Proposed NS-Calculator for Well-known Number Systems

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ABSTRACT
Calculator is "an electronic/mechanical device for the performance of mathematical computations and implemented with physical hardware devices", while a software calculator is a calculator that has been implemented as a software program. Similarly a number system is a set of rules & symbols used to represent a number. So, number system calculator is a software calculator used to perform mathematical computations on number systems. Today everyone is familiar with decimal number system (using 0-9). However digital devices almost use binary number system (using 0 & 1). Binary and other famous number systems e.g. octal (using 0-7) and hexadecimal (using 0-9 & A-F) number systems are based on the same fundamental concept of decimal number system. The knowledge of number systems, their representation, limits, arithmetic, compliments and inter-conversion of numbers between prescribed number systems is essential for understanding of computers and successful programming for digital devices. Understanding all these number systems and related terms/concepts requires allot of time and a large number of techniques to expertise. To overcome this problem, we propose calculating software which will cover and perform all the prescribed calculations within a fraction of second. It will perform various operations like number validity, arithmetic's, conversion from one to another system and the compliments of number in any required system. Four most common number systems taken under the consideration are binary, octal, decimal, and hexadecimal.

Index terms
Numbering system, Digital Electronics, Data Communication, Microprocessor, Digital Logic/Computer Design

Keywords
Calculating software, arithmetic, binary, octal, hexadecimal, inter conversion, compliments

1. INTRODUCTION
Today's computer first emerged in the 1940s and 1950s. The software that they ran was naturally used to perform calculations, but it was not limited to simple calculations. Software for performing calculations as its main purpose was first introduced in the 1960s, and the first software package for general calculations to obtain widespread use was released in 1978 [3]. It was called an interactive visible calculator, but it was actually a spreadsheet. The software calculators imitated the hardware calculators by implementing the same functionality with mouse-operated, rather than finger-operated, buttons. Such software calculators first emerged in the 1980s as part of the Windows operating system. There is now a very wide range of software calculators, and searching the internet results very large numbers of programs that are called calculators. These results include numerical calculators that apply arithmetic operations or mathematical functions to numbers, and that produce numerical results or graphs of numerical functions. Modern civilization is well familiar with decimal number system using ten digits and as it perform the computations since childhood, using the digits 0 – 9, that's why the it does not experience a need to think that how to use these numbers. However when it deals with computers it require to be familiar that how a number will be used. In digital world, most commonly computer science and IT normally we requires a working knowledge of various number systems, four basic/most common of these are binary, octal, decimal and hexadecimal. More specifically, the use of the microprocessor and its programming requires a working knowledge of binary, decimal and hexadecimal number system [1, 2].

Computers communicate and operate in binary digits while human beings generally use the decimal number systems using ten digits 0-9. Other number systems used in digital systems are octal with eight digits i.e. 0 through 7 and hexadecimal system with digits from 0 through 15. These all number systems use unique and distinct symbols. Some of these numeral system use only numeric digits (0, 1, 2... 9), while other use alphabets as well along the numeric digits. In case of hexadecimal system, digits 10-15 are designated as A through F to avoid confusion with the decimal numbers, 10 to 15 [4].

In computer science, we need to learn about number systems and the involved mathematics at very initiate stage. Commonly, the mathematics of number system refers to the simple traditional operations of addition, subtraction, multiplication and division with smaller values of numbers, called arithmetic [5]. More simply, arithmetic is a branch of mathematics concerned with the addition, subtraction, multiplication, and division of the numbers.

In various digital telecommunication technologies, we often need to change the simple signal into a pattern recognizable to the sender and receiver as representing the information intended. So at very first, the information must be translates into a patterns of 0s and 1s, for example, using ASCII of BCD. Also, data is stored in the computers in the form of 0s and 1s. To be carried from one place to another, data are usually converted to digital signals. Some times we need to convert an analog signal (such as voice in a telephone conversation) into a digital signal and vice versa [6]. So, in many applications we deal with the inter conversion of number systems. Remember: all number systems are inter-convertible i.e. from one number system to another, but each conversion often takes place in a different way, using different techniques [7]. There are various techniques that are used for these inter conversions.

To store the data in computer memory representing negative numbers, compliments are used. Also, Subtraction is the opposite of addition, that's why subtraction process also uses the compliments. Subtraction finds the difference between two numbers, the minuend minus the subtrahend. If the minuend is larger than the subtrahend, the difference is positive; if it is smaller than the subtrahend, the difference is negative; if they are equal, the difference is zero. So for calculating these results, several methods are used, one of which is compliment technique particularly helpful to machine calculation, i.e. digital computers make use of the method of compliments (radix and radix-1 complements).

In this particular paper, we are taking under the consideration a software calculator for the prescribed four number systems. This software is designed so that, it shows the validity of numbers in each system i.e. either the number is valid or invalid in required number system (base system), performs arithmetic operations on numbers in any given base, converts the numbers from one to another base, and finds the compliments of numbers in any required base system. Here at this stage, it covers four most common number systems i.e. binary, octal, decimal, and hexadecimal. This proposed software calculator is based on [2]. In which the complete description of well-known number systems is presented using single table.

