SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

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Lecture session 1

SCSA1201- FUNDAMENTALS OF DIGITAL SYSTEMS

TOPIC: Number system, Number system conversion Binary arithmetic

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UNIT 1

NUMBER SYSTEMS,COMPLEMENTS AND CODES

1.Number Systems – Binary Numbers-Number base conversions-Octal and Hexa Decimal Numbers

2. Complements

3.Signed Binary Numbers-Binary Arithmetic

4. Binary Codes-Decimal Code-Error Detection code-Gray Code- Reflection and Self Complementary codes-BCD number representation – Alphanumeric codes ASCII/EBCDIC

5.Hamming Code- Generation, Error Correction

INTRODUCTION TO DIGITAL SYSTEM

A Digital system is an interconnection of digital modules and it is a system that manipulates discrete elements of information that is represented internally in the binary form.

Now a day's digital systems are used in wide variety of industrial and consumer products such as

1.automated industrial machinery
2.pocket calculators
3.microprocessors
4.digital computers
5.digital watches
6.TV games and signal processing .etc.,

Characteristics of Digital systems

- Digital systems manipulate discrete elements of information.

- Discrete elements are nothing but the digits such as 10 decimal digits or 26 letters of alphabets and so on.

- Digital systems use physical quantities called signals to represent discrete elements.

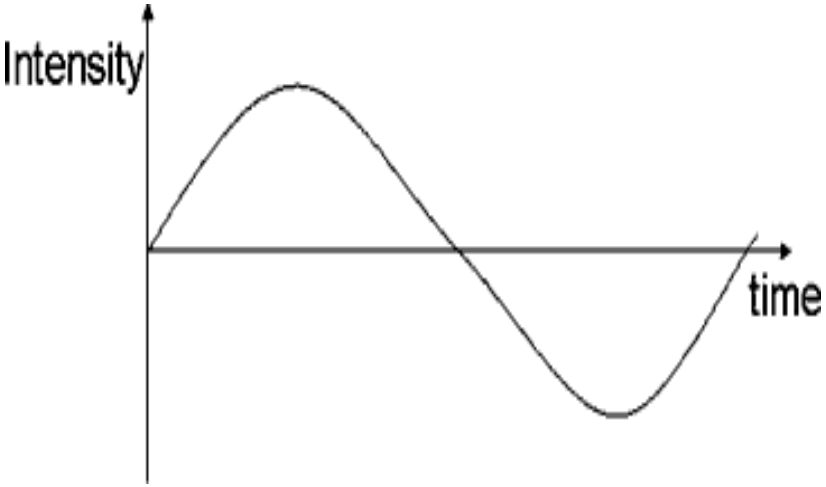
- In digital systems, the signals have two discrete values and are therefore said to be binary.

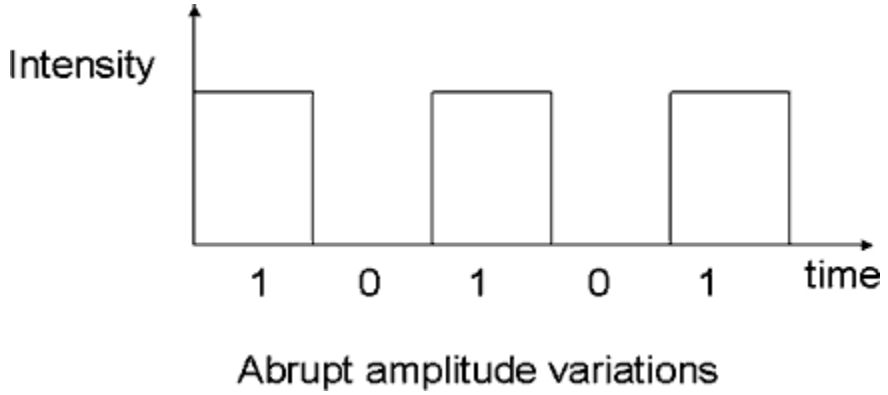
- A signal in digital system represents one binary digit called a bit. The bit has a value either 0 or 1.

