B.C.A. Science : Semester-II

COMPUTER ORGANIZATION

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NIRALI PRAKASHAN
ADVANCEMENT OF KNOWLEDGE

Text Book Of

COMPUTER ORGANIZATION

For
B.C.A. Science : Semester - II

As Per New Syllabus

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Price ₹ 200.00

NIRALI PRAKASHAN
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N3866

Computer Organization

Second Edition : January 2018

Published By :
NIRALI PRAKASHAN
Abhyudaya Pragati, 1312, Shivaji Nagar
Off J.M. Road, PUNE – 411005
Tel - (020) 25512336/37/39, Fax - (020) 25511379
Email : niralipune@pragationline.com

Printed By :
STAR COPIERS PVT. LTD.
Kumthekar Road, Sadashiv Peth
Pune - 411 030
Tel - (020) 24479201

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Preface ...

We take an opportunity to present this book entitled as **"Computer Organization"** to the students of **B.C.A. Science, Semester-II** as per the New Syllabus, June 2016-2017.

The book covers theory of Data Representation and Computer Arithmetic, Logic Gates, Combinational Circuits, Sequential Circuits, CPU Organization, Memory Organization, I/O Organization and Architecture of Microprocessor 8086 and Parallel Processing.

A special words of thank to Shri. Dineshbhai Furia, Mr. Jignesh Furia for showing full faith in us to write this text book. We also thank to Mr. Amar Salunkhe and Mr. Akbar Shaikh of M/s Nirali Prakashan for their excellent co-operation.

We also thank Ms. Chaitali Takale, Mr. Ravindra Walodare, Mr. Sachin Shinde, Mr. Nilesh Deshmukh, Mr. Ashok Bodke, Mr. Moshin Sayyed and Mr. Nitin Thorat.

Although every care has been taken to check mistakes and misprints, any errors, omission and suggestions from teachers and students for the improvement of this text book shall be most welcome.

Authors

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    1.1 Decimal, Binary, Octal, Hexadecimal Number system and their Inter-conversion, BCD Code, Gray Code, Excess-3 Code, ASCII , EBCDIC, Unicode, Concept of Parity Code. Signed and Unsigned Numbers, 1's and 2's Complement of Binary Numbers, Binary Arithmetic (Addition, Subtraction and Subtraction using 1's Complement and 2's Complement).

2. **Logic Gates (09 L)**

    2.1 Introduction to Digital Signal, Positive and Negative Logic Concept, Logic Gates – Statement, Symbol, Expression and Truth Table of Basic and Derived Logic Gates (AND, OR, NOT, XOR, XNOR, NOR, NAND), Boolean Algebra and Identities, De-Morgan's Theorem and Inter Conversion of Logic Gates.

3. **Combinational Circuits (07 L)**

    3.1 Half Adder, Full Adder, Half Subtractor, Parallel Adder, Nibble Adder, Multiplexer (up to 4 to 1 MUX), and Demultiplexer (up to 1 to 4 DEMUX), Encoder (Decimal to BCD Encoder and 3 Bit Priority Encoder), Decoder (3 to 8 Line Decoder using Gates only).

4. **Sequential Circuits (08 L)**

    4.1 Concept of Sequential Circuits; Latch, Flip-flops RS, Clocked RS, JK, T, D, Counter – (Types: Synchronous, Asynchronous), Upto 3 Bit Up, Down and Up-Down Counter (Asynchronous only), Modulo-N Counter, Shift Register (IC 7495), Ring Counter, Johnson Counter.

5. **CPU Organization (07 L)**

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6. **Memory Organization (08 L)**

    6.1 Memory System Overview, Memory Design, Cache Memory, Internal Memory, External Memory, Virtual Memory.

7. I/O Organization (08 L)

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8. Architecture of Microprocessor 8086 and Parallel Processing (07 L)

8.1 Block Diagram of 8086, 8086 Registers, Numerical Coprocessor Concept and Block Diagram and Functional Diagram of Numerical Co-processor. Concept of Parallelism, Parallel Computer Structures, Concept of Pipeline, Instruction Pipeline, Arithmetic Pipeline, Concept of RISC and CISC.

