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Topic :Number System Theory

Number Systems

Number systems are techniques used to represent numbers within a computer system. Every value stored or retrieved from computer memory follows a specific number system. Computer architecture supports the following number systems:

1. **Binary Number System**
2. **Octal Number System**
3. **Decimal Number System**
4. **Hexadecimal (Hex) Number System**

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1. Binary Number System

- **Digits**: 0, 1
- **Base**: 2
- **Description**: Uses only two digits, 0 and 1, to represent values.
- **Example**: $(11110000)_2$

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2. Octal Number System

- **Digits**: 0, 1, 2, 3, 4, 5, 6, 7
- **Base**: 8
- **Description**: Represents numbers using eight digits from 0 to 7.

- **Example**: $(360)_8$

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3. Decimal Number System

- **Digits**: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- **Base**: 10
- **Description**: Uses ten digits from 0 to 9 to represent values.
- **Example**: $(240)_{10}$

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4. Hexadecimal Number System

- **Digits**: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
- **Base**: 16
- **Description**: Has sixteen alphanumeric values, where A = 10, B = 11, ..., F = 15.
- **Example**: $(F0)_{16}$

Number System	Base (Radix)	Digits Used	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-F	$(F0)_{16}$

Decimal and Binary Numbers

In the decimal (base 10) system, positional notation is used, where each digit's position represents a power of 10:

Example:
$843_{10} = 8 \times 10^2 + 4 \times 10^1 + 3 \times 10^0$
$= 800 + 40 + 3$

In binary (base 2), each position represents a power of 2:

Example:
$101101_2 = 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$
$= 32 + 8 + 4 + 1 = 45_{10}$

Converting Binary to Decimal

Example: Convert 11011_2 to decimal.

$$
\begin{aligned}
&11011 \\
&= 1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 \\
&= 16 + 8 + 0 + 2 + 1 \\
&= 27_{10}
\end{aligned}
$$

Converting Decimal to Binary

Convert a decimal number to binary using successive division by 2 until the quotient is 0. The remainders, in reverse order, form the binary equivalent.

Example: Convert 37_{10} to binary.

1. 37 ÷ 2 = 18 remainder **1**
2. 18 ÷ 2 = 9 remainder **0**
3. 9 ÷ 2 = 4 remainder **1**
4. 4 ÷ 2 = 2 remainder **0**
5. 2 ÷ 2 = 1 remainder **0**
6. 1 ÷ 2 = 0 remainder **1**

Binary: 100101_2

Hexadecimal Digits and Binary Equivalents

Hexadecimal	Binary
0	0000
1	0001
2	0010
3	0011
4	0100

5	0101
6	0110
7	0111
8	1000
9	1001
A (10)	1010
B (11)	1011
C (12)	1100
D (13)	1101
E (14)	1110
F (15)	1111

Converting Binary to Hexadecimal

Convert binary to hexadecimal by dividing into groups of 4 digits from the right.

Example: Convert 10110101_2 to hexadecimal.

1. Group digits: **1011 0101**
2. Convert each group: 1011 = B, 0101 = 5

Hexadecimal: $B5_{16}$

To convert the binary number 0110101110001100 to hexadecimal:

1. **Divide into groups of 4 digits**: 0110 1011 1000 1100
2. **Convert each group to a hex digit**:
    - 0110=6
    - 1011=B
    - 1000=8
    - 1100=C

Result: 6B8C16

END