Programming for BASIC

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Second Edition

PROGRAMMING for BASIC

SECOND EDITION

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PROGRAMMING FOR BASIC

To my Daughter
SREE VIDYA

Preface

This book introduces the concepts of computer programming of the BASIC (Beginners All-purpose Symbolic Instruction Code) language. After the introduction of Micro-computers in India in 1980, these computers have made a dent in almost all walks of life. Even companies having an yearly turn-over of just more than Rs. 2 crores have started buying or using these computers, which have revolutionized the computer world itself. Every month about 10 to 15 new micro-computers are being installed in India and their impact will be felt in the days to come. They are being used for Business, Industry, Science, Engineering, and in many other day-to-day applications. All these computers have BASIC translators. The presentation in this book mostly conforms to the BASIC developed at Dartmouth College, though some variations to this standard Basic have also been presented for wider use of this book.

BASIC possesses three important advantages over the other computer languages : (1) it is easy to learn ; (2) it offers powerful additional facilities for the most advanced user ; and above all (3) it is designed for interactive use rather than batch mode processing. These advantages make it more suitable for the non-professional. In many computer schools, BASIC is taught as the first language to understand the principles of programming. The interactive nature of BASIC helps the user correct his errors as and when they arise. This type of interactive approach is interesting and extremely important to the new user and speeds up the learning process (with computer as a companion).

The level of presentation is elementary to enable readers with little mathematical background to follow the text. Any reader who has knowledge of algebra up to the higher secondary standard and can think logically can understand the text. All the concepts presented in this book are illustrated with examples. This will enable readers to use the book effectively for self-study. Though the examples presented in this book have been developed for the DEC-10 system, with little modifications, they can be run on other computer systems. A number of tables have also been included to help the readers to know about the facilities available in other types of computers.

The present text is the second edition of the book "Programming for Basic." The warm reception accorded to the first edition encouraged the author to rewrite the book incorporating the latest developments in programming methodology like structured programming. The general spirit of the earlier edition has been carried into this edition. However, all the chapters have been revised, a number of new examples and explanations have been added to make the text more clear. In addition, a new chapter on *File Handling Facilities* is included. Most of the example programs were tested by the author using PET Commodore Series 2001 and CDC

6600 computers when he was with the Technical University of Berlin, Federal Republic of Germany. For this he is thankful to the Alexander von Humboldt Foundation and to Prof. Dr.-Ing. habil. J. Lindner. A few of these examples were tested using the author's own UPTRON S-800 micro-computer system.

This book also provides the newcomer to computer science with an overview of computer hardware. More emphasis is given to micro-computers, since it's population is increasing at an alarming rate in India. One more additional feature of this book is that whenever and wherever possible the most widely used FORTRAN language features are compared with that of BASIC. This will enable the readers, who are already familiar with that language, to understand the principles of BASIC more quickly.

A book on computers and programming cannot claim much originality except in the nature of presentation of the material. Needless to say, the author's experience in computer programming, acquired over the past 8-9 years of computation, has been based on numerous ideas acquired from several books and articles on this subject. Some of these are listed at the end of each chapter.

The author would like to express his gratefulness to all his friends, students and numerous readers of the first edition of this book, who helped him to improve the book by their constructive criticism. Sincere thanks are due to Professor S. Sampath, Director, Indian Institute of Technology, Kanpur, without whose encouragement, the author might not have attempted writing this book at all.

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Madras **Dr. N. Subramanian**

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Computers and Programming Languages

1.1 INTRODUCTION

A Computer is basically a calculating machine, capable of performing the operations of addition, subtraction, multiplication and division. It can store the data and make use of it at a later stage. It can perform billions of computations in a few minutes. It can give intellectual results as a human brain.

Computers are today being used for a wide range of commercial, scientific, engineering and other applications. Apart from dealing with numbers, computers have also been used for non-numerical work such as proving theorems, playing chess, etc.

1.2 TYPES OF COMPUTERS

Present day Computers can be divided into two major types—analog and digital, according to the manner in which they represent data. The analog computer does not compute directly with numbers; rather it measures, continuous physical magnitudes (e.g., pressure, temperature, voltage, speed, etc.) which represent or are analogous to the numbers under consideration. The examples of analog computers are: (1) the widely used slide rule, which permits computations by the movement of one length along another, (2) the thermometer which represents the temperature in analog form. Analog computers are used for scientific and engineering applications; because they deal with quantities that are continuously variable, they give only approximate results.