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CHAPTER 1

Data Representation and Computers Arithmetic

Contents ...

1.1 INTRODUCTION

- Data representation refers to the internal method used to represent various types of data stored on a computer. Computers use different types of numeric codes to represent various forms of data, such as text, number, graphics and sound.

- In all modem computers, storage and processing units are made of a set of silicon chips and each containing a large number of transistors.
- A transistor is a two-state electronic device that can be put OFF and ON by passing an electric current through it. Since, the transistors are sensitive to currents and act like switches, we can communicate with the computers using electric signals, which are represented as a series of "pulse" and "no-pulse" conditions.
- For the sake of convenience and ease of use, a pulse is represented by the code "1" and a no-pulse by the code "0". They are called bits, an abbreviation of "binary digits". A series of 1's and 0's are used to represent a number or a character and thus they provide a way for humans and computers to communicate with each.
- Information is therefore organised in groups of bits, usually eight bits. A group of eight bits is referred to as a byte, derived from "by eight". A byte may represent a number, a letter, a mathematical symbol and so on.
- Computer arithmetic deals with the study, design, optimization and validation of theoretical and practical means of computing operations such as addition, subtraction, multiplication, division etc.
- Various representations of numbers (or number systems) can be used depending on the application and implementation constraints like integer, fixed point, floating point etc.
- In our daily life, we see electronic calculators, computers, microprocessors etc. perform operations like addition, subtraction, multiplication and division. These devices use various number systems.
- The system in which an ordered set of digits are used to specify any number is called number system.
- A number system is defined as, "a set of values used to represent quantity".
- There are two types of number system as explained below:

1. Non Positional Number Systems:

- In ancient times, people used to count with their fingers. When fingers became insufficient for counting, stones and pebbles were used to indicate values. This method of counting is called the non-positional number system.
- In non-positional number system, we have symbols like I for 1, II for 2, III for 3, IIII for 4 etc. Each symbol represents the same value regardless of its position in a number and to find the value of a number, one has to count the number of symbols present in the number.
- Non-positional number system is also called unitary number system.
- The most common non-positional number system is the Roman Number System.

2. **Positional Number Systems:**

- A positional number system is any system that requires a finite number of symbols/digits of the system to represent arbitrarily large numbers.
- When using these systems the execution of numerical calculations becomes simplified, because a finite set of digits is used. The value of each digit in a number is defined not only by the symbol, but also by the symbol's position.
- The most popular positional number system being used today is the Decimal Number System.

Base or Radix in Number System:

- The base or radix of a number system defines the range of possible values that a digit may have.
- A number in the number system of base or radix (r) is represented by a set of symbols from r distinct symbols. The decimal number system uses 10 digits from 0 to 9, thus its base is 10. The binary number system uses two distinct digits 0 and 1, thus its base is 2. For octal number system (base r = 8), a number is represented by 8 distinct digits 0 to 7. The 16 symbols used in hexadecimal number system (base 16) are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E and F. Here, the symbols A, B, C, D, E, and F correspond to the decimal numbers 10, 11, 12, 13, 14, and 15 respectively.

1.2 NUMBER SYSTEMS AND THEIR INTER-CONVERSIONS

1.2.1 Decimal Number System

- The number system that uses ten digits (or symbols), viz. 0,1,2,3,4,5,6,7,8 and 9 is called a decimal number system.
- Deci means 10. There are only 10 basic digits ranging from 0 to 9.
- The decimal position values as power of 10 are as shown in Fig. 1.1.