Analog systems vs Digital systems

Analog system process information that varies continuously i.e; they process time varying signals that can take on any values across a continuous range of voltage, current or any physical parameter.

Digital systems use digital circuits that can process digital signals which can take either 0 or 1 for binary system.





Advantages of Digital system over Analog system

1. Ease of programmability
2. Reduction in cost of hardware
3. High speed
4. High Reliability
5. Design is easy
6. Result can be reproduced easily

Disadvantages of Digital system over Analog system

1.Use more energy than analog circuits
2. Digital circuits are often fragile, in that if a single piece of digital data is lost or misinterpreted the related data can completely change.
3.Digital computer manipulates discrete elements of information by means of a binary code.
4. Quantization error during analog signal sampling.

NUMBER SYSTEMS

- Binary Number system
- Decimal Number system
- Octal Number system
- Decimal Number system

To define any number system we have to specify

- Base of the number system such as 2,8,10 or 16.
- The base decides the total number of digits available in that number system.
- First digit in the number system is always zero and last digit in the number system is always base-1.

Binary number system:

The binary number has a radix of 2. As r = 2, only two digits are needed, and these are 0 and 1. In binary system weight is expressed as power of 2.

Decimal Number system

The decimal system has ten symbols: 0,1,2,3,4,5,6,7,8,9. In other words, it has a base of 10.

Octal Number System

Digital systems operate only on binary numbers. Since binary numbers are often very long, two shorthand notations, octal and hexadecimal, are used for representing large binary numbers. Octal systems use a base or radix of 8. It uses first eight digits of decimal number system. Thus it has digits from 0 to 7.

Hexa Decimal Number System

The hexadecimal numbering system has a base of 16. There are 16 symbols. The decimal digits 0 to 9 are used as the first ten digits as in the decimal system, followed by the letters A, B, C, D, E and F, which represent the values 10, 11,12,13,14 and 15 respectively.

Decimal	Binary	Octal	Hexadecimal
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Number Base conversions

Binary to other number system

The human beings use decimal number system while computer uses binary number system.

Therefore it is necessary to convert decimal number system into its equivalent binary.

i) Binary to octal number conversion

ii) Binary to hexa decimal number conversion

The binary number:	001	010	011	000	100	101	110	111
The octal number:	1	2	3	0	4	5	6	7

The binary number:	0001	0010	0100	1000	1001	1010	1101	1111
The hexadecimal number:	1	2	5	8	9	A	D	F

Octal to other Number system

Octal to binary

Each octal number converts to 3 binary digits

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

To convert 653_8 to binary, just substitute code:

6 5 3

↓ ↓ ↓

110 101 011

(1) $(7612)_8$ to Binary.

7 - 111

6 - 110

1 - 001

2 - 010

$(111110001010)_2$

(2) $(536.62)_8$ to Binary.

5 - 101

3 - 011

6 - 110

6 - 110

2 - 010

$(101011110.110010)_2$

Octal to Decimal conversion

Convert (4057.06)8 to Decimal

=4x8^3+0x8^2+5x8^1+7x8^0+0x8^-1+6x8^-2

=2048+0+40+7+0+0.0937

=(2095.0937)10

Octal to hexadecimal conversion:

The simplest way is to first convert the given octal no. to binary & then the binary no. to hexadecimal.

Ex: 756.603_8

7	5	6	.	6	0	3
111	101	110	.	110	000	011
0001	1110	1110	.	1100	0001	1000
1	E	E	.	C	1	8

Hexadecimal to octal conversion:

First convert the given hexadecimal no. to binary & then the binary no. to octal.

