Computer Organization: Input/output and data storage devices

1.1 Computer

A computer is an electronic device that manipulates data provided to it according to a set of instructions called program. A computer is essentially used as a data processor. The user provides the data to the computer through input (section 1.3.1) and the computer after processing the data provides information to the user through output (section 1.3.2). The computers have been classified into three categories. These are:

(a) Analog Computer
(b) Digital Computer
(c) Hybrid Computer

1.1.1 Analog computer

As is evident from the name itself the computations are carried out with the analog information or continuous physical quantities such as temperature, length, current, voltage, time etc. It is made up of operational amplifiers, transistors, resistors and capacitors. Analog computers are faster in calculations as they operate by measuring rather than counting, but their accuracy is poor in comparison to digital computers. The accuracy of the results depends upon the circuit parameters like tolerance of capacitors and resistors, offset voltage of Op Amp etc. They are mostly used in engineering and scientific applications e.g. Weighing balance.

1.1.2 Digital computer

The digital computer processes discontinuous data. It converts the data into digital form (i.e. binary digits 0 and 1) and operates on these digits. The result provided by this computer is accurate. The size of this computer is much smaller than analog computer. These computers are used in business and scientific applications.

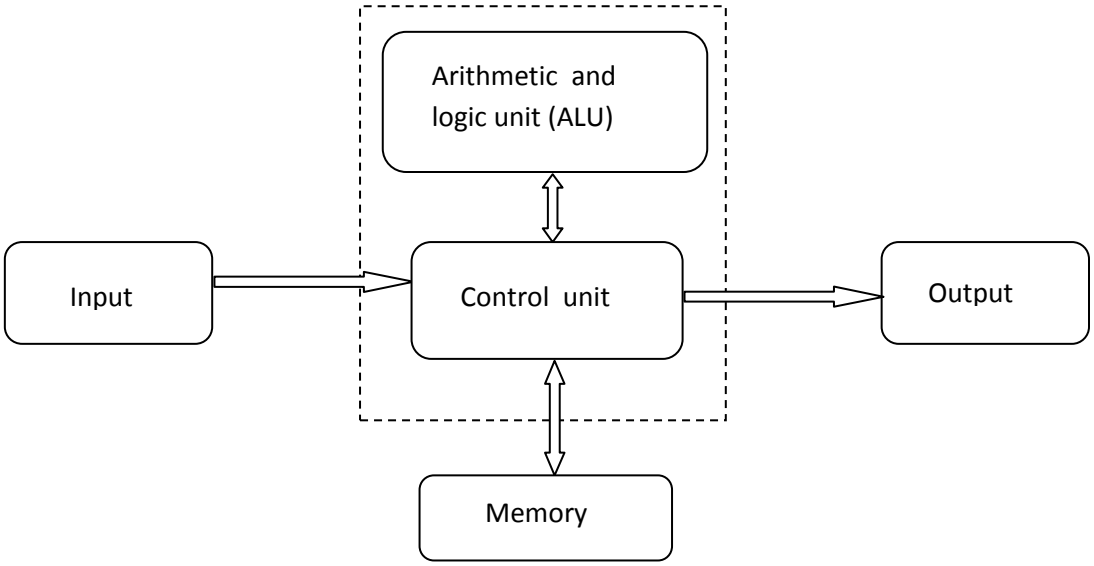
1.1.3 Hybrid computers

The best qualities of both digital and analog computers are utilized by hybrid computer. Calculations are done using analog as well as digital techniques. These computers are used in weather forecasting and hospitals for measurement of blood pressure, temperature and heart beat.

The digital computers are used almost everywhere but analog and hybrid computers perform specialized task.

1.2 Computer organization

Figure 1.1 Schematic diagram of a computer



1.2.1 Input/output unit

The input unit links the computer with external world/devices. It performs following functions:-(a) accepts or reads the data from the outside world (b)converts this data into computer understandable form i.e. binary form (c) supply the binary data to computer for further processing.There are several input devices which can be attached to the input unit for example mouse, keyboard, joystick, digital camera, optical character reader, scanner etc.

The output unit is the one which performs the task exactly opposite to what is done by the input unit, that is (a) accepts the results from computer, which are in coded form (b)converts the results to user readable form (c) transfer the results to the desired output device. Some of the commonly used output devices are monitor or visual display unit(VDU), printer, plotter etc.

