<u>Digital Logic (CSC 116)</u>

Full Marks: 60(Theory) + 20(Assessment) + 20(Practical)

Pass Marks: 24 + 8 + 8

<u>Text Book</u>: 1. M. Morris Mano, "Digital Logic and Computer Design"

2. Thomas L. Floyd, "Digital Fundamentals"

<u>Unit 1</u>- Digital Signals and Wave forms

Digital signal is a signal that is being used to represent data as a sequence of discrete values. In most digital circuits, the signal can have two possible valid values; this is called a **binary signal** or **logic signal**. They are represented by two voltage bands: one near a reference value (typically termed as *ground* or zero volts), and the other a value near the supply voltage. These correspond to the two values "zero" and "one" (or "false" and "true").

Example of digital wave form: 0101100100

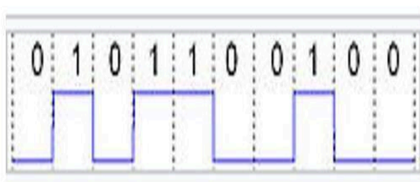


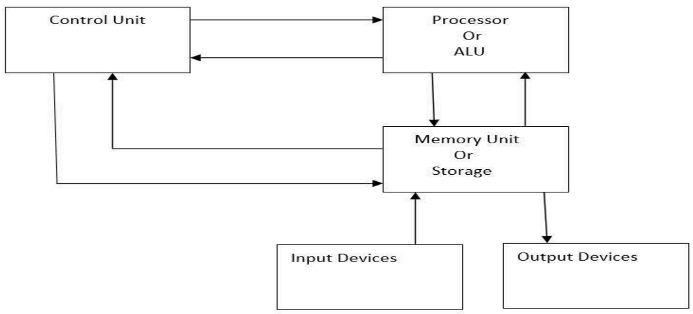
Fig: Digital Wave Form

Analog signal: Analog signal represents continuous values; at any given time it represents a real number within a continuous range of values.

Digital System: Digital system is data technology that uses discrete (discontinuous) values. This system operates on binary digits (signals) 0 and 1. Working of digital computers, communication systems, calculators etc. are based on digital techniques and these systems are known as digital system.

Analog System: An analog system is a system that use analog i.e. continuous range of values to present information. Like voltmeter, automobile speedometer are the example of analog system.

Block diagram of digital computer



Functions or working principle of digital computer:

1. Memory unit stores programs as well as input and output.
2. The control unit supervises the flow of information between various units and retrieves the instructions stored in memory unit.
3. After getting control signal from control unit, memory unit sends the data to the processor.
4. For each instruction, control unit informs the processor to execute the operation according to the instructions.
5. After getting control signal processor sends the processed information to memory unit sends that information to the output unit.

Advantages of digital system:

1. In case of digital system large numbers of ICs are available for performing various operations, hence digital systems are highly reliable, accurate, small in size and speed of operation is very high.
2. Computer controlled digital systems can be controlled by software that allows new functions to be added without changing hardware.

Disadvantages of digital system:

1. It is difficult to install digital system, because it requires many more complex electronic circuits and ICs.
2. In digital systems, if a single piece of digital data lost, large blocks of related data can completely change.

Number System

Number system is concerned with different numbers and representation of that number in different system. It is the set of symbols used to express quantities as the basis for counting, determining order, comparing amounts, performing calculations and representing value. The given number system is determined by the base value of that number.

Base/Radix is defined as the total number of digits available in the number system. On the basis of base the number system is categorized by:

- Decimal Number System
- Binary Number system
- Octal Number System
- Hexadecimal Number System

Decimal Number System: The number system that uses 10 digits from 0 to 9 is known as decimal number system and its base value is 10.

Binary Number System: The number system that consists of only two digits i.e. binary digits 0 and 1 and whose base value is 2 is called binary number system.

Octal number system: Number system that consists of numbers from 0 to 7 is known as octal number system. Its base value is 8.

Hexadecimal Number System: Number system that consists of 16 digits, ten numbers: 0 to 9 and six letters: A, B, C, D, E and F. The letters A, B, C, D, E and F represents the decimal numbers 10, 11, 12, 13, 14 and 15. Its base value is 16.