Ex: B9F.AE16

B	9	F	.	A	E		
1011	1001	1111	.	1010	1110		
101	110	011	111	.	101	011	100
5	6	3	7	.	5	3	4

=5637.534

Hexadecimal to Decimal Conversión

Ex: $(5C7)_{16}$ to decimal

=(5x16^2)+(C x16^1)+ (7 x16^0)
=1280+192+7
=14710

Decimal to hexadecimal.

1. $(464)_{10}$ to hexa.

$16 \mid 464$

$16 \mid 29 - 0$

$1 - D$

$(1D0)_{16}$

---

2. $(121.650)_{10}$ to hexa.

$16 \mid 121$

$7 - 9$

$0.650 \times 16 = A + .400$

$0.400 \times 16 = 6 + 0.400$

$0.400 \times 16 = 6 + 0.400$

$0.400 \times 16 = 6 + 0.400$.

$(79.A666\ldots)_{16}$

Decimal to octal.

(1) $(153)_{10}$ to octal.

8 | 153		
8 | 19	-1	$= (231)_8$
2	-3	

(2) $(645.926)_{10}$ to octal.

8 | 645	
8 | 80	-5
8 | 10	-0
1	-2

$0.926 \times 8 = 7 + .4080$

$0.4080 \times 8 = 3 + .2640$

$0.264 \times 8 = 2 + 0.112$

$0.112 \times 8 = 0 + 0.869$

$0.869 \times 8 = 7 + 0.168$

$0.168 \times 8 = 1 + 0.334$

$0.334 \times 8 = 2 + 0.752$

Ans: $(1205.732071 2\cdots)_8$

Convert $(21.6875)_{10}$ to binary.

$2 \mid 21$

$2 \mid 10 - 1$

$2 \mid 5 - 0$

$2 \mid 2 - 1$

$1 - 0$

$(10101)_2$

$0.6875 \times 2 = 1.3750$

$= 1 + 0.3750$

$0.3750 \times 2 = 0.7500$

$= 0 + 0.7500$

$0.7500 \times 2 = 1.5000$

$= 1 + 0.5000$

$0.5000 \times 2 = 1.0000$

$= 1 + 0.0000$

$(10101.1011)_2$

$(1011)_2$

BINARY ARITHMETICS

Addition

It is a key for binary subtraction, multiplication, division. There are four rules of binary addition.

In fourth case, a binary addition is creating a sum of (1 + 1 = 10) i.e. 0 is written in the given column and a carry of 1 over to the next column.

Example

0011010 + 001100 = 00100110

11	carry
0011010	$=26_{10}$
+0001100	$=12_{10}$
0100110	$=38_{10}$

Case	A + B	Sum	Carry
1	0 + 0	0	0
2	0 + 1	1	0
3	1 + 0	1	0
4	1 + 1	0	1

Subtraction

Subtraction and Borrow, these two words will be used very frequently for the binary subtraction. There are four rules of binary subtraction.

Case	A - B	Subtract	Borrow
1	0 - 0	0	0
2	1 - 0	1	0
3	1 - 1	0	0
4	0 - 1	0	1

Example

0011010 - 001100 = 00001110

```
    1 1      borrow
  0 0 1 1 0 1 0   = 26(10)
- 0 0 0 1 1 0 0   = 12(10)
-----------------
  0 0 0 1 1 1 0   = 14(10)
```

Multiplication

Example:

0011010 x 001100 = 100111000

$$
\begin{array}{rl}
0011010 & = 26_{10} \\
\times 0001100 & = 12_{10} \\
\hline
0000000 & \\
0000000 & \\
0011010 & \\
0011010 & \\
\hline
0100111000 & = 312_{10}
\end{array}
$$

Division

Binary division is similar to decimal division. It is called as the long division procedure.

Example

101010 / 000110 = 000111

```
                111      = 7₁₀
          ____________
000110 ) 101010          = 42₁₀
         -110            = 6₁₀
         ____
          1001
          -110
          ____
           110
           -110
           ____
              0
```

Thank you

Queries?