1.2.2 Central processing unit (CPU)

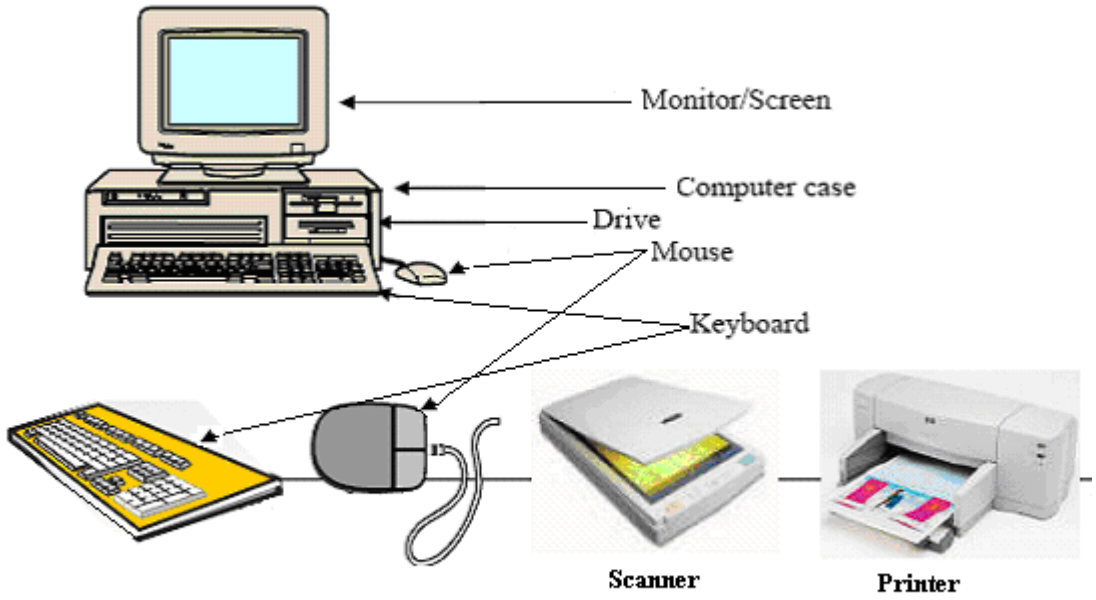
CPU is the brain of the computer it has two important components (1) Arithmetic and logic unit (ALU) and (2) control unit (CU). All arithmetic (+,-,*, /) and logical operations (<,>, =) are performed by ALU.

The CU synchronizes the functioning of different units by sending control signals. Another important function of CU is to decode, interpret and execute the instruction.

1.2.3 Memory unit

Memory unit of computer is known as main memory or primary memory. It is volatile or temporary memory i.e. data is lost as soon as power is switched off therefore secondary memory is required which can store data permanently, the details of which will be discussed later in this unit.

Figure 1.2 Diagram showing different components of computer



1.3 Input/output devices

We are going to discuss some of the important and commonly used input and output devices.

1.3.1 Input devices

Mouse:

Mouse controls movement of the pointer on the screen when it is moved over a flat surface. A ball under the mouse rotates when it is moved and turns two rods one for up/down movement and one for left/right movement of the pointer. It is ideal to use with desktop computers but not convenient in case of laptop, palmtop or notebook computers.

Figure 1.3 Mouse

Keyboard:

Keyboard is the most common device used for entering text as well as numerical data along with arithmetic (+,-,*, /) and logical symbols. Each individual key is a switch, which when pressed sends a digital code to the computer.

Figure 1.4 Keyboard

Magnetic strip reader:

Magnetic strips are thin strips of magnetic tapes found on the back of credit and debit cards. When card is inserted into ATM (Automatic Teller Machine)the tapes slide past a play back head, reads the data from the strip and passes it to a computer. It is simple to use and cheap to produce. The data can be altered when required. However the disadvantage is that they have small storage capacity and data can be destroyed easily by strong magnetic field.

Sensors:

They detect changes in physical and chemical environment and convert them into electrical signals. These signals can be digitized and used by the computer.

Bar Code Reader:

Bar codes commonly found on packaging are sequence of bars and spaces of different thickness. These codes give information about the name and country of the manufacturer and the product itself such as price. A bar code reader uses laser beam to read this information. Bar codes are fast and reliable methods of data input but only limited amount of information can be given.

Figure 1.5 Bar code

Optical Mark Reader:

Optical mark reader is used in multiple-choice examination answer sheets and application forms. It is similar to bar code reader but uses infra-red light to scan marks. It provides a very fast and accurate method of inputting large amount of data, provided the optical marks are clear and accurate.

Scanner:

Scanners digitize the image of a page or an object. A slow moving light scans the surface of the page and the colors of the reflected light are detected and digitized to build up a digital image. The advantage is that high resolution images can be generated but the disadvantage is that the digital images generated occupy large memory.

