Number system

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Contains:

- Decimal number system
- Binary number system
- Octal number system
- Hexadecimal number system

Decimal number system

- 0,1,2,3,4,5,6,7,8,9 - ten unique symbol, each symbol is called ‘digit’.
- Hence called base or radix is 10
- Positional weighted system means value attached with symbol depends upon its position where it placed with respect to decimal point.
- MSB – Most Significant Bit – greatest positional weight out of all number
- LSB – Least Significant Bit – lowest positional weight out of all number

➢9's complement

- **Need of complement in digital number system :**Complements are used by a machine to represent negative number. By taking the complement of a negative number, the number can be converted into another number suitable for machines.
- 9's complement can be perform by subtracting each digit from 9
- If carry is generated answer is called positive , add it to least bit is called all around carry
- If no carry is generated answer is called negative
- Example : 3652 , 695.65

9999		999.99
-3652		-695.65
6347	9's complement	304.34

➢10's complement:

- Is generated by adding 1 to 9's complement.
- Example : 3652 , 695.65

9999		999.99
-3652		-695.65
6347	9's complement	304.34
+ 1		+ 1
6348	10's complement	304.35

➢Subtraction using 9's and 10's complement

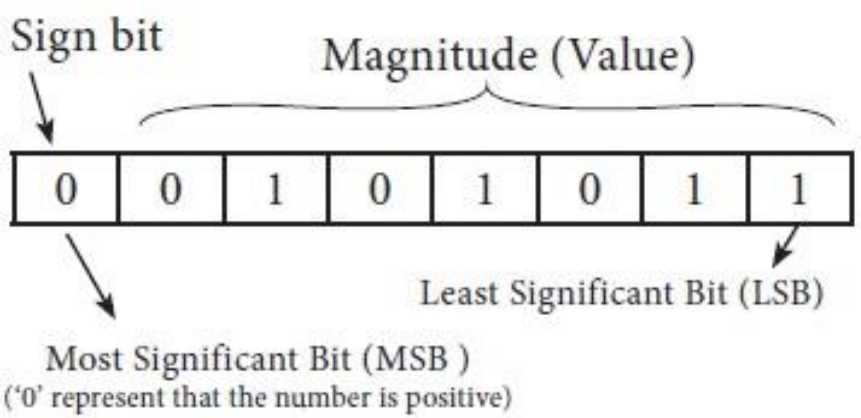
1. 896.66 – 659.15 = 421.30

9's complement	steps
896.66	
+ 524.63	9's complement of number to be subtracted
①421.29	Result
1	Add around carry
421.30	Answer

10's complement	steps
896.66	
+ 524.64	10's complement of number to be subtracted
① 421.30	Result
	Ignore carry
421.30	Answer

Signed and Unsigned number:

- In sign magnitude form, extra bit is added is known as sign bit.
- If sign bit is 1- number is negative
- If sign bit is 0 – number is positive



Binary number system:

- Only two digits 0 and 1 and base or radix is 2
- Numbers of column is decided by 2^n

  i.e for $2^1 = 2$ so 0,1

  $2^2 = 4$ so 00,01,10,11 further on……
- Binary number with its decimal value is shown in below table:

Decimal	Binary
0	0
1	1
2	10
3	11
4	100
5	101
6	110

➢Binary to decimal conversation:

Convert number $(100101.11)_2$ to decimal

- Method – 1:

positional weights – $2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0\ 2^{-1}\ 2^{-2}$

$1\ \ 0\ \ 0\ \ 1\ \ 0\ \ 1\ .\ 1\ \ \ 1$

$=1x2^5 + 0x2^4 + 0x2^3 + 1x2^2 + 0x2^1 + 1x2^0 + 1x2^{-1} + 1x2^{-2}$

$= 32+0+0+4+0+1+0.5+0.25$

$= 37.75$

- Method – 2:

MSB $=1$

Multiply by 2, add next bit $(1x2)+0 = 2$

Multiply by 2, add next bit $(2x2)+0=4$

Multiply by 2, add next bit $(4x2)+1=9$

Multiply by 2, add next bit $(9x2)+0=18$

Multiply by 2, add next bit $(18x2)+1=37$

➢Decimal to Binary conversation:

