

Unit



Basic Electronics and Computer Fundamentals

INTRODUCTION

Computer is an electronic equipment that works on electricity. Every component of a computer needs electrical power to run and this power can come from a wall outlet in the form of alternating current or from a battery in the form of direct current. Internal components of a computer receive the power from the internal power supply known as SMPS (switched mode power supply). A computer installation technician must understand the basic principles of electrical and electronics, and also be aware of the computer fundamentals, its internal components, and working.

This Unit explains the basic concept of electricity and energy foundation, electrical quantities—current, voltage, and resistance; the electronic components — active and passive, integrated circuits (IC), and semiconductor memory. Further, the Unit also describes the basic components of a computer system, hardware and software, functional units of a computer, primary and secondary memory of a computer, different types of computers along with their capacity. Various input and output devices are used to enter the data in the computer as well as to produce output. The variety of input and output devices, their functionality and connectivity to the computer system are also discussed in this Unit.



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BASIC ELECTRONICS

INTRODUCTION

Electricity has an important place in modern society. In the current age, most of the electronic devices work on electricity. Computer is also an electronic device which works mainly on electricity. The peripheral devices attached to the computer also work on electricity. It is necessary to provide proper and continuous power to the electronics equipment to work properly. For this purpose, the surge protector and uninterrupted power supply (UPS) are used, which also work on electricity. Hence, electricity has an important place in the world of computing and computer. In this Chapter, you will understand the basic concept of electricity, electrical quantities, and various electronic components.

ELECTRICITY

Electricity is the set of physical phenomena associated with the presence and flow of electric charge. It has a wide range of well-known effects, such as lightning, static electricity, electromagnetic induction, and electrical current.

ENERGY FOUNDATION

Electric charge is a fundamental physical property of matter. The forms of matter are—solid, liquid, and gases which are made up of atoms. Atoms are the fundamental building blocks of all molecules. The centre of an atom is called the nucleus. Atoms consist of three subatomic particles—protons, electrons, and neutrons. Electrons spin around the nucleus in shells, at a great distance from the nucleus. Protons carry a positive (+) charge, electrons carry a negative (-) charge, neutrons are neutral and have no net charge. One coulomb of charge is equal to 6×10^{18} (6,250,000,000,000,000,000) electrons.

Protons are found in the center of the atom, with a charge of +1 and a mass of 1 atomic mass unit, which is approximately equal to 1.66×10^{-27} kg. Electrons are found in the periphery of the atom and have a charge of -1. They are much smaller than protons and their mass is $1/1836$ amu.

The steady flow of electrons is called current. Current is what flows through electrical wires and powers electronics items, from light bulbs to televisions.

The positively charged protons attract negatively charged electrons, hence holding the atomic structure as shown in Figure 1.1.

Conductors and Insulators

The materials can be categorised as insulators or conductors based on its physical property known as resistivity. In an insulator, the electric charge does not flow freely from one atom to another due to high resistivity. In a conductor, the electric charge flows freely from one atom to another due to low resistivity. This flow of charge is electric current.

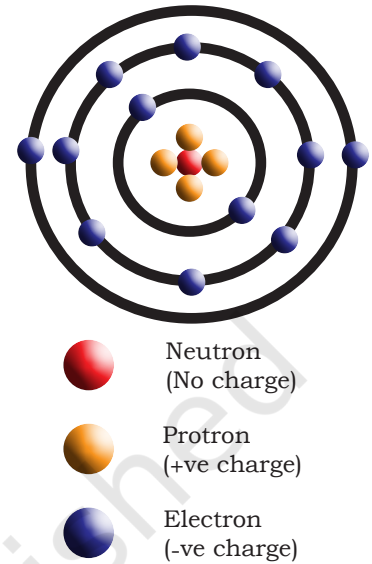


Fig. 1.1: Atomic structure

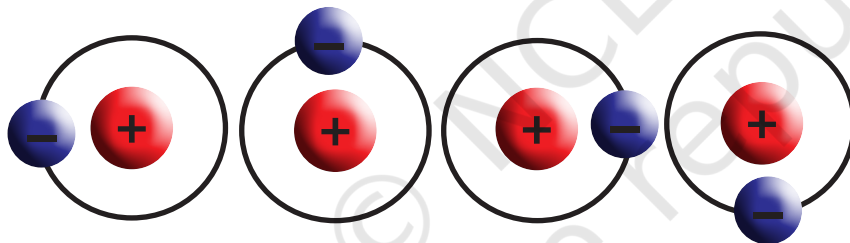


Fig. 1.2: Atoms in a wire, showing electrons travelling from one atom to another atom

Conductors

The material in which the electrons are loosely held can move very easily. These are called conductors. Metals like copper, aluminium, and steel are good conductors of electricity.

Insulators

The materials which hold their electrons very tightly do not allow the movement of the electrons through them very well. These are called insulators. Rubber, plastic, cloth, glass, and dry air are good insulators and have very high resistance.



Fig. 1.3: Conductor and insulator in a wire

The conductors are used to carry electrical current through wires. Insulators are commonly used as coating for the wires as shown in Figure 1.3. This wire consists of a core of copper (a conductor) and a coating of polyethylene (an insulator). The copper allows current to flow through the wire, while the polyethylene resists the flow of the current.

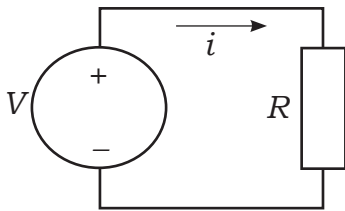


Fig. 1.4: A simple electric circuit made up of a voltage source and a resistor

Current = flow of charge

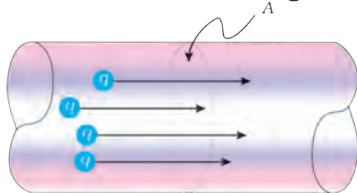


Fig. 1.5: Flow of charge through a cross section 'A'

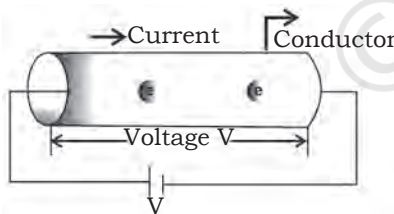


Fig. 1.6: Flow of electrons in the conductor

Electrical Quantities

Current, voltage, and resistance are the three basic building blocks of electrical and electronics. They are called electrical quantities.

Voltage

This is the potential difference between two points. It is also the amount of work required to move one coulomb charge from one point to another point. Mathematically it can be written as $V=W/Q$ where, 'V' is the voltage, 'W' is the work in joule, 'Q' is the charge in coulomb.

Value of voltage is measured in volt or joules per coulomb. Symbolic representation of voltage is 'V' or 'v'.

Electric Current

This is the movement of electric charge through a conductive medium. In equation form, electric current 'I' is defined to be $I=\Delta Q/\Delta T$ where, 'Q' is the amount of charge passing through a given area in time 'T'. The SI unit for current is the ampere (A), named after the French physicist André-Marie Ampère (1775–1836). Since, $I=\Delta Q/\Delta T$, we see that an ampere is one coulomb per second, $1\text{ A}=1\text{ C/s}$.

The flow of electricity requires a conductive medium for the flow of charge known as a conductor. The material's ability to conduct charge is called electrical conductance. The SI unit for conductance is siemens (S).

Resistance

It resists the flow of electrons and hence electric current in the circuit. Conceptually, the resistance controls the flow of electric current. An object or medium that has high electrical resistance is called a resistor. The



resistance is represented by the symbol 'R'. The SI unit of electrical resistance is ohm (Ω). Figure 1.7(a) and (b) show the resistor and its symbol.

To understand how to measure current and voltage in a circuit, you must also have a general understanding of how a circuit works and how its electrical measurements are related.

An electrical circuit is a type of network that has a closed loop, which provides a return path for the current. A simple circuit consists of a voltage source and a resistor.

According to Ohm's law, the electrical current 'I', or movement of charge, that flows through most substances is directly proportional to the voltage 'V' applied to it. The electric property that impedes current is called resistance 'R'. Collisions of moving charges with atoms and molecules in a substance transfers the energy to the substance and limits the current. Resistance is inversely proportional to current. Ohm's law can therefore be written as follows: $I=V/R$ where 'I' is the current through the conductor in amperes, 'V' is the potential difference measured across the conductor in volts, and 'R' is the resistance of the conductor in ohms (Ω). More specifically, Ohm's law states that 'R' in this relation is constant, independent of the current. Using this equation, we can calculate the current, voltage, or resistance in a given circuit.

For example, if we had a 1.5 V battery that was connected in a closed circuit to a light bulb with a resistance of $5\ \Omega$, what is the current flowing through the circuit? To solve this problem, we would just substitute the given values into Ohm's law: $I = 1.5V/5\Omega$; $I = 0.3$ amperes. If we know the current and the resistance, we can rearrange the Ohm's law equation and solve for voltage 'V' where $V=IR$

Components—Active and Passive

An electronic circuit is composed of various components. Electronic components usually have two or more leads, which can be fitted into the PCB to form a working electric

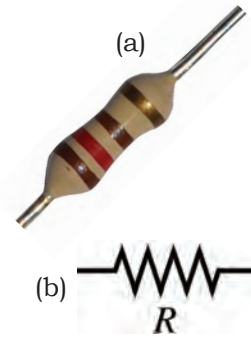


Fig. 1.7: (a) Resistor, (b) Resistor symbol



Fig. 1.8: Different types of components used in electrical and electronics

circuit. Electronic components are mainly classified into two classes— active and passive components.

Active components

They produce energy in the form of voltage or current. These components require an external source for their operation. An active component has an analog electronic filter with the ability to amplify a signal or produce a power gain. Examples of active components are—diode, transistors, as shown in Figure 1.9(a).



Fig. 1.9: (a) Active components

Passive components

These do not produce energy in the form of voltage or current. They do not require external energy to operate. They cannot generate energy of their own and depend on the power provided from the AC circuit. Examples of passive components are resistors, capacitors, inductors, sensors, and transducers as shown in Figure 1.9(b).



Fig. 1.9: (b) Passive components

Active components

The basic material used to manufacture active components is a semiconductor. Let us first understand the basics of semiconductors.

Semiconductor

These are materials whose conductivity is between that of conductors and insulators. Electronic devices are made up of semiconductor material. In semiconductor industry, silicon and germanium are used. Semiconductors are of two types, which are as follows:

Intrinsic (pure)

It is the pure form of semiconductor. The 'pure' word here represents that this semiconductor does not contain any other impurity atom.

Extrinsic (impure)

It is an impure form of semiconductor. When impurity atoms are added in the pure (intrinsic) form of semiconductor, then that semiconductor is known as extrinsic semiconductor. The extrinsic semiconductors are also known as impure semiconductors.



P-type semiconductor: When pentavalent impurity atom is added, an extrinsic semiconductor is formed which is known as P-type semiconductor.

N-type semiconductor: When trivalent impurity atom is added, an extrinsic semiconductor is formed which is known as N-type semiconductor.

Diode

It is an electronic device which allows current to flow easily in circuit. The most common form of diode is P-N junction diode, which is formed when two semiconductors, that is, P-type semiconductor and N-type semiconductor are combined to form a new component which is known as diode. The diode and its symbol are shown in Figure 1.10 (a) and (b). The silver ring in a diode represents the cathode.

Diode passes current only in one direction, therefore it is also known as unidirectional. The P-side is called anode and the N-side is called cathode. When the anode and cathode of a P-N junction diode are connected to external voltage source, such that, the positive end of a battery is connected to the anode and negative end of the battery is connected to the cathode, diode is said to be forward biased or we can say that diode will act as a close switch (it will be turned 'on'). In a forward biased condition, diode will pass the current through it.

When the P-side of the diode is connected to the negative terminal of the battery and N-side of the diode is connected to the positive terminal of the battery, diode is said to be reverse biased or we can say that diode will act as an open switch (it will be turned 'off'). In a reverse biased condition, diode will not pass the current through it.

Diode can be connected in forward bias and reverse bias as shown in Figure 1.11(a) and (b).

There are various types of diodes such as avalanche diode, crystal diode, light emitting diode (LED), photodiode, varactor diode, and zener diode.

