Number System

Presentation · October 2017

DOI: 10.13140/RG.2.2.18838.04167

1 author:

Ajayi Olusola Olajide
Adekunle Ajasin University
80 PUBLICATIONS **29** CITATIONS

ajayioo.ict@gmail.com

COMPUTER NUMBER SYSTEM

Number System

A number system in computer ideology is regarded as the method or system of numbering and representing of digits in the computer 'inner' system. In other words, it is a technique used in representing numbers in the computer system architecture. The digital computer represents all kinds of data and information in binary numbers. This implies every value/number that you are saving or feeding into/fetching from the computer system memory has a defined number system. The value/data feed in/fetch from can includes but not limited to: audio, graphics, video, text file, numbers etc. The total number of digits used in a number system is called its base or radix. The base is written after the number as subscript; for instance 1000110_2 (1000110 base 2), 56_{10} (56 to base of 10), 71_8 (71 base 8) etc.

Computer architecture supports following number systems.

i. Binary number system (Base 2)
ii. Octal number system (Base 8)
iii. Decimal number system (Base 10)
iv. Hexadecimal number system (Base 16)

1) Binary Number System

A Binary number system has only two digits, which are **0 and 1**. Every number (value) is represented with 0 and 1 in this number system. The base of binary number system is 2, because it has only two digits. Though DECIMAL (No 3) is more frequently used in Number representation, BINARY is the number system form which the system/machine accepts.

2) Octal number system

Octal number system has only eight (8) digits from **0 to 7**. Every number (value) is represented with 0,1,2,3,4,5,6 and 7 in this number system. The base of 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) is represented with 0,1,2,3,4,5,6, 7,8 and 9 in this number system. The base of 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 hexadecimal number system is 16, because it has 16 alphanumeric values. Here, we have 0 to 9, representing 0 – 9 but from 10, we have **A is 10**, **B is 11**, **C is 12**, **D is 13**, **E is 14** and **F is 15**.

The table above shows the sample representations

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

Number System Conversions

There are three types of conversion:

- **Decimal Number System to Other Base**
  [for example: Decimal Number System to Binary Number System e.g. Base 10 to Base 2 etc.]
- **Other Base to Decimal Number System**
  [for example: Binary Number System to Decimal Number System e.g. Base 2 back to Base 10 etc.]
- **Other Base to Other Base**
  [for example: Binary Number System to Hexadecimal Number System e.g. Base 2 to Base 16 etc.]

Let’s pick them one after the other to see how the computations are done and the underlying logic behind them!

ajayioo.ict@gmail.com

Decimal Number System to Other Bases

The underlisted are the steps/procedures:

A) Divide the Number (Decimal Number) by the base of target base system (in which you want to convert the number to e.g. Binary (2), Octal (8) OR Hexadecimal (16)).

B) Write the remainder from step 1 as a Least Signification Bit (LSB) to Step last as a Most Significant Bit (MSB); that is, write from down-up.

Example 1: Convert 12345_{10} to Base 2

Solution 1:

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

Example 2: Convert same no (12345_{10}) this time, to Base 8

Solution 2:

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

Furthering, ….

Example 3: Convert 12345_{10} to Base 16

Solution 3:

Decimal to Hexadecimal Conversion	Result
Example 1 Decimal Number is : **$(12345)_{10}$**	Hexadecimal Number is **$(3039)_{16}$**

16	12345	9	LSB
16	771	3	
16	48	0	
8	3	3	MSB

A more complex Example 4: Convert 725_{10} to Base 16 Decimal Number is : **$(725)_{10}$**	Hexadecimal Number is **$(2D5)_{16}$** **Convert** **10, 11, 12, 13, 14, 15** **to its equivalent...** **A, B, C, D, E, F**

16	725	5	5	LSB
16	45	13	D	
	2	2	2	MSB

Other Base System to Decimal Number Base

The procedures are spelt out thus:

A) Determine the base value of 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/Sum up the resulted value in step-B.

Example 5: Convert 1101101_2 to Base 10

Solution:

Binary to Decimal Conversion

1 * 2 + 1 * 2 + 0 * 2 + 1 * 2 + 1 * 2 + 0 * 2 + 1 * 2 (Comment: What we did here is in line with step A e.g. we multiply the given/source base's number (e.g. Base 2 - 1101101) with the base index e.g. 2.

