Reference: Number Systems (Applied in C)

What are the number systems in computers?

Number systems are the technique to represent numbers in the computer system architecture, every value you are saving or getting into/from computer memory has a defined number system.

Computer architecture supports the following number systems.

- **Binary number system**
- **Octal number system**
- **Decimal number system**
- **Hexadecimal (hex) number system**

1) Binary Number System

A Binary number system has only two digits that are **0 and 1**. Every number (value) is represented with 0 and 1 in this number system. The base of the binary number system is 2, because it has only two digits.

2) Octal number system

Octal number system has only eight (8) digits from **0 to 7**. Every number (value) represents with 0,1,2,3,4,5,6 and 7 in this number system. The base of the octal number system is 8, because it has only 8 digits.

3) Decimal number system

Decimal number system has only ten (10) digits from **0 to 9**. Every number (value) represents with 0,1,2,3,4,5,6, 7,8 and 9 in this number system. The base of the decimal number system is 10, because it has only 10 digits.

4) Hexadecimal number system

A Hexadecimal number system has sixteen (16) alphanumeric values from **0 to 9** and **A to F**. Every number (value) represents with 0,1,2,3,4,5,6, 7,8,9,A,B,C,D,E and F in this number system. The base of the hexadecimal number system is 16, because it has 16 alphanumeric values. Here **A is 10**, **B is 11**, **C is 12**, **D is 13**, **E is 14** and **F is 15**.

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Table of the Numbers Systems and their Representation in C language

Number system	Base	Used digits	Example	C Language assignment
Binary	**2**	**0,1**	**$(11110000)_2$**	**int val=0b11110000;**
Octal	**8**	**0,1,2,3,4,5,6,7**	**$(360)_8$**	**int val=0360;**
Decimal	**10**	**0,1,2,3,4,5,6,7,8,9**	**$(240)_{10}$**	**int val=240;**
Hexadecimal	**16**	**0,1,2,3,4,5,6,7,8,9, A,B,C,D,E,F**	**$(F0)_{16}$**	**int val=0xF0;**

Number System Conversions - There are three types of conversion:

- **Decimal Number System to Other Base**
  Ex: Decimal Number System to Binary Number System
- **Other Base to Decimal Number System**
  Ex: Binary Number System to Decimal Number System
- **Other Base to Other Base**
  Ex: Binary Number System to Hexadecimal Number System

Decimal Number System to Other Base

To convert Number system from **Decimal Number System** to **Any Other Base** is quite easy; you have to follow just two steps:

A) Divide the Number (Decimal Number) by the base of target base system (in which you want to convert the number: Binary (2), octal (8) and Hexadecimal (16)).

B) Write the remainder from step 1 as a Least Signification Bit (LSB) to Step last as a Most Significant Bit (MSB).

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Decimal to Binary Conversion	Result
Decimal Number is : $(12345)_{10}$	Binary Number is $(11000000111001)_2$

2	12345	1	**LSB**
2	6172	0	
2	3086	0	
2	1543	1	
2	771	1	
2	385	1	
2	192	0	
2	96	0	
2	48	0	
2	24	0	
2	12	0	
2	6	0	
2	3	1	
	1	1	**MSB**

Decimal to Octal Conversion	Result
Decimal Number is : $(12345)_{10}$	Octal Number is $(30071)_8$

8	12345	1	LSB
8	1543	7	
8	192	0	
8	24	0	
	3	3	MSB

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Decimal to Hexadecimal Conversion	Result
Example 1 Decimal Number is : $(12345)_{10}$ 16 | 12345 — 9 LSB 16 | 771 — 3 16 | 48 — 0 8 | 3 — 3 MSB	Hexadecimal Number is $(3039)_{16}$
Example 2 Decimal Number is : $(725)_{10}$ 16 | 725 — 5 — 5 LSB 16 | 45 — 13 — D 2 — 2 — 2 MSB	Hexadecimal Number is $(2D5)_{16}$ **Convert** **10, 11, 12, 13, 14, 15** **to its equivalent...** **A, B, C, D, E, F**

Other Base System to Decimal Number Base - To convert Number System from **Any Other Base System** to **Decimal Number System**, you have to follow just three steps:

A) Determine the base value of the source Number System (that you want to convert), and also determine the position of digits from LSB (first digit's position – 0, second digit's position – 1 and so on).

B) Multiply each digit with its corresponding multiplication of position value and Base of Source Number System's Base.

C) Add the resulting value in step-B.

Explanation regarding examples:

Below given exams contain the following rows:

A) Row 1 contains the **DIGITs** of number (that will be converted).

B) Row 2 contains the **POSITION** of each digit in the number system.

C) Row 3 contains the multiplication: **DIGIT* BASE^POSITION**.

D) Row 4 contains the calculated result of **step C**.

E) And then add each value of **step D**, resulted value is the Decimal Number.

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Binary to Decimal Conversion

Binary Number is : **(11000000111001)2**

1	1	0	0	0	0	0	0	1	1	1	0	0	1
13	12	11	10	9	8	7	6	5	4	3	2	1	0
$1x2^{13}$	$1x2^{12}$	$0x2^{11}$	$0x2^{10}$	$0x2^{9}$	$0x2^{8}$	$0x2^{7}$	$0x2^{6}$	$1x2^{5}$	$1x2^{4}$	$1x2^{3}$	$0x2^{2}$	$0x2^{1}$	$1x2^{0}$
8192	4096	0	0	0	0	0	0	32	16	8	0	0	1

=8192+4096+32+16+8+1

=12345

Octal to Decimal Conversion

Octal Number is : **(30071)8**

3	0	0	7	1
4	3	2	1	0
$3*8^4$	$0*8^3$	$0*8^2$	$7*8^1$	$1*8^0$
12288	0	0	56	1

Result

=12288+0+0+56+1
=12345
Decimal Number is: **(12345)10**

Hexadecimal to Decimal Conversion

Hexadecimal Number is : **(2D5)16**

2	D (13)	5
2	1	0
$2*16^2$	$13*16^1$	$5*16^0$
512	208	5

Result

=512+208+5
=725
Decimal Number is: **(725)10**