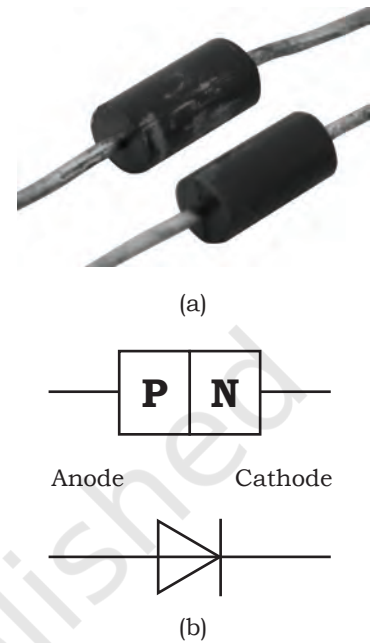


Fig. 1.10: (a) Diode (b) Diode symbol

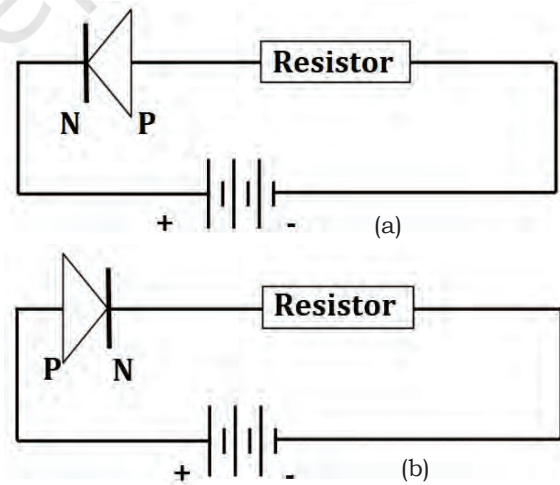


Fig. 1.11: (a) Diode connected in forward bias, (b) Diode connected in reverse bias

Transistor

It is an active semiconductor device that has two P-N junctions which amplify electric current and voltage. It is a three layer semiconducting device. These three layers have three terminals—emitter, base, and collector respectively. It has two junctions and where the two layers touch each other is called a junction. Junction where emitter and base layer touch each other is known as an emitter base (EB) junction. Whereas junction where collector and base layer touch each other is known as a collector base (CB) junction.

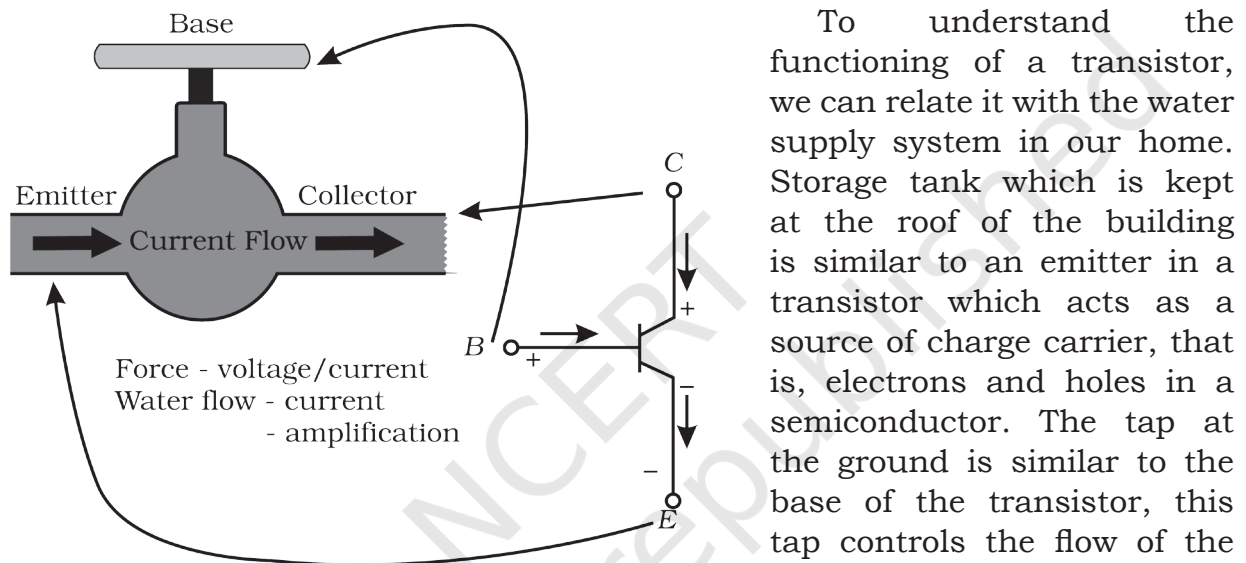


Fig. 1.12: Analogy showing a tap as the base of the transistor

To understand the functioning of a transistor, we can relate it with the water supply system in our home. Storage tank which is kept at the roof of the building is similar to an emitter in a transistor which acts as a source of charge carrier, that is, electrons and holes in a semiconductor. The tap at the ground is similar to the base of the transistor, this tap controls the flow of the water like base controls the flow of the charge carrier.

Like the bucket at the ground collects the water coming from the storage tank, similarly the collector of the transistor collects the charge carriers coming from emitter.

Identifying BJT Terminals

Keep the transistor such that the flat surface faces you, as shown in the below Figure 1.13(a).

The bipolar junction transistor has three terminals namely—

1. Emitter (E)
2. Base (B)
3. Collector (C)



The bipolar junction transistor (BJT) and its symbol are shown in Figure 1.13(a) and (b).

Figure 1.14 shows the details junctions of BJT.

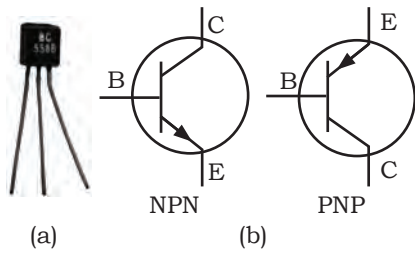


Fig. 1.13: (a) Bipolar Junction Transistor (b) Symbol of BJT

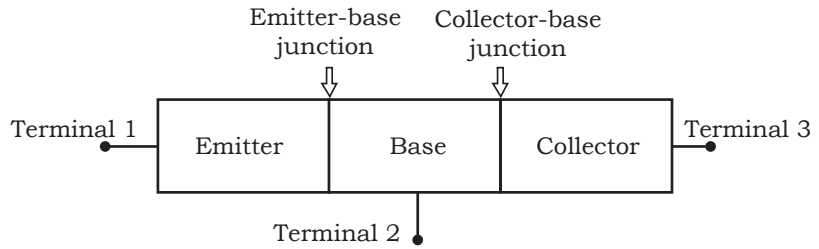


Fig. 1.14: EB and CB junction of bipolar junction transistor

Passive Components

Resistor

It is the basic component in an electronic circuit, which is used to calculate voltage and current in the circuit. It opposes movement of electrons or it controls the amount of current flow in the circuit. This opposition is known as resistance. Resistance is measured in ohms (Ω).

Colour bands on a resistor are used to represent the resistance values. There are 4-band, 5-band, and 6-band resistors.

In a 4-band resistor as shown in Figure 1.15, the first and the second band represent the numerical value of the resistor, the third band is a multiplier to the power of ten, and the fourth band is the tolerance level. In a 5-band resistor, first three bands represent significant digit, fourth band represents multiplier, and fifth band represents tolerance.

Each colour on the colour coded resistor has the specific value as per the colour scheme shown in Table 1.1.

The tolerance gives an upper and lower value of resistor. Take the following example for a 100Ω resistor as shown in Table 1.2.

The resistance of the resistor in Table 1.2 is calculated as: resistance of resistor is the value of the first band, succeeded by value of the second band, succeeded by number of zeros as per the value of colour code mentioned Table 1.1 and the fourth band represents the tolerance value to be taken from Table 1.2.

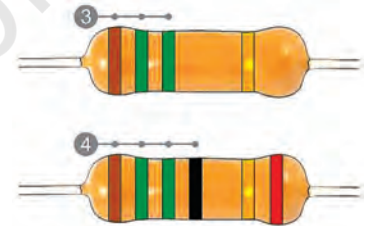


Fig. 1.15: 4-band and 5-band colour coded resistor

Table 1.1 Colour code

Code	Number
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9

Table 1.2 Tolerance value

Tolerance	Colour	Stated Resistor Value	Allowed Upper Value	Allowed Lower Value
+/- 1%	Brown	100 Ω	101 Ω	99 Ω
+/- 2%	Red	100 Ω	102 Ω	98 Ω
+/- 5%	Gold	100 Ω	105 Ω	95 Ω
+/- 10%	Silver	100 Ω	110 Ω	90 Ω

For example, resistance of the four band resistor with colours yellow, violet, orange, and gold is calculated as: yellow = 4, violet = 7, orange = 3 number of zeros, gold = 5% tolerance, resistance = 47000 Ω (or 47 kΩ), 5% tolerance.

According to Ohm's law, power is calculated as the product of voltage and resistance.

Assignment: Calculate the value of resistors by using the color code.



(a)



(b)



(c)

- (a) Brown-black-yellow-yellow
- (b) Yellow-violet-red-yellow
- (c) Red-red-brown-yellow

Alphanumerically coded (surface mounted) resistors

These are rectangular in shape as shown in Figure 1.16. They have leads, which come out from the resistor, these leads are used for mounting of resistor on the printed circuit board (PCB). Some surface mount resistors use plates on the bottom side of the resistor.

The first two or three numbers printed on the surface mount resistor represent significant digits and the last digit represents the number of zeros that should follow. For example, as shown in Figure 1.16, a resistor reading 1252 indicates a value of 12,500 ohms. For tolerance value, one must refer to the letter at the end of the code. Compare this letter at the end of the code with the tolerance. There are two types of resistors—fixed resistor and variable resistor.

Fixed resistor

The resistors made up of ceramic body and cylindrical in shape with definite or fixed resistance values are fixed resistors. The resistive element could be either carbon film, thick film, or a wound wire element. The properties of fixed resistors depend upon the type of fixed resistor used.

Based on the type of material used in constructing a resistor, it is classified into—carbon composition, carbon pile, carbon film, metal film, and metal oxide film.

- (i) Carbon composition is made up of carbon clay composition with plastic coating around it.
- (ii) Carbon pile is made up of a stack of carbon disks compressed between two metal contact.
- (iii) Carbon film is deposited on an insulating substrate and cut into thin resistive path.
- (iv) Metal film is cylindrically shaped and coated with nickel chromium.
- (v) Metal oxide film is made up of tin oxide.

For example, a carbon film resistor has 5% tolerance, power rating of 0.125W–2W, temperature coefficient of 250–450 ppm/k.



Fig. 1.16: Surface mount resistor



Fig. 1.17: (a) Fixed resistor

A metal film resistor has 1% tolerance, power rating of 0.1–5W and temperature coefficient of 10–250 ppm/K.



Fig. 1.17:(b) Variable resistor

Variable Resistor

These are the resistors whose resistance value can be changed. They have three terminals out of which two are connected to the ends of the track and a third terminal is connected to the wiper. The motion of the wiper allows increase and decrease of resistance. Potentiometer, rheostat, and trimpot are variable resistors.

Capacitor



Fig. 1.18: Capacitor showing capacitance value 4700 micro farad and maximum voltage value of 10 V

It is a passive electronic component used to store electric charge. The unit for measuring capacitance is farad (F). In a capacitor, energy is stored in the form of an electric field. It has two parallel plates and between these plates, energy is stored. It is also marked with colour bands to denote value. The first two bands are the first and second digits whereas the third band denotes the multiplier. The capacitor is indicated by the symbol || .

The capacitance of capacitor can vary from –20% to +80% of actual capacitance.

The parameters of capacitor are maximum voltage, capacitance, and tolerance. Maximum voltage defines the maximum voltage value of a capacitor. The Figure 1.18 shows the various parameters which are mentioned on a capacitor.

The capacitor is marked with the value of capacitance and voltage. You can calculate the amount of charge in capacitor by using equation $Q = C \times V$ where, Q = charge in coulomb, C = capacitance in farad, V = voltage in volt.

Types of capacitors

There are various types of capacitors based on the type of material used between plates of capacitor. They are ceramic capacitors, film power capacitors, super capacitors, electrolytic capacitors, and variable capacitors, etc.

Ceramic capacitors: They are made up of ceramic and metal where metal acts as the electrode and ceramic



is the dielectric. This type of capacitor is used in applications of high frequency and high current pulse loads.

Film power capacitors: In these, the dielectric films are drawn to a thin layer surrounded by metallic electrodes on a cylindrical wiring. Polypropylene is used as the dielectric.

Super capacitors: These are electrochemical capacitors with no specific dielectric in it. The storage of charge is obtained by either separation of charge or redox reaction.

Electrolytic capacitor: An electrolytic capacitor is a type of capacitor that uses an electrolyte to achieve a larger capacitance than other capacitor types. An electrolyte is a liquid or gel containing a high concentration of ions.

Variable capacitors: Above mentioned capacitors are fixed capacitors which cannot vary their capacitance. A variable capacitor can vary its capacitance through mechanical motion.



Fig. 1.19: Different types of capacitors

Inductor

It is a two terminal electrical component which resists changes in electric current. The value of inductance is measured in henry. Inductive tolerance is usually in the range of -5% to +20%.

In an inductor, copper wire is used which is wound on a plastic or ferromagnetic material in the form of a coil. The inductor is shown in Figure 1.20 and it is indicated by the symbol $\text{---}\text{---}\text{---}$.



Fig. 1.20: Inductor

When current flows through the coil, a magnetic field is set. This field restricts the flow of current. Once the field is created, then current passes normally through it thus resisting any change in the flow of current.