The digital computer, on the other hand, operates by counting numbers or, in other words, it represents information in discrete form. It operates directly on numbers expressed as digits in the familiar decimal system. These are more accurate than the analog computers since there is no analogous representation. This computer is best suited for business as well as scientific and engineering applications.

There is also a third type of computer called the hybrid computer which combines analog and digital capabilities. Hybrid computers are used for some special applications.

The digital computer can be further divided into two classes: *special purpose* computers and *general purpose* computers. A special purpose computer, as the name implies, is designed to solve a specific type or class of problems. The computers used in ships or aircrafts to solve

navigational problems are examples of special purpose computers. These computers produce results quickly and efficiently but cannot be used to perform other operations unless their circuits are redesigned. A general purpose computer is one that has the ability to perform a variety of operations. It can store different programs. In the remainder of this book, the term computer will be taken to represent the general purpose digital computer.

1.3 HISTORY OF COMPUTERS

1.3.1 Early Calculating Devices

The performing of simple arithmetic calculations on one's fingers is a well known example of a computing function. Historians start the history of calculations with the abacus (a wooden frame with balls strung on wires) and describe its development as early as 5000 and 2000 B. C. The abacus is still used in many countries as a calculating aid for children. Although the storage was limited to one number, it introduced the concept of storing data. In the seventeenth century, Napier, a Scots mathematician invented computing rods which are called Napier's Bones.

To Blaise Pascal of France goes the credit of inventing in 1671, the first digital gear-driven calculating machine. The working principles of today's computer were provided by an English mathematician, Charles Babbage around 1890. In 1923 he invented the "difference engine", a machine which would calculate and print tables of functions by using finite difference technique. He also proposed an Analytical Engine which had four components, viz., storage device, arithmetic unit, control unit and input-output device. It is interesting to note that these four basic elements are used in our present day computers.

In the nineteenth century, Herman Hollerith developed techniques and machines that had a significant impact on the future design of computers. Dr. Hollerith invented modern punched card technique. He designed a device called the census machine, which could handle 50-80 cards per minute. The 80 column card of Hollerith measured 7.5 by 12.5 cm.

After World War II, there was a need for increased calculations. Realizing this need, Dr. Howard Aiken with the support of IBM installed the Mark I Computer at Harvard University in 1944. This machine used punched tape and cards and operated on the principle of sequential control as developed by Babbage.

1.3.2 Electronic Digital Computers

The first electronic calculator called ENIAC (Electronic Numerical Integrator and Calculator) was installed by Dr. John Mauchley and Presper Eckert Jr. at the University of Pennsylvania in 1945. It occupied a room measuring 9m by 15m and contained 18,000 vacuum tubes and 1500 relays. It could perform 5,000 additions in one second. The internal operations in this machine were conducted by electronic impulses generated at a rate of 1,00,000 per second.

John von Newmann, renowned as one of the world's great mathematicians, conceived the idea of "Stored Program" to replace the cumbersome and complicated wired control panels of ENIAC. One of the first computers using this concept was built by the Moore School personnel and the Ballistics Research Laboratory of the U.S. Army in 1948, at the University of Pennsylvania. This computer was called EDVAC (Electronic Discrete Variable Automatic Computer) and had a storage capacity of 1024 words of 44 bits each.

The 1950's saw the beginning of the take over of computer manufacture by commercial concerns from the Government and University Laboratories. Remington Rand built the first commercially available computer (UNIVAC I) in 1951. In 1950, the IBM developed a general purpose computer (IBM 650) which had a magnetic drum as its storage device. In the period between 1954 and 1958 numerous computers were introduced in the market by several manufacturers.

In the first generation of computers vacuum tubes were used. The second generation of computers started with the introduction of transistorized computers. The transistor performed the same functions as the vacuum tube, was much less expensive, required little power and generated much less heat than the vacuum tubes. By 1958, most of the computers produced used transistors, and as a result, computers became smaller in size and cost, and could be operated much faster.

The third generation of computers was introduced in 1964 by IBM with its 360 line of computers, which used integrated circuits in the hardware. It also had the provision of facilities for time sharing and multiprogramming. Almost all computers introduced after 1965 were declared by their manufacturers to be third generation computers. Due to the integrated circuitry, these computers were much faster and smaller than the second generation computers.

1.3.3 Mini and Midi Computers

The term mini computer was first used after the introduction of a few computers introduced in 1962, designed exclusively for aerospace applications. This was followed by the marketing of the first commercially available DEC PDP-5 mini computer at a cost of 27,000 U.S. dollars in 1963 and the PDP-8 at a cost of 17,000 Dollars and many others from 1965. Some of the characteristic features of the mini co;mputer are : (1) its CPU measures approximately 48 cm $\times$ 23 cm $\times$ 52 cm (2) its word size can generally be taken as 16 bits* (machines with 8, 12, 18, 24 and 32 bits word length are also available); (3) it has a core memory of 4-32 K (1K =1024 words) words(machines with 64 K and 128 K words are also available); and (4) its cost is around 25,000 U.S. dollars for a minimum and usable configuration.