This paper is ordered in such a way that it consist of seven sections. Section one covers the brief introduction of the number systems, need of various number systems, their representation, arithmetic, compliments, inter conversion and the proposed work. Section two is the overview of the number systems and their representations. Section three covers the arithmetic of all four number systems. Section four contains the compliment concepts for subtraction. Section five contains the tabulated form. Section six covers the model of the proposed number system calculator, while last one section concludes the paper.

2. INTRODUCTION TO NUMBER SYSTEMS

Humans are using a particular language made of words and letters to speak to one another. Although we type words and letters in the computer, the computer does not understand the words and letters, rather those words and letters are translated into numbers. It means that computers "talk" and understand only in numbers. Beside the fact that many students know the decimal (base 10) system, and are very comfortable with performing operations using this number system, it is too important for students to know and understand that the decimal system is not the only number system. By studying other number systems such as binary (base 2) quaternary (base 4), senary (base 6), octal (base 8), hexadecimal (base 16) and so forth, students will gain a better understanding of how number systems work in general.

2.1 Digits of number

Such a symbol used in a system of numeration or one of the ten Arabic number symbols, 0 through 9 is called digit. The first digit of/in any number system is always a zero. For example, a base 2 (binary) numbers have 2 digits: 0 and 1, a base 8 (octal) numbers have 8 digits: 0 through 7 and so forth. Remember that a base 10 or decimal numbers does not contain the digit 10, similarly base 8 or octal numbers does not contain a digit 8, and same is the case for the other number systems. Once the digits of a number system are understood, each and every larger numbers can be constructed using positional notation or place-value notation method. According to this method, the first right most digit (integer) has a unit's position in decimal number. Further, to the left of the units position is the ten's position, the position to the left of the ten's position is the hundred's position and so forth. Here, the units position has a weight of 10^0, or 1; the tens position has a weight of 10^1, or 10; and the hundreds position has a weight of 10^2, or 100. The exponential powers of the positions are significant for understanding numbers in other number systems. Always, the unit's position in any number system is the position to the left of the radix point. For example the position to the left of the binary (radix) point is always 2^0, or 1; the position to the left of the octal (radix) point is always 8^0, or 1 and so on. Similarly the position to the left of the unit's position is always the number whose base is raised to the first power; i.e. 2^1, 8^1 and so on. These concepts can be extended to each and every number system.

2.2 representation in any base system Number

A number in any base system can be represented in a generalized format as follows:

$N = A_n B^n + A_{n-1} B^{n-1} + - - - + A_1 B^1 + A_0 B^0$, where
N = Number, B=Base, A= any digit in that base

For example number 154 can be represented in various number systems as follows:

Table: 2.1 Number representations in various number systems

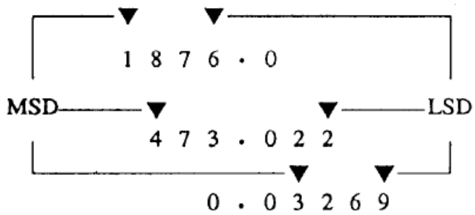
Decimal	154	$1\times10^2 + 5\times10^1 + 4\times10^0$ = 100 + 50 + 4	154
Binary	10011010	$1\times2^7 + 0\times2^6 + ... + 0\times2^0$ = 128+0+0+16+8+0+2+0	154
Octal	232	$2\times8^2 + 3\times8^1 + 2\times8^0$ = 128 + 24 + 2	154
H-decimal	9A	$9\times16^1 + A\times16^0$ = 144 + 10	154

2.3 Most Significant Digit and Least Significant Digit

The MSD in a number is the digit (right most) that has the greatest effect on that number, while The LSD (left most) in a number is the digit that has the least effect on that number. You may see this effect in following examples that a change in the MSD will increase or decrease the value of the number in the greatest amount, while changes in the LSD will have the smallest effect on the value. The MSD & LSD of a number can be understood using the under given examples:

1876.0 → MSD = 1, LSD = 6
473.022 → MSD = 4, LSD = 2 (last 2 of the number at left)
0.03269 → MSD = 3, LSD = 9

These examples can be understand more easily using graphical representation such as,



(Remember that significant 0s are taken under the consideration in these examples)

2.4 Counting

Counting procedure is similar in each number system. When the symbols for the first digit are finished, the next-higher digit (to the left) is incremented, and counting starts over at 0. For example in decimal number system, counting proceeds like that: 00, 01, 02 ... 07, 08, and 09 (rightmost digit starts over, and next digit is incremented) **1**0, 11, 12 ... 19 ... 90, 91, 92 ... 97, 98, and 99 (rightmost two digits start over, and next digit is incremented) **1**00, 101, 102 ... and so on. After a digit reaches 9, an increment resets it to 0 but also causes an increment by 1 in the next digit to the left. In binary, counting is same except that only the two symbols 0 and 1 are used. Thus after a digit reaches 1 in binary, an increment resets it to 0 but also causes an increment of the next digit to the left: 0, 1, 10, 11, 100, 101, 110, 111, 1000 … and so on. This counting procedure is applicable to octal and hexadecimal number systems as well.