The types of inductors are—air core inductor, ferromagnetic core inductor, and variable inductor.

Air core inductor

It has its coil wound on non-magnetic material like plastic or ceramic and there is only air present in between the windings.

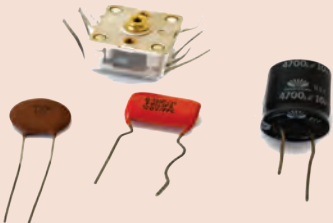

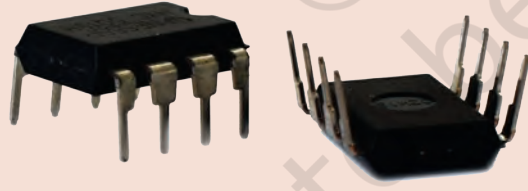

Ferromagnetic inductor

It has its coil wound on a magnetic core made up of ferromagnetic material.

Variable inductor

It is made up of ferrite magnetic core which can be slid or screwed to change inductance.

Assignment: Identify the components used in electrical and electronics.

Pictorial representation of the component	Write down the name of the components and identify which category they belong to—active or passive.
	Name of the components: _____ Category: Active <input type="checkbox"/> Passive <input type="checkbox"/>
	Name of the components: _____ Category: Active <input type="checkbox"/> Passive <input type="checkbox"/>
	Name of the components: _____ Category: Active <input type="checkbox"/> Passive <input type="checkbox"/>
	Name of the components: _____ Category: Active <input type="checkbox"/> Passive <input type="checkbox"/>

Transformer

It is an electric unit that transfers energy between two circuits using electromagnetic induction. It is a static unit that simply transforms the voltage level of an AC signal. It either steps-up or steps-down the AC voltage. It does not change the frequency of applied AC signal.

It consists of a core made up of ferromagnetic or ceramic material and a coil made up of some insulating magnetic material or copper wires. Transformer oil is used for cooling of transformer.

Based on the purpose, there are different types of transformers such as power transformers, instrument transformers, RF transformers, and audio transformers. However, in computers the step-down, center tap, and high frequency transformers are used. A center tapped transformer is shown in Figure 1.22.

Integrated Circuit (IC)

Digital ICs are used in computers and computer networks. An integrated circuit is a combination of electronic components on a single piece (or 'chip') of semiconductor material as shown in Figure 1.23. It has a large number of tiny transistors on a small chip and results in circuits that are smaller, cheaper, and faster. It also has a number of pins.

Semiconductor Memory

It is an electronic data storage device, which is fabricated on integrated circuits (IC). As we have discussed, semiconductors have conductivity which is in between that of conductors and insulators. Electronic devices are made up of semiconductor material. In

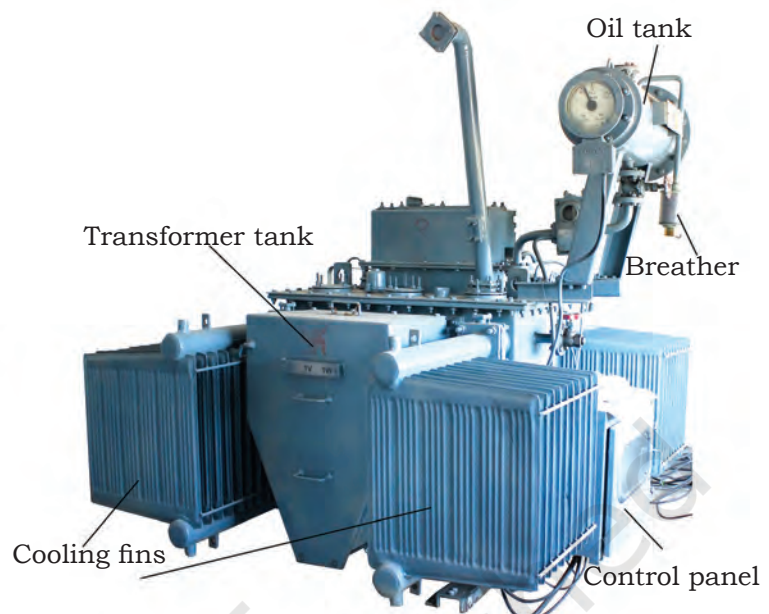


Fig. 1.21: Transformer parts



Fig. 1.22: Center tapped transformer

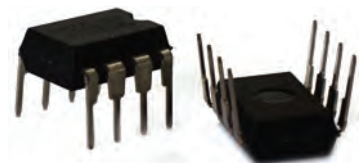


Fig. 1.23: Integrated circuit





Fig. 1.24: RAM



Fig. 1.25: ROM

semiconductor industry, silicon and germanium are widely used. Computer memory is a physical electronic device. Semiconductor memories are used to store applications and data. This storage can be temporary or permanent, as required by a computer and/or its user. There are two types of memory—primary and secondary. Primary memory includes RAM, ROM, and secondary memory is—hard disk drive, CD/DVD, magnetic tape, pen drive, etc. Primary memory is classified into two types—read-only memory (ROM) and random access memory (RAM).

Power Supply

It is an electrical device which provides operating voltage to the computer. It is used to provide power to a personal computer. It requires a minimum load of 7A at 5V and 2.5A at 12V. Modern PC requires power in the range of 60W–250W. The electronic components inside the computer require very low DC voltage.

The various types of power supply used in computing are DC power supply, AC power supply, linear regulated power supply, batteries, uninterruptible power supply, and switched mode power supply (SMPS).

Rectifier

AC power supply takes voltage from the mains and converts it to DC before transmitting it to any device. To convert AC into DC, a rectifier circuit is used which ensures that the current does not reverse its direction. Rectifier circuits can be classified as single phase and three phase circuits. Again, every phase has half wave rectifiers and full wave rectifiers.

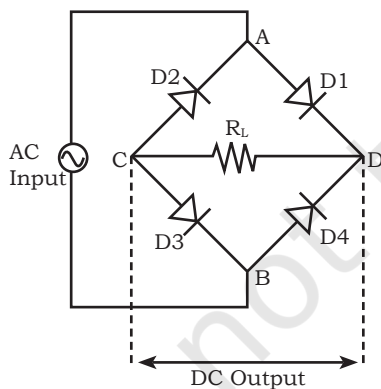


Fig. 1.26: Construction of bridge rectifier circuit

Full wave bridge rectifier

A bridge rectifier is a type of full wave rectifier which uses four or more diodes in a bridge circuit configuration.

Bridge rectifier construction

The bridge rectifier is made up of four diodes namely D1, D2, D3, D4, and load resistor R_L . The input AC signal is applied across two terminals A and B and

the output DC signal is obtained across the load resistor R_L , which is connected between the terminals C and D.

During the positive half cycle, the terminal A becomes positive while the terminal B becomes negative. This causes the diodes D1 and D3 to become forward biased and at the same time, it causes the diodes D2 and D4 to become reverse biased. The current flow direction during the positive half cycle is shown in the Figure 1.27 (that is A to D to C to B).

During the negative half cycle, the terminal B becomes positive while the terminal A becomes negative. This causes the diodes D2 and D4 to become forward biased and at the same time, it causes the diodes D1 and D3 reverse biased. The current flow direction during negative half cycle is shown in the Figure 1.28 (that is B to D to C to A).

From the Figure 1.27 and Figure 1.28, we can observe that the direction of current flow across load resistor R_L is same during the positive half cycle and negative half cycle. Therefore, the polarity of the output DC signal is same for both positive and negative half cycles.

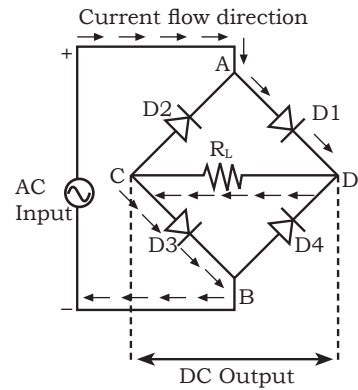


Fig. 1.27: Bridge rectifier circuit during positive half of the input cycle

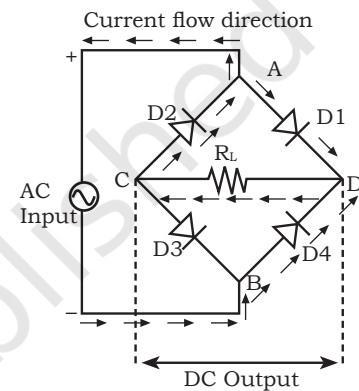


Fig. 1.28: Bridge rectifier circuit during negative half of the input cycle

Battery

This is a device that converts chemical energy directly to electrical energy. It consists of a number of voltaic cells connected in series by a conductive electrolyte containing anions and cations. One half-cell includes electrolyte and the anode or negative electrode; the other half-cell includes electrolyte and the cathode or positive electrode.

Batteries are convenient sources of electricity that can be easily stored and utilised.

Battery is shown in the Figure 1.29(a). The positive terminal is cathode and negative is anode. It is important to show the correct flow of electrons in the circuit diagrams by indicating the positive and negative terminal as shown in Figure 1.29(b).

Batteries can be broadly classified into two types—primary and secondary.

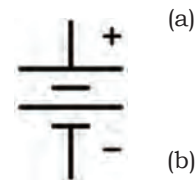


Fig. 1.29: (a) Battery used in UPS (b) Battery symbol in a circuit diagram

Primary batteries

They are non-rechargeable. They convert chemical energy to electrical energy irreversibly.

Secondary batteries

They are rechargeable. Their chemical reactions can be reversed by supplying electric energy to the cell.

Switched Mode Power Supply (SMPS)

It is used to achieve voltage regulation and conversion of power. SMPS functions in three stages—input rectifier, where AC is converted to DC; inverter phase, where again the DC is converted into inverted AC; and output rectifier stage, where the inverted AC is given to the high winding transformer.

SMPS is the board on which electronic components are assembled for the regulation of electric power. In it, input AC voltage is converted into low DC voltage. It is used in PCs so that every part of the PC gets proper power supply separately. It helps split

the power to motherboard, hard disk, floppy drive, CD drive, etc.

It contains several wires of multiple colour. Each wire carries different amount of voltage value, which will pass to different hardware parts of the computer. The Table 1.3 shows the different colour cables and amount of voltage they carry.

Table 1.3

Yellow	12 V
Blue	12 V
Black	Common [0]
Red	5 V
White	5 V
Green	Power supply ON
Orange	3.3 V
Purple	+5 SB (Standby)



Fig. 1.30: SMPS

Uninterrupted Power Supply (UPS)

It is an electronic device which supplies power to a load when the mains supply or input power source fails. Any UPS has a power storage element which stores energy in the form of chemical energy, for example, the energy is stored in batteries. A UPS uses double conversion method of accepting AC input, rectifying to DC, passing this through a string of batteries, and inverting it to AC again.

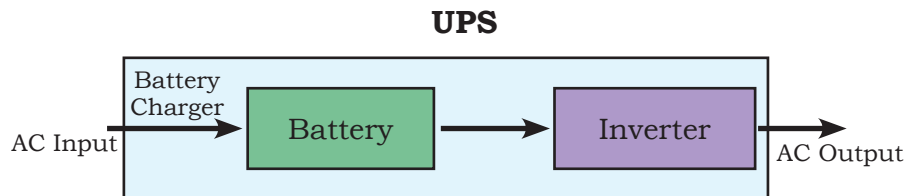


Fig. 1.31: Block representation of an UPS

Classification of UPS

It plays a vital role in maintaining the regularity of electric power. There are a variety of UPS used in power system. Some of them are discussed below—

Online UPS

In an online UPS, the batteries are always connected to the inverter, so that, no power transfer switches are necessary. In case of a power cut, there will be no momentary power breaks.

Standby or offline UPS

A system where normally AC input (utility power) is output, as it is to connected devices and when a power outage or abnormal voltage is detected, inverter starts feeding using power from the batteries. In the event of a power outage, a few milliseconds of momentary break occurs in the AC output.

Printed Circuit Board

This is used to electrically connect various components using tracks, pads, etc. Internally, all the components are connected, which reduces the complexity of the circuit. It can be found in many electronics devices



like—TV, mobile, digital camera, computers parts like—graphic cards, motherboard, etc.

Types of PCB

There are several types of PCBs available. Out of these types of PCB, we have to choose the appropriate type of PCB according to our application—

Single-layer PCB

Single sided consisting of one layer of copper on a rigid base material.

Double-layer PCB

Double sided consisting of two layers of copper on a rigid base material.

Multi-layer PCB

They are boards with more than three copper layers on double-sided boards which are stuck to each other with a particular glue.

Flexible PCB

It consists of a single conductor layer on a dielectric film.

Soldering

It is the process of melting a metal onto other metal components in order to bind them. It differs from welding. In welding, the component pieces are melted together; in soldering, a softer metal with a lower melting point is used to connect them. Because soldering does not melt components, it is useful for delicate applications, such as electronics works. The purpose of soldering is to bind two other components. Solder can be thought of as a sort of 'metal glue'. It can be used to fill in gaps or hold pieces in place, but does not serve any more complicated purpose. Since solder is metallic, it conducts electricity, which is another reason for it being widely used for connecting electronic components.