Now, to complete the conversion computation, superscript the index position starting from 0 backward increasing downward. For instance, the equation becomes:

$1 * 2^6 + 1 * 2^5 + 0 * 2^4 + 1 * 2^3 + 1 * 2^2 + 0 * 2^1 + 1 * 2^0$

$= 1 * 64 + 1 * 32 + 0 * 16 + 1 * 8 + 1 * 4 + 0 * 2 + 1 * 1$

$= 64 + 32 + 0 + 8 + 4 + 0 + 1$

$= 109_{10}$ (QED)

Example 6: Convert 53_8 to Base 10

Solution:

Octal to Decimal Conversion

5 * 8 + 3 * 8 (Comment: What we did here is in line with step A e.g. we multiply the given/source base's number (e.g. Base 8 - 53) with the base index e.g. 8.

Now, to complete the conversion computation, superscript the index position starting from 0 backward increasing downward. For instance, the equation becomes:

$5 * 8^1 + 3 * 8^0$ $= 5 * 8 + 3 * 1 = 40 + 3$ $= 43_{10}$ (QED)

Example 7: Convert 294_8 to Base 10

Solution:

Octal to Decimal Conversion

2 * 8 + 9 * 8 + 4 * 8 (Comment: What we did here is line with step A e.g. we multiply the given/source base's number (e.g. Base 8 - 294) with the base index e.g. 8.

Now, to complete the conversion computation, superscript the index position starting from 0 backward increasing downward. For instance, the equation becomes:

$2 * 8^2 + 9 * 8^1 + 4 * 8^0$ = 2 * 64 + 9 * 8 + 4 * 1 = 128 + 72 + 4=

= 204_{10} (QED)

Example 8: Convert $3F6_{16}$ to Base 10

Solution:

Hexadecimal to Decimal Conversion

3 * 16 + F(15) * 16 + 6 * 16 (Comment: What we did here is line with step A e.g. we multiply the given/source base's number (e.g. Base 16 – 3F6) with the base index e.g. 16.

Now, to complete the conversion computation, superscript the index position starting from 0 backward increasing downward. For instance, the equation becomes:

$3 * 16^2 + 15 * 16^1 + 6 * 16^0$ = 3 * 256 + 15 * 16 + 6 * 1 = 768 + 240 + 6 =

= 1014_{10} (QED)

Example 9: Convert $2C4E_{16}$ to Base 10

Solution:

Hexadecimal to Decimal Conversion

2 * 16 + C(12) * 16 + 4 * 16 + E(14) * 16 (Comment: What we did here is line with step A e.g. we multiply the given/source base's number (e.g. Base 16 – 2C4E) with the base index e.g. 16.

Now, to complete the conversion computation, superscript the index position starting from 0 backward increasing downward. For instance, the equation becomes:

$2 * 16^3 + 12 * 16^2 + 4 * 16^1 + 14 * 16^0$ = 2 * 4096 + 12 * 256 + 4 * 16 + 14 * 1

= 8192 + 3072 + 64 + 14 = 11342_{10} (QED)

Other Base System to Decimal Number Base

To execute this type of conversion, simply convert the given base to base ten, then convert to the target base.

Example 10: Convert 10011_2 to base 8

Solution:

$1 * 2^4 + 0 * 2^3 + 0 * 2^2 + 1 * 2^1 + 1 * 2^0 = 1 * 16 + 0 * 8 + 0 * 4 + 1 * 2 + 1 * 1$

$16 + 0 + 0 + 2 + 1 = 19_{10}$ ……this is the conversion to base ten; now to eight:

8	19
8	2

3
2

So, $10011_2 = 23_8$

Shouldn't you do some exercises now? Yes, I think you should. So, have these:

Exercises

1. Convert the following Base 2 numbers to Base 10:
   i. 11000011
   ii. 1001111
   iii. 001101111
2. Convert the underlisted Base 8 numbers to Base 10:
   i. 67
   ii. 21
   iii. 34
3. Convert the specified Base 16 numbers to Base 10:
   i. 2A5
   ii. 7E3D
   iii. 82CA
4. Convert the listed Base 10 numbers to Base 2, 8 and 16
   i. 34
   ii. 89
   iii. 68
5. Convert:
   i. 110110_2 to base 8
   ii. 678954_8 to base 16