Paper 7, TDC Part-3
Chapter– 3, Number Systems and Codes
Electronics
Lecture - 1

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Number Systems and Codes

- **Introduction: -**

To deal with different aspects of life people need some number systems. For day to day activities in our life we use decimal number system to represent numerical value certain quantities.

Decimal Number System has an ordered set of 10 digits (symbols) – 0,1,2,3,4,5,6,7,8,9. So the base or radix of this number system is 10. Any number that we use to represent numerical value is collection of these 10 symbols.

Example- 1234, 34.72, 0.11 etc

Number Systems and Codes

1234 is an integer number

34.72 has 2 parts, One in integer part equal to 34 while other is fractional part equal to 0.72.

0.11 is a fractional number

To represent any numerical value we need at least 2 digits or symbols.

So depending on the number of symbols or digits used, some other number systems are also there.

For example- Binary, Octal, Hexadecimal etc number systems

Number Systems and Codes

Binary, Octal, Hexadecimal number systems are widely used in digital systems like microprocessor, computers, logic circuits etc.

As in first chapter we see that the digital circuit deal with only two types of signals ‘High’ or ‘1’ and ‘Low’ or ‘0’. So such number systems is sufficient which has two digits. These two digits will be sufficient to express any numerical value. Binary number systems use only two digits- 0 and 1. So for Digital circuits we will use binary number system.

Number Systems and Codes

Data, that may be in any form – Alphabets, Numerical value represented by other number systems, Special characters are processed by the digital circuits. These data is required to be converted into binary data so that it can be understood by Digital circuits for processing.

To convert these data into binary format, process of coding is employed whereby each type of data is coded into a unique combinations of 0s and 1s. This process of coding is called Encoding.

Number Systems and Codes

Different types of codes (coding scheme) are in use in digital systems to serve different operations such as arithmetic calculations, error detection and correction etc. This coding is achieved by code converter circuits.

- **Number Systems : -**

In any number systems there is an ordered set of digits (symbols). To form a number these digits are placed side by side and each position in the number is assigned a weight or index.

Number Systems and Codes

Collection of digits makes a number, which has two parts- 'integer' and fractional.

These two parts are set apart by a radix point (.)

So a number N can be in below format

$$(N)_b = \underbrace{d_{n-1}d_{n-2}\ldots d_i\ldots.d_1d_0}_{\text{Integer Portion}} . \underbrace{d_{-1}d_{-2}\ldots.d_{-f}\ldots.d_{-m}}_{\text{Fractional Portion}}$$

Radix Point

Where N = A number,

b = base or radix of number system

n = number of digits in integer portion

m = number of digits in fractional portion

Number Systems and Codes

d_{n-1} = most significant digit

d_m = least significant digit

and

$0 <= (d_i \text{ or } d_{-f}) <= b-1$

Details of commonly used number systems-

Number System	Base or Radix (b)	Digits Used	Weight assigned to position I	Weight assigned to position -f	Example
Binary	2	0,1	2^i	2^{-f}	1101.101
Octal	8	0,1,2,3,4,5,6,7	8^i	8^{-f}	671.04
Decimal	10	0,1,2,3,4,5,6,7,8,9	10^i	10^{-f}	8901.59
Hexadecimal	16	0,1,2,3,4,5,6,7,8,9, A,B,C,D,E,F	16^i	16^{-f}	4EAF.1B7

Number Systems and Codes

- **Binary Number Systems : -**

A number system that uses only two digits or symbols ‘0’ and ‘1’ to represent any numbers or characters or special characters is known as the *binary number systems*. So the base or radix of this number system is 2.

These 0’s and 1’s in a representation is referred as ‘bits’. Group of 4 bits is called ‘nibble’ while group of 8 bits or 2 nibbles is called ‘byte’.

Similar to decimal number system, the left most bit is known as the most significant bit (MSB) and the right most bit is known as least significant bit (LSB).

Number Systems and Codes

Examples- 1011, 11111, 10001, 10110.00101 etc

Depending on the number of bits available in a binary number we called it 1-bit, 2-bit, 3-bit, 4-bit ….. binary number.

1-bit binary number can represent $2^1 = 2$ numbers that is ‘0’ and ‘1’.

Similarly 2-bit binary number can represent $2^2 = 4$ numbers that is ‘0’, ‘1’, ‘2’ and ‘3’.

Similarly 3-bit binary number can represent $2^3 = 8$ numbers that is ‘0’, ‘1’, ‘2’, ‘3’, ‘4’, ‘5’, ‘6’ and ‘7’.

