



# SNS COLLEGE OF TECHNOLOGY

Coimbatore-35  
An Autonomous Institution



Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade  
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

## DEPARTMENT OF COMPUTER SCIENCE ENGINEERING

### 19ECB231 – DIGITAL ELECTRONICS

II YEAR/ III SEMESTER

Number Systems/19ECB231-Digital  
Electronics/E.Ramya/AP/ECE/SNSCT

### UNIT 1 – MINIMIZATION TECHNIQUES AND LOGIC GATES

TOPIC – NUMBER SYSTEMS



# Learning Objectives



In this chapter you will learn about:

Non-positional number system

Positional number system

Decimal number system

Binary number system

Octal number system

Hexadecimal number system



# Number Systems



**Two types of number systems are:**

- Non-positional number systems
- Positional number systems



# Non-positional Number Systems



## Characteristics

- Use symbols such as I for 1, II for 2, III for 3, IIII for 4, IIIII for 5, etc
- Each symbol represents the same value regardless of its position in the number
- The symbols are simply added to find out the value of a particular number

## Disadvantages:

It is difficult to perform arithmetic with such a number system



# Positional Number Systems

- **Characteristics**
  - Use only a few symbols called digits
  - These symbols represent different values depending on the position they occupy in the number



# Decimal Number System

## Characteristics

- A positional number system
- Has 10 symbols or digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9). Hence, its base = 10
- The maximum value of a single digit is 9 (one less than the value of the base)
- Each position of a digit represents a specific power of the base (10)
- We use this number system in our day-to-day life



# Decimal Number System

## Example

$$\begin{aligned} 2586_{10} &= (2 \times 10^3) + (5 \times 10^2) + (8 \times 10^1) + (6 \times 10^0) \\ &= 2000 + 500 + 80 + 6 \end{aligned}$$



# Binary Number System

## Characteristics

- A positional number system
- Has only 2 symbols or digits (0 and 1). Hence its base = 2
- The maximum value of a single digit is 1 (one less than the value of the base)
- Each position of a digit represents a specific power of the base (2)
- This number system is used in computers





# Binary Number System



## Example

$$\begin{aligned}10101_2 &= (1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (1 \times 2^0) \\ &= 16 + 0 + 4 + 0 + 1 \\ &= 21_{10}\end{aligned}$$



# Representing Numbers in Different Number Systems



In order to be specific about which number system we are referring to, it is a common practice to indicate the base as a subscript. Thus, we write:

$$10101_2 = 21_{10}$$



# Bit

- Bit stands for **binary digit**
- A bit in computer terminology means either a 0 or a 1
- A binary number consisting of  $n$  bits is called an  $n$ -bit number



# Octal Number System

## Characteristics

- A positional number system
- Has total 8 symbols or digits (0, 1, 2, 3, 4, 5, 6, 7). Hence, its base = 8
- The maximum value of a single digit is 7 (one less than the value of the base)
- Each position of a digit represents a specific power of the base (8)



# Octal Number System



- Since there are only 8 digits, 3 bits ( $2^3 = 8$ ) are sufficient to represent any octal number in binary

## Example

$$\begin{aligned}2057_8 &= (2 \times 8^3) + (0 \times 8^2) + (5 \times 8^1) + (7 \times 8^0) \\ &= 1024 + 0 + 40 + 7 \\ &= 1071_{10}\end{aligned}$$



# Hexadecimal Number System



## Characteristics

- A positional number system
- Has total 16 symbols or digits (0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F). Hence its base = 16
- The symbols A, B, C, D, E and F represent the decimal values 10, 11, 12, 13, 14 and 15 respectively
- The maximum value of a single digit is 15 (one less than the value of the base)

Number Systems/19ECB231-Digital  
Electronics/E.Ramya/AP/ECE/SNSCT



# Hexadecimal Number System

Each position of a digit represents a specific power of the base (16)

- Since there are only 16 digits, 4 bits ( $2^4 = 16$ ) are sufficient to represent any hexadecimal number in binary

## Example

$$\begin{aligned} 1AF_{16} &= (1 \times 16^2) + (A \times 16^1) + (F \times 16^0) \\ &= 1 \times 256 + 10 \times 16 + 15 \times 1 \\ &= 256 + 160 + 15 \\ &= 431_{10} \end{aligned}$$



# Converting a Number of Another Base to a Decimal Number



## Method

- Step 1: Determine the column (positional) value of each digit
- Step 2: Multiply the obtained column values by the digits in the corresponding columns
- Step 3: Calculate the sum of these products





# Converting a Number of Another Base to a Decimal Number



## Example

$$4706_8 = ?_{10}$$

$$4706_8 = 4 \times 8^3 + 7 \times 8^2 + 0 \times 8^1 + 6 \times 8^0$$

$$= 4 \times 512 + 7 \times 64 + 0 + 6 \times 1$$

$$= 2048 + 448 + 0 + 6 \leftarrow \text{Sum of these products}$$

$$= 2502_{10}$$

Common values multiplied by the corresponding digits



# Converting a Decimal Number to a Number of Another Base



## Division-Remainder Method

- Step 1: Divide the decimal number to be converted by the value of the new base
- Step 2: Record the remainder from Step 1 as the rightmost digit (least significant digit) of the new base number
- Step 3: Divide the quotient of the previous divide by the new base