Fig. 1.32: Soldering kit



The soldering process is classified into soft soldering, silver soldering, and brazing.

Soldering techniques

There are various types of soldering techniques. The following are the most commonly used soldering techniques in PCB:

Conduction soldering

It is basically the traditional hand soldering technique.

Induction soldering

Uses induction heat to melt the solder.

Laser

This method is used at a power of 30–50W for electrical connection joints.

Desoldering

It is the process of removing the solder and components from PCB for troubleshooting, repair, or replacement.

Check Your Progress

A. Multiple choice questions

1. Which of the following components is used to provide resistance?
(a) Heat (b) Energy
(c) Product (d) Resistor
2. A diode _____.
(a) is the simplest of semiconductor devices
(b) has characteristics that closely match those of a simple switch
(c) is a two-terminal device
(d) All of the above
3. Which of the following is a semiconductor material?
(a) Silicon
(b) Germanium
(c) Both A and B
(d) None of these
4. Transformer works on _____.
(a) AC
(b) DC
(c) Both AC and DC
(d) None of these

NOTES

5. Transistor has _____ layers and _____ junctions.
(a) two, three (b) three, two
(c) three, three (d) two, two
6. Diode is reverse biased when _____.
(a) cathode is connected to the positive and anode is connected to the negative terminal of the battery
(b) cathode is connected to the negative and anode is connected to the positive terminal of the battery
(c) no specific polarity is required
(d) None of these
7. What is the ohmic value for the colour code of orange, orange, orange?
(a) 22 k Ω
(b) 33 k Ω
(c) 3300 Ω
(d) 44000 Ω
8. Which of the following will be the correct value of resistance for the colour code of brown, brown, red, gold and for what ohmic value?
(a) 1.2k Ω 5%
(b) 1.1k Ω 5%
(c) 1.3k Ω 5%
(d) 1.5k Ω 5%
9. Which of the following will be the correct value of resistance for the colour code of black, brown, green, gold, and for what ohmic value?
(a) $1 \times 10^5 \Omega$ 5%
(b) $1 \times 10^4 \Omega$ 5%
(c) $1 \times 10^5 \Omega$ 10%
(d) $1 \times 10^4 \Omega$ 10%

B. Fill in the blanks

1. Electrons have _____ charge.
2. The SI unit for measuring the rate of flow of electric charge is _____.
3. Transformers work on _____ voltage.
4. Extrinsic semiconductor is _____ form of semiconductor.
5. Intrinsic semiconductor is _____ form of semiconductor.
6. Capacitor stores energy in the form of _____ field.
7. Inductor stores energy in the form of _____ field.
8. Diode has _____ terminals.
9. Silicon is _____ material.
10. Transistor has _____ terminals.
11. A three terminals semiconducting device is _____.

C. State whether the statements given below are True or False

1. Transformer is used to step up the voltage.
2. Transistor is used as an amplifier and switch.



3. The electromagnetism in a transformer is the energy source for the transformer.
4. Transformer changes the frequency of the applied signal.
5. The junction where emitter layer and base layer touch each other is named as emitter base junction.
6. Amplification is the process of increasing the level of voltage and current.
7. The base unit of capacitance is farad.
8. Green, orange, orange, violet colour coded resistor is $62\text{k}\Omega$ 5%.
9. Violet, green, orange, silver colour coded resistor is $75\text{k}\Omega$ 10%.
10. Blue, red, orange, gold colour coded resistor is $62\text{k}\Omega$ 5%.
11. Orange, orange, yellow, gold colour coded resistor is $330\text{k}\Omega$ 5%.

D. Short answer questions

1. Describe the relationship between the electrical current, voltage, and resistance in a circuit.
2. Explain the difference between a conductor and insulator.
3. List the name of conductors and insulators which are used in our day-to-day life.
4. What does 10 A define?
5. Write short notes on—
 - (a) Diode
 - (b) Transistor
 - (c) LED, capacitor
 - (d) Inductor
6. Explain the types of semiconductors.
7. What are the applications of a transistor?
8. Write down the specifications of a capacitor.
9. Describe the functions and identify the major components of a battery.
10. What is the role of active and passive components in an electric circuit?

INTRODUCTION

Computers are an essential tool of information technology (IT). They are multi-purpose machines that are used to solve a variety of problems in different fields. The basic working principle of a modern computer is based on the analytical engine designed by Charles Babbage in the 19th century. Computers have changed our daily routine as the entire task performed by us in our daily routine is automated. Our lives are directly or indirectly affected by the computers. It was in the past era where computers were used in industries. In this era of information, we are dependent on the storage, flow, and processing of data and information which can only be possible with the help of computers. This is the reason a computer is called a multi-purpose machine. The purpose of this Chapter is to introduce you to a computer.

COMPUTER SYSTEM



Fig. 2.1: Computer system

The term ‘computer’ is derived from the word ‘compute’, meaning ‘to calculate’. A computer is a programmable electronic machine that accepts data from the user, processes it by performing calculations and operations on it, and generates the desired output results. Computer performs both simple and complex operations, with speed and accuracy.

Computing is not restricted to only mathematical computing but to a variety of logic-based tasks. Computer, process the data as per the given set of instructions. It can perform operations like generating bills, reserving tickets, printing mark-sheets, printing business reports, or communicating messages. Data can be text, number, audio, video, graphs, or animations.

Characteristics and Limitations of a Computer

As we know, computers can execute millions of instructions per second. The computer gives a correct result only if the data and instructions given are correct.

The term garbage in, garbage out (GIGO) is used to refer to this feature. Computers are very useful because of their characteristics like speed, accuracy, automation, programming ability, storage, diligence, versatility, and ability to retain data.

Characteristics

Speed: The speed of computer data processing is measured in terms of instructions per second. Modern computers can process the data very fast that is at the rate of millions of instructions per second. It means the calculations which otherwise require hours and days to compute manually, can be completed in a few seconds using computers.

Accuracy: Computers can perform complex arithmetic and logical computations with 100% accuracy. For example, the computer can accurately give the result of division of any two numbers up to ten decimal places.

Automation: Computers can automatically perform a given task based on the given instructions. Once data and necessary instructions are stored in the computer memory, human intervention is not required.

Programability: Computers can be programmed to execute predefined set of instructions. The program once written can be modified later for the revised task.

Storage: Computers can store large volumes of data permanently in secondary storage for a long time. The stored content can be retrieved whenever required. A limited amount of data can be stored, temporarily, in the primary memory.

Diligence: Computers are machines and hence they can operate consistently for long hours without any break. They can perform long and complex calculations with the same speed and accuracy from the start till the end.

Versatility: Computers are versatile in nature. They can perform different types of tasks with the same ease. At one moment, you can use the computer to prepare a letter document and the next moment you may play music or print a document.

Limitations

Computers also have some limitations. Computers do not have emotions, knowledge, experience, and feelings. They can only perform tasks as per the instructions given by the user and do not take their own decisions.

Generations of Computer

The computer has evolved from a large simple calculating machine to a smaller but much more powerful machine. The evolution of the computer to the current state is defined in terms of generations of the computer. Each generation of the computer is designed based on a new technological development, resulting in better, cheaper, and smaller computers that are more powerful, faster, and efficient than their predecessors. There are five generations of the computer.

Table 2.1 Generations of computer

Generations	Hardware Technology	Systems Examples
First Generation (1942–1954)	Main electronic component: vacuum tubes Input/Output device: punch card	ENIAC, EDVAC, EDSAC, UNIVAC, IBM 701
Second Generation (1955–1964)	Main electronic component: transistors Input/Output device: floppy disk and tape	IBM 7030, IBM 7094, IBM 1400 series, CDC 164, UNIVAC series
Third Generation (1964–1975)	Main electronic component: integrated circuits (IC) Input/Output device: keyboard and mouse as input device, high capacity disk for secondary storage	IBM 360/370, UNIVAC 1108, UNIVAC AC 9000, PDP 11, CDC 6600
Fourth Generation (1975–Present)	Very large scale integrated circuits (VLSI) technology, microprocessor Input/Output device: keyboard and mouse as input device, high capacity disk for secondary storage	STAR 1000, CRAY-X-MP (super computer), DEC 10, PDP 11 CRAY-1, IBM 4341, ALTAIR 8800, Apple computers, VAX9000
Fifth Generation (Present–Future)	These machines will incorporate bio-chip and VVLSI (very very large scale integration) or ultra-large scale integration (ULSI) artificial intelligence (AI)	IBM notebooks, Pentium PCs, SUN workstations



Hardware and Software

A computer needs both hardware and software to function properly.

Hardware: It consists of mechanical and electronic devices which we can see and touch. CPU, keyboard, mouse, and monitor are examples of hardware.

Software: It consists of programs, operating systems, and the data that resides in the memory and storage devices. Windows, Microsoft Office, LibreOffice, and Photoshop are some examples of software.

A computer system is useful only if it consists of both hardware and software.

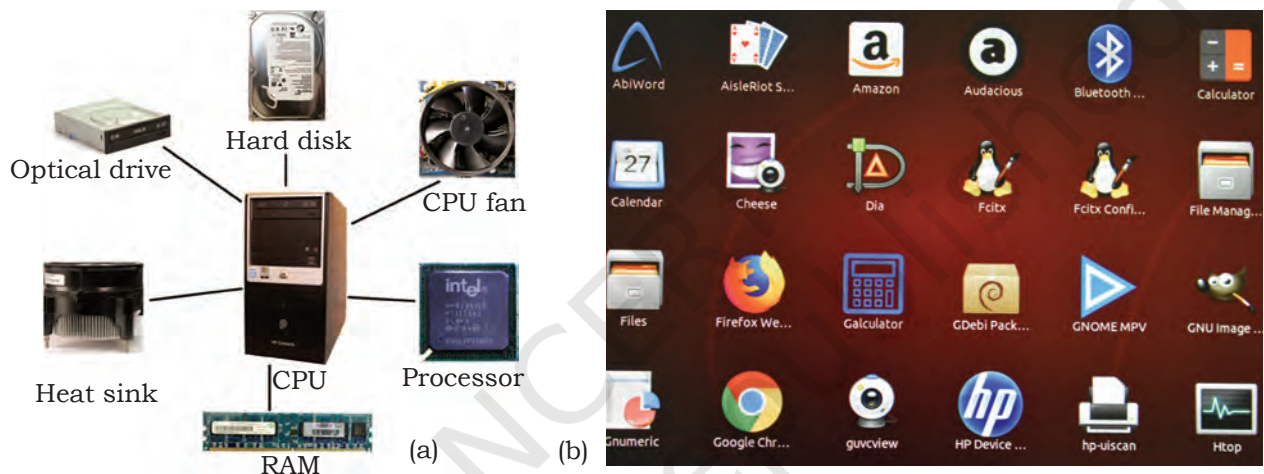


Fig. 2.2: (a) Hardware and (b) Software

Practical Exercise

Identify whether the following are a part of the computer hardware or software.

Component	Hardware/Software
Motherboard	
Monitor	
DVD drive	
Hard disk	
Microphone	
MS Office	
Keyboard	
CorelDraw	
LibreOffice	
RAM	

The Input-Process-Output Concept

A computer is an electronic device that accepts data, processes data, generates output, and stores data. A computer mainly performs the following four functions:

Input

The computer accepts input data from the user via an input device like keyboard. The input data can be characters, word, text, sound, images, document, etc.

Process

The computer processes the input data. It performs arithmetic or logic calculation, editing, modifying a document, etc. During processing, the data, instructions, and the output are stored temporarily in the computer's main memory.

Output

It is the result generated after the processing of data. The output may be in the form of text, sound, image, document, etc. The computer may display the output on a monitor and send the output to the printer for printing.

Storage

The input data, instructions, and output are stored permanently in the secondary storage devices like hard disk. The stored data can be retrieved, whenever needed.

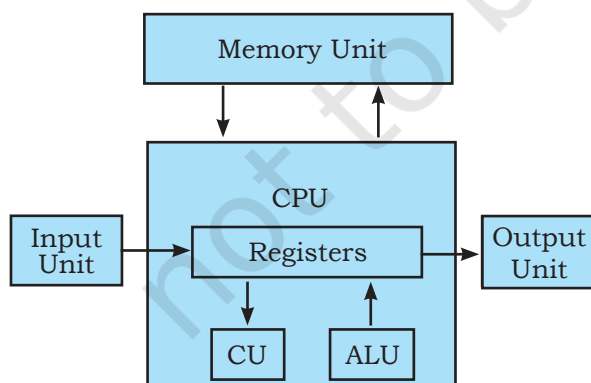


Fig. 2.3: John von Neumann architecture

Main Components of the Computer System

The internal design of a computer differs from one model to another but the basic components of all computers remain the same. The basic working model of a computer is based on the John von Neumann architecture. The interconnection diagram for a simple computer is shown in the Figure 2.3. John von Neumann proposed the first



usable draft of a working computer. It consists of some functional units namely input/output unit, central processing unit (CPU), and memory.