1.3.2 Output devices

Monitors:

Screen, monitor or Visual display unit (VDU) is the most common output device which can display text or graphics in a wide range of colors in the most reliable way. Different types of monitors based on the technologies used are:

Cathode ray tube (CRT):

- Use cathode ray tube as used in traditional televisions.
- CRT consists of electron gun at the back of the tube which emits electrons that strike on the group of phosphor dots coating present on the inner side of the screen. In colored monitors one red, one green and one blue dot constitute group of dots. One group of dots is called pixel (picture element).

- Spacing of the pixels determines the clarity or resolution of the screen image. Three standards currently in use are:

VGA (Video Graphic Arrays) 640 × 480 pixels.
SVGA (Super Video Graphic Arrays) 800 × 600 pixels.
XGA (Extended Graphic Arrays) 1024 × 768 pixels.

Liquid crystal displays (LCDs):

- LCDs consist of tiny crystals; these crystals polarize the light passing through them when the charge is applied across them. They are used in watches and calculators as they consume much less power as compared to normal monitors.

Thin Film Transistors (TFTs):

- TFTs use more advanced technology and therefore have high quality pictures giving full colors and good resolution. In these monitors each pixel on the screen is controlled by its own transistor and this provides high resolution.

Field emission displays (FEDs):

- FEDs consist of two thin sheets of glass a millimeter apart, separated by vacuum. The back glass is made up of number of tiny tips that can be switched on and off and electrons are fired at the front screen across the vacuum. When the phosphor dots are hit by the electrons, they glow to produce sharp, bright images. FEDs are used in Flat Panel Displays.

Figure 1.6 Monitor (a) TFT screen (b) CRT screen

(a) **(b)**

Printers:

Dot matrix printer

- It has a print head which travels across the paper. The print head has a set of pins which are activated according to the shape of the character to be printed.
- The activated pins hit an ink ribbon against the paper and the character gets printed.
- The advantage is that it is very cheap and suitable for bulk printouts but the disadvantage is that it has poor quality.

Ink-jet printers

- The print head consists of tiny nozzles through which different colored inks can be sprayed on to the paper to form the desired characters.
- The ink is forced out by heat or by tiny piezoelectric crystals.
- The advantage is that it has good quality printing but is suitable only if less amount of printing is required as it is costly.

Laser Printers

- Laser printers use powdered ink called toner. It is transferred to the paper and then fixed by heat and pressure.
- It is suitable wherever fast, high quality bulk printing is required and the disadvantage is that it is costly.

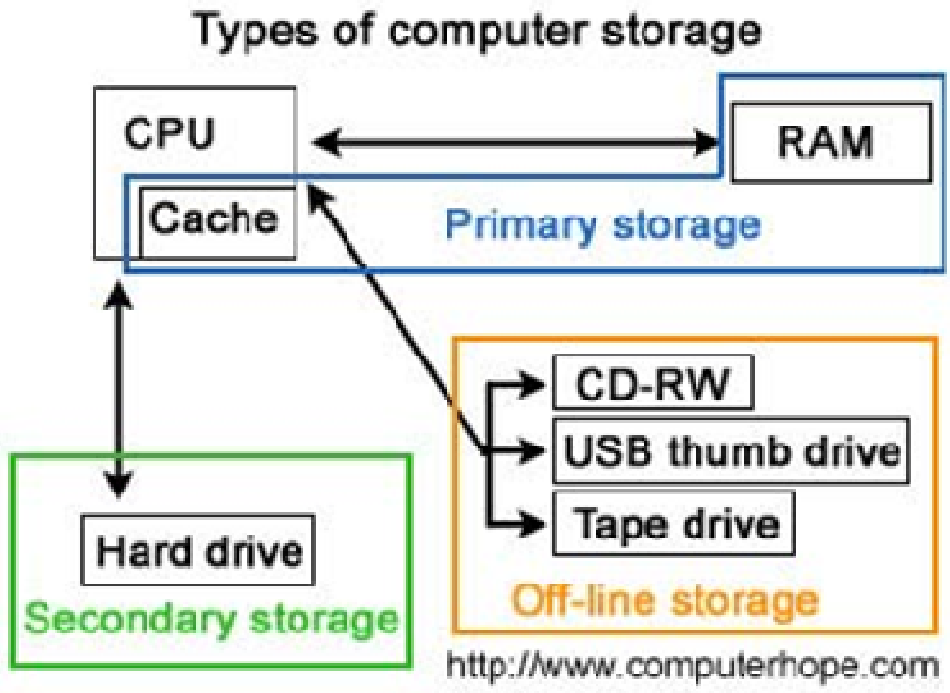
Figure 1.7 Laser Printer

1.4 Computer memory and data storage

1.4.1 Memory

Memory is an integral part of computer. There are different types of computer memories like semiconductor memory, magnetic memory and optical memory which are fabricated using different technologies.