2.5 Decimal Number System

The decimal number system is known as international system of numbers [8]. It is also called base 10 or denary number system. It uses 10 as its base. It is the numerical base most widely used by modern civilization [9].

Decimal notation is a base-10 positional notation system. Positional decimal systems include a zero and use symbols (called digits) for the ten values i.e. 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 to represent any number, no matter how large or how small.

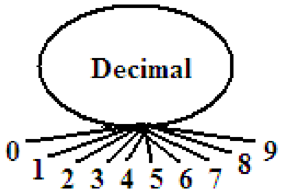
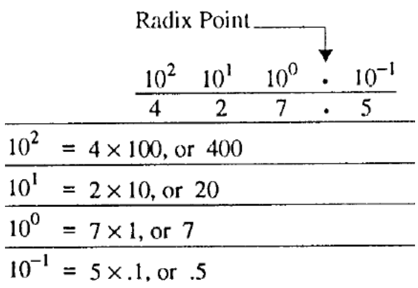


Figure: 1. Symbols used in decimal number system

Let's examine the decimal value of 427.5. You know that this value is four hundred twenty-seven and one-half. Now examine the position of each number:

427.5 → 5 represent 0.5 or ½ units
→ 7 represent 7 units
→ 2 represent 20 units, and
→ 4 represent 400 units

Each digit has its own value (weight) as shown in the above example. Now let's look at the value of the base 10 number 427.5 with the positional notation line graph:



You can see that the power of the base is multiplied by the number in that position to determine the value for that position. All numbers to the left of the decimal point are whole numbers or integers, and all numbers to the right of the decimal point are fractions.

2.5 Binary Number System

The number system with base 2 is known as the binary number system. Only two symbols are used to represent numbers in this system i.e. 0 and 1 known as bits. It is a positional system i.e. every position is assigned a specific weight. Moreover, its number has two parts the Integral part or integers and the fractional part or fractions, set a part by a radix point. For example $(1101.101)_2$

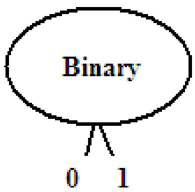


Figure: 2. Symbols used in binary number system

In binary number system the left–most bit is known as most significant bit (MSB) and the right–most bit is known as the least significant bit (LSB). The following graph shows the position and the power of the base (2 in this case):

$$\cdots\ 2^3\, 2^2\, 2^1\, 2^0 .\ 2^{-1}\, 2^{-2}\, 2^{-3}\ \cdots$$

The arithmetic operations such as addition, subtraction, multiplication and division of decimal numbers are also performed on binary numbers. Also binary arithmetic is much simpler than decimal arithmetic because only two digits, 0 and 1 are used here.

2.6 Octal Number System

Octal stands for 8, so the number system with base 8 is known as the octal number system. This system uses eight symbols, 0, 1, 2, 3, 4, 5, 6, and 7 to represent the number. Hence, any octal number can not have any digit greater than 7 [10].

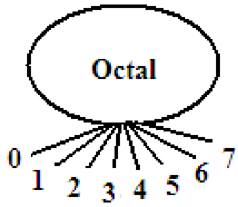


Figure: 3. Symbols used in octal number system

Similar to decimal and binary number systems, it is also a positional system; the octal number system uses power of 8 to determine the value of a number's position. The following graph shows the positions and the power of the base (8 in this case):

$$\cdots\ 8^3\, 8^2\, 8^1\, 8^0 .\ 8^{-1}\, 8^{-2}\, 8^{-3}\ \cdots$$

Integral and fractional part of octal number is set a part (separated) by a radix point, for example $(6327.\ 4051)_8$

In digital transmission system it is highly tedious to handle long strings of binary numbers. It may also cause errors. Therefore, octal numbers are useful to use for entering binary data and displaying certain information in short.

2.7 Hexadecimal Numbering System

Hexadecimal number system is very popular in computer uses. The base for hexadecimal number system is 16 which require 16 distinct symbols to represent the number. These are numerals 0 through 9 and alphabets A through F [11]. This is an alphanumeric number system because its uses both alphabets and numerical to represent a hexadecimal number. Hexadecimal number system use 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F.

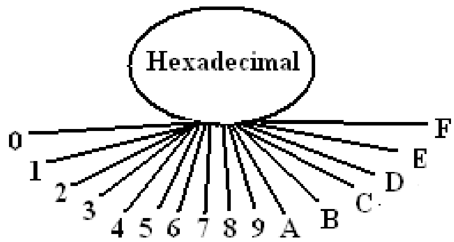


Figure: 4. Symbols and alphabets used in hexadecimal number system

Any number in hexadecimal number system having integral and fractional parts can be represented as $(B52.AC3)_{16}$.

$$\cdots\ 16^3\, 16^2\, 16^1\, 16^0 .\ 16^{-1}\, 16^{-2}\, 16^{-3}\ \cdots$$

Like the binary, octal, and decimal systems, the hexadecimal number system is a positional system. Powers of 16 are used for the positional values of a number. The following graph shows the positions and power of the base (16 in this case):

3 ARITHMETIC OF NUMBER SYSTEMS

The arithmetic is the most basic branch of mathematics, used by almost everyone from simple day-to-day counting to advanced science and business calculations. It simply refers to the basic mathematical operation such addition, subtraction, multiplication and division. As at the present, binary number system is the most common number system used by computer systems. However, long ago, there were such computer systems which were based on the decimal (base 10) number system rather than the binary number system. Therefore, despite the truth that decimal arithmetic is generally inferior to binary arithmetic; the need for decimal arithmetic still persists.