It can be said that the mini computer does the same job that the large computer can do, but it cannot do so many jobs so fast, and there are a few specialized large computer jobs that it cannot do at all.

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*'bit' is an abbreviation for binary digit: both 'word' and 'number' represent a coded combination in the respective computer languages based on words and numbers.

1.3.4 Micro Computers

It is the development in micro-electronics caused by the Large Scale Integrated Circuit (LSI) Technology in the early seventies that gave birth to micro computers. These are very small computers, low in price and consisting of only a few LSI Circuit packages. The organisation of the micro computer is based on that of the mini computer, but the former uses the LSI chips only for memory and logic circuits.

Microcomputers like main-frame computers manipulate information represented by binary digits, called bits. Groups of bits are called words and word sizes vary from micro processor to microprocessor as 4,8,12 and 16 bits (32 bits being still at the planning stage). The word-length determines the characteristics of different microprocessors.

A microcomputer needs to store program steps and data and recall them at the appropriate time in order to perform its function. In situations where the memory values do not change, read only memory (ROM) is used to store program steps and data values. Read-write memory (RWM), also called random access memory (RAM), is used to store data which change during the operation of the system.

Microcomputers are making an impact on the design of virtually all digital systems. They are increasingly finding applications in systems which formerly used random logic. In Complex systems, a microprocessor is preferred to hardwired random logic, because of the flexibility in programming, simplified design, reduced cost and higher reliability. The microprocessor cost continues to diminish as integration moves up from a ingle LSI chip with 8000 to 10000 transistors to a single VLSI chip apable of incorporating 100,000 transistors. A micro-computer with 8K words of memory costs about 1000 U.S. dollars. Compared to the ENIAC which weighed 30 tons and occupied 15,000 sq.ft. of space and which could perform about 5,000 additions per second, the present day microcomputers are not only 1,000 times faster but they are compact desk-sized machines, keeping every thing within an operators reach.

Microcomputers fall under the categories of single-chip microprocessors, single-chip analog-signal microprocessors, and with a family of co-processors and I/O processors to form a high-throughput computer.

After the Government of India policy to allow the production of micro and mini computers in India, a number of companies are manufacturing them. Virtually all microprocessors in India are imported and are based on popular components available from U.S. industries as follows.

1. Intel series : 4004 (4 bit), 8080/8085 (8-bit), 8086 (16 bit)
2. Zilog series : Z80 (8 bit), Z8000 (16 bit)
3. Motorola series : 6800 (8 bit), 6800(16 bit)
4. Texas instruments series TI 990 (8 bit), TI 9900 (16 bit)

Out of 80 Indian firms licensed in the past two or three years to produce microcomputers, about 15 to 20 firms have gone on stream. The total turnover of Indian microcomputers is around Rs. 50 crores per annum. Some of the manufacturers who are producing these machines are Electronics Corporation of India, Hyderabad (Micro-78, TDC 12, 312, 316, System 332), Bharat Electronics Ltd., Bangalore (mini computer peripherals), Hindustan Computers, Delhi (8C, System 4), ICIM, Bombay

(2904, S-101), DCM Data Products, Delhi (Spectrum 1-7, Galaxy 9,11,21, Micro-1121), ORG, Baroda (2001, 80), Nelco, Bombay (4000, 8000), PSI, Bangalore (Action Station, Omni, Data Wealth) Uptron, Lucknow (S-800), MMC, Bangalore (MMC 201, 401), IDM, Bombay (IDM-30), WIPRO, Bombay (86 Series), BPL, Bangalore (IDB-8) and Zenith Computers Ltd., Bombay (ORION 8000). After the introduction of these micro computers, many companies and banks have acquired them for their data processing use. It is estimated that there are about 600-800 main frame computers in India. The number of micro computers, which was introduced only in the 1980's, is constantly increasing, and is estimated to be around 2000.

To give an idea of the speed and capabilities, Intel 8080 microprocessor has a set of 78 instructions, instruction execution speed of 2-9 microseconds, RAM speed of 500 nanoseconds, and ROM Speed of 600 nanoseconds. As regards cost, while a microprocessor chip was priced at $160 in 1974, chips with new and improved performance are available in the $5 to $20 range all over the world.