Equivalence of numbers in different Number Systems:

Decimal	Binary	Hexadecimal	Octal
0	000	0	0
1	001	1	1
2	010	2	2
3	011	3	3
4	100	4	4
5	101	5	5
6	110	6	6
7	111	7	7
8	1000	8	10
9	1001	9	11
10	1010	A	12
11	1011	B	13
12	1100	C	14
13	1101	D	15
14	1110	E	16
15	1111	F	17

Number Base Conversion

Decimal to Binary: Steps to convert a Decimal number to its binary equivalent. **Conversion of Integer part:**

1. Divide the given integer part of decimal number by 2 successively and write down the remainders until the quotient is zero.
2. Write all the remainders starting with the MSB (Most Significant Bit) i.e. from bottom to LSB (Least Significant Bit) i.e. top. **Conversion of Fractional part:**
3. Multiply the given fractional part of decimal number by 2 successively until the fractional part becomes zero.
4. Note down the integer part starting from first.
5. Note: If fractional part does not become zero then, result has been taken up to places

Example: Convert $(25.125)_{10}$ into binary

For Integer part:

2	25	1 (Least Significant Bit)
2	12	0
2	6	0
2	3	1
2	1	1 (Most Significant Bit)
	0	

$(11001)_2$

For Fractional part:

$$0.125 \times 2 = 0.250 \rightarrow 0 \qquad 0.25 \times 2 = 0.50 \rightarrow 0 \qquad 0.5 \times 2 = 1.0 \rightarrow 1$$

$\therefore (25.125)_{10} = (11001.001)_2$

Binary to decimal: Steps to convert a Binary number to its Decimal equivalent.

<u>Conversion of Integer part</u>:

1. Multiply each digit of binary numbers with its place value. The place value of binary number is positive power of 2.
2. Add all the products of multiplication. The total number is the decimal equivalent number of this binary number.

<u>Conversion of Fractional part</u>:

I. Multiply first digit of positional value by 2^{-1} and so on up to last fractional digit. Example:

Convert $(1101.011)_2$ into decimal.

Here;

Given $(1101.011)_2$

$= 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 + 0 \times 2^{-1} + 1 \times 2^{-2} + 1 \times 2^{-3}$

$= 8 + 4 + 0 + 1 + 0 + 1/4 + 1/8$

$= 13 + 0.25 + 0.125$

$= (13.375)_{10}$

Decimal to Octal: Steps to convert a Decimal number to its octal equivalent.

<u>Conversion of Integer part</u>:

1. Divide the given integer part of decimal number by 8 successively and write down the remainders until the quotient is zero.
2. Write all the remainders starting with the MSB (Most Significant Bit) i.e.
3. from bottom to LSB (Least Significant Bit) i.e. top.

<u>Conversion of Fractional part</u>:

1. Multiply the given fractional part of decimal number by 8 successively until the fractional part becomes zero.
2. Note down the integer part starting from first.
3. **Note:** If fractional part does not become zero then, result has been taken up to 6 places.

Example: Convert $(63.0625)_{10}$ into Octal

For Integer part:

8	63	7 (Least Significant Bit)
8	7	7 (Most Significant Bit)
	0	

For Fractional part:

0.0625	0.5
×8	×8
0. 5000	4.0
↓	↓
0	4

$\therefore (63.0625)_{10} = (77.04)_8$

Octal to Decimal: Steps to convert Octal number to its Decimal equivalent.

Conversion of Integer part:

1. Multiply each digit of Octal number with its place value. The place value of octal number is positive power of 8.
2. Add all the products of multiplication. The total number is the decimal equivalent number of this binary number.

Conversion of Fractional part:

1. Multiply first digit of positional value by 8^{-1} and so on up to last fractional digit.

Example: Convert $(61.25)_8$ into decimal.

Here Given,

$(61.25)_8$

$= 6 \times 8^1 + 1 \times 8^0 + 2 \times 8^{-1} + 5 \times 8^{-2}$

$= 48 + 1 + 2/8 + 5/64$

$= 49 + 0.25 + 0.078125$

$= (49.328125)_{10}$

Binary to Octal: Steps to convert Binary number to its octal equivalent.

1.As $8 = 2^3$, for binary to octal conversion groups of 3 binary bits each are formed in the binary number.

2. After forming groups, each group of three binary bits is converted to its octal equivalent.
3. For integer part of the binary number, the group of three bits is formed from right to left. In the binary fraction the group of three bits is formed from left to right.

Example: Convert $(10011010.10001101)_2$ into Octal

Here Given,

$(10011010.10001101)_2$

= 010 011 010 . 100 011 010

$= (232.432)_8$

Octal to Binary: To convert Octal number to its Binary equivalent, each digit of given octal number is directly converted to its 3 – bit binary equivalent.

Example: Convert $(57.342)_8$ into Binary,

Given,

$(57.342)_8$

= 101 111 . 011 100 010

$= (101111.011100010)_2$

Decimal to hexadecimal: Steps to convert a decimal number to its hexadecimal equivalent.

Conversion of Integer part:

1. Divide the given integer part of decimal number by 16 successively and write down the remainders until the quotient is zero.
2. Write all the remainders starting with the MSB (Most Significant Bit) i.e. from bottom to LSB (Least Significant Bit) i.e. top. **Conversion of Fractional part:**

3. Multiply the given fractional part of decimal number by 16 successively until the fractional part becomes zero.
4. Note down the integer part starting from first.

