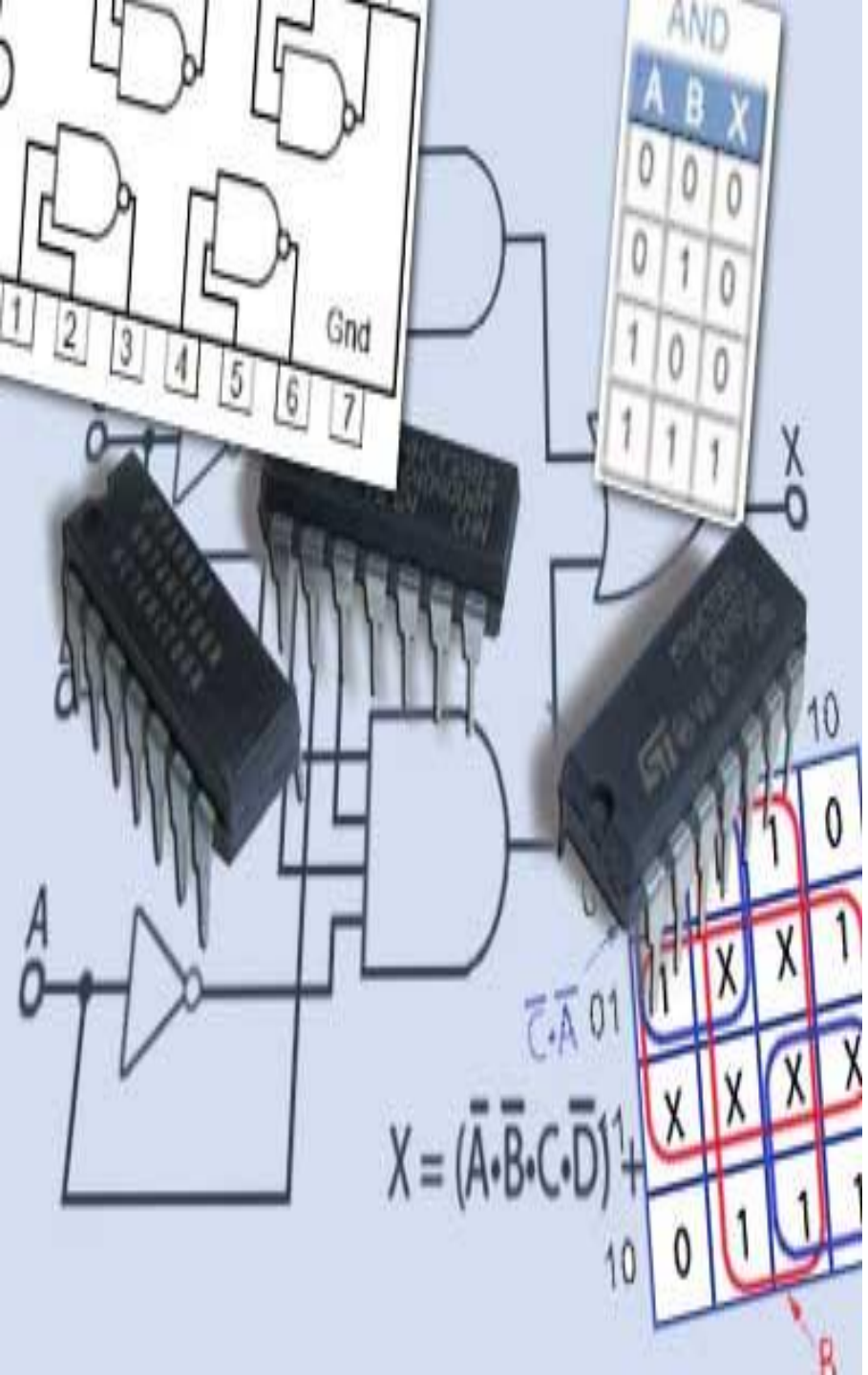

Medical Instrumentations Techniques Engineering
Al-Rasheed University College
Second Level

Digital Techniques

Lecture 02

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NUMBER SYSTEMS CONVERSION

This lecture presents the method of converting binary, octal, and hexadecimal numbers to decimal numbers.

Lecture objectives

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

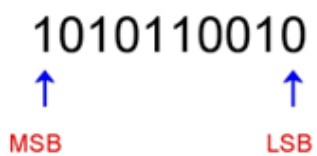
1- Convert decimal numbers to binary, octal, and hexadecimal.
2- Convert octal to binary and vice versa.
3- Convert hexadecimal to binary and vice versa.

Conversion of decimal numbers to other types

The following subsections present the method of converting decimal numbers to binary, octal and hexadecimal numbers.

Conversion of decimal to binary number

To convert the decimal number to binary, divide the number by 2 (the base) until the value is 0. When the number is fractional number, the numbers after point are multiplied by 2. The least significant bit (LSB) and the most significant bit (MSB) are as shown:



Example: Convert the decimal number $(13)_{10}$ to binary.

Step 1: Divide the given number 13 repeatedly by 2 until you get '0' as the quotient

$13 \div 2 = 6$ (Remainder 1)
$6 \div 2 = 3$ (Remainder 0)
$3 \div 2 = 1$ (Remainder 1)
$1 \div 2 = 0$ (Remainder 1)

Step 2: Write the remainders in the reverse order

1 1 0 1

$\therefore 13_{10} = 1101_2$

(Decimal) (Binary)

Example: Convert the decimal number $(36)_{10}$ to binary.