Figure 1.8 Schematic diagram showing different computer storage devices



Since the CPU operates at a very high speed, the speed of the memory should also be very high and it must match that of CPU therefore a very fast semiconductor memory called **cache memory** is directly connected to the CPU. The access time of cache memory is nearly 10ns.

The next level of memory used in computer is main memory also known as primary memory. It is again a semiconductor memory with access time of about 50ns. It stores the programs and information which is being processed.

The main memory can be divided into two parts:

- RAM(Random Access Memory)
- ROM(Read Only Memory)

RAM:

In RAM any memory location can be accessed directly without going through any other location. It is a read/write memory of a computer system. RAM is a volatile memory i.e. the information is lost as soon as the power is switched off. The user has to reload the program and data as and when power supply is resumed. RAM chips are basically of two types:

SRAM (Static RAM)

It retains the information as long as power supply is on. The SRAM consists of conventional flip-flop (A flip-flop is a memory cell capable of storing one bit of information) circuit that stores binary information.

DRAM (Dynamic RAM)

It loses the stored information in few milliseconds even though the power supply is on. This is so because DRAM stores the information in the form of charge on a capacitor, which leaks away in very short time, therefore, it's contents must be periodically refreshed by recharging the capacitor to its full value. DRAM consumes less power in comparison to SRAM. However, it is slower than SRAM.

ROM:

ROM is Read Only Memory. It is non-volatile memory i.e. it stores the information permanently and has random access property. ROMs are however, slower than RAMs. Different types of ROM available are:

PROM (Programmable ROM)

PROMs are only once programmable i.e. once the chip has been programmed, the recorded information cannot be altered. A special equipment called PROM programmer is required for writing
programs into a PROM.

EPROM (Erasable Programmable ROM)

The contents of EPROM can be erased and it can be reprogrammed more than once. The erasure of contents is done using an equipment with ultraviolet source called EPROM eraser. The EPROM chip is exposed to high intensity ultraviolet rays for about 20 minutes. This method has two big disadvantages:

(a) Entire contents are erased in this process.
(b) EPROM chip has to be taken out of the system and placed in an EPROM eraser's chamber.

EEPROM (Electrically Erasable PROM)

This type of ROM can be programmed and erased by electrical signals.
Advantages of EEPROM:

(a) There is no need to remove EEPROM chip from the system board for the purpose of erasing data.

(b) The selective erasure of contents is possible i.e. we can erase the contents on byte by byte basis even programming can also be done on this basis.

Disadvantages of EEPROM:

(a) Different voltages are required for erasing, writing or reading the stored information.

(b) Due to complex memory cell structure it has low density, high cost and low reliability.

EEPROMs are also known as EAROM-Electrically Alterable ROM.

1.4.2 Data storage devices/Secondary memory/back-up memory

The primary memory has a limited storage capacity and is not permanent; therefore, secondary storage devices also called backup memory are used. Some of the most common storage devices are:

- Hard disks
- Floppy disks

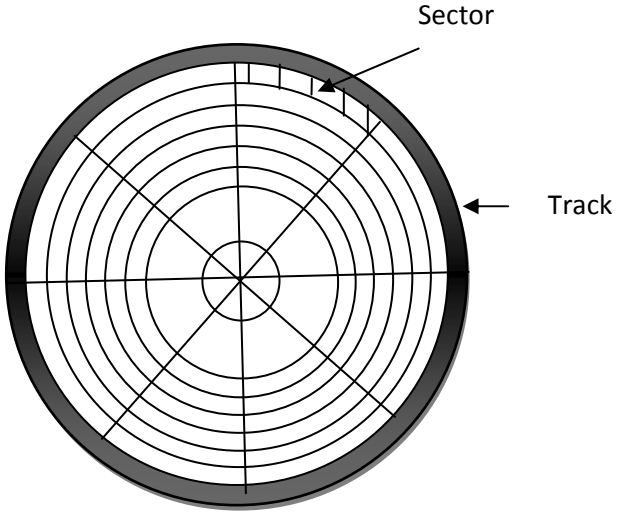
} Magnetic memories

- CD ROMs
- DVDs

} Optical memories

Hard disk:

- They are on-line storage devices used for mass storage of information permanently. They store programs, data, operating system, compilers and application program.
- A hard disk is made up of metal, metal alloy or glass base with a thin coating of magnetic material over it.
- The surface of the hard disk is divided into a number of concentric tracks and each track is divided into number of sectors (Fig 1.9). Tracks and sectors are logical things they do not have any physical existence.
- The hard disk memories store information on one or more circular disks called platters. This increases the storage capacity of hard disk.
- Storage capacity of a disc having platters = (number of recording surfaces) **x** (no. of tracks per surface) **x** (no. of tracks per sector) **x** (number of bites per sector).