Remember that the arithmetic operations such as addition, subtraction, multiplication and division of decimal numbers can be performed on all other numbers from binary, octal and hexadecimal as well. Therefore, in this section of the paper only the decimal arithmetic is described.

3.1 Decimal arithmetic

Addition: In decimal numbers addition, a one quantity is added to another (for example 5+7=12). The basic terms of addition are:

AUGEND: The quantity to which an addend is added (first number i.e. 5 in this example)

ADDEND: A number to be added to an earlier number (second number i.e. 7 in this example)

SUM: The result of an addition (i.e. 12, the sum of 5 and 7)

CARRY: A carry is produced when the sum of two or more digits equals or exceeds the base of the number system in use.

The following table shows the addition operation of four number systems with the help of example from each system;

Table: 3.1 Addition in various number systems

Binary	$(1001)_2 + (011)_2 = (1100)_2$
Octal	$(74)_8 + (24)_8 = (120)_8$
Decimal	$(96)_{10} + (08)_{10} = (104)_{10}$
Hexadecimal	$(3F)_{16} + (09)_{16} = (48)_{16}$

Subtraction: Subtraction is the opposite of addition. Subtraction finds the difference between two numbers, the minuend minus the subtrahend. In other words, subtraction means to take away a part from the whole number or one number from another number. If the minuend is larger than the subtrahend, the difference is positive; if the minuend is smaller than the subtrahend, the difference is negative; if they are equal, the difference is zero. For example: 25-7 =18

The basic terms of subtraction are:

MINUEND: The number from which another number is to be subtracted (i.e. 25 in the above example)

SUBTRAHEND: The number to be subtracted (i.e. 7 here)

REMAINDER or DIFFERENCE: That number which is left after subtraction (i.e. 18 here)

BORROW: To transfer a digit (equal to the base number) from the next higher order column for the purpose of subtraction.

The following table shows the subtraction operation of four number systems with the help of example from each system;

Table: 3.2 Subtraction in various number systems

Binary	$(1001)_2 - (011)_2 = (110)_2$
Octal	$(74)_8 - (24)_8 = (50)_8$
Decimal	$(96)_{10} - (08)_{10} = (88)_{10}$
Hexadecimal	$(3F)_{16} - (09)_{16} = (36)_{16}$

Multiplication: Multiplication is also one of the basic operations of arithmetic. It also combines two numbers into a single number, called "product". In this arithmetic operation simply multiply the multiplicand by each digit of the multiplier and then add up all the properly shifted results.

For example: 32 × 8

The basic terms of multiplication are:

MULTIPLIER: The number by which another number is multiplied (i.e. 8 is the multiplier in above example)

MULTIPLICAND: The number that is to be multiplied by another. Here the multiplicand is 32

PRODUCT: The number or quantity obtained by multiplying two or more numbers together, i.e. 32 × 8 = 256

Binary, octal, and hexadecimal multiplication is similar to decimal multiplication except that base and counting is changed accordingly. Each digit of the multiplier (2nd number), multiplies to the whole multiplicand number (1st number).

The following table shows the multiplication operation of four number systems with the help of example from each system;

Table: 3.3 Multiplication in various number systems

Binary	$1001_2 * 011_2 = 11011_2$
Octal	$(74)_8 * (24)_8 = (2260)_8$
Decimal	$(96)_{10} * (08)_{10} = (768)_{10}$
Hexadecimal	$(3F)_{16} * (09)_{16} = (237)_{16}$

Division: Division is basically the opposite of multiplication. Division obtains the quotient of two numbers, when the dividend is divided by the divisor. Any dividend divided by zero is undefined. If the dividend is larger than the divisor, the quotient is greater than 1 otherwise it is less than 1. While in reverse if the quotient is multiplied by the divisor, it always yields the dividend. For example: 45 ÷ 3 = 15

The basic terms of division are:

DIVIDER: One number that divides another number (i.e. 3 here)

DIVIDEND: A number to be divided (i.e. 45 here)

QUOTIENT: The number obtained by dividing one number by another (i.e. 15)

REMAINDER: The number left over when one number is divided by another (in this example remainder is 0)

Binary, octal, and hexadecimal division is obtained using the same procedure like decimal division except that base and counting is changed accordingly.

