ \hline 0100 \end{array}$$

Extra Example

① Binary to decimal

$$\textcircled{1} \quad \begin{array}{ccccccc} 1 & 1 & 0 & 1 & 1 & 0 & 1 \\ 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 \end{array}$$

$$\underline{2^6 \times 1} + \underline{2^5 \times 1} + \underline{0} + \underline{2^3 \times 1} + \underline{2^2 \times 1} + 0 + 2^0 \times 1$$

$$= 64 + 32 + 8 + 4 + 0 + 1$$
$$= \underline{109}$$

$$\textcircled{2} \quad 1101110.011$$

$$\begin{array}{ccccccccccc} 1 & 1 & 0 & 1 & 1 & 1 & 0 & . & 0 & 1 & 1 \\ 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 & & 2^{-1} & 2^{-2} & 2^{-3} \end{array}$$

$$64 + 32 + 8 + 4 + 2 + \underline{1 \times \frac{1}{4}} + 1 \times \frac{1}{8}$$

$$110 + 0.25 + 0.125$$

$$110 + 0.375$$

$$110.375$$

$$\textcircled{3} \quad 1011 \rightarrow 11$$

$$\textcircled{4} \quad 1101.11 \rightarrow 13.75$$

Decimal to Binary

① 37

2	37	
2	18	1
2	9	0
2	4	1
2	2	0
2	1	0
	0	1

Ans: (100101)₂

(2)

2	28	
2	14	0
2	7	0
2	3	1
2	1	1
	0	1

Ans: (11100)₂

(197.56)

2	197.	
2	98	1
2	49	0
2	24	1
2	12	0
2	6	0
2	3	0
2	1	1
	0	

Ans - (10000101.
000100)

$$0.56 \times 2 = 1.12 \quad \downarrow$$

$$0.12 \times 2 = 0.24$$

$$0.24 \times 2 = 0.48$$

$$0.48 \times 2 = 0.96$$

(4) (205.05)

2	205	
2	102	1
2	51	0
2	25	
2	12	1
2	6	0
2	3	0
1	1	1

2	205	
2	102	1
2	51	0
2	25	
2	12	1
2	6	0
2	3	0
2	1	1
	0	1

$$0.05 \times 2 = 0.1 \quad 4$$

$$0.1 \times 2 = 0.2$$

$$0.2 \times 2 = 0.4$$

$$0.4 \times 2 = 0.8$$

$$0.8 \times 2 = 1.6$$

(11001101.0000)

Carry Sum

1 0

1

1+1=

1+1+1

1+1+1+1

1+1+1+1+1

1+1+1+1+1+1

Binary Addition

$$\begin{array}{r} 1010 \\ 111 \\ \hline 10001 \end{array}$$

$$\begin{array}{r} 111110 \\ 111010 \\ \hline 10101000 \end{array}$$

Sum carry
 $1+1=0$
 $1+1+1=1$
 $1+1+1+1=0$
 next 1
 next 1
 next 1
 next 1

$$\begin{array}{r} 1111 \\ 1101 \\ + 1101 \\ \hline 101000 \end{array}$$

$$\begin{array}{r} 1101 \\ 1101 \\ + 1101 \\ \hline 110000 \end{array}$$

$$\begin{array}{r} 1011101 \\ 110111010 \\ \hline 1001110111 \end{array}$$

$$\begin{array}{r} 421 \\ 101 \end{array}$$

$$\begin{array}{r} 421 \\ 100 \\ 101 \end{array}$$

$$\begin{array}{r} 421 \\ 110 \end{array}$$

$$\begin{array}{r} 1+1=0 \\ 1+1+1=1 \\ 1+1+1+1=0 \\ 1+1+1+1+1=1 \\ 1+1+1+1+1+1=0 \end{array}$$

| | 0 |

| 0 |

| | 0 |

0 0 0 0 0

| 0 | 0 0

| 0 0 0 0 0 |

| | 0 |

x | 0 |

| | 0 |

0 0 0 0 0

| | 0 | 0 0

| 0 0 0 0 0 |

3

| | 0 0 |

x | 0

0 0 0 0 0

| | 0 0 |

| | 0 0 | 0

1 1 0 1 . 1 1

1 0 1 . 1 0

1 0 0 0 0 . 0 0

1 1 0 1 1 1

1 1 1 0 1 1 1

0 0 0 0 0 0

~~1 1 0 1 1 1~~

1 1 0 1 1 1

1 0 0 1 0 1 1 . 1 0 1 0

1 0 0 1 0 1 1 . 1 0 1 0

(5)

1 0 1 1 0 . 0

1 0 . 1

1 1 0 1 1 0 0

0 0 0 0 0 0

1 0 1 1 0 0

1 1 0 1 1 1 . 0 0

$$1011.101 \times 101.01 = 1111101.00001$$

* Binary Subtraction

(1)

$$\begin{array}{r} 0100 \\ - 100 \\ \hline 0110 \end{array}$$

(2)

$$\begin{array}{r} 010110 \\ - 101011 \\ \hline 001011 \end{array}$$

(3)

$$\begin{array}{r} 0111 \\ - 101 \\ \hline 0110 \end{array}$$

(4)

$$\begin{array}{r} 1010 \\ - 1011 \\ \hline 0111 \end{array}$$

0 0 1 0 0
1 1 0 0 1 0
1 1 1 0 1



0 1 0 1 0 1

⑥

0 1 1 1 0
1 0 0 0 1 0 1
1 1 1 1 1 1
0 0 0 0 1 1 0

	32	16	8	4	2	1	
①	1	0	1	0	0	1	= +41
②	1	0	1	0	0	1	= -41

unsigned and signed numbers

unsigned Binary $\rightarrow$ positive number

m bit: 8 bit: $2^m - 1$

$= 2^8 - 1$

$= 255$

0 to 255 = 255

Signed numbers required an arithmetic system

MSB $\rightarrow$ in binary system used to represent signed bit

If signed bit is zero $\rightarrow$ +ve
one $\rightarrow$ -ve

+3 : 0011
+7 : 0111

-3 : ①011
-7 : 1111