(a)

(b)

Figure 1.9 (a) Representation of tracks and sectors on hard disk
(b) Hard disk

- A motor rotates the disk at a rapid speed. Data are recorded on the tracks of the spinning disk surface and read from the surface by one or more read/write heads. Due to high speed a thin air cushion of about 10 micro-inch is formed between the rotating disk and the head. Thus, the head floats on the air-cushion and does not make any physical contact with the hard disk.

Floppy Disks:

- Floppy disks are amongst oldest portable storage devices, which enable the transfer of small files between computers and also store data/information as backup.
- It is a thin circular disk coated with magnetic material on the surface. Floppy disc is made up of flexible substance called Mylar.
- Floppy disks have to be formatted before storing any data. Formatting implies dividing the disk into tracks and sectors.
- The storage capacity of the disks is 1.44MB which is approximately 350 A4 pages of text.
- The main advantage of floppy disks is there low cost but their disadvantage is that they have much smaller storage capacity, longer access time and high failure rates compared to hard disk.

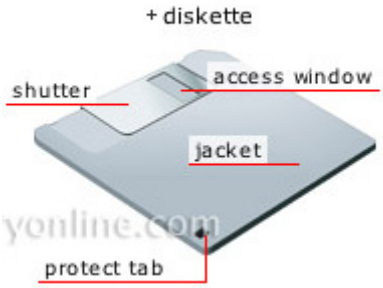


Figure 1.10 Floppy disk

Compact Disks (CDs):

The compact disks are optical media. Laser beam (wavelength 780nm) is used to read/write the information. An optical disk has a single track in spiral form. There are three main types of CDs. They come in various sizes ranging from 12.0 inch to 3.0 inch in diameter. The most popular one is of 5.25 inch diameter.

Storage capacity= Numbers of sectors x number of bites per sector. The 5.25 inch optical disks typically have 3,30,000 sectors each of 2352 bytes. The storage comes out to be 3,30,000 x 2352 bytes $=776x10^6$ bytes=776 Megabytes. This is unformatted capacity Formatted capacity is about 650 Megabytes.

CD-ROMs

- These are read only memory. Manufacturers write information on CD-ROMs. Information is written on to the disk by burning pits (pit spacing = 1.6×10^{-6} meters) on to the disk surface with controlled laser beam. A typical value of track density is 16000 tracks per inch.
- CD-ROMs hold large quantities of data (650MB) in the form of programs, text, sound, still pictures and video clips.
- It is read from center to outer edge.

CD-R

- These are initially blank but the user can use special read/write CD-drive unit to store programs and data on to the disc but they can only be written once.
- Both CD-Rs and CD-ROMs can be referred to as WORM devices, which implies write once and read many times.

CD-WR

- These are the drives on to which the user can read, write or delete files many times just as in hard disk.

Like a floppy disk, a CD only starts spinning when requested and it has to spin up to the correct speed each time it is accessed. It is much faster than a floppy but it is slower than hard disk.
A CD-WR disk usually has a life time of 100 or more erase write cycle.

(a) (b)

Figure 1.11 Compact disk (a) CD-Read (b) CD-Read-Write

Digital Versatile Disk (DVD):

- DVDs are now replacing CDs. DVD is an optical storage device that looks the same as CD but is able to hold about 15 times as much information as a CD-ROM.
- The Laser beam used to perform read/write operation is in the range of 650nm which is shorter then that use in case of CDs.
- A single sided, single layer DVD can store data upto 4.7GB which is equivalent to 26 CD-ROMs. Multilayer double sided DVD can hold upto 17GB of data and therefore it is called Super density disk.
- The significant advantage of DVD is that digital images and sound tracks are of high quality and do not deteriorate with constant use. The DVDs are 20 times faster as compared to CDs. They have random access mode.
- The disadvantage is that they are expensive however; DVD technology is coming down in price these days.

(a) (b)

Figure 1.12 Digital-versatile-disk (a) DVD-Read-write (b) DVD-Read

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