The following table shows the division operation of four number systems with the help of example from each system;

Table: 3.4 Division in various number systems

Binary	$(1001)_2 / (011)_2 = (11)_2$
Octal	$(74)_8 / (24)_8 = (03)_8$
Decimal	$(96)_{10} / (08)_{10} = (12)_{10}$
Hexadecimal	$(3F)_{16} / (09)_{16} = (07)_{16}$

4. INTER CONVERSION

As discussed earlier, the most common and well-known number systems are the decimal, binary, octal and hexadecimal. Number systems are given in the ascending order as,

Binary
Octal
Decimal
Hexadecimal

A given number in any of the above number systems may consist of two parts i.e. the integral part and the fractional part. Each part some times, required a different technique for conversion. In other words, in case of fractions the conversion process requires additional techniques. So as a whole, more than 20 steps and various techniques are required to complete the conversion process.

It is very difficult to cover all the conversion in short time of one contact hour or so. To overcome this problem a table is given as under which reveals the conversion between the four number systems in three steps along the methods of conversion (for integers and fractions). Remember, in step 2 and 3 conversion technique (method) for integral and fractional part is not mentioned in the table. It is so, because in both steps, same technique is used for both integers and fractions conversion.

Table: 4.1 Conversion table for Decimal, Binary, Octal and Hexadecimal along the conversion techniques

Step No:	Part-A	Part-B
Step 1	Decimal - to - others [binary, octal, hexadecimal] $(==)_{10} \rightarrow (==)_{2,8,16}$ **Integer:** repeated division method **Fraction:** repeated multiplication method	Others [binary, octal, hexadecimal] - to - decimal $(==)_{2,8,16} \rightarrow (==)_{10}$ **Integer:** sum of [(+ve weights) × (integer)] **Fraction:** sum of[(-ve weights) × (fraction)]
Step 2	binary – to - other [octal, hexadecimal] $(==)_{2} \rightarrow (==)_{8,16}$ **To octal:** replace group of 3-binary bits by octal digit **To hex:** replace group of 4-binary bits by hexadecimal digit (same method for both integral and fraction part)	Other [octal, hexadecimal] - to - binary $(==)_{8,16} \rightarrow (==)_{2}$ **From octal:** replace each octal digit by 3-bit binary **From hex:** replace each hexa-decimal digit by 4-bit binary (same method for both integral and fraction part)
Step 3	octal to hexadecimal $(==)_{8} \rightarrow (==)_{16}$ Direct conversion not applicable Octal → Decimal → Hexadecimal	hexadecimal to octal $(==)_{16} \rightarrow (==)_{8}$ Direct conversion not applicable Hexadecimal → Decimal → Octal

5. COMPLIMETS

In digital technology the complement is a technique used to subtract one number from another using addition of positive numbers. This method was commonly used in mechanical calculators and is still used in modern computers. For example to subtract a number B (the subtrahend) from another number A (the minuend), the radix complement of B is added to A and the initial '1' (i.e. MSB in case of binary or MSD = most significant digit in case of other number systems) of the result is discarded or added back to the result. Moreover, a number of times we store data in complimented form to represent negative numbers. Indeed, two's complement is used in most modern computers to represent signed numbers.

Decimal compliments: To subtract a decimal number Y from another decimal number X, two compliment methods may be use i.e. ten's (radix) compliment method and nine's (radix-1) compliment method.

To understand the decimal compliments, let try an example by subtracting 218 from 873 (i.e. X – Y = 873 - 218). The nines' complement of Y is first obtained by determining the complement of each digit. The complement of a decimal digit in the nines' complement system is the number that must be added to it to produce 9, for example, the complement of 3 is 6, and the complement of 7 is 2, and so on. So nine's compliment of 218 is 781 (or 999-218=781). Next, sum the X and the nines' complement of Y, i.e. 873+781. If carry is generated then add it with result. I.e. 873+781= 1654

Adding the carry to the result gives 654+1= 655.

For ten's compliment, first obtain the nine's compliment of Y and then add 1 with the nine's compliment of Y. this becomes the ten's compliment of Y. Next sum the X with ten's compliment of Y. if carry is generated then simply discard it.

For example, X – Y = 873 - 218

So ten's compliment of 218 is 781+1=782

Sum of X and complimented Y is 873+782=1655

Now discard the carry and get the result i.e. 655

In case of other number systems i.e. binary, octal and hexadecimal both the radix and radix-1 compliments can be calculated in analogous to decimal compliments. These compliments can be realized with the help of the examples given in table 5.1.

Table: 5.1 Examples of the binary, octal and hexadecimal compliments

Number system	Subtraction Example	(Radix-1) Compliment	Radix Compliment
Binary	1001 0110 - 0011	1001 1001+ (1's) ①0010 ↳ +1 0011	1001 1010 + (2's) ①0011 Discard the MSB =1, so the result is 0011
Octal	753 23 - 730	753 754 + (7's) ①727 ↳ +1 730	753 755 + (8's) ①730 Discard the MSD =1, so the result is 730
Hexa-decimal	B52 97 – ABB	B52 F68 +(15,s) ①ABA ↳ +1 ABB	B52 F69 + (16's) ①ABB Discard the MSD =1, so the result is ABB

6. COMPLETE DESCRIPTION OF WELL KNOWN NUMBER SYSTEMS USING SINGLE TABLE

So far we have studied that how a number can be represented in various number systems, how mathematical operation can be perform on numbers of various systems, how number systems are interconvert-able and how a compliment of a number can be calculated.