A comparison of the various aspects of mini, micro and main frame computers is presented in Table 1.1.

Table 1.1

Comparison of Mini, Micro and Main-Frame Computers

	Main Frame Computer	Mini Computer	Micro Computer	Desk Top Computer
Example	IBM 370/168	PDP 11/45	DCM Spectrum 7	PET Commodore
Cost (Rupees)	1-10 crores	6-25 lakhs	2-6 lakhs	1-2 lakhs
Word length (bits)	32-64	12-32	8-16	4-8
Memory capacity 8 bit bytes	8.4 million	256 kb*	64 kb	32 kb
Processor add time	0.13 μs	0.9 μs	2.0 μs	>3 μs
Max I/o data rate (bytes/Sec)	16 million	4 million	5 lakhs	1-2 lakhs
Peripherals	All types	Wide variety	Paper tape floppy disk Mag. tape	non-Standard floppy-disk
Languages	all	all	Pascal Fortran Basic, Cobol PL/1	Basic
Software	All types	Wide variety	limited	limited

* 1 kb=1024 bits

1.4 ORGANIZATION OF COMPUTER COMPONENTS

Although the details of the construction and operation of an overall computer system are not directly discussed in this book, the following comments are given to help the reader to become oriented to the machine with which he will be conversing. Fig. 1.1 gives a rough idea of the functional construction of a computer. The arrows show the direction of the flow or the sequences of electrical pulses which represent the information sent from one point to another. A program and any associated data are introduced into the computer by an input unit which converts the given information, for example, alphabetic or numerical symbols, into the appropriate sequence of electrical pulses. This information passes into the control unit which directs all the computer's activities. The control unit decides what must be done (as per the instructions of the programmer) and by using the memory unit and the arithmetic unit causes the program to be executed. (The memory unit is used for storing the program and data until they are needed, and the arithmetic unit performs the actual arithmetic and logic operations as indicated by the program). When the execution of a particular program is over, the results and other informations are sent to the output unit which transforms this information into a form understandable to a human.

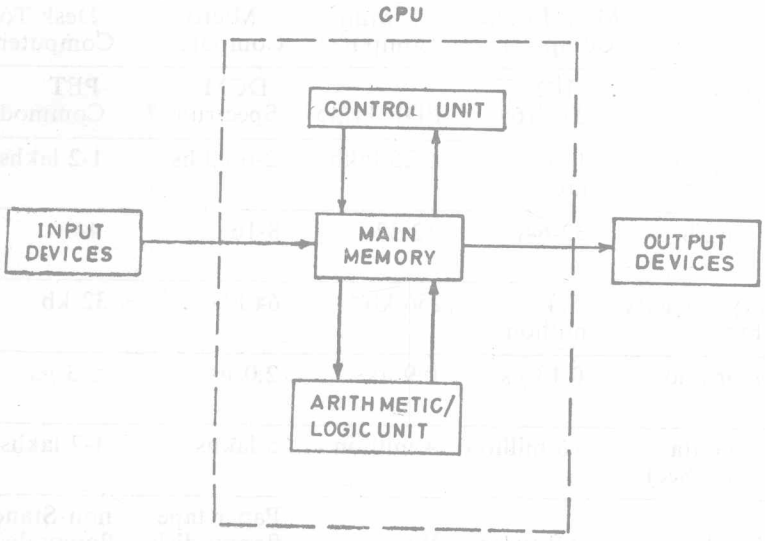

Fig. 1.1. Organization of basic computer components

The control, memory and arithmetic units are usually thought of as a single unit and called the central processing unit (CPU).

The input and output devices are usually called *Peripheral devices*. Input devices can read data recorded as holes punched into cards or paper tapes; or they can accept data typed at a keyboard terminal. Card and paper-tape readers are relatively slow, but also relatively inexpensive. Data can also be stored is magnetic tapes, discs, and drums, and called by the computer whenever required. These units are often called *secondary*

storage of the computer in contrast to the memory unit which is called the *primary storage*. Keyboard-terminal units such as console typewriters, teletypewriters and visual-display devices can provide a direct link between the user and the computer while a program is running.

Output devices accept results from CPU and write the results for human use or for input to subsequent programs or machines other than computers. These units can record information on cards, paper tape, magnetic tapes, discs or drums. They can print the information on paper or direct the same information to visual-display devices. A high speed digital printer is usually used when much data is to be printed. A console typewriter can be used for short outputs. Output to be read by other programs may be punched into cards or paper tape. Magnetic tapes, discs and drums are used to store massive amounts of data.