Convert Number 183.875

- **Method – 1: Sum of weights**

Subtract number from its maximum power 2 number

As $2^7 = 128$ and $2^8 = 256$, so 183-128 = 55 and $2^7 = 1000000$

Now same way $2^5 = 32$ so 55-32 = 23 and $2^5 = 10000$

$2^4 = 16$ so 23-16 = 7 and $2^4 = 1000$

$2^2 = 4$ so 7-4 = 3 and $2^2 = 10$

$2^1 = 2$ so 3-2 = 1 and $2^1 = 1$

Now reminder is only 1 which is power of 2^0 so it will be as it is = 1

Now add them all 1000000 + 10000 + 1000 + 10 + 1 + 1 = 10110111 (Binary addition)

For Fractional part process will be same but it will be in 2^{-1} format

So for 875 = $(111)_2$

Continue…

Convert Number 183.875

- **Method – 2: Double Dabble**

Successive	Division	Reminder
2	183	
2	91	1
2	45	1
2	22	1
2	11	0
2	5	1
2	4	1
2	2	0
2	1	1
	0	

Fractional	Answer	Reminder
Multiply 0.875 by 2	1.750	1
Multiply 0.750 by 2	1.5	1
Multiply 0.5 by 2	1.0	1

So Answer will be $(183.875)_{10} = (10110111.111)_2$

➢Binary Addition, subtraction, multiplication, division:

```
  1 1   1
 1011.01
+  11.011
---------
 1110.101
```

```
    1011.01
x    110.1
---------
  101101
 0000000
1011010 0
1011010 00
---------
1001001.001
```

```
          11.1110
       ---------
11 ) 1011.11000
     11
     ---
      101
      11
      ---
       101
       11
       ---
        101
        11
        ---
         100
         11
         ---
          100
```

Binary Subtraction	Decimal Subtraction
0 10 1 0 1 1 - 1 0 0 1 0 0 0 0 1 1	2 1 - 1 8 3
$00011_2 = 3_{10}$	

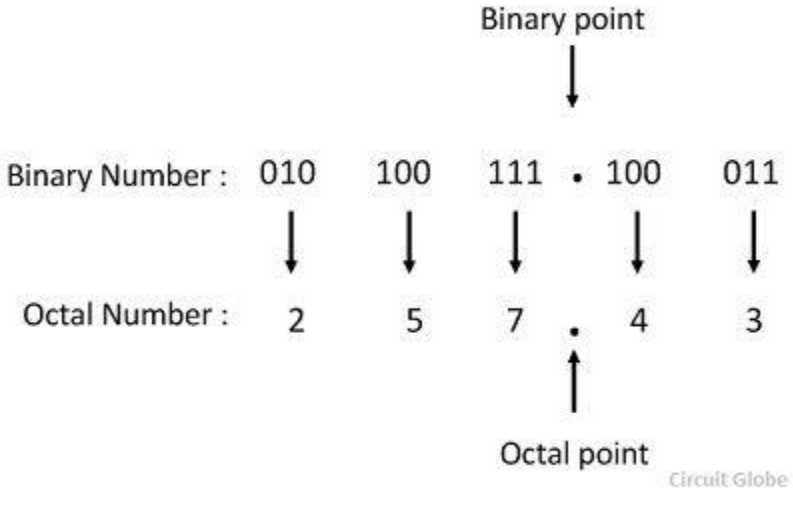
Octal Number system:

