MCA Part 1

Paper 2: Computer Organisation

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Lecture 01

Number System

A digital system can understand positional number system only where there are a few symbols called digits and these symbols represent different values depending on the position they occupy in the number.

A value of each digit in a number can be determined using

* The digit
* The position of the digit in the number
* The base of the number system (where base is defined as the total number of digits available in the number system).

Decimal Number System

The number system that we use in our day-to-day life is the decimal number system. Decimal number system has base 10 as it uses 10 digits from 0 to 9. In decimal number system, the successive positions to the left of the decimal point represents units, tens, hundreds, thousands and so on.

Each position represents a specific power of the base (10). For example, the decimal number 1234 consists of the digit 4 in the units position, 3 in the tens position, 2 in the hundreds position, and 1 in the thousands position, and its value can be written as

(1×1000) + (2×100) + (3×10) + (4×l)

(1×103) + (2×102) + (3×101) + (4×l00)

1000 + 200 + 30 + 1

1234

|  |  |
| --- | --- |
| **S.N.** | **Number System & Description** |
| 1 | **Binary Number System**  Base 2. Digits used: 0, 1 |
| 2 | **Octal Number System**  Base 8. Digits used: 0 to 7 |
| 3 | **Hexa Decimal Number System**  Base 16. Digits used: 0 to 9, Letters used: A- F |

Binary Number System

Characteristics

* Uses two digits, 0 and 1.
* Also called base 2 number system
* Each position in a binary number represents a 0 power of the base (2). Example: 20
* Last position in a binary number represents an x power of the base (2). Example: 2x where x represents the last position - 1.

Example

Binary Number: 101012

Calculating Decimal Equivalent −

|  |  |  |
| --- | --- | --- |
| **Step** | **Binary Number** | **Decimal Number** |
| Step 1 | 101012 | ((1 × 24) + (0 × 23) + (1 × 22) + (0 × 21) + (1 × 20))10 |
| Step 2 | 101012 | (16 + 0 + 4 + 0 + 1)10 |
| Step 3 | 101012 | 2110 |

**Note:** 101012 is normally written as 10101.

Octal Number System

Characteristics

* Uses eight digits, 0,1,2,3,4,5,6,7.
* Also called base 8 number system
* Each position in an octal number represents a 0 power of the base (8). Example: 80
* Last position in an octal number represents an x power of the base (8). Example: 8x where x represents the last position - 1.

Example

Octal Number − 125708

Calculating Decimal Equivalent −

|  |  |  |
| --- | --- | --- |
| **Step** | **Octal Number** | **Decimal Number** |
| Step 1 | 125708 | ((1 × 84) + (2 × 83) + (5 × 82) + (7 × 81) + (0 × 80))10 |
| Step 2 | 125708 | (4096 + 1024 + 320 + 56 + 0)10 |
| Step 3 | 125708 | 549610 |

**Note:** 125708 is normally written as 12570.

Hexadecimal Number System

Characteristics

* Uses 10 digits and 6 letters, 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F.
* Letters represents numbers starting from 10. A = 10, B = 11, C = 12, D = 13, E = 14, F = 15.
* Also called base 16 number system.
* Each position in a hexadecimal number represents a 0 power of the base (16). Example 160.
* Last position in a hexadecimal number represents an x power of the base (16). Example 16x where x represents the last position - 1.

Example −

Hexadecimal Number: 19FDE16

Calculating Decimal Equivalent −

|  |  |  |
| --- | --- | --- |
| **Step** | **Hexadecimal Number** | **Decimal Number** |
| Step 1 | 19FDE16 | ((1 × 164) + (9 × 163) + (F × 162) + (D × 161) + (E × 160))10 |
| Step 2 | 19FDE16 | ((1 × 164) + (9 × 163) + (15 × 162) + (13 × 161) + (14 × 160))10 |
| Step 3 | 19FDE16 | (65536 + 36864 + 3840 + 208 + 14)10 |
| Step 4 | 19FDE16 | 10646210 |

**Note −** 19FDE16 is normally written as 19FDE.

**Conversion of Numbers**

There are many methods or techniques which can be used to convert numbers from one base to another. We'll demonstrate here the following −

* Decimal to Other Base System
* Other Base System to Decimal
* Other Base System to Non-Decimal
* Shortcut method − Binary to Octal
* Shortcut method − Octal to Binary
* Shortcut method − Binary to Hexadecimal
* Shortcut method − Hexadecimal to Binary

Decimal to Other Base System

Steps

* **Step 1** − Divide the decimal number to be converted by the value of the new base.
* **Step 2** − Get the remainder from Step 1 as the rightmost digit (least significant digit) of new base number.
* **Step 3** − Divide the quotient of the previous divide by the new base.
* **Step 4** − Record the remainder from Step 3 as the next digit (to the left) of the new base number.

Repeat Steps 3 and 4, getting remainders from right to left, until the quotient becomes zero in Step 3.

The last remainder thus obtained will be the Most Significant Digit (MSD) of the new base number.