1.4.1 Magnetic Diskettes

Magnetic floppy diskettes, which look like an ordinary LP record are often used with a micro computer. Hence we will discuss about them in detail in the following paragraphs. These diskettes are available in 5 in. or 8 in. diameters, (standard being 8 in. diameter). Single sided or double sided diskettes with single or double densities are also available. Two different types of floppies are available. viz. Soft sectored (generally referred to as IBM or IBM compatible format) and hard sectored.

The hard sectored format is further divided into several variations of which the primary types are the hard sector inner diameter (ID) often called as the "shugart type" and the hard sector outer diameter (OD) often called as the "Memorex type".

These diskettes will have $1\frac{1}{2}$'' diameter hole in the center for mounting them in the diskette drive. These diskettes are permanently enclosed in a flexible square plastic envelope. The inside of the envelope is covered with a special non-woven fiber to permit easy rotation of the disk while providing a continuous wiping or cleaning action for the surface of the diskette.

With all these formats, there is a large slot type opening in the envelope which exposes a portion of the disk surface. This is the opening through which the read-write head of the recording system comes in contact with the disk.

In the soft sector format there is an additional small circular hole in the envelope near the center hole. There is also one hole through the disk itself, which when lined up with the hole in the jacket serves as an index to signal the beginning of recorded material on the diskette. The ID hard sectored format is nearly identical in appearance to the IBM format but with one significant difference. Instead of just one index hole through the disk, there are 32 holes to signal the beginning of each of the diskette's 32 sectors. However there will be only one index hole in the jacket for both these floppy disks. In both soft sector format and the ID hard sector format there is often a small write protect notch on one edge of the disk jacket.

In the OD hard sector format also there will be a small index hole, but it will be far away from the center as indicated in Fig. 1.2. Both

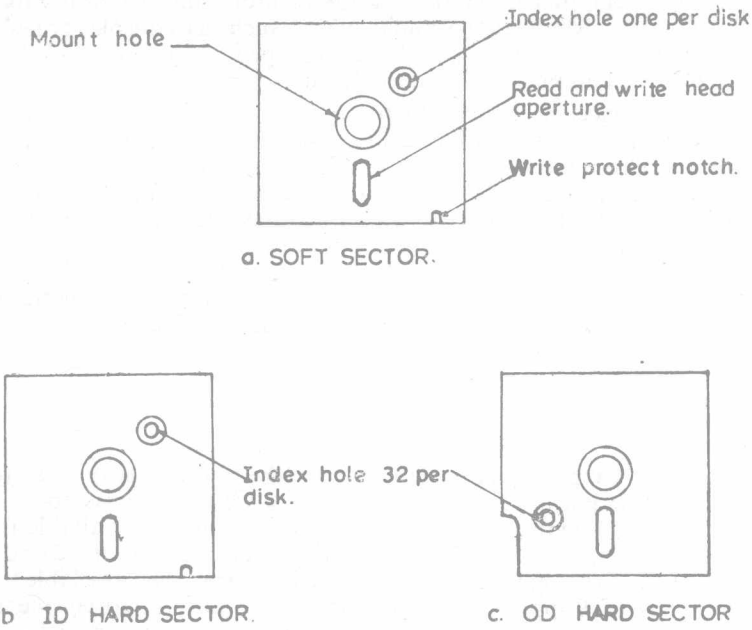

Fig. 1.2. Different type of Diskettes

ID and OD disks have 32 sector holes, but in OD type they circle the dish near the outer edge. One other noticeable difference with OD hard sectored disk is a small cornered "notch" in the lower left corner of the jacket.

In the IBM soft sector format, a series of 77 tracks are recorded around the disk in concentric circles beginning at the outer edge and proceeding towards the center. The disk is further divided into 26 wedges, called sectors. Each track can hold 128 bytes of information. Thus a typical single sided single density floppy has a secondary storage of 256 kb and a double sided, double density floppy 1 mb. (Double sided floppies should be used with a floppy drive having two heads, one above and one below to engage both sides of the floppy).

Each of the tracks in the soft sector format is identified by a double digit number beginning with 00 and proceeding to 77. The sectors are also assigned numbers from 01 to 26. With the disk having 77 tracks and 26 sectors, the combination gives a total of 1976 (track 00 is not used for data recording) distinct and discrete recording areas, which can be specified by calling out the track numbers, say 05 and the sector number, for example 17. A zero is used to separate the track number and sector number. Thus in this example 05017 is a specific and complete "address" on the disk. The information or data which is recorded or stored at a specific address is called as a *record.*

When soft sector disks are delivered, they are usually initialized. This means that record indexes have been pre-recorded at the beginning of