Note: If fractional part does not become zero then, result has been taken up to 6 places.

Example: Convert $(952.62)_{10}$ into hexadecimal
For Integer part:

16	952	8	(Least Significant Bit)
16	59	11	
16	3	3	(Most Significant Bit)
	0		

0.62	0.92	0.72	0.52	0.32	0.12
×16	×16	×16	×16	×16	×16
9.92	14.72	11.52	8.32	5.12	1.92
↓	↓	↓	↓	↓	↓
9	14	11	8	5	1

$\therefore$ $(952.62)_{10} = (3B8.9EB851)_{16}$

Hexadecimal to decimal: Steps to convert a hexadecimal number to its decimal equivalent.

Conversion of Integer part:

1. Multiply each digit of hexadecimal numbers with its place value. The place value of binary number is positive power of 16.
2. Add all the products of multiplication. The total number is the decimal equivalent number of the hexadecimal number.

Conversion of Fractional part:

I. Multiply first digit of positional value by 16^{-1} and so on up to last fractional digit. Example: Convert $(6E.2B)_{16}$ into decimal.

Here;

Given $(6E.2B)_{16}$

$= 6 \times 16^1 + 14 \times 16^0 + 2 \times 16^{-1} + 11 \times 16^{-2}$

$= 96 + 14 + 2/16 + 11/256$

$= 110 + 0.125 + 0.4296875$

$= (110.554688)_{10}$

Binary to Hexadecimal: Steps to convert Binary number to its Hexadecimal equivalent.

1. As $16 = 2^4$, for binary to hexadecimal conversion groups of 4 binary bits each are formed in the binary number.
2. After forming groups, each group of four binary bits is converted to its hexadecimal equivalent.
3. For integer part of the binary number, the group of four bits is formed from right to left. In the binary fraction the group of four bits is formed from left to right.

Example: Convert $(10011010.10001101)_2$ into Hexadecimal

Here Given,

$(1001101011.10001101)_2$

= 0010 0110 1011. 1000 1101

$= (26B.8D)_{16}$

Hexadecimal to Binary: To convert from hexadecimal to its binary equivalent, each digit of the given hexadecimal number is converted to its 4-bit binary equivalent.

Example: Convert $(6D.3A)_{16}$ into binary

Here given,

$(6D.3A)_{16}$

= 0110 1101.0011 1010

$= (1101101.00111010)_2$

Octal to Hexadecimal: Steps to convert from octal to its hexadecimal equivalent.

1. Each digit of given octal number is converted into its 3-bit binary equivalent.
2. Now, form the groups of 4 binary bits to obtain its hexadecimal equivalent

Example: Convert $(46.57)_8$ into binary

$(46.57)_8$

Converting 46.57 first to its 3-bit binary equivalent we get

46.57 = 100 110.101 111

Now forming the groups of 4 binary bits to obtain its hexadecimal equivalent we get, 100110.101111 =

0010 0110.1011 1100

$= (26.BC)_{16}$

Hexadecimal to octal: Steps to convert from hexadecimal to its octal equivalent.

1. Each digit of given hexadecimal number is converted into its 4-bit binary equivalent.
2. Now, form the groups of 3 binary bits to obtain its octal equivalent.

Example: Convert $(5B.3A)_{16}$ into binary

Here given,

$(5B.3A)_{16}$

Converting 5B.3A first to its 4-bit binary equivalent we get, 5B.3A = 0101 1011.0011 1010

Now forming the groups of 3 binary bits to obtain its octal equivalent we get,

01011011.00111010 = 001 011 011.001 110 100 = $(133.164)_8$

Binary Addition:
Rules:

A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	0 (Carry over 1)

```
Example:    1 1 0 1
         +  1 1 1 1
         ----------
          1 1 1 0 0
```

Binary Subtraction:
Rules:

A	B	A-B
0	0	0
0	1	1 (Borrow 1)
1	0	1
1	1	0

```
Example:   1 1 0 0 1
         - 1 0 1 1 0
         -----------
           0 0 0 1 1
```

Binary Multiplication:
Rules:

A	B	A*B
0	0	0
0	1	0
1	0	0
1	1	1

```
Example:  1 1 0 1
           X1 0 1
        ---------
          1 1 0 1
        0 0 0 0
    + 1 1 0 1
    -------------
    1 0 0 0 0 0 1
```

Binary Division:

Example: 11101 / 101

```
101) 1 1 1 0 1 ( 1 0 1
    - 1 0 1
     -------
      0 1 0 0
      - 0 0 0
     --------
        1 0 0 1
        -1 0 1
     ----------
         1 0 0
```

R = 100
Q= 101