# Converting a Decimal Number to a Number of Another 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, recording remainders from right to left, until the quotient becomes zero in Step 3

Note that the last remainder thus obtained will be the most significant digit (MSD) of the new base number



# Converting a Decimal Number to a Number of Another Base



## Example

$$952_{10} = ?_8$$

## Solution:

| 8 | 952        | Remainder |
|---|------------|-----------|
|   | <u>119</u> | S 0       |
|   | 14         | 7         |
|   | <u>1</u>   | 6         |
|   | 0          | 1         |

Hence,  $952_{10} = 1670_8$



# Converting a Number of Some Base to a Number of Another Base



## Method

- 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



# Converting a Number of Some Base to a Number of Another Base



## Example

$$545_6 = ?_4$$

Solution:

Step 1: Convert from base 6 to base 10

$$\begin{aligned} 545_6 &= 5 \times 6^2 + 4 \times 6^1 + 5 \times 6^0 \\ &= 5 \times 36 + 4 \times 6 + 5 \times 1 \\ &= 180 + 24 + 5 \\ &= 209_{10} \end{aligned}$$



# Converting a Number of Some Base to a Number of Another Base



Step 2: Convert  $209_{10}$  to base 4

| 4 | 209 | Remainders |
|---|-----|------------|
|   | 52  | 1          |
|   | 13  | 0          |
|   | 3   | 1          |
|   | 0   | 3          |

Hence,  $209_{10} = 3101_4$

So,  $545_6 = 209_{10} = 3101_4$

Thus,  $545_6 = 3101_4$



# Shortcut Method for Converting a Binary Number to its Equivalent Octal Number



## Method

- Step 1: Divide the digits into groups of three starting from the right
- Step 2: Convert each group of three binary digits to one octal digit using the method of binary to decimal conversion





# Shortcut Method for Converting a Binary Number to its Equivalent Octal Number



- Example

- $1101010_2 = ?_8$

- Step 1: Divide the binary digits into groups of 3 starting from right

- 001      101      010

- Step 2: Convert each group into one octal digit

$$001_2 = 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 1$$

$$101_2 = 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 5$$

$$010_2 = 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0 = 2$$

Hence,  $1101010_2 = 152_8$



# Shortcut Method for Converting an Octal Number to Its Equivalent Binary Number



## Method

- 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



# Shortcut Method for Converting an Octal Number to Its Equivalent Binary Number



## Example

$$562_8 = ?_2$$

Step 1: Convert each octal digit to 3 binary digits

$$5_8 = 101_2, \quad 6_8 = 110_2, \quad 2_8 = 010_2$$

Step 2: Combine the binary groups

$$562_8 = \begin{array}{ccc} \underline{101} & \underline{110} & \underline{010} \\ 5 & 6 & 2 \end{array}$$

$$\text{Hence, } 562_8 = 101110010_2$$



# Shortcut Method for Converting a Binary Number to its Equivalent Hexadecimal Number



## Method

- Step 1: Divide the binary digits into groups of four starting from the right
- Step 2: Combine each group of four binary digits to one hexadecimal digit



# Shortcut Method for Converting a Binary Number to its Equivalent Hexadecimal Number

## Example

$$111101_2 = ?_{16}$$

Step 1: Divide the binary digits into groups of four starting from the right

$$\underline{0011} \quad \underline{1101}$$

Step 2: Convert each group into a hexadecimal digit

$$0011_2 = 0 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 = 3_{10} = 3_{16}$$

$$1101_2 = 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 13_{10} = D_{16}$$

Hence,  $111101_2 = 3D_{16}$



# Shortcut Method for Converting a Hexadecimal Number to its Equivalent Binary Number



## Method

- Step 1: Convert the decimal equivalent of each hexadecimal digit to a 4 digit binary number
- Step 2: Combine all the resulting binary groups (of 4 digits each) in a single binary number



# Shortcut Method for Converting a Hexadecimal Number to its Equivalent Binary Number



## Example

$$2AB_{16} = ?_2$$

Step 1: Convert each hexadecimal digit to a 4 digit binary number

$$2_{16} = 2_{10} = 0010_2$$

$$A_{16} = 10_{10} = 1010_2$$

$$B_{16} = 11_{10} = 1011_2$$

Number Systems/19ECB231-Digital  
Electronics/E.Ramya/AP/ECE/SNSCT



# Shortcut Method for Converting a Hexadecimal Number to its Equivalent Binary Number



Step 2: Combine the binary groups

$$2AB_{16} = \begin{array}{ccc} \underline{0010} & \underline{1010} & \underline{1011} \\ 2 & A & B \end{array}$$

$$\text{Hence, } 2AB_{16} = 001010101011_2$$





## Assessment



1. What is Number system?
2. List the different types of number systems.
3. How is converting binary to hexadecimal number system?

Number Systems/19ECB231-Digital  
Electronics/E.Ramya/AP/ECE/SNSCT



**THANK YOU**