A computer has the following three main components—

- (i) input/output unit
- (ii) central processing unit
- (iii) memory unit

Input and output unit

The user interacts with the computer via the I/O unit. The input unit accepts data from the user and the output unit provides the processed data that is the information to the user. The input unit accepts data from the user, converts it into computer understandable form. Similarly, the output unit provides the output in a form that is understandable by the user. The input is provided to the computer using input devices like keyboard and mouse. The commonly used output devices are monitor and printer.

Central Processing Unit (CPU)

It is the main component of the computer. It performs all the processing of input data and is responsible for activating and controlling the operations of other units of the computer. In microcomputers, the CPU is built on a single chip or integrated circuit (IC) and is called microprocessor. Internal architecture of a CPU consists of the following parts—

- (i) arithmetic logic unit (ALU)
- (ii) registers
- (iii) control unit (CU)
- (iv) buses
- (v) clock

Arithmetic logic unit (ALU)

It consists of two units—arithmetic unit and logic unit. The arithmetic unit performs arithmetic operations such as addition, subtraction, multiplication, and division. Logic unit performs comparisons of numbers, letters, and special characters. Logic operations include



Fig. 2.4: Input and output devices

NOTES

testing for greater than, less than or equal to condition. ALU performs arithmetic and logic operations and uses registers to hold the data that is being processed.

Registers

They are high speed but have low storage in the CPU. They are referred to as the CPU's working memory and are directly accessed and manipulated by the CPU during instruction execution. They store data, instructions, addresses, and intermediate results of processing. The data and instructions are brought in the registers processing. For example, if two numbers are to be added, both numbers are brought in the registers and added and the result is also placed in a register. There are different registers for different specific purposes. Some of the important registers in CPU are as follows—

- Accumulator (ACC): stores the result of arithmetic and logic operations.
- Instruction register (IR): contains the most recently fetched instruction.
- Program counter (PC): contains the address of next instruction to be processed.
- Memory address register (MAR): contains the address of next location in the memory to be accessed.
- Memory buffer register (MBR): temporarily stores data from memory or the data to be sent to memory.
- Data register (DR): stores the operands and any other data.

The number of registers and the size (number of bits) of each register in a CPU helps to determine the power and the speed of a CPU. The overall number of registers can vary from about ten to many hundreds, depending on the type and complexity of the processor. The size of the register also called word size, indicates the amount of data with which the computer can work at any given time. The size of a register may be 8, 16, 32, or 64 bits. In 32-bit CPU, each register is 32 bits wide and it can manipulate 32 bits of data at a time. The modern PCs have 32-bit or 64-bit registers and are



referred to as 32-bit processor and 64-bit processor. A 64-bit processor can process the data twice as much as a 32-bit processor.

Control unit (CU)

It controls the input, output, and processing activities inside the computer. It maintains the order and controls the operation of the entire system. The control unit interprets the instructions given to the computer, determines the data to be processed, where to store the results (output), and sends the control signals to the devices required for the execution of the instructions. It directs the computer to carry out stored program instructions by communicating with the ALU and the registers. CU uses the instructions in the instruction register (IR) to decide which circuit needs to be activated. It also instructs the ALU to perform the arithmetic or logic operations. When a program is run, the program counter (PC) register keeps track of the program instruction to be executed next. CU tells when to fetch the data and instructions, what to do, where to store the results, the sequencing of events during processing, etc. CU also holds the CPU's instruction set, which is a list of all operations that the CPU can perform.

Buses

Data is stored as a unit of 8 bits in a register. Each bit is transferred from one register to another by means of a separate wire. This group of eight wires which is used as a common way to transfer data between registers is known as a bus. Bus is a connection between two components to transmit signals between them. Bus is of three major types namely—data bus, control bus, and address bus.

Clock

It is an important component of CPU which measures and allocates a fixed time slot for processing each and every micro operation. CPU executes the instructions in synchronisation with the clock pulse. The clock speed of a CPU is measured in terms of mega

hertz or millions of cycles per second. The clock speed of a CPU varies from one model to another.

Memory unit

It stores the data, instructions, intermediate results and output, temporarily during the processing of data. The memory unit consists of cache memory and primary memory. Primary memory or main memory of the computer is used to store the data and instructions during execution of the instructions. Random access memory (RAM) and read-only memory (ROM) are the primary memory. The input data that is to be processed is brought into the main memory before processing. The instructions required for processing of data and any intermediate results are also stored in the main memory. The output is stored in memory before being transferred to the output device. CPU can work with the information stored in the main memory. In addition to the main memory, there is another kind of storage device known as the secondary memory. It is non-volatile memory and is used for permanent storage of data and programs. A program or data that has to be executed is brought into the RAM from the secondary memory. Magnetic disks, optical disks, and magnetic tapes are examples of secondary memory.

Cache memory

During processing, data and instructions are brought to RAM from secondary storage devices. For processing, the data and instructions are accessed from the RAM and stored in the registers. The time taken to move the data between RAM and CPU registers is large. This affects the speed of processing of a computer and results in decreasing the performance of CPU. Cache memory is a very high speed memory placed in between RAM and

CPU. It increases the speed of processing and it is a storage buffer that stores the data that is used more often temporarily and makes it available to the CPU at a fast rate. During processing, CPU first checks cache for the required data. If

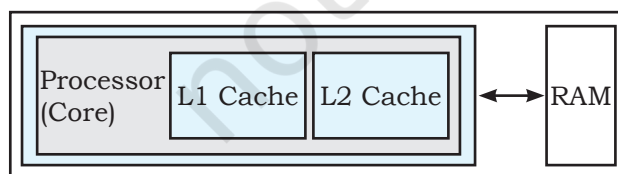


Fig. 2.5: Illustration of cache memory



data is not found in cache, then it looks in the RAM for data. To access the cache memory, CPU does not have to use the motherboard's system bus for data transfer.

Cache memory is built into the processor and may also be located next to it on a separate chip between the CPU and RAM. Cache built into the CPU is faster than separate cache, running at the speed of the microprocessor itself. However, separate cache is roughly twice as fast as RAM.

The CPU has a built-in level 1 (L1) cache and level 2 (L2) cache, as shown in Figure 2.5. In addition to the built-in L1 and L2 cache, some CPUs have a separate cache chip on the motherboard. This cache on the motherboard is called level 3 (L3) cache. Modern processor comes with built-in L3 cache, like in Intel core i7. The L1, L2, and L3 cache store the most recently run instructions, the next ones and the possible ones, respectively. Typically, CPUs have cache size varying from 256KB (L1), 6 MB (L2), to 12MB (L3) cache. Cache memory is very expensive, so it is smaller in size. Generally, computers have cache memory of sizes 256 KB to 2 MB.

Primary memory

It is the main memory of a computer. It is used to store data and instructions during the processing of data. It is semiconductor memory and is of two kinds—random access memory (RAM) and read-only memory (ROM).

Read-only memory (ROM)

It is an essential memory unit in every computer. It holds the boot up program called BIOS (Basic Input Output System) required to boot the computer. This memory is permanent and is not erased when the system is switched off. The memory capacity of ROM varies from 64 KB to 256 KB depending on the model of the computer.

Random access memory (RAM)

It is used to store data and instructions during the execution of programs. CPU accesses the data and the

NOTES

instructions from RAM, as it can access them at a faster speed than the storage devices connected to the input and output unit. The input data that is entered using the input unit is stored in RAM, to be made available during the processing of data. Similarly, the output data generated after processing is stored in RAM before being sent to the output device. Any intermediate results generated during the processing of program are stored in RAM. RAM is volatile meaning it is temporary and is erased when the computer is switched off. It is a read/write type of memory and thus can be read and written by the user. As it is possible to randomly use any location of this memory, it is known as random access memory. The memory capacity of RAM starts from 640 KB and the present computers have 4 GB to 16 GB RAM.

Memory representation

In a computer, data is stored as a machine code. The machine code has only two states either 0 or 1. Binary digit or bit is the basic unit of memory. A bit is a single binary digit that is 0 or 1. A bit is the smallest unit of representation of data in a computer. The storage capacity of memory is measured in bytes. A group of 8 bits form a byte. One byte can store 2^8 that is 256 different combinations of bits and thus can be used to represent 256 different symbols. In a byte, the different combinations of bits fall in the range 00000000 to 11111111.

Binary digit = 1 bit = 0 or 1

1 Nibble = 4 bits

1 Byte (B) = 8 bits

1 Kilobyte (KB) = 2^{10} = 1024 bytes

1 Megabyte (MB) = 2^{20} = 1024KB

1 Gigabyte (GB) = 2^{30} = 1024 MB = 1024*1024 KB

1 Terabyte (TB) = 240 = 1024 GB = 1024*1024*1024 KB

A computer with 2GB of RAM can hold 2 billion bytes of data and instructions at any time.

Secondary memory

It stores data and instructions permanently. The information can be stored in secondary memory for



a long time (years), and is generally permanent in nature unless erased by the user. It is a non-volatile memory. It provides backup storage for data and instructions. Hard disk drive and optical disk drives are some examples of storage devices.

The data and instructions that are currently not being used by CPU, but may be required later for processing are stored in secondary memory. It has a higher storage capacity and is also cheaper than the primary memory. But it takes a longer time to access the data and instructions stored in secondary memory than in primary memory.

Magnetic Storage Devices

These use plastic tape or metal or plastic disks coated with magnetic materials. Data is recorded magnetically in these devices. Read/write heads are used to access data from these devices. Hard disk drive is the most popular magnetic storage device now.

Hard disk drive (HDD): This consists of metal disks coated with magnetic material concealed in dust free containers. Hard disks have a very high storage capacity, high data transfer rates, and low access time. They are more durable, less error prone, and are the most common secondary storage device used in computers.



Fig. 2.6: Hard disk drive

Optical storage devices: This is a data storage medium which uses a low power laser beam to read from and write data into it. The laser beam reads the pits and lands (all optical media have pits and lands which are microscopic) as 0s and 1s. It is very cheap to manufacture optical disks in large quantities and it is a popular secondary storage medium. The main types of optical disks are—CD, DVD, and Blu-ray.



Fig 2.7: CD, DVD, and Blu-ray disc

Compact disc (CD): This is an optical storage medium capable of storing up to 700 MB of data. A CD drive uses red laser beams for reading from and writing data into CDs. There are two types of CDs—CD-R and CD-RW. In CD-R (compact disc recordable), data can be written once and read many times whereas in CD-RW (compact

disc rewritable) disks, it can be erased and rewritten at any time.

Digital versatile disk (DVD): This is an optical storage media similar to CD-ROM but with a higher storage capacity. This is achieved by using smaller spots to record data. Recording and reading of data is done using a DVD drive. Here also, red laser beam is used for these operations. The capacity of a DVD varies from 4.37 GB to 15.9 GB. DVDs also come in the form of DVD-ROM and DVD-RW.

Blu-ray DVD: This is an optical disk format developed to enable recording, rewriting, and playback of high definition (HD) video as well as storing huge amounts of data. CD and DVD technologies use red laser to read and write data while Blu-ray format uses a blue-violet laser. The benefit of using a blue-violet laser is that it has a shorter wavelength than a red laser, which makes it possible to focus on the laser spot with greater precision. This allows data to be packed more tightly. Therefore, it is possible to store more data on the disk even though it is the same size as that of a CD or DVD. The format offers more than five times the storage capacity of traditional DVDs and can hold up to 25 GB on a single layer disc and 50 GB on a dual layer disc.



Fig. 2.8 (a): Flash drive



Fig. 2.8 (b): Flash memory cards

Semiconductor storage (flash memory)

Flash drives use EEPROM chips for data storage. Flash memory is faster and durable as compared to other types of secondary memory. USB flash drive and flash memory cards are the examples of flash memory.

USB flash drive: This is a small external storage device. It is portable and rewritable. The storage capacity of an USB drive currently varies from 2 GB to 128 GB.

Flash memory card: This is of size about 1 inch × 0.75 inches with a thickness of about 2 mm. It has storage capacities in the range of 1 GB–32 GB. It also has a smaller version which is used within cell phones and tablets. These smaller cards are

about 6 mm × 3 mm in size and are less than 1 mm thick. These cards have various speed levels as per their usage.

Table 2.2 summaries the characteristics of the various kinds of data storage in the storage hierarchy. Modern computers are designed with this hierarchy due to the characteristics listed in the table.

Table 2.2 Comparison of different types of memory

Storage	Speed	Capacity	Relative Cost	Volatile
Registers	Fastest	Lowest	Highest	Yes
Cache	Faster	Low	Very high	Yes
RAM/ ROM	Fast	Low/ Moderate	High	Yes
Hard Disk	Moderate	Very high	Very low	No

Practical Activity

Identify the computer hardware and software.