Number Systems and Codes

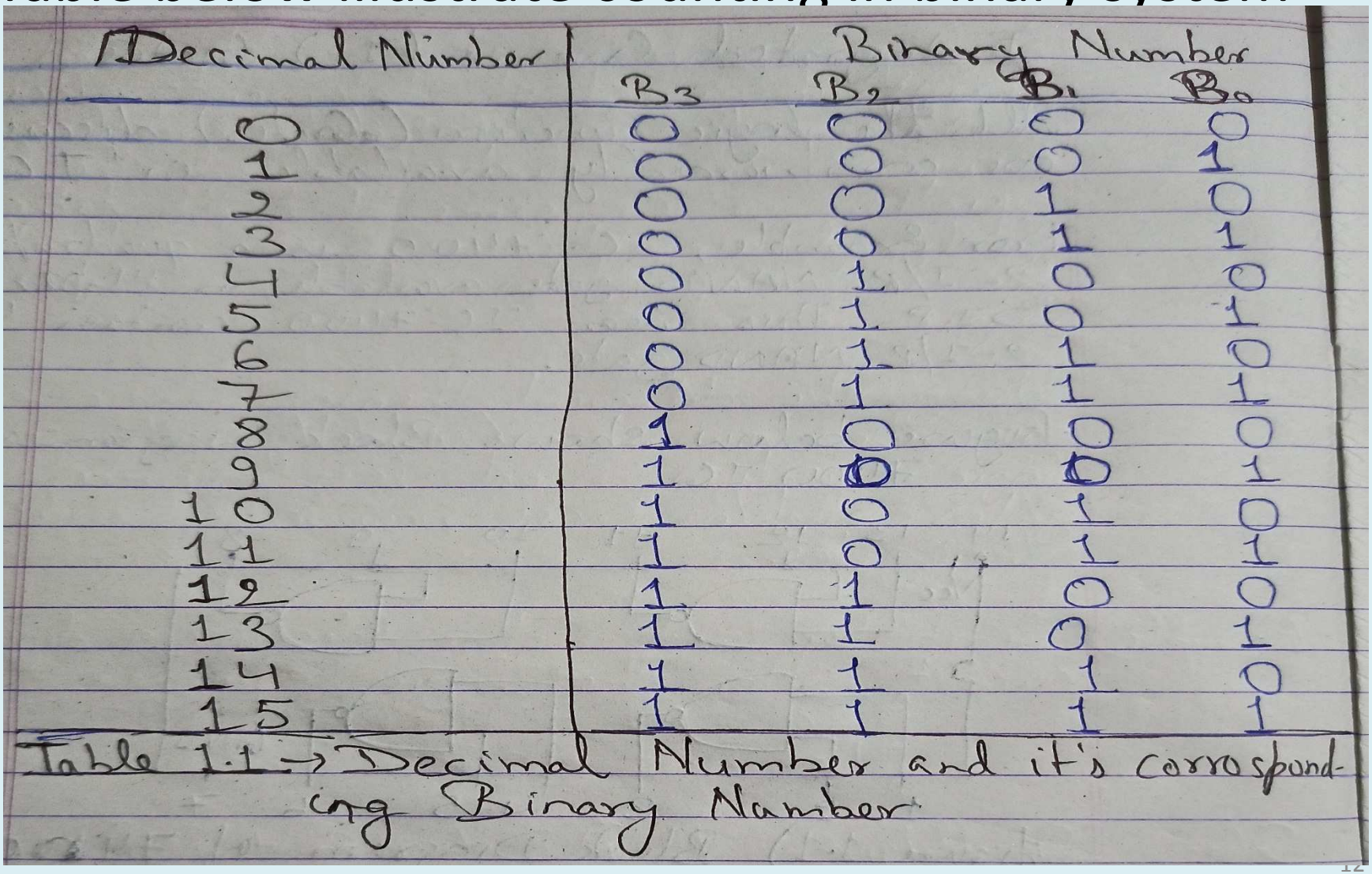
So n-bit binary number can represent 2^n numbers that is ‘0’, ‘1’,…….. upto (2^n -1).

Example- To count from 0 to 29 that is total of 30 quantities in binary system we need 2^5 >= 30 means 5- bit binary numbers.

The position of a 0 or 1 in a binary number indicates its weight, or value within the number, just as the position of a decimal digit determines the value of that digit. The weights in a binary number are based on powers of 2.

Number Systems and Codes

Table below illustrate counting in binary system



Decimal Number	Binary Number B_3	B_2	B_1	B_0
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

Table 1.1 → Decimal Number and it's corresponding Binary Number