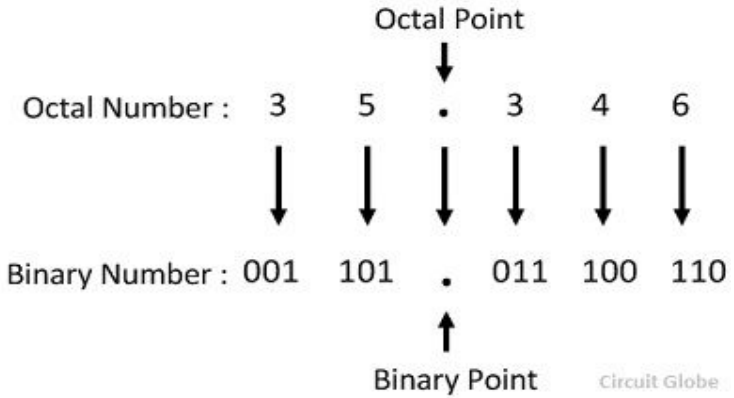
- Radix or base is 8
- 8 independent symbol – 0,1,2,3,4,5,6,7
- More useful than binary while dealing with large number of data

Decimal	Octal	Binary
0	0	0
1	1	1
2	2	10
3	3	11
4	4	100
5	5	101
6	6	110
7	7	111

➢Octal to binary and vice versa:

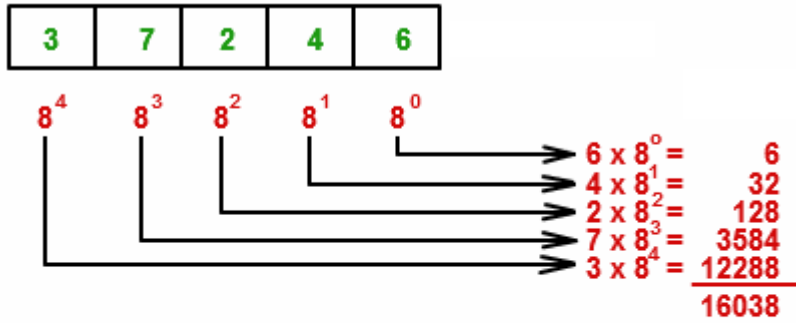
- Its very simple to convert number to binary
- For any binary to octal conversation just make group of 3 i.e. for any binary number from its right most starts making group of 3 and put its octal value.
- For any octal to binary conversation, any octal digit put its 3 digit binary value.





➢Octal to Decimal and vice versa:

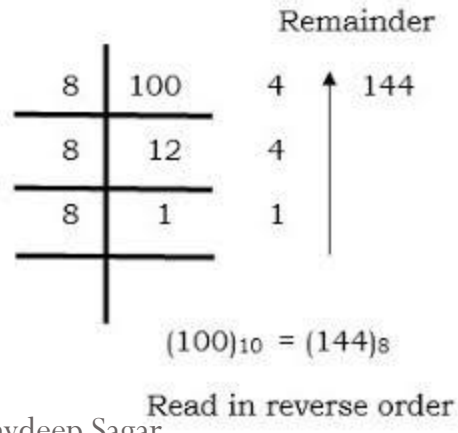
- The process will be same as was in binary to decimal conversation



Octal to Decimal conversation

Octal = 37246

Decimal = 16038



Decimal to Octal Conversation

➢Octal Addition, Subtraction, Multiplication, Division:

1 1	carry	
4 5 6	$= 302_{10}$	
+1 2 3	$= 83_{10}$	
6 0 1	$= 385_{10}$	

Octal
7 6 2
x 4 5
4 6 7 2
3 7 1 0
4 3 7 7 2

Carry

Octal		Decimal		Octal
5 x 2	=	$(10)_{10}$	= (8 x 1) + 2 =	12
5 x 6 + 1 =		$(31)_{10}$	= (8 x 3) + 7 =	37
5 x 7 + 3 =		$(38)_{10}$	= (8 x 4) + 6 =	46
4 x 2	=	$(8)_{10}$	= (8 x 1) + 0 =	10
4 x 6 + 1 =		$(25)_{10}$	= (8 x 3) + 1 =	31
4 x 7 + 3 =		$(31)_{10}$	= (8 x 3) + 7 =	37

8	borrow	
$^{3}4\ 5\ 6$	$= 302_{10}$	
-1 7 3	$= 123_{10}$	
2 6 3	$= 179_{10}$	

```
                    2   .2   1
        ------------------------
1 5 6 | 3   7   2   .0   0
        3   3   4
        ---------
            3   6   0
            3   3   4
            -------
                2   4   0
                1   5   6
            -------------
Remainder           6   2
```