Material required

Computer, RAM, hard disk drive, CD, DVD, pen drive

Procedure

1. Identify the RAM chip and note its memory capacity.
2. Identify the hard disk drive and note its memory capacity.
3. Insert the CD in the CD drive and note its memory capacity.
4. Insert the DVD in the DVD drive and note its memory capacity.
5. Insert the pen drive in the USB slot and note its memory capacity.
6. Categorise all of the above memory into primary and secondary memory.

Classification of Computers

Generally, the word computer refers to a personal computer such as a desktop or laptop. However, we

see different types of computers in our daily lives performing various tasks, for example while operating an ATM, purchasing groceries at the store, etc.

Purpose

According to purpose, computers can be classified into two types:

General purpose computers

These computers are used for general use such as office applications, banking, invoice, sales analysis, and financial accounting. They are used at home, offices, and educational institutions.

Special purpose computers

These computers are designed to perform scientific applications, weather forecasting, space applications, etc.



Fig. 2.9: Digital and analog signals

Working principle

According to the technology used, computers can be classified into three types—analogue, digital, and hybrid computers.

Analog computers

These deal with analog data which represents the continuously varying physical quantities, such as current, voltage, or frequency. They are used to measure physical quantities like pressure, temperature, speed, etc., and to perform computation on these measurements. Examples are thermometer and speedometer.

Digital computers

These operate on digital data. Input and output is in the form of on/off type (digit 1 and 0). Digital computers are based on counting operation. Any data to be manipulated by a digital computer must be converted to a discrete (1,0) representation. The digital computers are mainly used in office, home, and industry.

Hybrid computers

These use the combination of digital and analog computers. These computers use digital-to-analog



(a)



(b)



(c)

Fig. 2.10: (a) Analog computer, (b) Digital computer, (c) Hybrid computer

(DAC) and analog-to-digital (ADC) technology to deal with both types of data. They store and process both analog and digital data. Hybrid computers are mainly used in artificial intelligence. The ECG machine used in hospitals is an example of hybrid computer. ECG machine reads the heart beat as an analog signal and then converts it into digital signal to print the graph.

Classification of computers according to size and storage capacity

Supercomputer: This is designed by interconnecting a number of processors. It has the highest processing speed with multiprocessing technology. It is mainly used in weather forecasting, biomedical research, aircraft design, remote sensing, and other areas of science and engineering. A supercomputer focuses on executing a few programs as fast as possible. Examples of supercomputers are CRAY YMP, CRAY2, NEC SX-3, CRAY XMP, and PARAM.

Mainframes: These are slower than the supercomputers in speed and processing power. They can support hundreds of users simultaneously. In one way, mainframes are more powerful than supercomputers because they support more programs simultaneously, while the supercomputer can execute a single program faster than a mainframe. Mainframes have a very large storage capacity and can handle large database systems, such as patient information system in a big hospital or student information system in an university. Example of mainframes are DEC, ICL, and IBM 3000 series. The capacity of a mainframe can be a hundred or even a thousand times that of a modern PC.

Mini computer: This uses multiprocessing. It is capable of supporting hundreds of users simultaneously. It has a large storage capacity and operates at a higher speed. The minicomputer is used in multi-user system where various users can work at the same time. This type of computer is generally used for processing a large volume of data. It is also used as a server in Local Area Networks (LAN).



Fig. 2.11: Supercomputer



Fig. 2.12: Mainframe computer



Fig. 2.13: Mini computer



Fig. 2.14: Micro Computer



Fig. 2.15: All in one computer



Fig. 2.16: Laptop computer

Micro computer: This has the lowest speed and storage capacity. Its CPU is a microprocessor. The 4 bit microprocessor chip was invented first. The 8 bit microprocessor chip was used in the first microcomputer. The microprocessor chip continues to improve 16 bit, 32 bit, and 64 bit chips. Examples of microcomputer are IBM PC, PC-AT. The PC supports a number of input and output devices. Today's microcomputer is so powerful that it can serve the purpose of a server, or sometimes that of a minicomputer that can be used as a server. The microcomputer can be categorised as below—

Desktop computers

Desktop computers are also known as personal computer (PC). They are intended for use at a fixed location. They consist of CPU, monitor, speaker, keyboard, and mouse. Desktop computers are easy to upgrade and expand. They are also less expensive.

All in one computer

All in one computers are the new form of desktop PC. They have inbuilt CPU and monitor like that of a laptop. They can also have a touch screen monitor and are mounted on a desk like a standard monitor. CPU is mounted on the back side of the monitor. It has a USB port for connection of a mouse and keyboard.

Laptop computers

A laptop has a built-in monitor, keyboard, touch-pad, and speakers to make a fully functional computer. The modern laptops also have touch screen, which minimises the use of a keyboard or mouse. They are called laptops because of their small size and being light enough to be used while being placed on one's lap. A laptop can perform almost all jobs of a desktop. The main components of laptop are—touchpad, battery, AC adapter and ports. A user can work on a fully charged laptop without connecting it to a power supply for three to seven hours. A laptop has a power cable and AC adapter designed to be used with

specific type of laptop. The laptop also have 3–4 USB ports to connect peripheral devices, a VGA or HDMI port to connect the projector and a slot to insert a memory card.

Mobile computers

Many mobile devices work as specialised computers. These are normally used for internet, e-mail, photography, capturing and storing images and videos. These devices are portable and consume very less space. The various mobile computers are categorised as—tablets, smartphones, wearable devices, vehicle-mounted, handheld computers, e-book readers, etc. The most common are tablets and smartphones, which are discussed here.

Tablets

They are handheld computers and are more portable than laptops. They use a touch sensitive screen for typing and navigation. The size of a tablet is about 7 to 10 inches. They work on specialised operating systems such as Android, Windows, and iOS. The iPad is an example of a tablet.

Smartphones

In addition to providing telephone services, a smartphone is designed to run a variety of applications (apps). They are small tablet computers and can be used for web browsing, watching videos, reading e-books, and playing games. Many apps can be installed on the smartphone which we use in our daily lives for booking tickets, bill payment, etc.

Personal Digital Assistants (PDAs)

They are just like a mobile phone with a touch screen and keypad. They have bigger screens than mobile phones. They use handwriting recognition software to enter text and are extremely portable and fit into pockets. They are a powerful computer that includes satellite navigation facilities (GPS), mobile phone capability, and versions of application software that have a limited range of functions.



Fig. 2.17: Smartphone



Fig. 2.18: PDA





Fig. 2.19: IBM computer



Fig. 2.20: Apple computer

Types of computers on the basis of brand

There are two types of PCs—IBM/IBM compatible Intel PC and Mac PC.

IBM PC

IBM PC began with the original IBM PC that was introduced in 1981. Other companies began manufacturing similar computers which were called IBM Compatible.

Apple/Macintosh

Macintosh introduced the first personal computer with graphical user interface (GUI) in 1984. Macs are made by Apple Inc., and use Mac OS X (an operating system).

Practical Exercise

Look through the list of computer types and state where they are being used. Discuss which computer should be used for what purpose. State three reasons to choose a laptop computer rather than a general purpose desktop computer.

Check Your Progress

A. Multiple choice questions

1. The computer system is used to _____.
(a) compute the result
(b) process the data
(c) produce result
(d) All of these
2. The data and information can be stored in _____.
(a) primary storage
(b) secondary storage
(c) Both (a) and (b)
(d) None of these
3. Which of the following are components of central processing unit (CPU)?
(a) Arithmetic logic unit, mouse, control unit
(b) Arithmetic logic unit, control unit, memory
(c) Arithmetic logic unit, integrated circuits, memory
(d) Control unit, monitor, memory



4. The device through which data and instructions are entered into a computer is _____.
 - (a) software
 - (b) output device
 - (c) input device
 - (d) memory
5. The measurement of storage capacity of memory is in _____.
 - (a) bite
 - (b) bytes
 - (c) kilobytes
 - (d) megabytes
6. The 'heart' of the processor which performs many different operations—
 - (a) arithmetic and logic unit
 - (b) motherboard
 - (c) control unit
 - (d) memory
7. Unit of computer which is capable of performing arithmetic, logical, and data manipulation operations on binary numbers is called _____.
 - (a) CU
 - (b) ALU
 - (c) I/O Unit
 - (d) processing unit
8. Operations of computer arithmetic and logic unit are directed by _____.
 - (a) ALU itself
 - (b) program
 - (c) control unit
 - (d) memory unit
9. CPU consists of _____.
 - (a) ALU, control unit and registers
 - (b) ALU and control unit
 - (c) ALU, control unit, and hard disk
 - (d) ALU, control unit, and monitor
10. The output of a computer is sent to _____.
 - (a) input device
 - (b) output device
 - (c) Both (a) and (b)
 - (d) None of these
11. Which among the following was found in the first generation of computers?
 - (a) Vacuum tubes and magnetic drum
 - (b) Integrated circuits
 - (c) Magnetic tape and transistors
 - (d) All of above

NOTES

12. Which of the following refers to the fastest, biggest, and most expensive computer?
- (a) Personal computer
 - (b) Supercomputer
 - (c) Laptop
 - (d) Notebook

B. Fill in the blanks

1. The _____ unit is used to perform the arithmetic operations.
2. The input, output, and processing activities are controlled by the _____
3. The _____ unit acts as central nervous system of the computer.
4. The _____ unit presents the results to the user.
5. The different parts of the CPU are _____, _____, and _____.
6. _____ and _____ are the main memory.
7. The fastest memory in a computer is _____.
8. ALU consists of the _____ unit and _____ unit.
9. The _____ memory is placed between the RAM and the CPU.
10. The result of input given to computer is called as _____.
11. The _____ is the physical part of the computer system which one can see, feel, or touch.
12. The _____ is also called the brain of the computer.
13. The wrong results produced by computer on wrong input are _____.
14. According to its size and memory capacity, the digital computer is categorised into _____ types.
15. A bit is a single binary digit _____ or _____.
16. One byte can store _____ different combination of bits.
17. 1 Byte = _____ bits
18. 1 Kilobyte (KB) = _____ bytes
19. 1 Megabyte (MB) = _____ KB
20. 1 Gigabyte (GB) = _____ MB = _____ KB
21. 1 Terabyte (TB) = _____ GB
22. The registers are located inside the _____.

C. State whether the statements given below are True or False

1. The random access memory is used to hold the boot up program.
2. Control unit is used to present the result to the user.
3. For entering data and instruction to a computer, an input device is used.



4. Control unit decides where to store processed data.
5. A computer can do anything without data and instruction.
6. A computer is a high speed calculator.
7. CPU is a microprocessor with high speed processing power.
8. Minicomputer uses microprocessor having large storage capacity.
9. Supercomputer has highest processing speed after mainframe with multiprocessing technology.
10. The output of the digital computer is in the form of 0 or 1 type.
11. Digital computers are used for measuring physical quantities like pressure, temperature, etc.

D. State the long form of the following acronyms—

1. CPU
2. ALU
3. CU
4. RAM
5. ROM
6. HDD
7. ENIAC
8. EDVAC
9. EDSAC
10. UNIVAC
11. GIGO
12. IBM
13. PDA
14. LSI
15. VLSI

E. Short answer questions

1. What is a computer?
2. Explain input and output with examples.
3. List the important characteristics of computers.
4. List the limitations of the computer.
5. Distinguish between software and hardware.
6. Explain the input-process-output cycle.
7. What are the main components of the computer system?
8. Define analog, digital, and hybrid computers.
9. Give an example of analog computer and digital computer.
10. Give names of different types of computers.
11. How is a computer a versatile machine?
12. Explain how a computer is diligent?
13. Draw a labeled diagram of a basic model of a computer system.

NOTES

14. List the functions of a computer.
15. List the components of central processing unit.
16. Name the functional units of a computer.
17. What is the function of ALU?
18. What is the function of control unit?
19. What is primary memory?
20. List five important registers of the CPU and state the purpose of each register.
21. Why are registers used in the CPU?
22. Define word size.
23. Explain the meaning of 64-bit processor.
24. List the key features of the internal memory.
25. List the key features of the main memory.
26. Which is the fastest memory?
27. Arrange the memories in increasing order of speed—register, RAM, hard disk drive, magnetic tape, cache memory.
28. Give the approximate speed and size of the registers, cache memory, RAM, and magnetic disk.
29. List the different memories available in the computer in order of their hierarchy with respect to the CPU.
30. Why is primary memory faster than the secondary memory?
31. What is the meaning of volatile memory? Also give an example of volatile memory. Differentiate between RAM and ROM.



INTRODUCTION

Input and output devices are required to communicate with the computer. These devices are connected to the CPU through various ports or with the help of wireless technologies. Input devices feed data and instructions into the computer, and output devices present information from a computer system. Output generated by the output devices may be hardcopy or softcopy output. Hardcopy outputs are permanent outputs which can be used later when required. They produce a permanent record on paper. Printer is a common output device, that produces hardcopy outputs. Softcopy outputs are electronic and are available on the screen in a digital form. They do not produce a permanent record. Monitor is a common softcopy output device.