Now we are presenting the tabulated form, which covers these entire concepts or complete description of the four number systems in a single table. Furthermore, this table consist of four sections. Section one describes that how much symbols (digits and alphabets) a number system will use and how the number in any number system may be represented. Section two describes the arithmetic operations of four number systems with the help of simple examples. Section three covers the complete inter conversion of numbers along the techniques used for these conversions, and the last section of the table presents the compliment techniques for each number system. The table 6.1 is shown on the last page of the paper.

7. PROPOSED NS-CALCULATOR

We can say that "calculating software perform a sequence of arithmetic operations, sequentially and automatically". Here the sequence of operations can be changed randomly, allowing the software to perform more than one kind of operation. Also we know that the several kind of operations performed on numbers from various number systems is much complex and time consuming. So this calculating software can make complex arithmetic easy and quick. It saves time and is useful in science, engineering, education, tele communication and anywhere digital calculations are needed. This calculating software is shown under with the help of the few figures, which reveals that how this software would be and what it should perform. Each figure represents a unique operation that can perform on various numbers from various number systems.

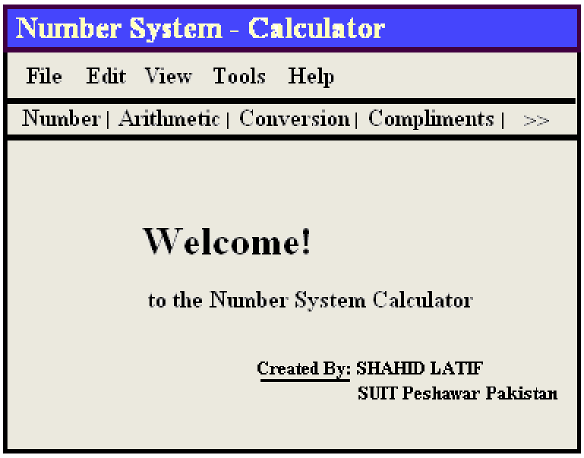


Figure: 5. Main/Start window of the calculator (software)

The above figure shows the main or starting window of the software, which may consist of menu bar, operation bar and welcome note etc.

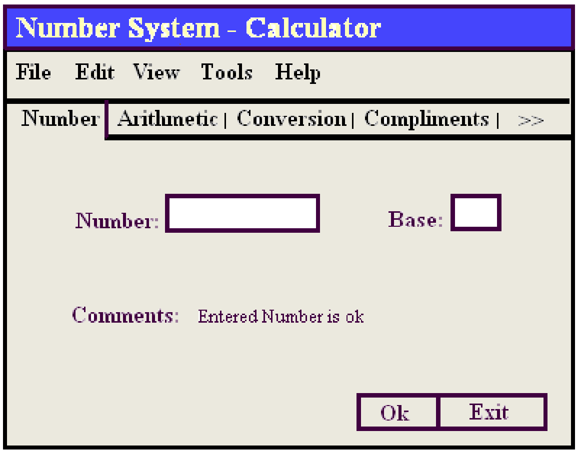


Figure: 6. Window for entered number validity
(In this case entered number is valid)

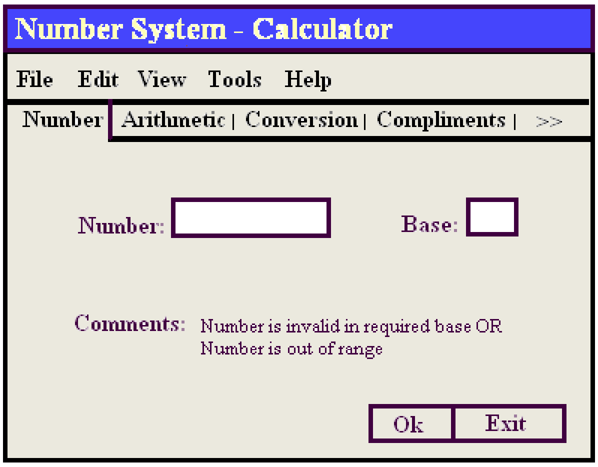


Figure: 7. Window for entered number validity
(In this case entered number is invalid)

Figure: 2 & 3 represents the numbers validity i.e. either the entered number is valid or invalid. If the number exists in the range of the mentioned base the message “Entered number is ok” will be displayed, other wise the message “Entered number is out of range” will be displayed.