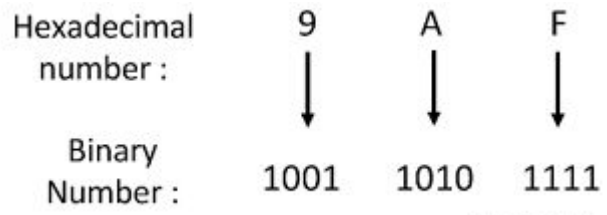
Hexadecimal number system:

- As name implies it has base or radix of 16 and symbols are: 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F
- Its machine language
- Group of 4 bit is called nibble and 2 nibble or 8 bit is called word.
- Also known as Hex number system

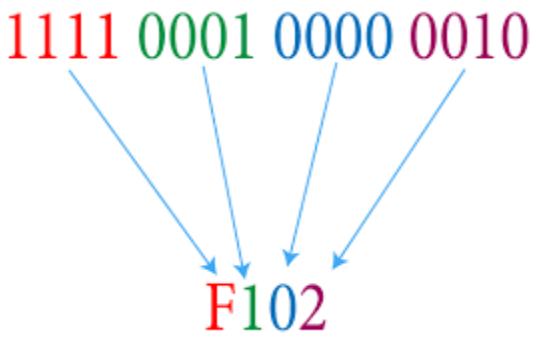
Hex	Dec	Oct	Bin
00	00	00	00000
01	01	01	00001
02	02	02	00010
03	03	03	00011
04	04	04	00100
05	05	05	00101
06	06	06	00110
07	07	07	00111
08	08	10	01000
09	09	11	01001
0A	10	12	01010
0B	11	13	01011
0C	12	14	01100
0D	13	15	01101
0E	14	16	01110
0F	15	17	01111
10	16	20	10000

➢Hex to binary and vice versa:

- Its very simple as in octal to binary conversation
- Like in octal, make group of for to convert binary to hex and put 4 digit binary value for any hex digit to convert it to binary



Hex to binary conversation



Binary to Hex Conversation

➢Hex to Octal and vice versa:

- To convert to octal number , first convert it to binary and then to octal and vice versa.

Hex to octal Conversation

Step 1:

Hex to Binary Conversion

B	5	A
1011	0101	1010

So the binary equivalent is 101101011010

Step 2:

Binary to Octal Conversion

101	101	011	010
5	5	3	2

Octal to Hex Conversation

Step 1:

Octal to Binary Conversion

7	5	2
111	101	010

So the binary equivalent is 111101010

Step 2:

Binary to Hex Conversion

0001	1110	1010
1	D	9

Hex to Decimal and vice versa:

- Method will be same as in binary to decimal conversation. Here we are using base of 16 instead of 2.

$1F4_{16}$

positional powers of 16:	16^3	16^2	16^1	16^0
decimal positional value:	4096	256	16	1
Hexadecimal number:		1	F	4

(1 x 256) + (F x 16) + (4 x 1)
= (1 x 256) + (15 x 16) + (4 x 1)

= 256 + 240 + 4 = 500_{10}

16	427	Remainders in hexadecimal
	26	11=B
	1	10=A
	0	1

➢Hex Addition, subtraction, multiplication, division:

1		carry
4 A 6	$= 1190_{10}$	
+ 1 B 3	$= 435_{10}$	
6 5 9	$= 1625_{10}$	

	10_{16}	Borrow
	2	Minuend reduced by 1
4 A 3 7	$_{16}$	Minuend
− 2 C 4 B	$_{16}$	Subtrahend
C	$_{16}$	Difference

	B 3 4 F	
X	D E	
1		
9 C E 5 2		} Add up
9 1 B 0 3		
9 B 7 E 8 2		

EX:

$$12\overline{)FACE}\ =\ DEF$$

EA	12 × D = EA
10C	FA − EA = 10
FC	12 × E = 10C
10E	10C − FC = 10
10E	12 × F = 10E
0	