Medical Instrumentations Techniques Engineering
Al-Rasheed University College
Second Level

Digital Techniques
Lecture 01

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# NUMBER SYSTEMS: BINARY, OCTAL, AND HEXADECIMAL

The number systems subject is a very important topic in digital techniques because it gives the basics of the types of data and their processing in digital technology and devices. This lecture presents the basics of decimal, binary, octal, and hexadecimal numbers.

Lecture objectives

At the end of this lecture, the student should be able to:

1. Know the types of numbers.

2. Know the methods of representing different types of numbers.

3. Converting binary, octal, hexadecimal to decimal numbers.

TYPES OF NUMBER SYSTEMS
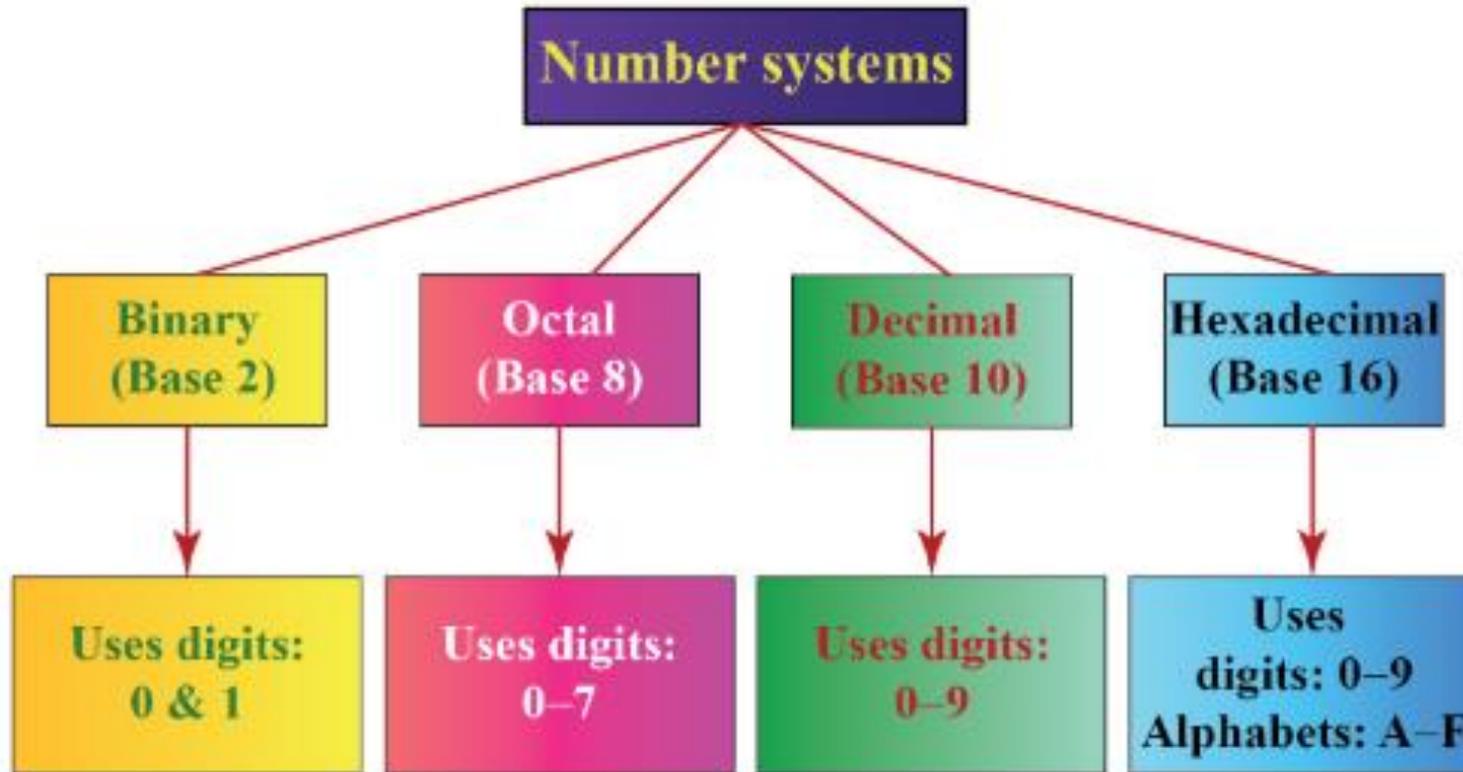
Decimal numbers

This system is composed of 10 numbers or symbols, these 10 symbols are:

0	1	2	3	4	5	6	7	8	9

These symbols are called digits.