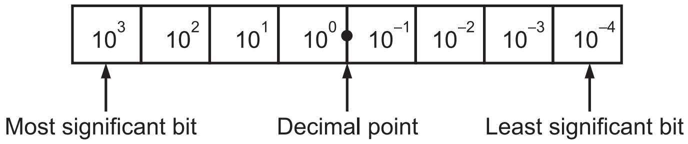


Fig. 1.1

- In this case the Most Significant Digit (MSD) and Least Significant Digit (LSD) are the left most and the right most digit respectively.

- For example, the decimal number 1275 (written 1275_{10}) can be expanded as follows :

1 2 7 5_{10}

$5 \times 10^0 = 5 \times 1 = 5$

$7 \times 10^1 = 7 \times 10 = 70$

$2 \times 10^2 = 2 \times 100 = 200$

$1 \times 10^3 = 1 \times 1000 = \underline{1000}$

$\mathbf{1275_{10}}$

- For example, $(4234)_{10}$ in decimal number system can be written as,

$= (4 \times 10^3) + (2 \times 10^2) + (3 \times 10^1) + (4 \times 10^0)$

$= (4 \times 1000) + (2 \times 100) + (3 \times 10) + (4 \times 1)$

$= 4000 + 200 + 30 + 4 = 4234$

1.2.2 Binary Number System

- The number system which uses only two digits (or symbols), viz. 0 and 1 and the base is 2 is called a binary number system.
- Naturally, the base (or radix) in this number system is 2. It uses only two digits namely 0 and 1.
- The bit positions in a binary system have weights as shown in Fig. 1.2.

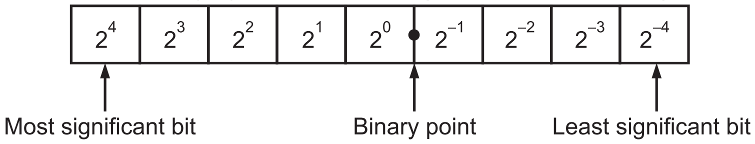


Fig. 1.2

- The leftmost bit in a given binary number with highest weight is called a Most Significant Bit (MSB). The right most bit in a given binary number with the lowest weight is called Least Significant Bit (LSB). Similarly, the point in a given binary number which acts as the indicator between positive and negative exponents is called binary point.
- For example, value of $(11100)_2$

$= (1 \times 2^4) + (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (0 \times 2^0)$

$= 16 + 8 + 4 + 0 + 0$

$= 28$

1. **Binary to Decimal Conversion:**

- Any binary number can be converted to its equivalent decimal number by adding together the weights of various positions in the binary number which contain 1.

- **Examples:**

(i)

$$\begin{aligned} (1011)_2 &= (?)_{10} \\ (1011)_2 &= \begin{array}{cccc} 1 & 0 & 1 & 1 \\ \downarrow & \downarrow & \downarrow & \downarrow \\ 2^3 & 2^2 & 2^1 & 2^0 \end{array} \\ &= (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) \\ &= 8 + 0 + 2 + 1 \\ &= (11)_{10} \end{aligned}$$

(ii)

$$\begin{aligned} (0111.11)_2 &= (?)_{10} \\ (0111.11)_2 &= \begin{array}{ccccccc} 0 & 1 & 1 & 1 & \cdot & 1 & 1 \\ \downarrow & \downarrow & \downarrow & \downarrow & & \downarrow & \downarrow \\ 2^3 & 2^2 & 2^1 & 2^0 & & 2^{-1} & 2^{-2} \end{array} \\ &= 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^0 + 1 \times 2^{-1} + 1 \times 2^{-2} \\ &= 0 + 4 + 2 + 1 + \frac{1}{2} + \frac{1}{4} \\ &= (23.75)_{10} \end{aligned}$$

(iii)

$$\begin{aligned} (110110)_2 &= (?)_{10} \\ \therefore \quad & \begin{array}{cccccc} 1 & 1 & 0 & 1 & 1 & 0 \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 \end{array} \\ &= (1 \times 2^5) + (1 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (0 \times 2^0) \\ &= 32 + 16 + 4 + 2 \\ &= (54)_{10} \end{aligned}$$