INPUT DEVICES

An input device is used to feed data into a computer. It is also defined as a device that provides communication between the user and the computer.

Text Input Devices

Keyboard

This is the most common input device. It is designed just like a conventional typewriter. It allows the user to input alphabets, numbers, and other characters. It provides keys for additional functions. It detects the key being pressed and generates the corresponding ASCII code which can be recognised by the computer. The standard US keyboard introduced in 1986 has 101 keys. It has a keyboard layout called the QWERTY design. QWERTY gets its name from the first six letters across in the upper left hand corner of the keyboard



Fig. 3.1: Keyboard



Fig. 3.2: Numeric keypad



Fig. 3.3: PIN pad



Fig. 3.4: Mouse

as shown in Figure 3.1. Normally, keyboards come in two sizes—one with integrated numeric keypad and other with a separate numeric keypad. Keyboards can be classified into wired and wireless. Wired keyboards are connected to the CPU through a serial, PS/2 port, or USB port. Wireless keyboards are connected to the computer through infrared (IR), radio frequency (RF), or bluetooth connections. Portable flexible keyboards are also available now. New generation keyboards like laser keyboards that project the keyboard layout to any surface are being developed.

Numeric keypad

It is a small keyboard having only numbers. It is used to enter only numeric data such as those in ATMs. The computer keyboards also have a numeric keypad.

PIN pad

This is a device with a numeric keypad used to enter a personal identification number (PIN) of debit card or credit card while doing the transaction.

Pointing Devices

These devices are used to move an onscreen pointer or cursor (usually an arrow). They are commonly used with graphical user interfaces (GUIs).

Mouse

It is a small handheld device used to indicate the position of a cursor or its movement on a computer's screen by rolling it over a mouse pad or flat surface. A mouse has one or more buttons and possibly a scroll wheel. This scroll wheel is used to scroll the screen vertically or horizontally. The different types of mouse are ball, optical, and laser mouse. Ball mouse works on the principle of the movement of the ball, whereas optical mouse uses LED and laser mouse uses laser beams for sensing the movement. Laser mouse has more precise movement when compared to other types of mouse. Wired mouse uses serial, PS/2, and USB ports, to communicate, whereas a wireless mouse communicates with the computer via radio waves.



Light pen

It is a pointing device shaped like a pen. The tip of the light pen contains a light-sensitive element which when placed against the screen detects the light from the screen, enabling the computer to identify the location of the pen on the screen. Light pens have the advantage of drawing directly on the screen. They are used by engineers, artists, fashion designers for Computer Aided Designing (CAD) and other drawing purposes.



Fig. 3.5: Light pen

Touch screen

It is an input device that allows the user to operate by simply touching on the display screen. Some computers, tablets, smartphones, etc., have touch-sensitive display screens. It can also be operated using a stylus which gives more precision. Information kiosks at railway stations and bank ATMs also use touch screens as input device. Nowadays, touch screens is the most common hardware interface for electronic gadgets.



Fig. 3.6: Touch screen

Graphic tablet

This consists of an electronic writing area and a special pen that works with it. It allows artists to enter natural hand movements to create graphical images with motions and actions similar to traditional drawing tools. A stylus is used like a pen and moved over the surface of the tablet. Stylus' movement data is then sent to the computer. The pen of the graphics tablet is pressure sensitive. Hard or soft pressure on the tablet using the pen can result in brush strokes of different widths in an appropriate graphics program.



Fig. 3.7: Graphic tablet

Touchpad

This is a pointing device found on the laptop computers in place of a mouse to control the pointer. It allows the user to move the finger across the touchpad just as a mouse pointer does and this movement in the form of data is sent to the computer. Touchpad is operated with fingers and dragging it across the flat surface, as the finger moves on the surface, the mouse cursor will move in that same direction. The touchpad also has two buttons below the touch surface that enables clicking.



Fig. 3.8: Touchpad



Fig. 3.9: Joystick

Joystick

This is an input device used for playing video games, controlling training simulators and robots. Joysticks and other game controllers can also be used as pointing devices. The joystick has a vertical stick which can move in any direction. It can be used to control objects in a video game or to make menu selections by the movement of a cursor displayed on the screen. It has a button on the top that is used to select the option pointed by the cursor.

Audio Visual Input Devices

Scanner



Fig. 3.10: Flatbed scanner

Scanning is a process of taking a close-up photograph. Scanner is an input device which functions like a photocopying machine. It has a glass plate to place the paper which is to be scanned. Scanners can capture information, like pictures or text, and convert it into a digital format that can be edited using a computer. The scanned image or document is captured by the laser beams and converted to digital data. The scanned picture or document can be saved in the computer. The quality of the image depends on the resolution of the scanner. The resolution of the image scanned is expressed in dots per inch (DPI). The higher the DPI, the better will be the resolution of the scanned image.

The different variants of scanners are flat bed, sheet feed, and hand held scanner. A sheet feed scanner can scan a single sheet, whereas a flat bed can scan even from a book but they are not portable. A hand held scanner is portable but the scanning action is not smooth as the scanner is moved manually.

Microphone



Fig. 3.11: Microphone

This is used to input human voice into the computer. It is attached to a computer for the input of sound. It accepts sound which is analogue in nature as input and converts it to digital format. The digitised sound can be stored in the computer for processing or playback. The headphones come with microphones to use chat applications. A computer loaded with speech recognition



software like the one pre installed in Windows 7 can convert what a person has said into text, which can be saved for word processing. A voice recognition program can process the input and convert it into machine recognisable commands.

Digital camera

This can take pictures and videos and convert them into digital format. Pictures or videos taken using a digital camera are stored inside its memory and can be transferred to a computer by connecting the camera to it. It is a kind of small computer that controls camera focus, stores images, etc. It runs a very simple operating system (stored on ROM) and usually provides a menu-based GUI for the user.

The quality of the lens, the density of charge coupled device (CCD), resolution (measured in megapixel), optical zoom, and the software used in the camera determines the quality of the picture. Each picture is made up of thousands of tiny pixels (picture elements) and the camera stores the data on the colour of each dot. The quality of the picture is determined by the number of pixels in each picture. Digital cameras have resolutions ranging from 2 mega pixel to 24 megapixels and optical zoom ranging from 3x to 60x.

Webcam

It is a compact and less expensive version of a digital camera. It is used in computers for video chatting. It does not have an internal memory. It is a very basic video camera used to feed live video into a computer. The video data from a web cam is low quality compared to a full video camera. It is positioned on top of the laptop monitor and for desktop computers it can be connected externally. Applications like Skype, Yahoo Messenger, etc., use webcam to capture images. Now, laptops also come with an inbuilt web camera.

Closed circuit TV (CCTV)

CCTV captures the images and videos fed as input to the computers. (Figure 3.14). CCTVs are commonly used to maintain road safety and the security on premises.



Fig. 3.12: Digital Camera



Fig. 3.13: Webcam



Fig. 3.14: CCTV



Input card Readers

Smart card or chip reader



Fig. 3.15: Smart card reader

This is a plastic card that stores and transacts data. It has a tiny ‘chip’ of computer memory embedded inside. Data can be stored in the chip’s memory and read back using a ‘chip’ reader. The data card may contain a memory or a microprocessor. Memory cards simply store data, while a microprocessor card on the other hand can add, delete, and manipulate information in its memory. The smart card is used in most banking, healthcare, telephone calling, electronic cash payments, and other applications.

Smart card readers are used to access data in a smart card. It can be contact type or contact less. A contact type of reader requires physical contact with the cards, which is made by inserting the card into the reader. A card is inserted into the reader where metal contacts connect to the metal pads on the front face of the card. The reader can access the data stored on memory chip. A contact less type of reader works with a radio frequency that communicates when the card comes close to the reader. Many contact less readers are designed specifically for toll gate payment in transportation applications and person identity applications. Satellite TV decoders use smart cards to store data regarding subscription of channels by the user. The data is encrypted so that it is not easy to alter. Many types of cards—ID cards, phone cards, credit cards, and door security cards use this system.

Magnetic strip reader

The credit cards have a magnetic strip. This strip stores the user’s data in the form of magnetised dots (for example, the credit card number, card expiry date, and customer name). The strip allows inputting of this data to a computer system faster and more accurately than typing. A magnetic strip reader is used to read the data by swiping the card through a slot on the reader.



Input-reading Text or Codes

Entering the data in a computer using a keyboard may be a slow process and it is prone to mistakes. Sometimes speed and accuracy may be essentially required. In such cases, the following input devices are used to read and input the data.

Barcode or Quick Response (QR) code reader

It is a set of vertical lines of different thickness and spacing that represent a number. These lines are read by a barcode reader or scanner. Barcode readers are devices that are used to input data from such set of barcodes (Figure 3.16 (b)). This code is converted to an alphanumeric value and is fed to the computer connected to it. The bar code reader reads and enters the value quickly and accurately than entering the data by using a keypad. Barcode is used to code items in a shop and books in a library. Handheld scanners are commonly seen in shops to scan codes and price information for each of the items to make billing easier. Mobile phones with camera and special software can also be used as a barcode reader.

QR codes are similar to barcodes. Barcodes are single dimensional, whereas QR codes are two dimensional as shown in Figure 3.17. The two dimensional way of storing data allows QR code to store more data than a standard barcode. This code can store website URLs, plain text, phone numbers, email addresses, and any other alphanumeric data. The QR code can be read using a barcode reader or a mobile phone which has a camera and special software installed.

Optical Mark Reader (OMR)

It is an input device that recognises marks made by a pencil or pen in a multiple-choice type form. It is commonly used to check forms filled with pen or pencil and to correct MCQs of exam papers. It can read the marks and feed that data to a computer (Figure 3.18).



(a)



(b)

Fig. 3.16: (a) Bar code, (b) its reading using BCR

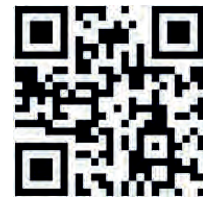


Fig. 3.17: QR code



Fig. 3.18: Optical mark recognition



Fig. 3.19: Optical mark recognition

OMR technology scans a printed form and reads predefined positions and records the marks on the form. This technology is useful for applications in which large number of forms needs to be processed quickly with great accuracy, such as objective type tests and questionnaires.

OMR sheets are normally used to evaluate multiple choice questions in competitive exams. It consists of bubble shaped options to mark the answers. Candidates are required to darken the correct bubble option using a pen or pencil (refer to Figure 3.19). For accuracy of results, good quality paper and accurate alignment of printing is essential.



Fig. 3.20: MICR

Magnetic Ink Character Reader (MICR)

It reads the data written by the magnetic ink. The cheque number is printed at the bottom of each bank cheque by special magnetic ink using a special font. It can be detected by a MICR reader. MICR reads this data and feeds it to the computer quickly and accurately (Figure 3.20).

Optical Character Recognition (OCR)

This is a software technology that converts images of text into an actual text file. To use this technology, first scan the document using the scanner. Then the scanned image is analysed by the OCR software. The result is such that it seems the text has been typed by hand.

Input Sensors

A sensor is a device that senses the real world data (for instance, temperature) and converts it into digital data to be processed by the computer. A computer system cannot sense the real world data such as light or dark, hot or cold, quiet or noisy. We use our senses (eyes, ears, mouth, nose, and skin) to read such data. In the same way, the sensor reads this kind of data and converts it into its digital equivalent. The sensors are connected to a computer.

Remote control

This is a very commonly used input device. It sends data signals each time a button is pressed using



infrared light or radio signals. The signals can control the system from some distance. It is also used to control a presentation slide show.

Biometric sensor

It is a device that identifies unique human physical features with high accuracy. It is an essential component of a biometric system which uses physical features like fingerprints, retina, iris patterns, etc., to identify, verify, and authenticate the identity of the user. The three major types of biometric sensors are semiconductor sensor, optical sensor, and ultrasound sensor. Figure 3.21 shows a biometric sensor.



Fig. 3.21: Biometric sensor

Practical Exercise

Identify the following input devices and list their features.

Output Devices

These can be categorised into three types based on the output produced by the computer in the following form:

1. soft copy
2. hard copy
3. sound output

Soft copy output device

The output on the screen is called a soft copy. The soft copy output can be provided on the following devices.

Visual Display Unit (VDU)

This is an output device that visually conveys text, graphics, and video information. Information shown on a display device is called softcopy because the information exists electronically and is displayed for a temporary period of time.

Display devices include Cathode Ray Tube (CRT) monitors, Liquid Crystal Display (LCD) monitors, Thin Film Transistor (TFT) monitors, Light Emitting Diode (LED) monitors, and gas plasma monitors.