The decimal system, also called base-10 system, because it has 10 digits which is a naturally result of the fact that man has 10 fingers. The decimal numbers can be integer of fractional.

Example decimal numbers: $(9485)_{10}$, $(34.234)_{10}$, $(100234)_{10}$

Binary numbers

In this system there are only two symbols or possible digit values that are: 0 and 1

These symbols are called binary numbers and the system called base-2 system.

Example binary numbers: $(101101)_2$, $(11011.010)_2$

Octal numbers

In this system there are 8 numbers or symbols that are:

0	1	2	3	4	5	6	7

These symbols are called octal numbers and the system called base-8 system.

Example octal numbers: $(675)_8$, $(563.43)_8$

Hexadecimal numbers

In this system there are 16 numbers or symbols that are:

0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

These symbols are called hexadecimal numbers and the system called base-16 system.

Representation of Numbers

The following subsections present the method of representing decimal, binary, octal and hexadecimal numbers in addition to the conversion of binary, octal and hexadecimal numbers to decimal numbers.

Representation of decimal numbers

value of digit in "Decimal numeral system"

$$(345)_{10} = 3 \times 10^2 + 4 \times 10^1 + 5 \times 10^0$$

$$(254.67)_{10} = 2 \times 10^2 + 5 \times 10^1 + 4 \times 10^0 + 6 \times 10^{-1} + 7 \times 10^{-2}$$

Representation of binary numbers

$$2^5 \quad 2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0 \qquad 2^{-1} \qquad 2^{-2}$$

$$\dots 654321.1\,2\dots$$

Sixth digit   Fifth digit   Fourt digit   Third digit   Second digit   First digit   First digit   Second digit

$$(101101)_2 = 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1$$
$$+ 1 \times 2^0 = (45)_{10}$$

$$(1011.11)_2 = 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1}$$
$$+ 1 \times 2^{-2} = (11.75)_{10}$$

Representation of octal numbers

$$8^5 \quad 8^4 \quad 8^3 \quad 8^2 \quad 8^1 \quad 8^0 \quad \quad 8^{-1} \quad 8^{-2}$$

$$....654321.1\,2...$$

Sixth digit   Fifth digit   Fourth digit   Third digit   Second digit   First digit   First digit   Second digit

$$(537)_8 = 5 \times 8^2 + 3 \times 8^1 + 7 \times 8^0 = (351)_{10}$$

$$(537.12)_8 = 5 \times 8^2 + 3 \times 8^1 + 7 \times 8^0 + 1 \times 8^{-1} + 2 \times 8^{-2}$$
$$= (351.15625)_{10}$$

Representation of hexadecimal numbers

$$16^5 \quad 16^4 \quad 16^3 \quad 16^2 \quad 16^1 \quad 16^0 \quad 16^{-1} \quad 16^{-2}$$

$$\ldots 654321.12\ldots$$

Fifth digit   Third digit   First digit   First digit

Sixth digit   Fourth digit   Second digit   Second digit

0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

$$(A01B)_{16} = 10 \times 16^3 + 0 \times 16^2 + 1 \times 16^1 + 11 \times 16^0$$

$$= (40987)_{10}$$

$$(F29.15)_{16} = 15 \times 16^2 + 2 \times 16^1 + 9 \times 16^0 + 1 \times 16^{-1} + 5$$

$$\times 16^{-2} = (3881.08203125)_{10}$$

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Exercise (Lecture 01)

Represent the following numbers as you learned in this lecture and convert them to their decimal form:

1- $(8304.27)_{10}$

2- $(11101.011)_2$

3- $(34.27)_8$

4- $(AD8.C)_{16}$