(iv)

$$\begin{aligned} (10001011)_2 &= (?)_{10} \\ \therefore \quad & \begin{array}{ccccccc} 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow & \downarrow \\ 2^6 & 2^5 & 2^4 & 2^3 & 2^2 & 2^1 & 2^0 \end{array} \\ &= (1 \times 2^6) + (0 \times 2^5) + (0 \times 2^4) + (1 \times 2^3) + (0 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) \\ &= 64 + 8 + 2 \\ &= (74)_{10} \end{aligned}$$

(v)

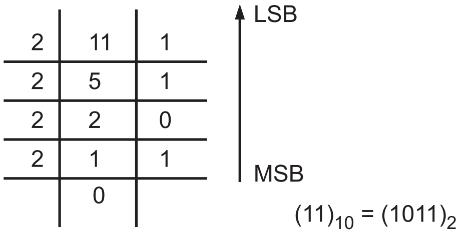
$$\begin{aligned} (10001011)_2 &= (?)_{10} \\ \therefore \quad & \begin{array}{cccccccc} 1 & 1 & 0 & 0 & \cdot & 0 & 1 & 0 \\ \downarrow & \downarrow & \downarrow & \downarrow & & \downarrow & \downarrow & \downarrow \\ 2^3 & 2^2 & 2^1 & 2^0 & & 2^{-1} & 2^{-2} & 2^{-3} \end{array} \\ &= (1 \times 2^3) + (1 \times 2^2) + (0 \times 2^1) + (0 \times 2^0) + (0 \times 2^{-1}) + (1 \times 2^{-2}) + (0 \times 2^{-3}) \\ &= 8 + 4 + \frac{1}{4} \\ &= (12.25)_{10} \end{aligned}$$

2. Decimal to Binary Conversion:

- For converting decimal numbers to binary, the decimal number is repeatedly divided by 2 and writing the remainder after each division, until a quotient 0 is obtained.

- Binary equivalent is obtained by writing the last remainder as the most significant bit and first remainder as the least significant bit, as the direction of arrow points upwards.
- **Examples:**

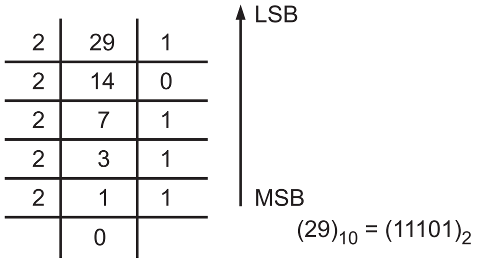
(i) $(11)_{10} = (?)_2$



2	11	1
2	5	1
2	2	0
2	1	1
	0	

$(11)_{10} = (1011)_2$

(ii) $(29)_{10} = (?)_2$.



2	29	1
2	14	0
2	7	1
2	3	1
2	1	1
	0	

$(29)_{10} = (11101)_2$

1.2.3 Octal Number System

- The number system which has the base (or radix) 8 and uses only eight digits or symbols, viz. 0, 1, 2, 3, 4, 5, 6 and 7 is called octal number system.
- The various digit positions in this system have weights as shown in Fig. 1.3.

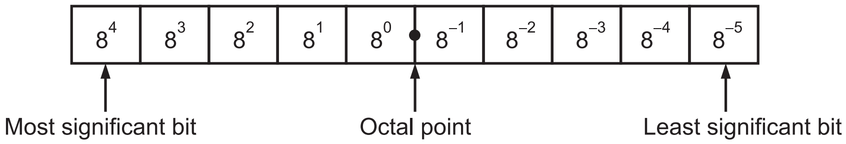


Fig. 1.3

- For example, $(4131)_8$ is,

$$= (4 \times 8^3) + (1 \times 8^2) + (3 \times 8^1) + (1 \times 8^0)$$

$$= 4 \times 512 + 1 \times 64 + 3 \times 8 + 1 \times 1$$

$$= 2048 + 64 + 24 + 1$$

$$= 2137$$

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