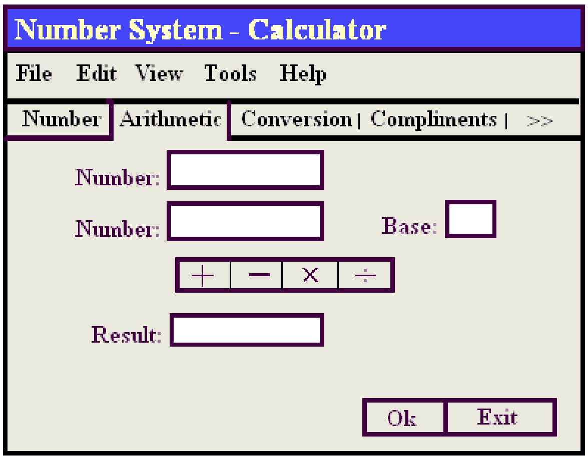


Figure: 8. Window for arithmetic operations

This figure represents the basic arithmetic operations such as addition, subtraction, multiplication and division, which may be perform on different numbers from any base. The operation can be selected by clicking one of the symbols representing that operation.

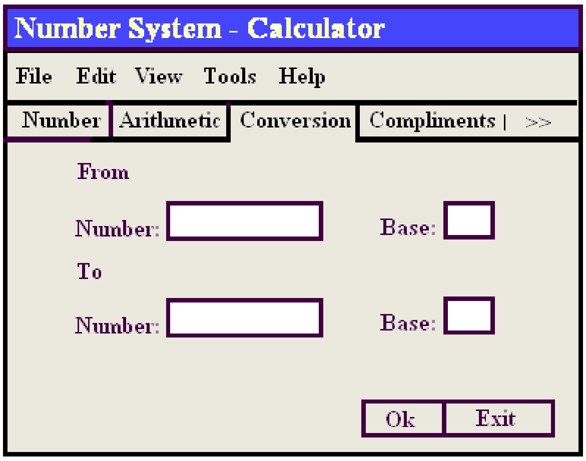


Figure: 9. Window for conversion operations

This figure reveals that a number given in any base can be converted to another required base.

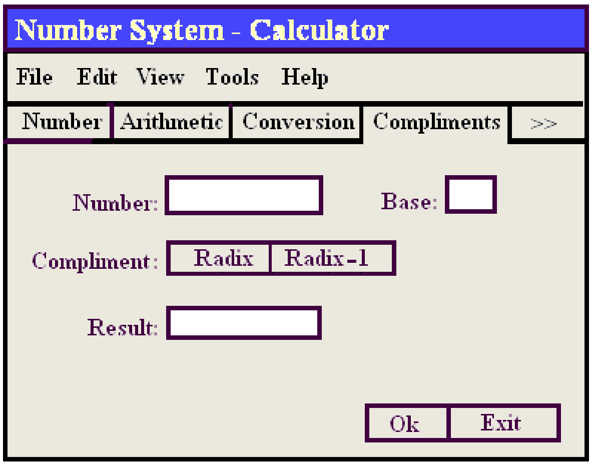


Figure: 10. Window for compliments

This above figure represents that how a number’s compliment can be calculated for given number in any base. One of the two i.e. radix or radix-1 compliment method can be selected by clicking the right option as shown in above figure.

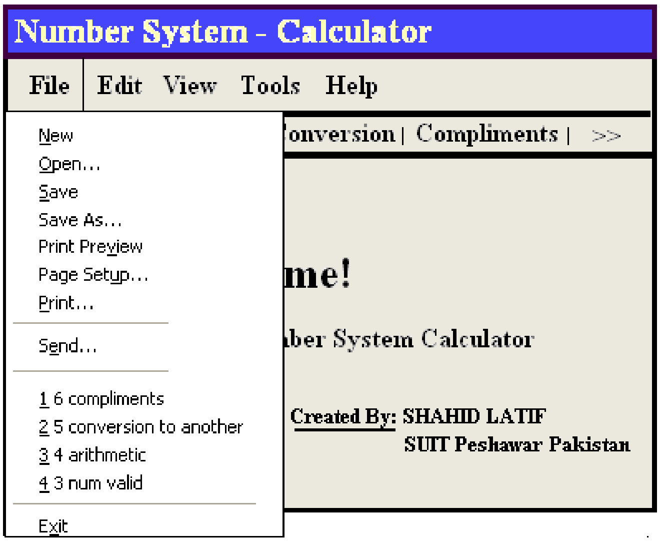


Figure: 11. Page showing the contents of File (menu bar)

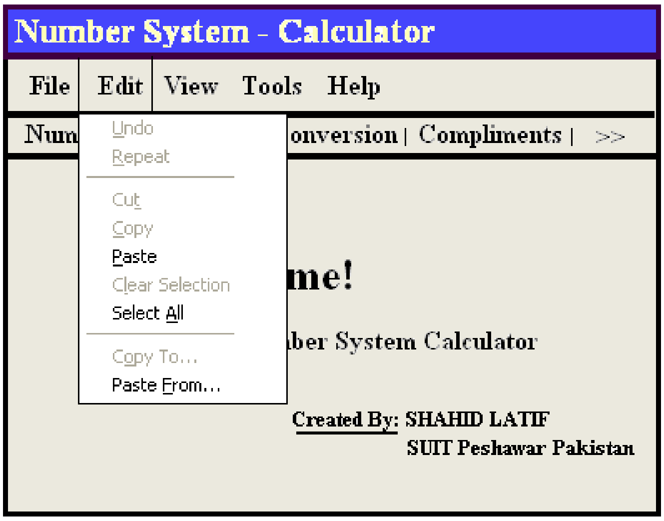


Figure: 12. Page showing the contents of view (menu bar)

Figure 11 & 12 shows that what will be the contents of the menu bar icons. Discussing all the features of the software is beyond the scope of the paper, so the remaining features will be thought and adapted by the programmer of the software himself.