Division by 2	Quotient	Remainder
36 ÷ 2	18	0 (LSB)
18 ÷ 2	9	0
9 ÷ 2	4	1
4 ÷ 2	2	0
2 ÷ 2	1	0
1 ÷ 2	0	1 (MSB)

$(36)_{10} = (100100)_2$

Example: Convert the decimal number $(39.5)_{10}$ to binary.

Division by 2	Quotient	Remainder
39 ÷ 2	19	1 (LSB)
19 ÷ 2	9	1
9 ÷ 2	4	1
4 ÷ 2	2	0
2 ÷ 2	1	0
1 ÷ 2	0	1 (MSB)
Multiplication by 2		
0.5 × 2	1	0
0 × 2	0	

$(39.5)_{10} = (100111.10)_2$

Conversion of decimal to octal number

To convert the decimal number to octal, divide the number by 8 (the base) until the value is 0. When the number is fractional number, the numbers after point are multiplied by 8.

Example: Convert the decimal number $(266)_{10}$ to octal.

Division by 8	Quotient	Remainder
266 ÷ 8	33	2 (LSB)
33 ÷ 8	4	1
4 ÷ 8	0	4 (MSB)

$(266)_{10} = (412)_8$

Example: Convert the decimal number $(20.75)_{10}$ to octal.

Division by 8	Quotient	Remainder
20 ÷ 8	2	4 (LSB)
2 ÷ 8	0	2 (MSB)
0.75 × 8	6	0

$(266)_{10} = (24.6)_8$

Conversion of decimal to hexadecimal number

To convert the decimal number to hexadecimal, divide the number by 16 (the base) until the value is 0. When the number is fractional number, the numbers after point are multiplied by 16.

Example: Convert the decimal number $(423)_{10}$ to hexadecimal.

Division by 16	Quotient	Remainder
423 ÷ 16	26	7 (LSB)
26 ÷ 16	1	10 ⇨ A
1 ÷ 16	0	1 (MSB)

$(423)_{10} = (1A7)_{16}$

Conversion of octal numbers to binary and vice versa

The following subsections present the method of converting octal numbers to their binary form and the reverse.

Conversion of octal to binary number

The conversion from octal to binary is performed by converting each octal digit to its 3-bit binary equivalent as shown in the following table.

Octal	0	1	2	3	4	5	6	7
Binary	000	001	010	011	100	101	110	111

Example: Convert the octal number $(472)_8$ to binary.

Octal	4	7	2
Binary	100	111	010

$(472)_8 = (100111010)_2$

Conversion of binary to octal number

The conversion from binary to octal is performed as follows:

Step1: Group the binary digits into 3's starting at least significant digit (if the number of bits is not evenly divisible by 3, then add 0's at the most significant end).

Step 2: Write the equivalent octal number to each group.

Example: Convert the binary number $(10101110)_2$ to octal.

Binary	10	101	110
Octal	2	5	6

$(10101110)_2 = (256)_8$

Example: Convert the decimal number $(177)_{10}$ to its 8-bit binary equivalent by first converting to octal.

Division by 8	Quotient	Remainder
177 ÷ 8	22	1 (LSB)
22 ÷ 8	2	6
2 ÷ 8	0	2 (MSB)

$(177)_{10} = (261)_8$

Octal	2	6	1
Binary	10	110	001

$(177)_{10} = (10110001)_2$

Conversion of hexadecimal numbers to binary and vice versa

The following subsections present the method of converting hexadecimal numbers to their binary form and the reverse.

Conversion of hexadecimal to binary number

The conversion from octal to binary is performed by converting each octal digit to its 4-bit binary equivalent as shown in the following table.

Hexadecimal	Binary	Hexadecimal	Binary
0	0000	8	1000
1	0001	9	1001
2	0010	A	1010
3	0011	B	1011
4	0100	C	1100
5	0101	D	1101
6	0110	E	1110
7	0111	F	1111

Example: Convert the octal number $(39C8)_{16}$ to binary.

Hexadecimal	3	9	C	8
Binary	0011	1001	1100	1000

$(39C8)_{16} = (0011100111001100)_2$

Conversion of binary to hexadecimal number

The conversion from binary to hexadecimal is performed as follows:

Step1: Group the binary digits into 4's starting at least significant digit (if the number of bits is not evenly divisible by 4, then add 0's at the most significant end).

Step 2: Write the equivalent octal number to each group.

Example: Convert the binary number $(1001111001110000)_2$ to hexadecimal.

Binary	1001	1110	0111	0000
Hexadecimal	9	E	7	0

$(1001111001110000)_2 = (9E70)_{16}$

Example: Convert the binary number (1111110100011)2 to hexadecimal.

Binary	1	1111	1010	0011
Hexadecimal	1	F	A	3

$(1111110100011)_2 = (1FA3)_{16}$

Exercise (Lecture 02)

Answer the following questions:

1- Convert the following numbers to decimal:
$(641)_8, (10011101)_2, (24CE)_{16}$
2- Convert $(3117)_{10}$ to hexadecimal, then from hexadecimal to binary.
3- Convert $(1001011110110101)_2$ to hexadecimal.
4- Convert $(3527)_8$ to hexadecimal.