Example −

Decimal Number: 2910

Calculating Binary Equivalent −

|  |  |  |  |
| --- | --- | --- | --- |
| **Step** | **Operation** | **Result** | **Remainder** |
| Step 1 | 29 / 2 | 14 | 1 |
| Step 2 | 14 / 2 | 7 | 0 |
| Step 3 | 7 / 2 | 3 | 1 |
| Step 4 | 3 / 2 | 1 | 1 |
| Step 5 | 1 / 2 | 0 | 1 |

As mentioned in Steps 2 and 4, the remainders have to be arranged in the reverse order so that the first remainder becomes the Least Significant Digit (LSD) and the last remainder becomes the Most Significant Digit (MSD).

Decimal Number − 2910 = Binary Number − 111012.

Other Base System to Decimal System

Steps

* **Step 1** − Determine the column (positional) value of each digit (this depends on the position of the digit and the base of the number system).
* **Step 2** − Multiply the obtained column values (in Step 1) by the digits in the corresponding columns.
* **Step 3** − Sum the products calculated in Step 2. The total is the equivalent value in decimal.

Example

Binary Number − 111012

Calculating Decimal Equivalent −

|  |  |  |
| --- | --- | --- |
| **Step** | **Binary Number** | **Decimal Number** |
| Step 1 | 111012 | ((1 × 24) + (1 × 23) + (1 × 22) + (0 × 21) + (1 × 20))10 |
| Step 2 | 111012 | (16 + 8 + 4 + 0 + 1)10 |
| Step 3 | 111012 | 2910 |

Binary Number − 111012 = Decimal Number − 2910

Other Base System to Non-Decimal System

Steps

* **Step 1** − Convert the original number to a decimal number (base 10).
* **Step 2** − Convert the decimal number so obtained to the new base number.

Example

Octal Number − 258

Calculating Binary Equivalent −

Step 1 − Convert to Decimal

|  |  |  |
| --- | --- | --- |
| **Step** | **Octal Number** | **Decimal Number** |
| Step 1 | 258 | ((2 × 81) + (5 × 80))10 |
| Step 2 | 258 | (16 + 5 )10 |
| Step 3 | 258 | 2110 |

Octal Number − 258 = Decimal Number − 2110

Step 2 − Convert Decimal to Binary

|  |  |  |  |
| --- | --- | --- | --- |
| **Step** | **Operation** | **Result** | **Remainder** |
| Step 1 | 21 / 2 | 10 | 1 |
| Step 2 | 10 / 2 | 5 | 0 |
| Step 3 | 5 / 2 | 2 | 1 |
| Step 4 | 2 / 2 | 1 | 0 |
| Step 5 | 1 / 2 | 0 | 1 |

Decimal Number − 2110 = Binary Number − 101012

Octal Number − 258 = Binary Number − 101012

Shortcut method - Binary to Octal

Steps

* **Step 1** − Divide the binary digits into groups of three (starting from the right).
* **Step 2** − Convert each group of three binary digits to one octal digit.

Example

Binary Number − 101012

Calculating Octal Equivalent −

|  |  |  |
| --- | --- | --- |
| **Step** | **Binary Number** | **Octal Number** |
| Step 1 | 101012 | 010 101 |
| Step 2 | 101012 | 28 58 |
| Step 3 | 101012 | 258 |

Binary Number − 101012 = Octal Number − 258

Shortcut method - Octal to Binary

Steps

* **Step 1** − Convert each octal digit to a 3 digit binary number (the octal digits may be treated as decimal for this conversion).
* **Step 2** − Combine all the resulting binary groups (of 3 digits each) into a single binary number.

Example

Octal Number − 258

Calculating Binary Equivalent −

|  |  |  |
| --- | --- | --- |
| **Step** | **Octal Number** | **Binary Number** |
| Step 1 | 258 | 210 510 |
| Step 2 | 258 | 0102 1012 |
| Step 3 | 258 | 0101012 |

Octal Number − 258 = Binary Number − 101012

Shortcut method - Binary to Hexadecimal

Steps

* **Step 1** − Divide the binary digits into groups of four (starting from the right).
* **Step 2** − Convert each group of four binary digits to one hexadecimal symbol.

Example

Binary Number − 101012

Calculating hexadecimal Equivalent −

|  |  |  |
| --- | --- | --- |
| **Step** | **Binary Number** | **Hexadecimal Number** |
| Step 1 | 101012 | 0001 0101 |
| Step 2 | 101012 | 110 510 |
| Step 3 | 101012 | 1516 |

Binary Number − 101012 = Hexadecimal Number − 1516

Shortcut method - Hexadecimal to Binary

Steps

* **Step 1** − Convert each hexadecimal digit to a 4 digit binary number (the hexadecimal digits may be treated as decimal for this conversion).
* **Step 2** − Combine all the resulting binary groups (of 4 digits each) into a single binary number.

Example

Hexadecimal Number − 1516

Calculating Binary Equivalent −

|  |  |  |
| --- | --- | --- |
| **Step** | **Hexadecimal Number** | **Binary Number** |
| Step 1 | 1516 | 110 510 |
| Step 2 | 1516 | 00012 01012 |
| Step 3 | 1516 | 000101012 |

Hexadecimal Number − 1516 = Binary Number − 101012