8. CONCLUSION

In this particular paper we propose software calculator suggested for the number systems calculations. This software will be capable of performing various operations on the number systems including checking of number validity in required base, arithmetic operations of numbers in any base; inter conversion of numbers from/to different bases, compliments of numbers in any required system etc. At this stage, this proposed software covers almost every thing associated with the four most common number systems. It envelops the number representation, allowed digits (symbols) in each number system, arithmetic of each number system; inter conversion of numbers, and the possible compliment techniques in each number system. This software can be design and implement for more number systems using the same concepts. In this paper we have design and suggest a model for the calculating software, the successful programming for this software can be achieved using programming languages JAVA, VB.net, and C++ etc. This calculating software can make complex calculations very easy and quick. It saves time and money in business. It is useful in science, engineering, education, telecommunication, and anywhere digital calculations are needed. Remember that, these four number systems are not the only number systems used in digital world, but are the very common and frequently used in most of the digital technologies and devices.

From this paper we conclude that this is the best tool for practising the famous number systems and their related terms. It will be very help full for those people who are new in the field of computer science or digital electronics. Moreover, this software can be used as the computer aider design (CAD) software in digital and computer laboratory. As a future work, the software calculator proposed in this paper may be enhanced by including more number systems and the related features. Also, the techniques used for conversion and compliments mentioned in this paper are almost old techniques, so newer techniques can be added in it.

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Table: 6.1 Number representation, arithmetic, inter-conversion and compliments of four number systems

Number Representation				
Decimal	0,1,2,3,4,5,6,7,8,9		1798.65 or $(1798.65)_{10}$	
Binary	0,1		1011.01b or $(1011.01)_2$	
Octal	0,1,2,3,4,5,6,7		1354.40o or $(135.40)_8$	
Hexa-decimal	0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F		B521.F9h or $(B521.F9)_{16}$	
Arithmetic				
	Addition	Subtraction	Multiplication	Division
Decimal	5 + 7 = 12	25 - 7 = 18	6 × 3 = 18	33 ÷ 3 = 11
Binary	$101_2 + 111_2 = 1100_2$	$11001_2 - 111_2 = 10010_2$	$110_2 \times 11_2 = 10010_2$	$100001_2 \div 11_2 = 1011_2$
Octal	$5_8 + 7_8 = 14_8$	$25_8 - 7_8 = 16_8$	$6_8 \times 3_8 = 22_8$	$33_8 \div 3_8 = 11_8$
Hexa-decimal	$5_{16} + 7_{16} = C_{16}$	$25_{16} - 7_{16} = 1E_{16}$	$6_{16} \times 3_{16} = 12_{16}$	$33_{16} \div 3_{16} = 11_{16}$
Inter conversion				
	Part-A		Part-B	
Step1	Decimal to others [binary, octal, hexadecimal] $(==)_{10} \rightarrow (==)_{2,8,16}$ **Integer:** repeated division method **Fraction:** repeated multiplication method		Others [binary, octal, hexadecimal] to decimal $(==)_{2,8,16} \rightarrow (==)_{10}$ **Integer:** sum of [(+ve weights)×(integer)] **Fraction:** sum of [(-ve weights) ×(fraction)]	
Step2	binary to other [octal, hexadecimal] $(==)_2 \rightarrow (==)_{8,16}$ **To octal:** replace group of 3-binary bits by octal digit **To hex:** replace group of 4-binary bits hexadecimal digit (same method for both integral and fractional part)		Other [octal, hexadecimal] to binary $(==)_{8,16} \rightarrow (==)_2$ **From octal:** replace each octal digit by 3-bit binary **From hex:** replace each hexadecimal digit by 4-bit binary (same method for both integral and fractional part)	
Step3	octal to hexadecimal $(==)_8 \rightarrow (==)_{16}$ Direct conversion not applicable Octal → Decimal → Hexadecimal		hexadecimal to octal $(==)_{16} \rightarrow (==)_8$ Direct conversion not applicable Hexadecimal → Decimal → Octal	
Compliments				
	Radix compliment		(radix-1) compliment	
	Minuend + subtrahend's radix compliment = result (Discard the carry or MSD of the result)		Minuend + subtrahend's (radix-1) compliment = result Add carry (if generated) to the result	
Decimal	Ten's Compliment		Nine's Compliment	
Binary	Two's Compliment		One's Compliment	
Octal	Eight's Compliment		Seven's Compliment	
H-decimal	Sixteen's Compliment		Fifteen's Compliment	