Some of the characteristics of a VDU are size, resolution, pixel pitch, and response time. VDUs are available in different sizes. The size of a monitor is measured diagonally across the screen in inches. The resolution of the monitor is the maximum number of pixels it can display horizontally and vertically (such as 800 x 600 or 1024 x 768 or 1600 x 1200). The pixel spacing on the screen is called the dot pitch. A screen with smaller dot pitch produces sharper images. Response time refers to the time taken for a pixel to turn from a state of brightness to a state of darkness and then back again. Monitors with lesser response time provide better movie viewing experience.

The CRT monitors were used earlier. Nowadays they are not being used, as flat LCD monitors are available at the same cost. But it is essential to know the old technology also. The CRT monitor looks like a television set from the past. It is large in size,



heavy, and consumes more electricity because it contains a large cathode ray tube. It is available in two forms—monochrome and color. A monochrome monitor displays characters and images in a single color on a dark background. Another variation of monochrome monitor is capable of displaying different shades of gray and is called a gray scale monitor. A color monitor uses three different basic colours such as red, blue, and green to display 16 to 1 million different colours. These monitors are preferred by graphic artists for their accurate colour rendering and by gamers for faster response to rapidly changing graphics.

Flat panel monitor

These are very thin, lightweight, and need very less power. Flat panel displays are thinner, lighter in weight, consume less power, and emit less heat as compared to CRT monitors. They are most commonly used in computers, especially in laptops. Different types of flat panel monitors are LCD (Liquid Crystal Display), LED (Light Emitting Diode) and OLED (Organic LED). LCD uses liquid crystal molecules for display, LED uses light emitting diodes for display, and OLED uses a special organic compound for display. LED displays have better brightness.

Liquid crystal display (LCD): This displays consists of liquid crystals sandwiched between two plastic plates. These crystals rearrange to form an image when an electric current passes through them. A light source at the back of this plate makes the picture visible. This light source can be a fluorescent lamp or LED.

Light emitting diode (LED) monitor: This uses LED directly behind the liquid crystal display (LCD) in order to light up the screen. This technique is very effective and gives each area of the screen its own light, which can be on or off. LED screens can produce massive contrast ratios resulting in better color quality and clarity. Further, wider viewing angle, faster refresh rates, and power saving are its other advantages, making this technology expensive.



Fig. 3.22: CRT monitor



Fig. 3.23: LCD and LED display



Fig. 3.24: Plasma monitors

Plasma monitors: A flat panel display consists of sandwiching neon or xenon gas between two sealed glass plates with parallel electrodes deposited on their surfaces. When a voltage pulse is passed between two electrodes, the gas lights up as different colours creating images on a monitor. Plasma monitors provide high resolution but are also expensive.

Organic light emitting diode (OLED) monitors: The panel of OLED is made up of millions of tiny LEDs. The 'O' in OLED stands for organic which means there is carbon in the light emitting layer of the panel. OLED screens are thinner and lighter than LCDs and LEDs. They can produce better quality images and have a better viewing angle. OLEDs consume less power but are again very expensive.



Fig. 3.25: Multimedia projector

LCD projector

This is a type of video projector used for displaying videos, images, or computer data on a large screen or any other flat surface. Several people in a classroom can view the output on a wide screen at the same time. It is a modern equivalent of the slide projector or overhead projector. A beam of high-intensity light travels through thousands of shifting pixels in a LCD display. This beam of light then passes through a lens which projects and focuses the image on the surface.

Hard copy output devices

Hard copies are tangible computer outputs. Printer and plotter are used to get a hard copy output.

Printer

This is used to produce a hard copy output. There are different kinds of printing technology. Two factors that determine the quality of a printer are its resolution and speed. Resolution is measured in terms of DPI. Speed is measured in terms of number of characters printed in a unit of time and is represented as characters per second (CPS), lines per minute (LPM), or pages per minute (PPM). Based on the technology used, they can be classified as impact or non-impact printers.



Impact printers

These use the typewriting or printing mechanism where a head or needle strikes against an ink ribbon to make a mark on the paper. The ink ribbon used in this printer is not very expensive. It is used in banks and shops for printing receipts, etc. Dot matrix printers fall under this category.

Dot matrix printers: Use small electromagnetically activated pins in the print head and an inked ribbon to produce images by impact. The most commonly used printer heads consists of nine pins. Certain printers use 24 pins for better print quality. A dot matrix printer prints a letter in a grid or matrix pattern of dots. It forms the letters by hitting the print on the ribbon and then both the papers. Its print quality is poor and also produces noise while printing. But its running cost is very less and one can also print multiple copies in one go using the carbon paper between the papers. These printers are slow and noisy and are not commonly used for personal use. The dot matrix printers are widely used at cash counters in shops due to their low printing cost and because we can get carbon copies from them.

Line Printer: The line printer also uses the similar technology but it is a fast printer which prints one row at a time. This means it can print upto 3,000 lines per minute (Figure 3.27).

Non-impact printers

These do not touch the paper while printing. And since they don't strike the printer head, they are not noisy. They use different technologies to print characters on paper. Inkjet, laser, and thermal printers fall under this category. Running cost of these printers is more expensive than impact printers.

Inkjet printers: These form the image on the page by spraying tiny droplets of ink from the print head. The four colour ink (cyan, yellow, magenta, and black) is used to produce colour printouts. The droplets of ink come from tiny holes (the jets). Each droplet creates



Fig. 3.26: Dot matrix printer



Fig. 3.27: Line printer



Fig. 3.28: Inkjet printer





Fig. 3.29: Laser printer



Fig. 3.30: Laser printer's toner



Fig. 3.31: Thermal printers

a tiny dot on the paper. Since the dots are so small, the quality of the printout is excellent (1200 dots per inch are possible). They are used to print photographs. They are inexpensive, but the cost of ink cartridges makes it a costly affair in the long run.

Laser printers: These produce a good quality output. It utilises a laser beam to produce an image (through a mirror) on a drum. The light of the laser alters the electrical charge on the drum and applies toner (dried ink) in the cartridge. The toner powder from the toner cartridge is then sprayed onto the drum. The toner powder sticks onto the portions traced on the drum by the laser beam. It is transferred to a paper by rolling the paper over the drum. Through heating, the powder is fused onto the paper. There are laser printers which print about four A4 size papers per minute. These printers produce clear and quality printouts. They are also faster and their speed is rated in pages per minute (PPM). Monochrome and colour laser printers are available. Colour laser printers use multiple colour toner cartridges to produce colour output and are expensive.

Thermal printers: These produce a printed image by selectively heating heat sensitive thermal paper when it passes over the thermal print head. The coating turns black in the areas where it is heated, producing an image. These printers are less noisy and faster than dot matrix printers. They are also smaller, lighter, and consume less power, making them ideal as portable printers. They are commonly used in business to print receipts in devices such as an ATM and in printing labels.

The features of all the above printers are summarised in the Table 3.1.

Table 3.1
Comparison of printers

Features	Laser Printers	Inkjet Printers	Thermal Printers	Dot Matrix Printers
Printing material used	Ink powder	Liquid ink	Heat sensitive paper	Ink soaked ribbon
How does it print?	It fuses the powder on the paper through heating.	It sprays liquid ink on paper through microscopic nozzles.	Thermal paper is passed over the thermal print head.	Pins are pushed against ribbon on paper.
Printing speed	20 pages per minute	6 pages per minute	150 mm per second	30550 characters per second
Quality	Printing quality is good. Best for black and white.	Printing quality is good, especially for smaller fonts.	Poor quality printing of images. Good quality text printing.	Poor printing quality for images. In terms of text, printing is good.
Advantages	Less noisy, prints faster, high print quality.	Less noisy, high print quality, no warm up time, device cost is less.	Less noisy, fast, smaller, lighter, consumes less power, portable	Cheaper to print as ribbon is cheap, carbon copy possible.
Disadvantages	More susceptible to paper jams. Toner is expensive. Device itself is expensive.	Ink is expensive and not waterproof, and nozzle is prone to clogging.	Requires special thermal quality paper, poor quality printing.	Initial purchase and maintenance are both expensive, printing is not fast, makes noise.

Three dimensional (3D) printers

This is a new generation output device used to print 3D objects. It can produce different kinds of objects in different materials and this can be done using the same printer. It can print anything from ceramic cups to plastic toys, metal machine parts, stoneware vases, fancy chocolate cakes, etc.

The 3D printing process turns the object to be printed into thousands of horizontal tiny little layers. It then prints these layers from bottom to top, layer by layer. These tiny layers stick together to form a solid object.

Plotter

It is an output device used to produce hard copies of graphs and designs on the paper. Plotters are used to print the drawings by using a special pen. Coloured pens are used to produce colour line drawings. The pens are held by an arm which can lift the pen up or down, and move across the paper. The arm and pen of the plotter creates drawing just like humans but with more speed and accuracy. A plotter is typically used to print large format graphs or maps such as construction maps, engineering drawings, and big posters. It is used in the designing of cars, ships, aircrafts, buildings, highways, etc. Plotters are used by designers and architects since they work with huge pieces of paper, that a normal printer cannot handle. They are not used to print the text and images. They are used to print the drawings prepared by the CAD software. Plotters are of two types: drum plotters and flatbed plotters.



Fig. 3.32: Drum plotter

Drum plotter

It is also known as a roller plotter. It consists of a drum or roller on which a paper is placed and the drum rotates back and forth to produce the graph on the paper. It also consists of a drawing arm that holds a set of coloured ink pens or pencils. The drawing arm moves side to side as the paper is rolled back and forth through the roller. In this way, a perfect graph or map is created on the paper.

Flatbed plotter

It is also known as a table plotter. It plots on paper that is spread and fixed over a rectangular flatbed table. The flatbed plotter uses two drawing arms, each of which holds a set of coloured ink pens or pencils. The drawing arms move over the stationary paper and draws the graph on the paper. Flatbed plotter is very slow in drawing or printing graphs. The large and complicated drawing can take several hours to print.



Fig. 3.33: Flatbed plotter

Sound output device

The device which gives a sound output is called a speaker. Speaker devices are designed for personal and public use.

The audio output is the ability of the computer to produce sound. Speakers are the output devices that produce sound. They are connected to the computer through audio ports. They produce sound by the movement of the diaphragm in the speaker, forward and backward according to the electrical signals coming out of the audio port. For high quality sound reproduction, computers use 2.1 (3 speakers), 5.1 (5 speakers), and 7.1 (7 speakers) speaker systems.



Fig. 3.34: Speaker

Practical Exercise

Identify the following output devices and list its features

Check Your Progress

A. Multiple choice questions

1. In ink jet printers, to produce an image it uses _____
 - (a) special pen.
 - (b) tiny droplets ink.
 - (c) laser beam.
 - (d) All of these
2. Printer in which printing head and paper is forced together to form letters is called _____
 - (a) impact printer.
 - (b) non-impact printer.

NOTES

- (c) page printer.
(d) line printer.
3. Which printer is an impact printer?
(a) Laser printer
(b) Line printer
(c) Ink jet Printer
(d) All of the above
4. Which of the following groups consist of only output devices?
(a) Scanner, printer, monitor
(b) Keyboard, printer, monitor
(c) Mouse, printer, monitor
(d) Plotter, printer, monitor
5. Printers are examples of _____ output device.
(a) hardcopy
(b) softcopy
(c) double copy
(d) None of these
6. In LCD, 'L' stands for _____.
(a) light
(b) liquid
(c) limit
(d) long
7. Which of the following is a type of monitor?
(a) LCD
(b) CRT
(c) LED
(d) All of above
8. Computer output which is printed on paper and is tangible is known as _____.
(a) hardware
(b) hard copy
(c) document
(d) result
9. The smallest unit of an output device display is called a _____.
(a) pixel
(b) picture unit
(c) VDT
(d) monitor
10. Touchscreen is usually used to detect the touch of a _____.
(a) human finger
(b) pen
(c) wooden stick
(d) None of these



B. Fill in the blanks

1. CRT and LCD are types of _____.
2. A digital camera can take pictures and videos and convert them into a _____ format.
3. Web camera is a compact and less expensive version of a _____ camera.
4. Smart card readers are used to access data in a _____ card.
5. The credit cards have a _____ strip.
6. A QR code is similar to _____.
7. Magnetic ink character reader reads the data written by the _____ ink.
8. The output on the screen is called a _____ copy.
9. Printers are used to produce a _____ output.
10. A laser printer produces _____ quality output.
11. The device which gives a sound output is called a _____.

C. State whether the statement given below are True or False

1. Thermal printer is used to print the drawings by using a special pen.
2. Speaker is an audio input device.
3. Inkjet printer is an impact printer.
4. CD, LED, and CRT are the technology used in monitor.

D. Short answer questions

1. What are non-impact printers?
2. What do you mean by output devices?
3. List all output devices.
4. Priyanka is taking up digital photography and she wants a printer that enables to print her photos, with the best results. Which printer would you recommend and why?
5. Printers are generally classified as 'impact' and 'non-impact'. Which category does a laser printer fall into?
6. In printing, DPI is the standard measure of printed image quality on the paper. What does DPI stand for?