**Hexadecimal Numbers**

Representing even small number such as 6918 requires a long binary string (1101100000110) of 0s and 1s. Larger decimal numbers would require lengthier binary strings.

Writing such long string is tedious and prone to errors.

The Hexadecimal number system is a base 16 number system and therefore has 16 digits and is used primarily to represent binary strings in a compact manner.

Hexadecimal number system is not used by a Digital System. The Hexadecimal number system is for our convenience to long binary strings in a short and concise form. Each Hexadecimal Number digit can represent a 4-bit Binary Number. The Binary Numbers and the Hexadecimal equivalents are listed in the following Table

| Decimal | Binary | Hexadecimal | Decimal | Binary | Hexadecimal |
|---|---|---|---|---|---|
| 0 | 0000 | 0 | 8 | 1000 | 8 |
| 1 | 0001 | 1 | 9 | 1001 | 9 |
| 2 | 0010 | 2 | 10 | 1010 | A |
| 3 | 0011 | 3 | 11 | 1011 | B |
| 4 | 0100 | 4 | 12 | 1100 | C |
| 5 | 0101 | 5 | 13 | 1101 | D |
| 6 | 0110 | 6 | 14 | 1110 | E |
| 7 | 0111 | 7 | 15 | 1111 | F |

**Counting in Hexadecimal**

Counting in Hexadecimal is similar to the other number systems.

The maximum value represented by a single Hexadecimal digit is F which is equivalent to decimal 15. The next higher value decimal 16 is represented by a combination of two Hexadecimal digits $10_{16}$ or 10 H. The subscript 16 indicates that the number is Hexadecimal 10 and not decimal 10. Hexadecimal Numbers are also identified by appending the character H after the number. The Hexadecimal Numbers for Decimal numbers 16 to 39 are listed in the following Table.

| Decimal | Hexadecimal | Decimal | Hexadecimal | Decimal | Hexadecimal |
|---|---|---|---|---|---|
| 16 | 10 | 24 | 18 | 32 | 20 |
| 17 | 11 | 25 | 19 | 33 | 21 |
| 18 | 12 | 26 | 1A | 34 | 22 |
| 19 | 13 | 27 | 1B | 35 | 23 |
| 20 | 14 | 28 | 1C | 36 | 24 |
| 21 | 15 | 29 | 1D | 37 | 25 |
| 22 | 16 | 30 | 1E | 38 | 26 |
| 23 | 17 | 31 | 1F | 39 | 27 |

**Binary to Hexadecimal Conversion**

Converting Binary to Hexadecimal is a very simple operation. The Binary string is divided into small groups of 4-bits starting from the least significant bit. Each 4-bit binary group is replaced by its Hexadecimal equivalent.

| | |
|---|---|
| 11010110101110010110 | Binary Number |
| 1101 0110 1011 1001 0110 | Dividing into groups of 4-bits |
| D 6 B 9 6 | Replacing each group by its Hexadecimal equivalent |

Thus 11010110101110010110 is represented in Hexadecimal by D6B96

Binary strings which can not be exactly divided into a whole number of 4-bit groups are assumed to have 0's appended in the most significant bits to complete a group.

| | |
|---|---|
| 1101100000110 | Binary Number |
| 1 1011 0000 0110 | Dividing into groups of 4-bits |
| 0001 1011 0000 0110 | Appending three 0s to complete the group |
| 1 B 0 6 | Replacing each group by its Hexadecimal equivalent |

**Hexadecimal to Binary Conversion**

Converting from Hexadecimal back to binary is also very simple. Each digit of the Hexadecimal number is replaced by an equivalent binary string of 4-bits.

| | |
|---|---|
| FD13 | Hexadecimal Number |
| 1111 1101 0001 0011 | Replacing each Hexadecimal digit by its 4-bit binary equivalent |

**Decimal to Hexadecimal Conversion**

There are two methods to convert from Decimal to Hexadecimal. The first method is the Indirect Method and the second method is the Repeated Division Method.

**1. Indirect Method**

A decimal number can be converted into its Hexadecimal equivalent indirectly by first converting the decimal number into its binary equivalent and then converting the binary to Hexadecimal.

**2. Repeated Division-by-16 Method**

The Repeated Division Method has been discussed earlier and used to convert Decimal Numbers to Binary by repeatedly dividing the Decimal Number by 2. A decimal number can be directly converted into Hexadecimal by using repeated division. The decimal number is continuously divided by 16 (base value of the Hexadecimal number system). The conversion of Decimal 2096 to Hexadecimal using the Repeated Division-by-16 Method is illustrated in the following Table. The hexadecimal equivalent of $2096_{10}$ is $830_{16}$.

| Number | Quotient after division | Remainder after division |
|---|---|---|
| 2096 | 131 | 0 |
| 131 | 8 | 3 |
| 8 | 0 | 8 |

**Hexadecimal to Decimal Conversion**

Converting Hexadecimal Numbers to Decimal is done using two Methods. The first Method is the Indirect Method and the second method is the Sum-of-Weights method.

**1. Indirect Method**

The indirect method of converting Hexadecimal number to decimal number is to first convert Hexadecimal number to Binary and then Binary to Decimal.

**2. Sum-of-Weights Method**

A Hexadecimal number can be directly converted into Decimal by using the sum of weights method. The conversion steps using the Sum-of-Weights method are shown.

| | |
|---|---|
| CA02 | Hexadecimal number |
| $C \times 16^3 + A \times 16^2 + 0 \times 16^1 + 2 \times 16^0$ | Writing the number in an expression |
| $(C \times 4096) + (A \times 256) + (0 \times 16) + (2 \times 1)$ | |
| $(12 \times 4096) + (10 \times 256) + (0 \times 16) + (2 \times 1)$ | Replacing Hexadecimal values with Decimal equivalents |
| 49152 + 2560 + 0 + 2 | Summing the Weights |
| 51714 | Decimal equivalent |

**Hexadecimal Addition and Subtraction**

Numbers represented in Hexadecimal can be added and subtracted directly without having to convert them into decimal or binary equivalents. The rules of Addition and Subtraction that are used to add and subtract numbers in Decimal or Binary number systems apply to Hexadecimal Addition and Subtraction. Hexadecimal Addition and Subtractions allows large Binary numbers to be quickly added and subtracted.

**1. Hexadecimal Addition**

| | |
|---|---|
| Carry | 1 |
| Number1 | 2 A C 6 |
| Number 2 | 9 2 B 5 |
| Sum | B D 7 B |

**2. Hexadecimal Subtraction**

| | |
|---|---|
| Borrow | 1 1 1 |
| Number 1 | 9 2 B 5 |
| Number 2 | 2 A C 6 |
| Difference | 6 7 E F |